Arboriculture & Urban Forestry 2025
https://doi.org/10.48044/jauf.2025.035

Increasing Urban Tree Diversity, Quality, and Abundance in the Chesapeake Bay Watershed: Challenges and Opportunities

By Andrew K. Koeser, Deborah R. Hilbert, Dexter Locke, Christopher B. Riley, and Nancy F. Sonti

Abstract. Background: While many tree professionals recognize the importance of planting quality stock and a diversity of species to enhance longevity and increase urban forest resiliency, the availability of such stock is often limited. Methods: To address this disconnect, we conducted 3 focus groups with growers, designers, urban foresters, and other technical experts from the Chesapeake Bay watershed region (USA) to identify challenges and opportunities for growing greater numbers of high-quality, underused species. Results: Contract growing was seen as a key opportunity for increasing quality and diversity. Additionally, increased communication between growers and tree purchasers, as well as potential partnerships with nonprofit or state nurseries, were identified as potential solutions where the marketability of underused species was limited. There were differences among participants regarding their preferences for native species, non-native species, cultivars, and non-cultivars. Conclusions: While this research focused on the tree supply chain within the Chesapeake Bay watershed, many of the challenges and opportunities discussed are not region-specific, making our findings applicable to professionals beyond the study area.

Keywords. Green Industry; Tree Nursery; Urban Greening.

INTRODUCTION

Tree species diversity is a crucial factor in enhancing urban forest resilience and ecosystem stability, especially in the face of changing climates and the emergence of pests and pathogens (Morgenroth et al. 2016; Huff et al. 2020). The overreliance on a single species or a few species in managed urban forests increases the risk of widespread mortality during outbreaks if the dominant species are vulnerable to emerging biotic or abiotic threats (Laćan and McBride 2008). Numerous guidelines for increasing species diversity at the species, genus, and family taxonomic levels have been proposed and promoted among urban forest managers (Santamour 1990; Raupp et al. 2006), and history has seen many cases of widespread die-offs of overly abundant urban tree species (Jernelöv 2017; Klooster et al. 2018; Bahder et al. 2019).

There are approximately 73,300 tree species worldwide, with over 1,800 species found in North America (Cazzolla Gatti et al. 2022). Despite this abundance of diversity, many urban areas rely heavily on a handful of "go-to" tree species. In their survey of urban forest managers across the United States, Ma et al. (2020) found that just 6 species account for the majority (62%) of street and park trees in any given city. Similar results were observed by Cowett and Bassuk (2017), who compiled tree inventories in the Northeastern United States and found that one species, *Acer platanoides*, represented over 16% of street trees recorded. Moreover, the *Acer* genus accounted for nearly 39% of the total population compiled during their search.

Outside the United States, Lohr et al. (2016) observed that a single tree species comprised 20% of the tree population in an average city. In Helsinki, Finland, and Bangkok, Thailand, this figure rose to 40%, with a single species dominating the urban forest inventory. Similarly, Galle et al. (2021) found that

the *Ulmus* genus represented nearly half of the trees in the city center of Amsterdam, Netherlands. In a similar study, Sjöman et al. (2012) reported that the *Tilia* genus accounted for 13.3% to 46.3% of urban trees across 10 Nordic cities.

Planting a diverse array of tree species is a valuable strategy to mitigate losses from future, unknown threats. Additionally, selecting high-quality nursery stock can enhance the potential longevity of urban trees, regardless of what the future may bring (Allen et al. 2017). Less commonly produced species may not be available in the size or quality desired by tree purchasers, prompting them to choose from more abundant (and potentially overused) alternatives (Burcham and Lyons 2013). In their study of tree planting decisions in Toronto, Canada, Conway and Vander Vecht (2015) observed that species selection was ultimately influenced by the available supply. Quantity often dictated what was planted in park settings, while quality constrained options for residential planting purchases.

These constraints on urban tree selection have been documented and analyzed to improve diversity, quality, and general availability (Sydnor et al. 2010; Burcham and Lyons 2013). Hilbert et al. (2023b) outlined the numerous layers of decision-making during production, design, procurement, and installation that filter out potential planting options and collectively reinforce the status quo, where relatively few species dominate planted urban landscapes. Some of these decisions fall outside the typical purview of green industry professionals, such as urban design and planning practices that limit site conditions (Nitoslawski et al. 2016). That said, conflicting goals within the green industry itself often unintentionally restrict tree selection options (Hilbert et al. 2023b). For example, urban forest policies that mandate the use of large-caliper stock for mitigation or planting projects generally limit the species that can be procured.

As part of the Chesapeake Bay Watershed Agreement, a strategic goal was set to expand urban tree canopy by 2,400 acres between 2014 and 2025. Partners in this regional agreement have additional goals at local levels, and have experienced challenges procuring trees of the species, size, quality, and/or quantity needed for some projects. In Maryland, which accounts for roughly one-fifth of the land area within the Chesapeake Bay watershed, 5 million trees are set to be planted by 2031, with 500,000 of those being planted in underserved urban areas (Gilbert 2023). Building on past research that has characterized regional tree supply chains and identified key constraints and opportunities, and acknowledging that tree production varies widely across the United States and beyond (Hilbert et al. 2023b), this study aimed to explore the challenges and possibilities of establishing a sustainable supply of high-quality, climate-resilient tree species suited for urban areas within the Chesapeake Bay watershed.

Motivated by a growing need for diverse, high quality nursery stock to meet urban forestry planting goals across the Chesapeake Bay watershed region, the research focused on two main questions: first, "What barriers impact the quantity and quality of trees commercially grown in this region?" and second, "What opportunities could enable growers to produce a sufficient number of climate-ready, lesser-used tree species to meet consumer needs?"

While the findings from this study are inherently tied to the region of inquiry, tree production systems worldwide face similar challenges (Burcham and Lyons 2013; Conway and Vander Vecht 2015; Avolio et al. 2018). As such, the challenges and opportunities identified in this study extend beyond the Chesapeake Bay watershed, contributing to the global discourse on the complex issue of low urban tree diversity.

METHODS

Study Area

The Chesapeake Bay watershed is a large and ecologically significant drainage basin spanning approximately 16.6 million hectares (64,000 square miles) across parts of 6 states—Delaware, Maryland, New York, Pennsylvania, Virginia, and West Virginia—as well as the District of Columbia. Land uses vary from rural farms and forests to major East Coast cities including Washington, DC; Richmond, Virginia; Annapolis, and Baltimore, Maryland; and Harrisburg, Pennsylvania. There are 207 jurisdictions (mostly counties) in the watershed, and from 2013 to 2018 only 26 (12.5%) reported net increases in tree canopy cover (Chesapeake Tree Canopy Network 2025). It is the largest estuary in the United States (NOAA 2021) and encompasses both humid subtropical and humid continental climate zones (Kottek et al. 2006). More than 18 million people reside in the region (Chesapeake Bay Foundation 2025).

Participant Selection

We conducted 3 focus group sessions in Spring 2024 with professionals involved in urban tree production, specification, and procurement across the Chesapeake Bay watershed. To ensure a balanced, cross-disciplinary dialogue, we purposively sampled 5 stakeholder categories: wholesale nursery growers, landscape architects, municipal foresters and arborists, representatives from environmental nonprofits and government agencies, and private-sector practitioners (e.g., landscape contractors)(Morgan 1997; Femdal and Solbjør 2018).

In total, 52 individuals were invited (15 Nursery, 12 Landscape Design, 11 Municipal Arborist/Urban Forester, 10 Nonprofit/Government, 4 Private Industry). Invitations were drawn from prior projects, regional NGOs, and referrals from the Chesapeake Bay Trust and USDA Forest Service Urban & Community Forestry program. We supplemented these lists via snowball sampling whenever a category's scheduled slots remained unfilled.

Of those invited, 20 (38.5 %) agreed to participate and were scheduled into 1 of 3 sessions:

- **Focus Group 1**: Scheduled $n = 6$ (2 Nursery; 0 Landscape Design; 1 Municipal Arborist/ Urban Forester; 3 Nonprofit/Government; 0 Private Industry)
- **Focus Group 2:** Scheduled $n = 7$ (1 Nursery; 0 Landscape Design; 2 Arborist/Urban Forester; 3 Nonprofit/Government; 1 Private Industry)
- **Focus Group 3:** Scheduled $n = 7$ (3 Nursery; 1 Landscape Design; 1 Municipal Arborist/Urban Forester; 1 Nonprofit/Government; 1 Private Industry)

In total, 17 participants ultimately attended (85% of those scheduled; 32.7% of invitees), with per-category recruitment rates ranging from 8.3 % (Landscape Design) to 60 % (Nonprofit/Government) (Table 1). Final group sizes were as follows: FG1 $n = 4$, FG2 $n = 7$, FG3 $n = 6$. This stratified, multi-stakeholder composition allowed us to explore decision-making around tree production, design, and maintenance from complementary professional perspectives.

Focus Group Logistics

A total of 3 focus groups were held. Each meeting lasted approximately 2 hours, with subsequent meetings spaced 1 to 2 weeks apart to allow time for preliminary analysis and any necessary improvements (clarifying questions, adjusting delivery timing, etc.). All meetings were conducted virtually using an online meeting service (Zoom), which facilitated recording and transcription. A shared virtual whiteboard (Google Jamboard) was used to facilitate discussion by recording and organizing responses to questions in real-time (Appendix). Zoom's chat feature also provided participants with the opportunity to write complex questions or responses.

Focus group discussions began by asking tree growers to identify factors influencing their production decisions and rank these by importance, followed by soliciting reactions from purchasers and planters (Appendix). We then reversed this process, asking purchasers and planters about their selection criteria and priorities, with growers providing feedback. Participants were asked to identify preferred tree species for urban areas and explain their choices based on important attributes. We introduced climate change projections for the region (4.5 to 10 °F warming with increased extreme weather events by the 2080s) and asked how these might alter their previous selections. After a short break, the discussion shifted to barriers

Table 1. Focus group recruitment rates by stakeholder category.

Category	Agreement (scheduled/invited)	Attendance (attended/scheduled)	Recruitment (attended/invited)
Nursery	6/15 = 40.0%	4/6 ≈ 66.7%	4/15 = 26.7%
Landscape design	1/12 ≈ 8.3%	1/1 = 100%	1/12 ≈ 8.3%
Municipal arborist/urban forester	4/11 ≈ 36.4%	4/4 = 100%	4/11 ≈ 36.4%
Nonprofit/government	7/10 = 70.0%	6/7 ≈ 85.7%	6/10 = 60.0%
Private industry	2/4 = 50.0%	2/2 = 100%	2/4 = 50.0%
Overall	20/52 ≈ 38.5%	17/20 = 85.0%	17/52 ≈ 32.7%

in the urban tree supply chain from both the purchaser/planter and grower perspectives. The session concluded by exploring potential solutions to these challenges, including industry changes, cross-sector collaboration, and examples of successful tree procurement arrangements. At the end of each focus group, the research team presented a slide summarizing the key discussion points. Participants were asked to review this bulleted list of key challenges and opportunities, making modifications, additions, or deletions as they saw fit.

Data Analysis

The transcripts were automatically downloaded from Zoom and cleaned through a multi-step process. Cleaning the transcripts was an iterative review process, including a full listen-through with pausing and rewinding to ensure accuracy. Consecutive responses from the same speaker were consolidated into a single block of text with the aid of AI (ChatGPT 4) then manually reviewed for errors. During the first review, subtle verbal cues (e.g., sarcasm, emphasis) were annotated by italicizing these words to provide contextual understanding and were revisited during subsequent analysis. Tags were inserted to indicate significant nonverbal actions, such as gestures or laughter, using square brackets. Verbal tics such as "um," "you know," and repeated words were removed without altering the original language or grammar. Fragmented or incomplete phrases that did not contribute meaning were also eliminated. Run-on sentences were broken up, and punctuation was added to improve readability. Instances of unintelligible speech were marked with a timestamp for reference.

The finalized transcripts were uploaded into Quirkos (Quirkos Software, Edinburgh, United Kingdom) for qualitative thematic analysis by a primary researcher. A combination of inductive and deductive coding approaches was used. Deductive coding focused on responses that directly addressed the research questions, for example grouping responses into themes such as "factors influencing production." Inductive coding captured new themes that emerged during the discussions, which were organized as sub-themes (e.g., "customer demand") within the larger thematic groups (e.g., "factors influencing production"). The analysis was an iterative process, involving multiple rounds of reviewing and refining thematic groupings as patterns emerged.

A second researcher reviewed the transcripts within a word processing software and added comments to code for themes and to add annotations. This was compared with the first round of coding completed by the primary researcher to ensure accuracy and consistency. Additionally, coded themes were compared to the key summary points drafted by the researchers and participants at the end of each focus group. This comparison helped contrast the initial takeaways with insights gained over time and through a more in-depth analysis of the conversations.

Throughout the analysis, a collaborative approach was maintained to ensure consistency in the coding process. Regular discussions between the primary researcher and the secondary researcher helped refine the analysis and thematic organization, validating emerging themes against the raw data. Despite these safeguards, all researchers are most familiar with the tree supply chain from a purchaser's perspective, which may have influenced our interpretation of certain aspects of the conversations.

RESULTS

Challenges to Enhancing Urban Tree Diversity, Quality, and Availability

Market Demand

Focus group participants indicated that market demand was the primary driver for nursery growers, with inventory shaped by consumer trends in design and home gardening. While growers may have preferred species to sell, customer preferences dominate. As one grower explained, "We're obviously in the business for profit, so we are trying to predict what the market is gonna demand. We're at the mercy of the landscape architects, and the contractors and our customers." Participants explained that to minimize financial risks, growers often focus on species and size classes with consistent sales. Although municipalities sometimes have specific requirements, these clients make up a smaller share of the market, which is largely influenced by commercial developers prioritizing price and availability over species diversity and quality. This leaves little incentive for growers to meet stricter specifications or contracts.

The pressure to produce low-cost trees is intensified by external market forces. Growers face competition from large-scale nurseries outside the Chesapeake Bay region, while closures and liquidation sales add a supply of cheap stock priced unsustainably low.

These closures often result from financial struggles or the retirement of nursery owners, with no succession plans in place. This can limit the local availability of high-quality trees.

Seed and Liner Availability

Growers in our focus group highlighted challenges in sourcing seedlings and liners (i.e., small plants grown from a rooted cutting, seedling, plug, or tissue culture plantlet that is grown to a marketable size) for new species. Many nurseries rely on purchasing liners from a small group of large-scale producers in Tennessee and the Western USA, which can lead to supply bottlenecks. One grower mentioned struggling for 5 years to purchase 400 liners of a preferred species, only receiving a tenth of his request annually. Additionally, the centralization of liner production makes it harder to obtain native species with local provenance, which are often preferred or required by municipal ordinances. As one grower noted, "It is because of the liners…we're having major issues in the pipeline with trying to get trees."

Funding vs. Production Cycles

Our focus groups highlighted the mismatch between the multi-year growth cycle of trees and the shorter-term nature of most urban forestry funding sources, which presents a significant challenge in shaping the market through tree purchases. Growing trees from seedlings to a size suitable for planting, especially larger caliper stock for urban areas, takes several years. However, funding cycles driven by local government budgets and planting grants are often annual or short-term, with even long-term grants typically lasting only 3 years, which is not enough time to impact nursery planting decisions. As one nonprofit expert noted, "To get what we need, the species we need, and the quality we need, we have to start 5 years in advance."

Participants further explained that the uncertainty of future funding from grants and budgets makes it difficult to commit to long-term tree production contracts or large-scale planting projects. Organizations often face pressure to meet short deadlines for grants, which may not align with optimal planting seasons or tree availability. Bureaucratic delays in fund distribution further complicate meeting seasonal planting windows. Additionally, the inconsistency of grant funding limits the ability to influence tree nursery production, as there's no guarantee of future resources to support changes in tree availability or species diversity, creating a cycle that hinders long-term market impact.

Technical Staff

Participants expressed a challenge not previously highlighted in earlier focus groups (Koeser et al. 2022; Hilbert et al. 2023a), which is the shortage of qualified technical staff who understand tree quality and species diversity. Municipalities and nonprofits often struggle to develop and maintain the capacity for effective tree management, with non-competitive pay scales exacerbating the issue by hindering the recruitment and retention of skilled professionals. Participants stressed the importance of these technical roles in ensuring the survival of newly planted trees, with one respondent from the nonprofit sector emphasizing, "[Regarding our earlier discussion of technical expertise] I really wanted to hit home that those positions need to be highly valued."

Opportunities for Enhancing Urban Tree Diversity, Quality, and Availability

Partnerships

Partnerships with growers were identified as a key strategy for improving tree availability and quality in urban forestry. Participants stressed the value of closer relationships between end-users and nurseries to better align production with demand. These collaborations range from informal arrangements, where foresters provide advance notice of needs, to structured contract growing agreements. Some organizations have successfully partnered with nurseries by placing advance orders or using brokers to tag trees meeting quality standards. As one arborist participant noted, "Relationships help you smooth all these little bumps out." Collaborations with industry, NGOs, and government entities were also seen as critical. Partnerships with universities, botanical gardens, zoos, and local agencies expand resources and expertise. One respondent shared efforts to work with universities to propagate specific species, while another described providing temporary storage for local groups to hold stock before planting.

Contract Growing

Contract growing emerged as a key solution for addressing tree availability challenges in urban forestry. It offers advantages like better alignment between grower production and end-user needs,

securing specific species and qualities, and potential cost savings. It also minimizes risks for growers producing new or specialized trees—a point highlighted by nursery operators. One grower explained:

> *"What would be most helpful for growers is more of a partnership with end users to find out what's in the pipeline, what they're going to need. Ideally, even some sort of contract grow situation where sizes, specs, and varieties are listed. Otherwise, as growers, we're taking the risk of trying to grow something we think will sell."*

Some organizations have successfully used short-term contracts for smaller materials, particularly for large projects, pre-funded initiatives, and hard-to-find or native species.

However, longer-term contracts for larger trees pose challenges. Participants noted the 5- to 7-year commitment required for urban trees brings risks, including business uncertainties and natural factors like weather or pests. As one grower shared, "From a grower's perspective, it scares me a little, committing to grow these trees, and then something happens—weather, nature, [pests], or whatever." Additional obstacles to contracts include short grant windows, funding uncertainties, and the lengthy growth cycle of trees. Despite these concerns, contract growing was recognized for its potential to improve tree availability and quality while reducing growers' financial risks. Participants indicated that stable, long-term funding and careful planning are critical for expanding these arrangements, especially for larger urban trees.

State Nurseries

As mentioned in the challenges section, many nurseries noted they outsource the propagation of seeds and cuttings to companies specializing in seedling or liner production. Respondents highlighted the underfunding of some state nurseries in recent years, with one arborist noting, "[the] Virginia State Forest Service, its nurseries have been up and down"; and a nonprofit expert sharing, "We go with [the] State of Maryland State Nursery because we got rid of our Delaware nursery years ago."

Respondents saw an opportunity to reinvest in these facilities. Such reinvestment might enable state nurseries to produce seedlings and liners for desirable tree species that are currently considered unprofitable by commercial nurseries. Additionally, these nurseries may focus on cultivating local provenances of broadly distributed species and offer more detailed information about seed sources than what is typically available from commercial stock.

Nonprofit Nurseries

Several participants described their experiences or interest in creating small-scale, in-house nurseries to grow hard-to-find tree species. These efforts often focused on producing smaller-sized stock, such as in propagation gardens or nurseries yielding a few thousand trees annually. Goals included cultivating rare species, reforesting former agricultural lands, and advancing local conservation initiatives. Approaches ranged from starting plants from locally collected seeds to purchasing and raising liner stock. This strategy enables organizations to combine self-grown stock with purchases from established nurseries, offering greater control over species selection and local adaptation.

Enhancing Communication Among Industry Associations

Improved communication between tree producers and buyers was seen by participants as being vital for addressing nursery tree availability. Trade shows, particularly the Mid-Atlantic Nursery Trade Show (MANTS), were highlighted as key networking opportunities, with one participant describing MANTS as "heaven on earth" for industry connections. Another grower echoed this in saying, "The state nursery organizations are probably the best place to go." These events provide a platform for face-to-face meetings, relationship-building, and staying informed about market demands. State-level organizations, such as the Pennsylvania Landscape Nurserymen's Association and the Maryland Nursery and Greenhouse Association, were also noted as critical resources for tackling industry challenges and fostering local connections.

While designers, arborists, and urban foresters benefit from networking and education opportunities within their own organizations, participants expressed a need for greater collaboration across green industry sectors. Expanding communication beyond these groups can address shared challenges and ensure a more coordinated approach to improving tree availability and quality.

Creation of a Centralized Plant Finder Database

Participants highlighted the need for nursery stock lists or some sort of centralized database to address

challenges in finding up-to-date information on nursery tree availability. They envisioned a system where users could search for trees within a specific radius, with details on sizes and quantities, streamlining the buying process. As one nonprofit purchaser noted, "...it'd be great to have some central database where you can see…what is available from the nurseries… Who has what? Of what size? It would make buying trees a lot easier." However, concerns were raised about maintaining accurate, real-time updates, especially for smaller nurseries that update inventories infrequently. Growers indicated that nurseries vary widely in their use of technology, with some adopting online ordering and commercial plant-finder apps, while others rely on traditional methods. This inconsistency in inventory management may pose significant obstacles to creating a unified database.

Other Insights—The Use of Natives and Cultivars

Many respondents expressed a preference for native tree species, with some exclusively purchasing or using them. One participant said that within their area, "all the jurisdictions are trying to get 90%, if not 100%, native trees." One participating grower noted that their retail garden business is receiving increased demand from customers. However, the preference for natives was not universal. Some respondents continue to use non-native species, recognizing their value when they are non-invasive and well-suited to urban environments. Relying solely on native species presents challenges, including limited variety and difficulty sourcing certain trees. As one municipal arborist explained, "We have about a list of 12 trees that we plant, [laughs] and it seems to be because we're limiting ourselves to purely native trees." This approach reflects the absence of many native species in nursery production, particularly in larger sizes, rather than a lack of local tree diversity in the Chesapeake Bay area.

Focus group participants explained that cultivars can offer benefits such as improved drought tolerance, winter hardiness, consistency in production, and disease resistance, like with American elm (*Ulmus americana*) cultivars. However, concerns about limited genetic diversity arise due to cloning and the overuse of similar genetic material, as pointed out by some participants. The market for cultivars is largely demand-driven, with commercial services often prioritizing them over straight species. As one grower mentioned, "It's demand driven, and maybe it'll change, but right now what's crossing my desk [are requests for] mostly 'Red Sunset' maples and 'October Glory' maples." This preference presents a challenge for nurseries balancing ecological considerations, as straight species are favored for restoration projects, and genetic diversity is crucial for ecosystem health. Additionally, producing cultivars in urban environments typically requires nurseries to balance the availability of disease-resistant varieties with site constraints.

DISCUSSION

As observed in past focus groups conducted in Florida (Hilbert et al. 2023a) and across the United States (Koeser et al. 2022), economic factors drive growers' decisions about which species to produce. Growers are primarily concerned with producing trees they have confidence they can sell. Moreover, Hilbert et al. (2023a) highlighted that the time required for a tree to reach a marketable size significantly impacts production costs. Slower-growing trees, although often ideal for compact urban planting sites, take longer to reach the larger sizes commonly specified in commercial and municipal contracts. This creates market pressure favoring the production of faster-growing, weedier tree species. Market pressure also comes in the form of supply chain disruptions and limitations (GoMaterials 2021; Koeser et al. 2022). Growers in this study shared the challenge of relying on large-scale liner producers that drive the tree palette for nurseries further down the supply chain. They also pointed out the challenge of being out-competed by low prices from nursery liquidation sales, something not found in similar studies of urban tree supply and likely exacerbated by major market disruptors like COVID-19 and extreme weather events (Sallin 2021).

Another challenge brought up in our groups that has not been discussed in similar urban tree supply chain studies is the lack of technical staff. This staffing gap can impact all areas of urban tree projects, from planning to long-term care (Roman et al. 2013; Hargrave et al. 2023). Having staff who understand nursery tree quality standards and procurement processes, and are able to build long-term relationships with growers is essential to getting desired trees in the ground.

Contract growing has been discussed in multiple focus groups involving both growers and urban tree purchasers (Koeser et al. 2022; Hilbert et al. 2023a).

Longer-term contracts provide additional stability, which is valued by growers producing long-term crops while navigating year-to-year fluctuations in the housing market or shifts in design trends. They also provide tree purchasers a communication pathway for specifying the species, sizes, and quality they desire (Stephens 2010). The mismatch between the multi-year growth cycle of trees and the shorter-term nature of most urban forestry funding sources can create a challenge to contract growing, something also discussed in similar focus group work (Koeser et al. 2022; Hilbert et al. 2023a). Urban forestry programs have successfully engaged in contact growing in the USA through implementing it as part of large-scale planting projects, such as with New York City Parks (Stephens 2010); through regional initiatives coordinated by nonprofits like Chicago Region Trees Initiative (T. Brannen, personal communication) or through intergovernmental cooperative purchasing agreements as with the Suburban Tree Consortium (West Central Municipal Conference 2020). While contracts were frequently mentioned in our discussions, participants noted that not every agreement needed to be formal. Establishing long-term business relationships and fostering a shared history were often sufficient for many growers to adjust their production to include preferred species for repeat clients.

Increased communication has also been a common theme in past focus group research (Koeser et al. 2022; Hilbert et al. 2023a). This includes informal exchanges between growers and purchasers that go beyond what is immediately necessary for one-time transactions. Focus group participants often express appreciation for their involvement in the research process, as it provides an opportunity to sit down and engage with other green industry professionals outside their immediate field. Attending and presenting at conferences beyond those directly relevant to one's work can also be an effective way to engage new audiences and networks across sectors.

A solution discussed by participants that has not come up in similar research is the role of state nurseries. There are 38 state, territorial and tribal nurseries in the USA that primarily focus on growing native, locally adapted species for reforestation efforts (USDA Forest Service 2025). State-operated nurseries could reinvest resources to grow seedlings and liners of urban-suitable species that private growers currently deem unprofitable. They could also prioritize local provenances of widely planted trees and provide far more detailed provenance information than is usually offered by commercial suppliers.

Although it may seem that the issue of low urban tree diversity is well understood and addressed by green industry professionals, actual diversity observed in urban landscapes tells a different story (Ma et al. 2020). Past research underscores the need for continued efforts to educate and engage those involved in growing, specifying, planting, and caring for urban trees (Polakowski et al. 2011; Lohr 2013). This includes fields often omitted from discussions, such as civil engineering, which significantly contribute to urban reforestation but are less likely to specify diverse planting palettes (Thompson et al. 2021). While urban tree supply chains are complex and slow to change, research projects like the one we present here provide a range of actionable opportunities that can be championed at the local level.

Future research may examine the barriers and solutions for local governments seeking to implement grower agreements. Several cities have successfully navigated budget and purchasing office processes to establish long-term agreements with local nurseries. However, many others perceive this as an unattainable ideal. Interviews with successful cases could highlight key strategies or indicators that a community may be receptive to such arrangements.

Similarly, future research may explore how nonprofit and state nurseries can address gaps in existing supply chains. This is a potentially sensitive issue as there may be tension between commercial nurseries and state-run operations in the marketplace. That said, certain species and nursery products (e.g., liners and finished trees) currently lack a viable market. State and nonprofit nurseries could play a crucial role in filling these gaps, helping to establish demand and allowing for commercial operations to eventually scale up production.

CONCLUSION

The urban tree nursery industry faces challenges that limit tree diversity and quality, largely driven by market demand and external price competition. The limited availability of seedlings and liners, coupled with the mismatch between long-term tree growth cycles and short-term funding, further complicates efforts to meet the needs of urban forestry. Additionally, the shortage of qualified technical staff in municipalities

and nonprofits exacerbates these issues. However, there are opportunities to address these challenges. Contract growing offers a promising solution to align nursery production with the specific needs of end-users, reducing risks associated with producing new or uncommon species. Collaborative partnerships between growers, municipalities, nonprofits, and research institutions could enhance the availability and quality of trees, particularly those that are underrepresented in commercial production but are essential for urban environments. Furthermore, the development of a centralized plant finder database and improved communication through industry events could streamline the tree-buying process, although implementing these solutions presents its own set of challenges. Overall, a combination of strategic partnerships, improved communication, and innovative growing models can help overcome current barriers and ensure the sustainable growth of urban forests.

LITERATURE CITED

Allen KS, Harper RW, Bayer A, Brazee NJ. 2017. A review of nursery production systems and their influence on urban tree survival. *Urban Forestry & Urban Greening*. 21:183-191. https://doi.org/10.1016/j.ufug.2016.12.002

Avolio ML, Pataki DE, Trammell TLE, Endter-Wada J. 2018. Biodiverse cities: The nursery industry, homeowners, and neighborhood differences drive urban tree composition. *Ecological Monographs*. 88(2):259-276. https://doi.org/10.1002/ecm.1290

Bahder BW, Soto N, Helmick EE, Dey KK, Komondy L, Humphries AR, Mou D, Bailey R, Ascunce MS, Goss EM. 2019. A survey of declining palms (Arecaceae) with 16SrIV-D phytoplasma to evaluate the distribution and host range in Florida. *Plant Disease*. 103(10):2512-2519. https://doi.org/10.1094/PDIS-03-19-0633-RE

Burcham DC, Lyons RE. 2013. An evaluation of tree procurement and acquisition strategies for urban planning. *Journal of Environmental Horticulture*. 31(3):153-161. https://doi.org/10.24266/0738-2898.31.3.153

Cazzolla Gatti R, Reich PB, Gamarra JGP, Liang J. 2022. The number of tree species on Earth. *Proceedings of the National Academy of Sciences of the United States of America*. 119(6):e2115329119. https://doi.org/10.1073/pnas.2115329119

Chesapeake Bay Foundation. Bay facts. Washington (DC, USA): Chesapeake Bay Foundation. [Accessed 2025 March 19]. https://www.cbf.org/about-the-bay/bay-facts.html

Chesapeake Tree Canopy Network. Understand your canopy. Annapolis (MD, USA): Chesapeake Tree Canopy Network. [Accessed 2025 June 26]. https://chesapeaketrees.net/understand-your-canopy

Conway TM, Vander Vecht J. 2015. Growing a diverse urban forest: Species selection decisions by practitioners planting and supplying trees. *Landscape and Urban Planning*. 138:1-10. https://doi.org/10.1016/j.landurbplan.2015.01.007

Cowett FD, Bassuk N. 2017. Street tree diversity in three Northeastern U.S. states. *Arboriculture & Urban Forestry*. 43(1):1-14. https://doi.org/10.48044/jauf.2017.001

Femdal I, Solbjør M. 2018. Equality and differences: Group interaction in mixed focus groups of users and professionals discussing power. *Social, Health & Vulnerability*. 9(1):1447193. https://doi.org/10.1080/20021518.2018.1447193

Galle NJ, Halpern D, Nitoslawski S, Duarte F, Ratti C, Pilla F. 2021. Mapping the diversity of street tree inventories across eight cities internationally using open data. *Urban Forestry & Urban Greening*. 61:127099. https://doi.org/10.1016/j.ufug.2021.127099

Gilbert A. 2023. "Five million trees, please": Maryland rolls out '5 million trees' initiative. Annapolis (MD, USA): Maryland Department of Natural Resources. [Updated 2023 June 1; Accessed 2025 January 17]. https://news.maryland.gov/dnr/2023/06/01/five-million-trees-please-maryland-rolls-out-5-million-trees-initiative

GoMaterials. 2021. Plant sourcing advice from three wholesale nursery leaders. Montreal (QC, Canada): GoMaterials. [Accessed 2025 June 26]. https://www.gomaterials.com/blog/plant-sourcing-advice-from-three-wholesale-nursery-leaders

Hargrave JR, Harper RW, Butler BJ, Mullins JT. 2023. Municipal forest program management in the United States of America: A systematic review. *Forests*. 14(1):35. https://doi.org/10.3390/f14010035

Hilbert DR, Koeser AK, Andreu M, Clarke M, Hansen G, Roman LA, Thetford M. 2023a. Expanding urban tree species diversity in Florida (USA): Challenges and opportunities for practitioners. *Society & Natural Resources*. 36(8):891-908. https://doi.org/10.1080/08941920.2023.2175285

Hilbert DR, Koeser AK, Andreu MG, Hansen G, Roman LA, Thetford M, Thompson GL. 2023b. Conceptualizing the human drivers of low tree diversity in planted urban landscapes. *Ambio*. 52(9):1532-1542. https://doi.org/10.1007/s13280-023-01876-7

Huff ES, Johnson ML, Roman LA, Sonti NF, Pregitzer CC, Campbell LK, McMillen H. 2020. A literature review of resilience in urban forestry. *Arboriculture & Urban Forestry*. 46(3):185-196. https://doi.org/10.48044/jauf.2020.014

Jernelöv A. 2017. Dutch elm disease in Europe and North America. In: *The long-term fate of invasive species*. Cham (Switzerland): Springer. p. 201-216. https://doi.org/10.1007/978-3-319-55396-2_12

Klooster WS, Gandhi KJK, Long LC, Perry KI, Rice KB, Herms DA. 2018. Ecological impacts of emerald ash borer in forests at the epicenter of the invasion in North America. *Forests*. 9(5):250. https://doi.org/10.3390/f9050250

Koeser AK, Brewer L, Hilbert DR, Thompson G, Salisbury A. 2022. Growing diverse urban forests: Green industry perspectives. Balm (FL, USA): University of Florida. 10 p. https://doi.org/10.13140/RG.2.2.13653.50409

Kottek M, Grieser J, Beck C, Rudolf B, Rubel F. 2006. World map of the Köppen-Geiger climate classification updated. *Meteorologische Zeitschrift*. 15(3):259-263. https://doi.org/10.1127/0941-2948/2006/0130

Laćan I, McBride JR. 2008. Pest vulnerability matrix (PVM): A graphic model for assessing the interaction between tree

species diversity and urban forest susceptibility to insects and diseases. *Urban Forestry & Urban Greening*. 7(4):291-300. https://doi.org/10.1016/j.ufug.2008.06.002

Lohr VI. 2013. Diversity in landscape plantings: Broader understanding and more teaching needed. *HortTechnology*. 23(1):126-129. https://doi.org/10.21273/horttech.23.1.126

Lohr VI, Kendal D, Dobbs C. 2016. Urban trees worldwide have low species and genetic diversity, posing high risks of tree loss as stresses from climate change increase. *Acta Horticulturae*. 1108:263-270. https://doi.org/10.17660/ActaHortic.2016.1108.34

Ma B, Hauer RJ, Wei H, Koeser AK, Peterson W, Simons K, Timilsina N, Werner LP, Xu C. 2020. An assessment of street tree diversity: findings and implications in the United States. *Urban Forestry & Urban Greening*. 56:126826. https://doi.org/10.1016/j.ufug.2020.126826

Morgan DL. 1997. *Focus groups as qualitative research*. 2nd Ed. Thousand Oaks (CA, USA): SAGE. 20 p. https://doi.org/10.4135/9781412984287

Morgenroth J, Östberg J, Konijnendijk van den Bosch CC, Nielsen AB, Hauer R, Sjöman H, Chen W, Jansson M. 2016. Urban tree diversity—Taking stock and looking ahead. *Urban Forestry & Urban Greening*. 15:1-5. https://doi.org/10.1016/j.ufug.2015.11.003

National Oceanic and Atmospheric Administration (NOAA). 2021. Where is the largest estuary in the United States? Washington (DC, USA): NOAA. [Updated 2021 January 4; Accessed 19 March 2025]. https://oceanservice.noaa.gov/facts/chesapeake.html

Nitoslawski SA, Duinker PN, Bush PG. 2016. A review of drivers of tree diversity in suburban areas: Research needs for North American cities. *Environmental Reviews*. 24(4):471-483. https://doi.org/10.1139/er-2016-0027

Polakowski NR, Lohr VI, Cerny-Koenig T. 2011. Survey of wholesale production nurseries indicates need for more education on the importance of plant species diversity. *Arboriculture & Urban Forestry*. 37(6):259-264. https://doi.org/10.48044/jauf.2011.033

Raupp MJ, Cumming AB, Raupp EC. 2006. Street tree diversity in eastern North America and its potential for tree loss to exotic borers. *Arboriculture & Urban Forestry*. 32(6):297-304. https://doi.org/10.48044/jauf.2006.038

Roman LA, McPherson EG, Scharenbroch BC, Bartens J. 2013. Identifying common practices and challenges for local urban tree monitoring programs across the United States. *Arboriculture & Urban Forestry*. 39(6):292-299. https://doi.org/10.48044/JAUF.2013.038

Sallin T. 2021. Spring 2021 ornamental tree and nursery market update. Groveland (FL, USA): Cherrylake. [Accessed 2025 June 26]. https://cherrylake.com/spring-2021-market-update

Santamour FS Jr. 1990. Trees for urban planting: Diversity, uniformity, and common sense. In: *Trees for the nineties: Landscape tree selection, testing, evaluation, and introduction: Proceedings of the 7th conference of the Metropolitan Tree Improvement Alliance (METRIA)*. METRIA 7; 1990 June 11–12; Lisle, Illinois, United States. Minneapolis-Saint Paul (MN, USA): University of Minnesota. 96 p. https://agroforestry.org/the-overstory/144-overstory-126-trees-for-urban-planting-diversity-uniformity-and-common-sense

Sjöman H, Östberg J, Bühler O. 2012. Diversity and distribution of the urban tree population in ten major Nordic cities. *Urban Forestry & Urban Greening*. 11(1):31-39. https://doi.org/10.1016/j.ufug.2011.09.004

Stephens M. 2010. Tree procurement contracts: New York City's quest for amazing trees. *City Trees*. 2010:10-12.

Sydnor TD, Subburayalu S, Bumgardner M. 2010. Contrasting Ohio nursery stock availability with community planting needs. *Arboriculture & Urban Forestry*. 36(1):47-54. https://doi.org/10.48044/jauf.2010.007

Thompson GL, McCombs A, Jansen MD. 2021. Relationships between consultant discipline and specified tree diversity: A case study of two Iowa (USA) communities. *Urban Forestry & Urban Greening*. 62:127183. https://doi.org/10.1016/j.ufug.2021.127183

USDA Forest Service. State and tribal nurseries. Washington (DC, USA): USDA Forest Service. [Accessed 2025 June 26]. https://www.fs.usda.gov/managing-land/forest-management/vegetation-management/nurseries/state-and-tribal

West Central Municipal Conference. Suburban tree consortium. River Grove (IL, USA): West Central Municipal Conference. [Accessed 2025 June 26]. https://westcook.org/suburban-tree-consortium

ACKNOWLEDGEMENTS

This paper is based on a presentation given at the 5th International Conference on Urban Tree Diversity (UTD5), held in Madrid, Spain, 24–25 October 2024. The conference was organized by Arbocity, the Forestry Engineering School from the Technical University of Madrid (UPM), and the Nature Based Solutions Institute (NBSI). This work was funded as the project "Scope of Work 4: Addressing Regional Tree Supply Challenges and Opportunities" by the Chesapeake Bay Trust using funding from the United States Environmental Protection Agency. The findings and conclusions in this publication are those of the authors and should not be construed to represent any official USDA or US Government determination or policy. Additional insights can be found in an expanded report titled, "Addressing Regional Tree Supply Challenges and Opportunities: A Rapid Assessment" (Koeser et al. 2024).

Andrew K. Koeser (corresponding author)
University of Florida
Gulf Coast Research and Education Center, IFAS
Wimauma, FL, USA
akoeser@ufl.edu

Deborah R. Hilbert
State University of New York
College of Environmental Science and Forestry
Department of Sustainable Resources Management
1 Forestry Drive
Syracuse, NY, USA

Dexter Locke
USDA Forest Service
Northern Research Station
Baltimore Field Station
Baltimore, MD, USA

Christopher B. Riley
Bartlett Tree Research Laboratories
Casey Trees Farm
Berryville, VA, USA

Nancy F. Sonti
USDA Forest Service
Northern Research Station
Baltimore Field Station
Baltimore, MD, USA

Conflicts of Interest: The authors reported no conflicts of interest.

Appendix on next page

Appendix.

Table S1.

Hour:Minute	Action	Script
10 minutes early	Log in and check screen share and host designations.	N/A
5 minutes early	Start letting participants in. Change to first names.	"Hello, welcome. We're going to wait for the last few folks to join before getting started."
0:00	Mute all participants.	"Welcome everyone. My name is Dr. Deborah Hilbert. You may call me Deb. I am an urban tree research scientist with the University of Florida and a consulting urban forester. I will be facilitating this meeting today with the help of my co-facilitator, Dr. Andrew Koeser. Andrew, would you like to introduce yourself? And here to observe and assist are our fellow researchers Drs. Chris Riley, Dexter Locke, and Nancy Sonti. XX, would you introduce yourselves? As facilitators, we are here to moderate the discussion and keep the group on topic, but not to give our own perspectives on the discussion itself. We want to hear from you. We're also here to help if you have technical issues. Before we get started, I want to show you some of the features on Zoom. First off, you can change the display on your screen by … We changed your names so that only your first name is displayed. You may change it to a different name by clicking on the three little dots next to your thumbnail. I encourage you to leave your video on so that we can all be invested. If you find looking at yourself uncomfortable or distracting, you can go to Gallery mode (the *Brady Bunch*–style view), right-click your video to display the menu and choose "Hide Self View." You can raise your hands by going to… Does anyone have any questions about how to use Zoom?"
0:05	Hit record to cloud (Deb).	"Great. We will proceed."
0:06	Share agenda slide.	"Here is the agenda for the day. Today, we will spend time discussing your experiences with growing and purchasing trees in the Chesapeake Bay Watershed region. Specifically, we want to hear your views about the constraints and opportunities for creating a sustainable supply of quality, diverse, climate-ready tree species for use in urban areas. During this meeting, I'm going to ask you several questions. Please share your honest opinions and thoughts on each of the questions. Your input is an important part of our effort to better understand what your strategies are for growing or procuring trees, and how this may affect the overall supply of trees for the urban forests in the Chesapeake Bay Watershed."
0:07	Share ground rules slide.	"We want to hear from everyone, and this is your conversation. With that in mind, let's set some ground rules that will help maximize our time together. First off, silence your mobile phones. Close competing windows. Jump in or raise your hand if you haven't been able to share. Do not be critical or judgmental of others. You may address each other if you'd like to follow up on something during the discussion. Everything that is said in this meeting should remain here." "Everyone's experiences and opinions are important. I may call on you if I haven't heard from you in a while. I also want to remind you that your participation is voluntary. You do not have to answer any question you do not wish to answer. You may leave at any time you wish." "This session is being recorded so that I can obtain a transcript of what is said when I summarize information later. This recording will not be posted anywhere. The information which you give will only be used by the researchers involved in this study and their partners at the Chesapeake Bay Trust. The final report and publication will not identify the views of any specific participant. Everyone's comments will be kept confidential. Any quotes that are used will not be attributed to anyone by name." "Are there any questions? Let's get started…"

Hour:Minute	Action	Script
0:10	Share ice breaker slide. Call on participants alphabetically. Jamboard: *Favorite species*.	"We are going to go around by alphabetical order to hear your answer to the ice breaker question. Tell us your first name, location, which sector of the landscape industry you work in, and your favorite tree species." "Thanks for sharing. We're going to delve into some more detailed questions. Some of these questions will be directed towards certain participants, but it's important that we all understand their experiences. Others will get a chance to respond."
0:15	Put question in chat Put answers on Jamboard: *Grower factors*.	"Could those of you who grow trees share with us what factors you consider when deciding which trees to grow?" "Which factor would rank as the most important to your decision-making?" "What do those of you who purchase or plant trees think about these responses? Any surprises? Any questions for the growers?"
0:30	Put answers on Jamboard: *Purchaser factors*.	"Could those of you who purchase or plant trees share with us what factors you consider when deciding which trees to choose?" "Which factor would rank as the most important to your decision-making?" "What do those of you who grow trees think about these responses? Any surprises? Any questions for the group?"
0:45	Put answers on Jamboard: *Species Wishlist*.	"Pretend you can grow or procure any regionally-appropriate species you want. What tree species would you choose to use in the region's urban areas?" "Can you explain why you chose XX species? What attributes are important?" "Climate change projections indicate that by the 2080s, most parts of the Watershed will experience an average of 4.5 to 10 degrees warming with more extreme drought and precipitation events. In light of climate change, would any of your answers above change? Do you have additional suggestions?"
1:00	Share break slide.	"Thanks so much for sharing your experiences and ideas so far. We're going to take a 10-minute break. Please be back promptly at XX:XX."
1:10	Come back from break. Restart recording. Jamboard: *Barriers*.	"Welcome back. We've discussed the factors that influence the selection of tree species and your experiences with this process. Let's talk about challenges in urban tree supply." "For those who purchase or plant trees, what do you think are barriers that prevent you from purchasing the trees you desire for urban use?" "Could those of you who grow trees share with us the barriers that prevent you from growing more trees for urban use?"
1:20	Jamboard: *Solutions*.	"Now let's talk about what would need to happen to overcome the challenges to sourcing trees in the quantity and quality needed for urban landscapes." "What is something your industry could do differently? What is something another industry could do to support your efforts?" "Are there examples of successful tree procurement contracts or other arrangements through which tree supply goals were met?"
1:40	Share summary slide.	"We've covered the main questions and are at a good stopping point. Based on this discussion, we think the major points that were brought up were XX, XX, XX." (Share a slide that has these points typed up). "How well does this summary capture what was said here?" "Remember, the purpose of this study is to understand the constraints and opportunities for creating a sustainable supply of quality, diverse, climate-ready tree species for use in urban areas in the Chesapeake Bay Watershed." "Regarding the purpose of the study, is there anything that we should have talked about but didn't? Is there anything that you have thought of that we didn't discuss?"

Table S1 continued on next page

Table S1. Continued.

Hour:Minute	Action	Script
1:50	Thank you slide.	"Thank you all again for your time and input. This is so helpful as we move forward in understanding this topic. We have a few more groups to conduct. We are organizing a 1-day virtual forum in August to discuss the findings of these focus groups and to hear talks from others on this topic. Please let me know if you would like to be invited to the forum or if you know of others who may want to attend or be a speaker." "If there are no more questions from you, then I'll call this meeting adjourned."
2:00	Stop recording. Save chat. Save Jamboards. End meeting.	
2:00	Debrief between facilitators.	1) What were the themes? 2) What are the most important points that we've learned from this group? 3) What was surprising or unexpected? 4) What quotes were particularly helpful? 5) How was this group similar to or different from earlier groups? 6) Does anything need to be changed before the next group?
2:15	Save all data!	Any lists, ratings, chat dialogue, or other important notes will be organized and labeled immediately after the group.