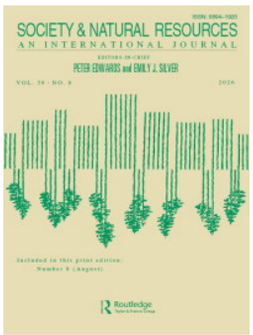

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Selection in the City: The Supply of Trees to Baltimore's Urban Forest

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ABSTRACT

Domestic selection creates the assemblages of organisms found in human-dominated environments, and urban forestry is a useful illustration of this process in action. In this study, we aim to understand how the process of domestic selection influences the nursery supply chain of trees to Baltimore, Maryland, USA. We interviewed actors in the supply chain to ask how they make decisions about which trees to grow, sell, select, and plant. We find tension between prioritizing diversity (at the species or genetic level) and other factors such as planting site conditions, esthetics, availability, demand, and production constraints. Reduction of genetic diversity within a species through the use of cultivars may counterintuitively be a path to increasing overall species diversity in nursery offerings. An in-depth approach to the supply of trees to one city allows for detailed analysis of variation within and across sectors, and tradeoffs experienced by actors along the supply chain.

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Biodiversity; genetic diversity; landscape architecture; landscape tree supply chain; nursery production

Introduction

Urban tree diversity at multiple levels of biological diversity (e.g., genetic, taxonomic, phylogenetic) can improve resilience to introduced pests and diseases, climate change, and other disturbances (Lohr, Kendal, and Dobbs 2016; Morgenroth et al. 2016). For decades, urban foresters have set urban tree diversity goals at the species, genus, and family level in order to create more resilient urban forests less prone to tree loss from invasive pests and disease (Laćan and McBride 2008; Morgenroth et al. 2016). Many studies have characterized urban tree diversity at the species, genus, and/or family level, and have found that urban areas typically do not meet diversity benchmarks, and that a few tree species account for large proportions of planted tree diversity (Cowett and Bassuk 2017; Galle et al. 2021; Kendal, Dobbs, and Lohr 2014; Ma et al. 2020). However, much less is known about the genetic diversity (within species) of

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urban tree populations (Love et al. 2025; Sjöman et al. 2024) and the impact of domestic selection on genetic diversity.

Domestic selection is a progression of selective filters that collectively result in the assemblage of organisms in a human-dominated environment (Avolio 2023). These filters may include artificial selection of traits desired by a breeder, as well as subsequent preferential selection of particular species or genotypes by human institutions or individuals. Urban forestry usefully illustrates domestic selection in action (Figure 1). For well over a century, urban trees have been selected from natural populations and horticultural collections to maximize seasonal aesthetic and functional traits, while minimizing nuisances (Dümpelmann 2025; Martin and Conway 2025). In addition to artificial selection by breeders, urban trees pass through iterative selective filters of preference: (1) by the nursery industry selecting which trees to propagate, (2) by urban planners and landscape architects directing policy or site plans, often under the restrictions of local ordinances, and (3) by urban foresters and private landowners selecting which trees to purchase and plant. These planted trees are typically sourced from local and regional nurseries (Avolio et al. 2018; Conway and Vander Vecht 2015), though the initial growing stock may be sourced from growers in an entirely different part of the country. While not all urban trees are planted (Nowak 2012), many urban trees are grown, sold, selected, and planted across varied site types as a result of a supply chain comprised of many different actors (Hilbert, Koeser, Andreu, Hansen, et al. 2023). This complex network of decisionmakers influences the assemblage of trees

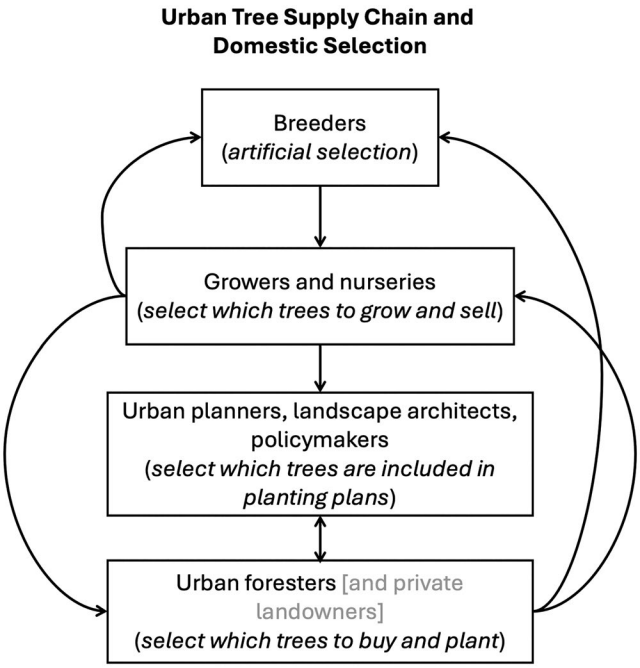

Figure 1. The process of domestic selection illustrated by the urban tree supply chain. Decisions made by actors in the supply chain influence other sectors (represented by arrows) and ultimately result in the assemblage of planted urban trees. Sectors are not always mutually exclusive (e.g., breeders or urban forestry organizations may also be growers). Private landowners are grayed out as they are not directly interviewed in this study.

present in an urban area through the combined processes of both natural and domestic selection (Avolio et al. 2021). This study focuses on the tree selection decisions made in large-scale urban planting projects (on public or private land), which may be influenced by landscape architects, public sector or nonprofit urban forestry professionals, as well as nurseries, growers, and breeders. While individual urban property owners and land managers also make small-scale decisions about which trees to plant (Conway 2016), they are not the focus of this study.

While ornamental trees have been clonally propagated for centuries (e.g., Hansen, Thomsen, and Rasmussen 2014), widespread development of commercially named cultivars (derived from "cultivated variety") in the U.S. nursery industry began in the mid-twentieth century (Iles and Vold 2003). Cultivars were developed to reliably preserve desired traits across generations and may be clonally or sexually propagated by cuttings, tissue culture, or controlled seed production techniques (Bricknell et al. 2016; Kester 1983). Today, many planted urban trees are cultivars that have undergone domestic selection for desired traits, resulting in limited genetic diversity among individuals (Iles and Vold 2003). Nurseries and their clients have become reliant on the uniformity and predictability of this stock, but planting trees of limited genetic backgrounds may limit the resilience of urban forests, which residents depend on for ecosystem services (Lohr 2013; Morgenroth et al. 2016). While it is recognized that the priorities and practices of urban forestry and nursery professionals may be reducing the genetic diversity of urban forests (Iles and Vold 2003; Shobe and Avolio 2026), the decisions made by these professionals to filter species and genetic diversity remains relatively unexplored.

Overall species richness of U.S. nursery flora has expanded as the number of nurseries has increased, yet standardized phylogenetic diversity has decreased over time and nursery flora have become increasingly homogenized (Kinlock, Adams, and van Kleunen 2023), mirroring the homogenization of urban plant communities (Pearse et al. 2018). The composition of cultivated yard plants resembles the composition of species available commercially (Cavender-Bares et al. 2020), highlighting the importance of the nursery industry in impacting urban biodiversity.

Tree supply and limited species selection have been identified as interrelated barriers to planting more diverse urban forests, which would increase resilience and sustainability (Esperon-Rodriguez et al. 2025). There are many known challenges to increasing planted tree diversity within urban areas and within the nursery industry that supplies them, including production capacity, stock availability, demand, local regulations, and urban site conditions (Hilbert, Koeser, Andreu, Clarke, et al. 2023; Hilbert, Koeser, Andreu, Hansen, et al. 2023; Koeser et al. 2026). Sydnor, Subburayalu, and Bumgardner (2010) found a mismatch between available nursery stock and demand from Ohio's urban foresters, where a few species were being produced in excess and others were lacking in availability. A previous survey of municipal arborists throughout the mid-Atlantic region of the U.S. found that their tree planting needs were quite similar, though they employed different approaches to working with commercial suppliers; some used formal contracts to enforce consistent standards in planting stock while others relied on personal relationships built on trust (Burcham and Lyons 2013). Nurseries and customers in South Africa valued the importance of increasing tree diversity in urban areas, and preferred native species (Arnoldi and Shackleton 2021),

though these attitudes are likely to vary by ecoregion and local politics. Indeed, some argue that native-only tree planting policies are too restrictive for harsh urban environments, where many native tree species may not be sufficient to provide needed ecosystem services (Sjöman et al. 2016).

Less has been published about nursery industry views on genetic diversity of landscape trees. Lohr (2013) conducted a survey of wholesale nurseries in Washington State, finding that most respondents agreed that biodiversity contributed to a healthy landscape, but that those that had "learned about plants" in college exhibited a deeper understanding of the risks from low diversity among landscape plants. While there may be some recognition that landscape trees are becoming increasingly homogenized (both at the species and genetic level), there remains uncertainty about who should take responsibility to reduce the risks associated with planting species or cultivar monocultures. Iles and Vold (2003) state that green industry professionals must work to combat overuse of common cultivars, while Lohr (2013) suggests that educators have an important role to play through college classes and written articles. Lohr (2013) found that nurseries generally felt that their offerings were diverse enough and that they did not play a role in the lack of diversity in landscape plantings but that they were helping to address the problem. Rather, they felt that customers and landscape designers should take responsibility for diversifying tree plantings.

This study aims to understand how the process of domestic selection influences the nursery supply chain of trees to large-scale planting projects using Baltimore, Maryland, USA as a case study. We interviewed actors in the supply chain to ask how they make decisions about which trees to grow, sell, select, and plant from seed (or cutting) to sidewalk. We focus on selection for tree diversity at the species and genetic level as well as for native trees. Our approach seeks to gain a deeper understanding of the dynamics between urban forestry professionals, landscape architects, regional nurseries, and the more distant growers who supply material that ends up planted in cities.

Methods

Study Area

Our study focuses on the selection and supply of trees to tree planting projects in Baltimore, Maryland, USA. With a population of 585,708 people in 2020, Baltimore is the largest city in the state of Maryland (US Census Bureau 2020) and is located in the Chesapeake Bay watershed. Baltimore is in the eastern deciduous forest ecoregion and has both piedmont and coastal plain geology. As of 2021, Baltimore City has a tree canopy cover of 28% (CBP 2025) with a goal to increase canopy cover to 40% by 2037 (City of Baltimore 2019). The Baltimore Sustainability Plan lays out specific action items to: "Insure *[sic]* a diversity of tree species. Emphasize the use of native plants and planting 'the Right Tree, in the Right Place.' Consider future climate conditions in plantings" (City of Baltimore 2019). In recent years, state and federal funding for urban tree planting and maintenance have supported these municipal goals. Maryland's Tree Solutions Now Act of 2021 mandated the planting of five million native trees across the state by 2031, with 500,000 of those trees planted in underserved urban areas, which includes many Baltimore neighborhoods (Maryland DNR 2023).

Additionally, USDA Forest Service Urban & Community Forestry grants, funded by the Inflation Reduction Act of 2022, have boosted tree planting efforts in Baltimore City.

Baltimore's street and landscaped park trees are largely planted, maintained, and removed by the City's Forestry Division. Additional tree planting and stewardship activities are coordinated through the Division's TreeBaltimore program (BCRP 2007), which is a mayoral initiative to expand the city's tree canopy cover through the establishment, management, and preservation of trees. Serving as an umbrella organization for all city agencies and nonprofit organizations working toward this goal, TreeBaltimore supports local groups like Baltimore Tree Trust and Blue Water Baltimore, who receive free trees to plant and establish on private and public property in neighborhoods throughout the city. TreeBaltimore and other organizations also provide trees to Baltimore residents during giveaway events throughout the spring and fall planting seasons. The Maryland Department of Natural Resource's Tree-Mendous program similarly provides trees to Baltimore organizations to plant on public land and community open space throughout the city (MD DNR 2025). The Baltimore City Office of Sustainability reviews private development plans that involve 5,000 ft^2 or more of site disturbance, which includes adherence to tree and shrub planting requirements (size, quantities, and diversity) described by the City's Landscape Manual (City of Baltimore 2017).

Study Design

We convened an advisory committee for this project, comprised of six urban forestry experts from the Maryland DNR Forest Service, Baltimore City Forestry Division, regional nonprofit organizations (Blue Water Baltimore, Baltimore Tree Trust), and the Maryland Cooperative Extension service. Advisory committee members were recruited from the researchers' professional networks. The advisory committee met twice during the project. During the first meeting in February 2022, the advisory committee helped the research team validate the proposed list of urban forestry organizations involved in selecting or planting trees in Baltimore City. When these contacts were interviewed, they were asked to suggest additional contacts and also to name the nurseries that provide the trees they plant. Baltimore City Department of Planning provided a list of landscape architecture and design firms that most frequently apply for development permits involving tree planting. These contacts were also asked to provide the names of nurseries involved in supplying trees to Baltimore City, if known. All named nurseries were contacted and, when interviewed, they were asked to provide the names of growers from which they source their material (if any). Thus, we used a snowball sampling approach, interviewing people involved in any aspect of the supply chain for Baltimore tree planting, until no new contacts were identified (Noy 2008). At our second advisory board meeting in February 2024, we also discussed preliminary findings and ensured we did not miss key actors in tree planting in Baltimore.

We conducted a total of 33 interviews across four sectors: urban forestry organizations (n = 6), landscape architects (n = 9), regional nurseries supplying directly to Baltimore City planting projects (n = 12), and more distant growers and/or seed collectors who supply material to the regional nurseries (n = 6). Our response rates for conducting the interviews across sectors were as follows: urban forestry organizations

(100%), landscape architects (56%), regional nurseries (79%), and growers (67%). Our study participants were all directly involved in the operations of their organization, including tree selection, and ranged from just one year in their current position to decades of experience. Most regional nurseries were located in Maryland or adjacent parts of the mid-Atlantic region, while most growers were located farther away in other regions of the United States. Nurseries and growers were typically wholesale operations, producing trees in large quantities for other businesses or for municipalities sourcing tree planting efforts, rather than selling directly to individual consumers. Growers typically supply "liners," or small, immature plants that have been started from seed, cuttings, or tissue culture and grown just long enough to be ready for transplanting into a larger container or in the field at a regional nursery. We also interviewed two tree planting contractors who work primarily in Baltimore City. However, the contractors stated that all decisions about tree species and cultivar selection were made by their clients, and their interviews did not yield any additional themes or insights, so for simplicity we exclude them from our results.

Interview Data Collection and Analysis

During the first project advisory committee meeting, we solicited input from the committee to ensure that the information generated through the analysis would be useful to urban forestry policymakers and practitioners in the Baltimore region and beyond. Two semi-structured interview scripts were developed, one for urban forestry professionals and landscape architects, and one for regional nurseries and growers (Table 1). Both scripts covered decision-making about tree species and cultivars to grow, sell, and/or plant; targets or considerations of tree diversity at different phylogenetic levels; and considerations of whether trees are native. In addition to the questions listed in Table 1, the interview protocol included questions from a related study about domestic selection of maple species in Baltimore (those results are not presented here).

All interviews were conducted remotely either over the phone or video conference during July 2022 – February 2024. Interviews were recorded using the video conferencing software or a smartphone audio recording application and transcribed with participant consent. Interviews lasted between 15 and 45 minutes and there was no discernable difference in interview time or quality between phone and video interviews. Interview transcripts were coded and analyzed using the qualitative data analysis software package NVivo 14 (QSR International, Melbourne, Australia). A combination of

Table 1. Interview questions used for each urban forestry supply chain sector.

Sector	Interview questions
Urban forestry professionals & landscape architects	"How do you decide which tree species and cultivars to plant in Baltimore?"
	"Do you think about or have targets for tree species diversity or genetic diversity when selecting species or cultivars to plant?"
	"Do you consider native status when you are selecting trees to plant?"
Regional nurseries & growers	"How do you decide which species and cultivars to grow and sell?"
	"Do you consider tree diversity in the species you offer?"
	"Do you consider genetic diversity in your operations?"
	"Have you noticed either a change in demand from customers or a change in availability from suppliers for native trees over time?"

deductive (predetermined) and inductive (emergent) coding approaches was used (Bingham and Witkowsky 2021). The interview protocol and study objectives provided initial codes for the deductive approach (e.g., species diversity, genetic diversity, native status) and the open-ended nature of the interview questions guided the creation of additional inductive codes reflecting the responses provided by participants. To enhance reliability, two coauthors independently coded a sample of the interviews across sectors, compared initial codes, and reconciled any discrepancies until consensus was reached. To further ensure validity of the data, preliminary findings and strategies for dissemination of results were discussed with the project advisory committee during the second committee meeting (Warren and Karner 2015).

Results

We identified twelve major themes related to tree species and cultivar selection, including three that we explicitly asked about (species diversity, genetic diversity, and native trees) and nine additional emergent themes that resulted from coding our open-ended questions (planting site conditions, esthetics, climate, demand, pest & disease impacts, policy/regulations, availability, familiarity, and production constraints; Table 2). For each theme, we discuss variation among responses by sector, moving from the end of the chain (urban forestry professionals and the landscape architects who design urban tree plantings) out to the beginning of the chain (growers developing new cultivars and providing planting stock to regional nurseries). Themes are presented in order from most to least prevalent across all participant interviews.

Species Diversity

All urban forestry professionals said that species diversity was a primary goal of their planting operations, with one respondent asserting that "biodiversity is the reason why we do what we're doing." More than half of urban forestry respondents mentioned that there are too many red maples (*Acer rubrum*) in Baltimore City and that they had a goal of moving away from this common species. Two urban forestry respondents

Table 2. Major themes identified in semi-structured interviews with urban forestry organizations, landscape architects, regional tree nurseries, and growers.

	Theme
Deductive	Species diversity
	Genetic diversity
	Nativity
Inductive	Planting site conditions
	Esthetics
	Climate
	Demand
	Pests & disease impacts
	Policy & regulations
	Availability
	Familiarity
	Production constraints

Note: Themes are presented in order from most to least prevalent among all participants.

mentioned quantitative targets for species diversity within a site or project (i.e., a certain number of species, or maximum percentage of trees made up of any particular species) but none had quantitative diversity goals for their operations as a whole across sites or seasons.

All landscape architects also felt that tree species diversity was important to their work, though none had quantified diversity targets. One respondent mentioned the importance of "using a variety from project to project, even if not within a project" while others said that they aim to avoid monocultures and make individual projects as diverse as possible. Some landscape architects articulated the importance of species diversity for urban wildlife (i.e., acorns from varied oak species) or for forest resilience: "I try to plant a little bit of lot of species because I feel like that's casting a wide net and you're likely to have better success with that in the long run." However, landscape architects also described the tension between diversity and other goals, such as esthetics or tree survival, with the implication that certain common cultivars are known for their reliable physical traits and success in urban planting conditions. One landscape architect remarked, "We're always striving for diversity, but we need trees that survive."

Regional nurseries talked about striving to offer a diverse suite of tree species and cultivars. Some were particularly concerned with increasing the diversity of native trees planted in urban landscapes. They also mentioned that customers are requesting a more diverse palette of species to support local biodiversity or to create more resilient plantings (against pests) and so diversifying their offerings is good for business. And as one nursery manager put it: "The strategy is kind of like the strategy for picking stocks for an investment portfolio: diversification solves a lot of uncertainty…So instead of trying to guess what the hot new thing is, we grow a little bit of everything." Similar to landscape architects, there was a recognition that known reliable species may be more dependable than obscure options. One nursery manager says, "We try to keep it broad but not too broad. You can get off in the weeds quite a bit with some of these plants that just don't do that good." A few regional nurseries make a point of growing "underused or underproduced" native trees, but this is a niche practice that is not widespread. As one nursery manager says, "Those weird plants are fickle and slow…it's hard to make money and we're in the business to make money…new trees are hard to incorporate…common species are easy to grow. Buyers are trying to diversify and do something different, but not always looking at survivorship." Some nurseries pointed out that urban forestry programs make up a small percentage of their sales in contrast to private developers who "might put 100 red maples around a Walmart or around Amazon."

Growers had similar responses to the regional nurseries but almost all seemed to feel that increasing diversity of planted trees on the landscape was part of their mission. Because of this, some stated that they offered a wide variety of trees and cultivars beyond what was economically beneficial to their business. One grower explained that they were "dabbling into nature further than the typical contractor's palette, and trying to bring that to the consumer base at large." There was a similar sentiment to regional nurseries that diverse offerings increase resiliency of local ecosystems and business strategy: "Diversity is critical for a number of reasons, not only for the health of the environment of which they're going into, but for us to have an offering." However, growers also recognized a financial limit to their experimentation with new species

and cultivars. As one grower put it: "We're working with all the plant breeders and brands and universities to try to bring as much diversity to our product line as we can, but ultimately, we have to be able to sell those trees. A lot of the time there's not a strong demand for some of the things that would be good in the landscape so if we can't sell it, we won't grow it." It was clear that growers (and some regional nurseries) did not always agree with customers about their preferences for certain common species or cultivars. While they attempted to broaden customers' preferences by discussing potential alternative selections, this did not always work.

Genetic Diversity

Baltimore urban forestry organizations all mentioned a desire to use straight species (typically sourced from field-collected seeds or randomly selected cuttings, and not selectively bred by humans) whenever possible, but they acknowledged that certain situations required the use of cultivars. For example, thornless honeylocust (*Gleditsia triacanthos var. inermis*) or fruitless (no mess) sweetgum (*Liquidambar styraciflua "Rotundiloba"*) trees were mentioned as examples of unavoidable cultivars. There was also a distinction between site types, where respondents preferred to use cultivars as street trees but avoided using them in other settings such as landscaped park areas, restoration projects, or tree giveaways. When asked whether they consider genetic diversity, one respondent explained that they experiment with as many cultivars as possible as they hear about them and were currently testing seven Dutch elm disease-resistant American elm (*Ulmus americana*) cultivars for widespread use.

Only one-third of landscape architects considered genetic diversity in their practice. One landscape architect said that they try to diversify their use of cultivars across their practice, if not within a single project. Others mentioned the requirement to use straight species for restoration projects. Most landscape architects felt that considerations of genetic diversity were beyond the scope or capacity of their work.

Similarly, one-third of regional nurseries explicitly consider genetic diversity in their work, although respondents seemed to interpret genetic diversity in different ways. Some nurseries talked about stocking a variety of native trees and native cultivars, or staying current on the latest cultivars to hit the market. In contrast, one nursery manager was clear on a desire for less genetic diversity in his business model: "I'd rather be planting 300 to 500 of something instead of having three times as many cultivars and 25 of each." When asked about genetic diversity, almost all regional nurseries mentioned the difficulties in growing straight species from seed and the need to grow cultivars that have uniform growth rate and form, both for customer expectations and for efficiency of their own operations. In addition, most felt that cultivars are better quality trees and didn't understand customers' desire for straight species.

All growers seemed to consider genetic diversity to some degree, although they did not all recognize it using those terms. The grower most concerned with genetic diversity was one that focused on native species. They said that everything they offer is straight species, 90% of which comes from seed, and for the few species that are grown from cuttings, they are taken from multiple individuals to preserve genetic diversity. A few growers mentioned that there is a demand for seed provenance, with

some customers wanting to know that their trees are sourced from a local population. However, a constraint to genetic diversity mentioned by a few growers was the increasing lack of seed collectors.

Growers mentioned the same themes as regional nurseries, a balanced desire to incorporate straight species or new cultivars with a recognition that they need reliable growing stock in order to turn a profit. One grower explained that there is a minority of customers who do wish to have straight species, but "selections (cultivars) are a better plant, whether it's in production, cultivation, in your yard, it's just a better plant. But there are situations where we still need straight species, although that's loosening up a bit—that's a good thing!" Growers also described species for which cultivars are the only viable production method. For example, one grower mentioned that American linden (*Tilia americana*) is known to have such dramatically variable growth rates and form that it is not commercially viable to grow them from seed. They also described their process of introducing underutilized species through selection: "If you grow *Ostrya* (hophornbeam) from seed, most of them are scrubby little things, they're really not going to do well when they're planted in a city, on a street or in a park. But if you can isolate some good genetic forms and then clonally produce them, then you do have a tree that's suitable that wouldn't be used otherwise." In this way, selection for desirable traits while reducing genetic diversity within a species can be a way to increase overall species diversity in nursery offerings.

Native Trees

All respondents consider whether the trees they are growing, selling, specifying, or planting are native, but for some this is a top priority and for others it is seen as more of a specialized issue that has a smaller impact on their work. Urban forestry organizations show a strong preference for planting native tree species, and some of their grant funding even requires native trees in planting projects. However, they recognize that programs and initiatives that require only native trees can be limiting or misguided, given that non-native trees can perform equally or better in challenging urban sites. Most landscape architects described a similar preference to specify native tree species whenever possible and to avoid invasive species (e.g., Norway maple; *Acer platanoides*). One firm mentioned a goal of specifying at least 50% native tree species in their designs, although it did not seem to be a strict requirement. Another said that they "start with 100% native approach and work from there."

Regional nursery managers and growers had similar responses when asked whether considerations of native species impacted their work. Respondents from both sectors described an increasing demand for native trees. While availability of native species is growing, some regional nurseries have difficulty sourcing the stock from liner growers to meet the increased demand for a wide variety of native species. All native tree species are not viewed equally; one nursery manager described "good and bad natives," contrasting stress tolerant and pest-free native species with "fickle" natives that are more drought-sensitive and have higher mortality rates. To this end, a regional nursery manager suggested contract growing for specific urban forestry projects as a solution to producing risky, slow-growing native species (e.g., hickories (*Carya* spp.), sassafras (*Sassafras albidum*), eastern red cedar (*Juniperus virginiana*)).

Some regional nurseries and growers expressed frustration about policies that require native trees, especially more obscure or underutilized native species. Although there are a few exceptions, most regional nurseries would prefer to supply cultivars and to relax the focus on native species. In part, there is confusion and frustration about the definition of "native" tree species for urban areas. One nursery manager says that the focus on native species is a "problem area for the industry" because it is "illogical" to think that trees that evolved in a region would still be suitable given a changing climate and urban planting conditions (i.e., street tree pits). Another says: "The (State of Maryland's) five million tree initiative is really good right up to the point where somebody said they have to all be native…any artificial constraints on diversification are not helpful in the big picture, I think. There's nothing natural about a street tree pit in Western Baltimore, there is nothing native about that location." Some respondents place blame on academic research for emphasizing the importance of pollinator or wildlife diversity over a legacy of hundreds of years of tree improvement. As one nursery manager says, "You know, native trees are great but these improved varieties are so much better it really doesn't make sense. I mean they're all red maples to start with, at their genetic base, and it just doesn't make sense to plant a [straight species] red maple when you can plant an October Glory and get a lot better color and growth." Growers also describe the emotional attachment that some people have to native tree species, which can lead to dogmatic views. As one respondent describes, "People on the street are questioning city foresters who are trained to take care of urban forest health and that diversity should include a good mix of native and non-native, just depending on what situation is…the rigidity of the camps is something that I'm seeing more. You know, it's kind of like our politics—extreme in both directions."

Planting Site Conditions

All urban forestry professionals and landscape architects mentioned planting site conditions as an important factor impacting tree selection in their work. This included consideration of soil volume, water availability, slope, aspect, and infrastructure conflicts such as power lines, underground utility lines, nearby buildings, or heavy traffic. Trees might be selected to match site conditions based on stature (small versus large), form (columnar versus spreading), growth rate, fruit/nut production, and salt spray, drought or flood tolerance. One landscape architect also described targeting low maintenance species because they "plan on low or no inputs" to the sites after planting. Only about half of regional nurseries and only one grower mentioned planting site conditions as a major factor influencing their species selection. The grower mentioned urban soil quality as a specific issue of concern, and regional nurseries were concerned with general tolerance to stressful urban site conditions.

Esthetics

Although not universally mentioned by urban forestry organizations, some recognized the importance of uniformity or historical precedence in maintaining a certain aesthetic (e.g., a block lined with London planetrees (*Platanus x acerifolia*). One professional acknowledged that some institutional property owners select trees that create a certain

image (e.g., flowering trees flanking the entrance of a prestigious private school). In contrast, every landscape architect described the importance of esthetics in tree selection, in order to create both variety and consistency, depending on the setting. Almost every landscape architect mentioned seasonal visual interest, including flowers and fall color. Similar to urban foresters, some mentioned matching the esthetics of existing trees on a planting site, or a look of "consistency" on a new site. One explained, "we try to create rhythms with the tree patterns…along the main street we want to have all the same type of tree." Part of these patterns might also include different tree species to mark different parts of a site, which one respondent called "special trees" or "entrance plants."

While regional nursery managers and growers do not necessarily consider esthetics to be important, almost all referenced the importance of esthetics to their customers or the landscape architects who inform their customers' orders. A few nursery managers mentioned noticing a recent increase in demand for flowering trees. Sometimes the focus on esthetics is presented in opposition to tree performance or diversity, which they see as a more important goal. For example, one regional nursery manager explains "We'll get a landscape architect that wants 40 littleleaf lindens [*Tilia cordata*] because they're going to plant this wonderful allée of two parallel cookie cutter rows of exactly the same color and I sort of suggest that maybe it'd be neat to alternate two different species, or maybe alternate two different species that don't have exactly the same pest and disease threats to them, you know that looks neat too. And sometimes they take me up on that and usually they don't." Some regional nursery managers talk about esthetics in the context of straight species, as mentioned above. Either they or their customers may consider straight species to look "weedy and unkempt" so they opt for cultivars instead when available. Growers also mention the influence of landscape architects. In addition, some growers who are actively developing new cultivars mention that color and form are critically important in their selection process, implying that any new cultivar must improve upon existing varieties, including in aesthetic traits.

Climate

Almost every urban forestry organization and landscape architect had detailed explanations about the importance of climate change in tree species selection. They talked about selecting species from more southern hardiness zones (e.g., sugarberry (*Celtis laevigata*), southern red oak (*Quercus falcata*)) to account for a warmer local climate, either now or in the future. Respondents also mentioned phasing out species with more northern distributions, such as northern red oak, or species thought to be more drought sensitive, such as serviceberry (*Amalanchier* spp.). Some urban foresters expressed a desire to source trees from more southern populations, although that seemed to be out of their scope or control, given how many times the trees change hands before arriving in their inventory. However, one respondent mentioned planting a southern, heat-resistant cultivar of sugar maple (*Acer saccharum*). Some landscape architects describe a preference for locally-grown trees, so that the initial nursery hardiness zone matches the ultimate planting hardiness zone. While this is not motivated by climate change, it reflects the importance of climate adaptation.

In contrast, very few regional nurseries and growers considered climate to be an important factor in their species and cultivar selections. Of those who did bring up climate, most had only a vague idea that a warming climate might be important for future tree selection decisions. The most specific examples given by regional nurseries and growers were cases that highlight the complexities of planning for climate change. For example, one mentioned having the coldest winter in 30 years, which "reminded people that planting trees for climate change isn't just as simple as planting things that you used to grow in California in Oregon." Another described their perception of a disconnect between the focus on native trees and climate change, given that native trees often struggle in the most heat prone urban locations which do not resemble the conditions in which they evolved (i.e., sidewalk tree pit).

Demand

All regional nurseries and growers described customer demand being a primary factor (often *the* primary factor) influencing their species and cultivar selections. Many of the other themes we coded contribute to customer demand, but sometimes the nursery or grower is not aware of all of those contributing factors and is simply responding to past sales or feedback from clients. Many respondents described their software or other methods for analyzing previous sales data to anticipate future demand, though they acknowledged that industry trends may change faster than the time it takes to grow trees for sale, creating risk. Nurseries and growers need to project demand four or five years into the future, which may be quite different from current demand, given changing policies, market trends, and pest or disease impacts. As one nursery manager says, "It is a big gamble, because what I'm planting today, I won't be digging and selling that tree for another four years or five years…it's hard to say what the industry is going to be like in five years…but that's just the thing, nobody has a crystal ball to say this is a surefire plant to have, otherwise we'd all be millionaires." Another says, "We always joke saying, 'This is the biggest gamble of our life, you know we could go to the casino and have better chances than we do here.'" One grower described their formal process for adding new trees to their inventory, with demand being a primary factor: "We have 20 reps across the country who have their ears to the ground; we have a plant nomination process that is formal…and the bottom line is how many can we sell?" Customer demand influences new species and cultivars that are grown and those that are no longer produced. Several respondents mentioned species that they no longer offer because demand has dried up (e.g., invasive Norway maple trees, ash trees susceptible to emerald ash borer).

Pest and Disease Impacts

Almost every urban forestry organization and landscape architect discussed their awareness of pests and diseases in the course of the interview. However, most said that it wasn't a major consideration for their tree selection except in extreme or obvious situations such as planting Dutch elm disease-resistant elms or avoiding ash trees (*Fraxinus* spp.) altogether because of emerald ash borer. Some landscape architects cited pest resilience as a justification for preferring cultivars over straight species.

In contrast very few regional nurseries mentioned pests and diseases as a primary consideration in species or cultivar selection. It may be that they consider the impact of established pests and pathogens like emerald ash borer and Dutch elm disease to be so obvious that they didn't include it in their response, while the impact of emerging pests is so uncertain that they didn't have a good ability to account for it. One nursery manager explained that a diverse inventory helps reduce their risk of losing their entire stock to pest or disease impacts, and also considered cultivars to be more disease-resistant than straight species. Only one grower specifically mentioned considering disease resistance in the development of new cultivars, but they felt it was less important than aesthetic and structural qualities.

Policy and Regulations

All urban forestry organizations referenced specific policies or regulations that shaped their tree selection processes. Some of these policies were very specific, such as the frequently referenced list of acceptable (and prohibited) street tree species required by Baltimore City. Others were more general, such as the goals in the City's Sustainability Plan to "ensure a diversity of tree species", to "emphasize the use of native plants," to plant "the right tree, in the right place," and to "consider future climate conditions in plantings." It is unclear how these policies translate to actual planting decisions. Landscape architects also frequently referenced the Baltimore City street tree planting list, as well as municipal and state requirements to plant certain species or a certain amount of tree cover on "conservation" sites. Several landscape architects also mentioned the City of Baltimore Landscape Manual, which influences the stature and species of trees needed to meet certain development site requirements. One respondent brought up an informal goal to meet the City's 40% tree canopy cover goal on each site they design. Thus, even if not required by law, there are many policies influencing tree selection in landscape designs.

Only one-third of regional nurseries mentioned policies or regulations as a factor influencing tree selection, and no growers discussed this theme. Regional nurseries each highlighted a different aspect of policy influence, including municipally-approved tree lists and statewide tree planting initiatives requiring native trees. Other nursery managers referenced ways that policies informally shape their clients' species selection. One said that Baltimore City was trying to decrease the number of red maples being planted in order to diversify the urban forest, while another said that they observed a focus on planting large canopy trees in order to meet tree canopy cover goals.

Availability

Most urban forestry organizations considered availability to be a major factor influencing tree selection. One professional who approves planting site permits says that they have "seen an increase in requests to substitute species or change sizes due to availability issues" and they anticipate that this issue may worsen with new state and federal funding for urban tree planting in the region. Another said that their "species offerings are mostly based on nursery availability." Similarly, about half of landscape

architects felt that nursery stock availability was a constraint to their tree selection, but they generally accepted "reasonable substitutions."

Less than half of regional nurseries mentioned issues of tree availability. When they did bring up this theme, they generally focused on their clients' frustrations with the lack of availability of uncommon "wish list" species that are hard for them to grow or to source. One regional nursery expressed desire to "talk with growers earlier on, find out what they have and will have available that could be suitable, or even start to leverage some of our grower partnerships and begin to grow and forecast out for future years some of those desirable but hard to get selections." Two-thirds of growers talked about availability, but their constraints were often related to seed availability. As one grower explained, "There are less and less people out there picking seed. We have a harder time pretty much every year sourcing our seed. A lot of people used to collect seed as a part time job or an extra job, and those people are retiring and no one's taking their place." In addition to seed sourcing, some growers described the challenges in growing stock several years out from when they will sell it, which can create mismatches around availability of certain species or cultivars when it is hard to predict future demand.

Familiarity

The concept of familiarity with certain tree species or cultivars was evenly spread across sectors, with about half of respondents from each sector mentioning this theme. Tree planting organizations described preferentially choosing species that residents are familiar with. Landscape architects referenced using "tried and true" species or "old faithfuls." As one landscape architect explains, "if you want to try something different it's a 'guess and test' process." Regional nurseries talk about their clients' familiarity with certain cultivars in addition to species. One nursery manager says: "Somebody could come along with the absolute best holly [variety] that's ever existed, but if [customers] don't know that name, then you really can't sell it." Even if he believes it is a superior holly variety, that may not be enough to convince his clients to try something new because "people most of the time won't buy things they haven't heard before" and "people like to plant what they've always planted." One grower articulates the challenges they face in introducing new species or varieties: "A frustrating point is, we introduce new trees every year and people's first question is, 'Oh, what's new?' And then they buy 10 or 20 of them and they buy 500 of what they know works. Most new tree introductions probably hit their sales potential after they've been on the market for 15 to 20 years because people are cautious about planting new trees or different trees because a tree's there for a long time and there's a lot that can go wrong." Respondents across sectors illustrate the ways in which growers, nurseries, and their clients are all taking a long-term, expensive risk in trying out a new species or cultivar.

Production Constraints

A final theme that was only mentioned by regional nurseries and growers was the influence of production constraints, and both sectors had similar descriptions for the constraints that limited their ability to offer additional species or cultivars. In general,

there is a need for trees to be "conducive to nursery production," which means that individuals of the species or cultivar need to grow at similar rates, in certain conditions (e.g., in containers, or able to withstand bareroot transport) and they need to be ready for market within a certain timeframe (for example, one grower mentioned 30 months for container trees and 48 months for larger stock). Time is money, so as one nursery manager says, "Nobody is going to want us to introduce a cultivar that takes an extra year of production time over what's already available." A high degree of variation in tree size and quality ties up land and personnel, ultimately reducing profit, so nurseries and growers need to prioritize species and cultivars with reliable growth. One grower gave the example of horsechestnut trees having too much natural variation: "Horsechestnuts are crazy…you can have a 2.5 inch [6.35 cm] tree or .5 inch [1.27 cm] caliper tree in the same four-year growing block. That's a $70 tree and $15 tree." Efficient and profitable production practices cannot accommodate this type of wild variation, even if there is demand for a species. A few respondents expressed the sentiment: "we love trees but ultimately we're in this business to take care of the people that work with us, our customers, and then to generate some profit."

Discussion

Decision-Making across Sectors

We found different factors driving decision-making across sectors of Baltimore's tree supply chain. While many of the same themes were identified across sectors, some were emphasized more heavily than others, depending on the motivations for tree selection at each step in the tree supply chain.

Urban forestry professionals were focused on planting native trees and increasing species diversity on the urban landscape, reflecting current trends in urban forestry practice (Conway and Vander Vecht 2015; Morgenroth et al. 2016; Sjöman et al. 2016). However, planting site conditions and tree availability were important considerations for this sector that may constrain tree selection decisions (Hilbert, Koeser, Andreu, Hansen, et al. 2023). Compared to other sectors, urban forestry professionals were more likely to consider genetic diversity, using straight species when possible or diversifying the number of different cultivars used in planting projects. Local or regional policies and regulations also strongly drove their tree selection decisions, and climate was identified as an important factor, though they were not always able to consider climate adaptation when selecting trees to plant (Bassett et al. 2025; Esperon-Rodriguez et al. 2022).

With a few exceptions, landscape architects' decisions were largely driven by esthetics and planting site conditions with species diversity as a secondary consideration, which is similar to previous findings from Toronto, Canada (Conway and Vander Vecht 2015). When landscape architects described the importance of climate adaptation or genetic diversity, they also typically acknowledged that it was largely beyond the scope of their work. More communication between landscape architects and other sectors may facilitate progress toward diverse and climate-adapted urban forests. Thompson, McCombs, and Jansen (2021) found that landscape architects specified a greater number of tree species and cultivars than other consultant disciplines (e.g., civil engineers) on urban

tree planting projects, but used cultivars more frequently than others, potentially leading to limited genetic diversity.

In contrast, regional nurseries and growers made decisions primarily based on production constraints and consumer demand. They were very clear that the need to stay profitable in a risky business limited their ability to consider other factors (Koeser et al. 2026). Although esthetics, diversity, nativity, and climate were factors they were familiar with, they were typically only considered for their impacts on consumer demand or production constraints. Avolio et al. (2018) found more tree species were offered in locally-owned nurseries compared with mass merchandizer stores, suggesting that there can be variation among regional nursery offerings. Similarly, we found that there were a few growers or regional nurseries with a specific mission to increase diversity in their offerings, as well as a few nurseries that engaged with customers to influence their preferences. However, most wanted to grow what they and their customers are familiar with and seemed resigned to providing what is requested, even if they didn't agree with the selection.

Regional nurseries and growers did not mention planting climate, site conditions, or policy and regulations as frequently as the other sectors, which makes sense given that they are further removed (sometimes by thousands of miles) from the actual planting sites. However, these factors inform their customer preferences, and more interaction with urban forestry professionals or researchers to understand the latest arboriculture and urban forestry science, practice, and policy may be beneficial to both sectors (Hilbert, Koeser, Andreu, Hansen, et al. 2023). Commercial nurseries have an important role to play in assisted migration responses to climate change across urban and rural landscapes, but challenges remain in integrating climate considerations into their operations (Williams and Dumroese 2014).

Among our respondents, growers were most likely to describe working with academic and private researchers or plant breeders to develop relationships and stay current on the latest science about new species or cultivars to introduce into production. Urban forestry professionals were most aware and supportive of scientists' and policymakers' focus on the benefits of tree diversity and climate adaptation. Thus, the professionals working at the beginning (growers) and end (urban foresters) of the supply chain appear to be more likely to make science-based decisions, though they are often geographically distant from one another and are operating with different priorities and constraints (Bassett et al. 2026; Esperon-Rodriguez et al. 2022). Regional nurseries and landscape architects also have enormous influence on which trees end up planted in Baltimore, yet have very different priorities than urban forestry professionals and may not be aware of the science and policy informing municipal planting goals (Conway and Vander Vecht 2015). Communication throughout the supply chain can help ensure that all sectors are operationally successful.

Considerations of Species and Genetic Diversity across Sectors

Much of the scientific literature on urban forest diversity is based on the premise that increasing diversity is an important goal, with few acknowledgements of the tradeoffs inherent in that goal. Morgenroth et al. (2016) review the current gaps in knowledge and caution against only managing the urban forest for diversity to the exclusion of

other ecosystem service considerations. Bassett et al. (2024) also found that planting a variety of trees is only one of many management actions that urban forestry professionals consider in their efforts to achieve urban sustainability goals, and may not be the highest priority when selecting species. Similarly, we found that respondents across all sectors considered tradeoffs between diversity and other factors, such as planting site conditions (urban forestry professionals), esthetics (landscape architects), demand (regional nurseries), or production constraints (growers). All sectors used some variation of a combined strategy of balancing diversification with familiar "old reliable" species or cultivars to mitigate risk, whether their primary concern was tree survival or sales.

Despite the fact that all respondents considered aspects of species diversity in their work, they did not quantify targets for species diversity. This finding is similar to Muller and Bornstein (2010) findings that while the majority of California municipalities indicated that species diversity was a management objective, fewer than half of those responding positively had codified the objective in an actual urban forest management plan. Lofty municipal sustainability goals are typically set without direct management guidelines and priorities, leading to policy that is disconnected from urban forest management (Bassett et al. 2025). It's possible that more specific and quantitative species diversity or genetic diversity goals would be more actionable for urban forestry organizations to implement, and would also trickle down to landscape architects, nurseries, and growers. Landscape architect respondents mentioned targeting other specific policy-related goals in their own designs, such as increasing tree size or canopy cover. Policies and funding supporting the planting of native trees in the Baltimore region have also clearly influenced all sectors that we interviewed, and have led to specific management actions (e.g., planting only native species in landscaped park settings). Both the Baltimore Sustainability Plan and Maryland's Tree Solutions Now Act also specifically prioritize tree maintenance in addition to tree planting, which may help expand the palette of available species and genotypes beyond the most resilient in harsh urban conditions (Vogt, Hauer, and Fischer 2015).

While all respondents consider species diversity in their operations, only a few think about genetic diversity when deciding which trees to grow, sell, select, and/or plant. Tree genotype or seed source information is not as easy to document and communicate as species level information, which probably contributes to this finding (Morgenroth et al. 2016). Some of our respondents from each sector expressed a desire to keep track of genetic diversity but said that it was virtually impossible to do so. For example, a recent analysis from Michigan presents a useful tool standardizing the use of urban tree diversity metrics and reporting in urban forest management plans, but does not extend beyond the species level (Dowtin and Hunt 2025). Although many respondents briefly mentioned susceptibility to pests and disease as considerations in tree selection, these were usually only factors for a handful of species with well-known issues. Genetic diversity was not described by respondents as an important safeguard against pests or disease, despite evidence in the scientific literature that genetic diversity of a tree population is important for resilience and adaptation to potential future threats such as pest outbreaks and climate change (Fernandez-Conradi et al. 2017; Jump and Peñuelas 2006; Lohr, Kendal, and Dobbs 2016). Finally, growers described cultivars as a method for increasing native species diversity, because they can isolate

a predictable form and growth rate for species that are more variable and difficult to produce. Thus, maintaining genetic diversity within all species may sometimes be at odds with increasing the total number of species offered by growers.

Nurseries serve many clients, and municipal forestry typically makes up a relatively small share of their sales (Koeser et al. 2026). The nursery industry also has some unique characteristics and challenges, including an extended production cycle combined with significant startup and operating expenses that result in a slow return on investment for producers (Burcham and Lyons 2013). In order to remain profitable, they are limited to growing trees that they are able to produce at scale and that customers will buy. Concerns such as diversity, nativity or climate adaptation must take a backseat to production factors and consumer demand, even if they are prioritized by regional policy incentives. Notably, cost was not described as a constraint to diversity, although it does factor into production constraints for nurseries and growers. We coded customer demand as a theme because it was mentioned by all nurseries and growers, but it represents a synthesis of many other themes identified in interviews across all sectors (e.g., familiarity, esthetics, planting site conditions).

Climate change is a topic linked to diversity that is receiving increasing attention in the urban forestry scientific literature (e.g., Esperon-Rodriguez et al. 2022, 2025), yet there was a disconnect between the perceived importance of climate-adapted species or genotypes by urban forestry professionals and landscape architects and the lack of knowledge or interest in this topic among nurseries and growers. In fact, some regional nurseries seemed to feel that climate change, diversity, or native tree initiatives were out of step with realistic constraints of the industry (Sjöman et al. 2016). Prioritizing native trees is not equivalent to increasing diversity, but it is typically a closely aligned policy goal as it prevents the introduction of potentially invasive species and generally supports a greater biodiversity of birds and insects (Burghardt, Tallamy, and Shriver 2009; Smallwood and Wood 2023). In Baltimore and throughout the Chesapeake Bay region, there is a focus on increasing native species diversity (CBT 2025; City of Baltimore 2019). However, we heard opposition and frustration from landscape architects, nurseries, and growers for several reasons: (1) there is no clear direction from policymakers about the definition of "native" trees, (2) expanding offerings of native trees grown from seed will be expensive and difficult given nursery production constraints, and (3) these policies are sometimes misguided given that many urban planting sites do not resemble "native" tree growing conditions.

Another potential hurdle to increasing native diversity is that seed collection was described as a dying art. Growers were having increasing difficulty finding seed collectors as the older generation of collectors retires and younger generations are not interested in this type of work. A lack of consistent seed supply and adequately trained workforce has also been identified as a major issue in wildland reforestation (Fargione et al. 2021). Despite the differences in planting stock size and quality, perhaps an alignment between urban and rural tree production efforts would help support planting goals across diverse regional landscapes.

Sectors are often operating at timeframes that may be misaligned to address the challenge of planting a more diverse or climate-adapted urban forest. Regional nurseries described looking at prior years' sales to determine demand and plan their next production cycle, while urban forestry professionals are often making decisions to align

with climate policies and plans that set goals many decades into the future. While collaboration between urban foresters and regional nurseries may help address these disconnects, regional nursery supply is heavily influenced by demand from a few large private development buyers rather than smaller purchases from municipal or nonprofit urban forestry operations. In addition to being smaller, public or nonprofit planting projects may be dependent on unpredictable funding cycles, making nurseries wary of changing production to meet their needs. In addition, growers mentioned a consolidation of regional nurseries, which may further limit the diversity of offerings (Avolio et al. 2018). As a result, a few large developers and a few large nurseries may be driving demand along the supply chain.

Communication and Diversification along the Supply Chain

Interviewees often expressed that their ability to diversify urban trees was limited by the preferences and decisions of other sectors, illustrating the interdependent nature of the supply chain (Figure 1). For example, nurseries are limited by the preferences of customers and landscape architects and by regional policies, while landscape architects and urban foresters are limited by nursery offerings. While challenging to implement, communication and collaboration across sectors may help alleviate these tensions and result in more effective policies and programs while supporting the nursery industry (Koeser et al. 2026). Furthermore, engagement with local communities may help urban forestry programs garner support for diversifying urban forests (Campbell et al. 2022). Co-producing neighborhood urban forestry planting targets and plans may allow community members to feel more ownership over tree selection decisions and more invested in the success of a diverse urban forest (Esperon-Rodriguez et al. 2025). Regionally for this study, both the Baltimore Sustainability Plan and Maryland's Tree Solutions Now Act prioritize the involvement of local residents and community organizations in tree planting projects. While neither policy formally targets tree nurseries, the Maryland Department of Natural Resources and the Chesapeake Bay Trust engaged researchers, growers, and the nursery industry through a formal working group in an effort to understand key constraints to expanding the diversity of landscape tree species offered in the state (K.T. Burghardt, pers. comm., April 28, 2026).

Recent cross-sector efforts to diversify the nursery industry are attempting to add species and genetic diversity to urban forests. Nonprofit wholesale nurseries can provide local expertise to tree-planting organizations and a reliable source of native plants adapted to urban areas (e.g., Tree Pittsburgh's Heritage Nursery, Casey Tree Farm as DC State Nursery). Other types of public and private institutions may be able to play a more active role in supporting research and innovation in urban tree supply. For example, the USDA Forest Service National Center for Reforestation, Nurseries, and Genetic Resources has recently hired the first National Urban Nursery Specialist and is revitalizing their support of urban and community serving nurseries (The Morton Arboretum 2025). Academic researchers can develop selection criteria to expand native diversity of urban trees (e.g., D'Amato et al. 2025), though these efforts may be most useful if they are conducted by university extension services or other organizations that provide outreach to practitioners, policymakers, and nursery industry professionals

(e.g., CBT 2025). Botanic gardens and arboreta can also play a more significant role in identifying and evaluating tree species and genetic background performance in urban environments (Cavender and Donnelly 2019; Hirons et al. 2021). Collaborative networks such as the Greening the Landscape Research Consortium in Ontario, Canada develop and share scientific knowledge across sectors in support of the "urban tree value chain" (Vineland Research and Innovation Centre 2025).

Conclusions

We found both synergy and tension among the themes we identified in our interviews. For example, the demand for certain trees was related to their availability and familiarity, as well as other factors such as esthetics, planting site conditions, or policy and regulations. Goals to increase diversity were balanced against these factors, as well as production constraints. All respondents said that species diversity was a consideration, but their focus on diversity varied by sector. The concept of genetic diversity was less familiar to respondents, particularly landscape architects and regional nurseries. Reduction of genetic diversity within a species through the use of cultivars may counterintuitively be a path to increasing overall species diversity in nursery offerings. Growers and urban forestry organizations were more familiar with the importance or tradeoffs of genetically diverse planted tree populations and more likely to be connected to researchers or other sources of information about innovative practices. While some respondents believed that prioritizing native trees was important, others felt that this perspective was limiting or misguided for trees in highly urban settings. Collaboration and communication across the urban tree supply chain may help all sectors more effectively achieve their goals.

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Ethical Approval

This study was approved by the Johns Hopkins University Institutional Review Board (IRB Case #HIRB00012208).

Author contributions

CRediT: **Nancy F. Sonti**: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Validation, Writing – original draft, Writing – review & editing; **Dexter H Locke**: Conceptualization, Formal analysis, Investigation, Methodology, Validation, Writing – review & editing; **Karin T. Burghardt**: Conceptualization, Funding acquisition, Methodology, Writing – review & editing; **Meghan L. Avolio**: Conceptualization, Funding acquisition, Methodology, Visualization, Writing – review & editing.

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References

Arnoldi, M., and C. M. Shackleton. 2021. "The Potential Influence of Commercial Plant Nurseries in Shaping the Urban Forest in South Africa." *Urban Forestry & Urban Greening* 64: 127254. https://doi.org/10.1016/j.ufug.2021.127254.

Avolio, M. L. 2023. "The Unexplored Effects of Artificial Selection on Urban Tree Populations." *American Journal of Botany* 110 (7): e16187. https://doi.org/10.1002/ajb2.16187.

Avolio, M. L., D. E. Pataki, T. L. E. Trammell, and J. Endter-Wada. 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.

Avolio, M. L., C. Swan, D. E. Pataki, and G. D. Jenerette. 2021. "Incorporating Human Behaviors into Theories of Urban Community Assembly and Species Coexistence." *Oikos* 130 (11): 1849–1864. https://doi.org/10.1111/oik.08400.

Bassett, C. G., S. D. Day, C. C. Konijnendijk, L. A. Roman, C. K. Yee, and K. M. Chan. 2026. "The Best Laid Plans: How Do Adopted City Sustainability Goals Influence Site-Level Action in Urban Forestry?" *Ambio* 55 (3): 591–607.

BCRP (Baltimore City Department of Recreation and Parks). 2007. "TreeBaltimore: Baltimore's Tree Planting Partnership." Accessed July 20, 2026. City of Baltimore. http://www.treebaltimore.org/.

Bassett, C. G., S. D. Day, C. C. Konijnendijk, K. M. Chan, and L. A. Roman. 2025. "From Tyranny to Hope: Harnessing the Power of Small Decisions to Achieve Urban Sustainability Goals." *Environmental Science & Policy* 170: 104125. https://doi.org/10.1016/j.envsci.2025.104125.

Bassett, C. G., S. D. Day, C. C. Konijnendijk, L. A. Roman, and V. Hemming. 2024. "Aligning Urban Forest Management Actions with Urban Sustainability Goals: A Multi-City Expert Elicitation." *Ecosphere* 15 (12): e70120. https://doi.org/10.1002/ecs2.70120.

Bingham, A. J., and P. Witkowsky. 2021. "Deductive and Inductive Approaches to Qualitative Data Analysis." In *Analyzing and Interpreting Qualitative Data: After the Interview*, edited by C. Vanover, P. Mihas, and J. Saldaña, 133–146. Thousand Oaks, CA: SAGE Publications, Inc.

Bricknell, C. D., C. Alexander, J. J. Cubey, J. C. David, M. H. A. Hoffman, A. C. Leslie, V. Malecot, X, and Jin, X. 2016. *International Code of Nomenclature for Cultivated Plants*. 9th ed. Scripta Horticulturae Number 18. Leuven, Belgium: International Society for Horticultural Science.

Burcham, D. C., and R. E. Lyons. 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.

Burghardt, K. T., D. W. Tallamy, and W. G. Shriver. 2009. "Impact of Native Plants on Bird and Butterfly Biodiversity in Suburban Landscapes." *Conservation Biology: The Journal of the Society for Conservation Biology* 23 (1): 219–224. https://doi.org/10.1111/j.1523-1739.2008.01076.x.

Campbell, L. K., E. S. Svendsen, M. L. Johnson, and S. Plitt. 2022. "Not by Trees Alone: Centering Community in Urban Forestry." *Landscape and Urban Planning* 224: 104445. https://doi.org/10.1016/j.landurbplan.2022.104445.

Cavender, N., and G. Donnelly. 2019. "Intersecting Urban Forestry and Botanical Gardens to Address Big Challenges for Healthier Trees, People, and Cities." *Plants, People, Planet* 1 (4): 315–322. https://doi.org/10.1002/ppp3.38.

Cavender-Bares, J., J. Padullés Cubino, W. D. Pearse, S. E. Hobbie, A. J. Lange, S. Knapp, and K. C. Nelson. 2020. "Horticultural Availability and Homeowner Preferences Drive Plant Diversity and Composition in Urban Yards." *Ecological Applications* 30 (4): e02082. https://doi.org/10.1002/eap.2082.

CBP (Chesapeake Bay Program). 2025. "Tree Cover Status & Change for Baltimore City, MD 2013–2021." Accessed September 18, 2025. Chesapeake Bay Trust. https://cicwebresources.blob.core.windows.net/tc-factsheets-2024edition/Tree%20Cover%20Fact%20Sheet%20Baltimore%20City,%20MD%202013-2021.pdf.

CBT (Chesapeake Bay Trust). 2025. "Urban Trees Mini Grant Program Request for Proposals, Appendix A: Native Tree Species Selection." Accessed September 21, 2025. Chesapeake Bay Trust. https://cbtrust.org/wp-content/uploads/Appendix-A-Native-Tree-Species-Selection.pdf.

City of Baltimore. 2017. "Baltimore City Landscape Manual." Accessed September 21, 2025. City of Baltimore. https://www.baltimoresustainability.org/landscape-manual/.

City of Baltimore. 2019. "The 2019 Baltimore Sustainability Plan." Accessed March 1, 2024. City of Baltimore. https://www.baltimoresustainability.org/wp-content/uploads/2019/02/Sustainability-Plan_01-30-19-compressed-1.pdf.

Conway, T. M. 2016. "Tending Their Urban Forest: Residents' Motivations for Tree Planting and Removal." *Urban Forestry & Urban Greening* 17: 23–32. https://doi.org/10.1016/j.ufug.2016.03.008.

Conway, T. M., and J. Vander Vecht. 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, F. D., and N. Bassuk. 2017. "Street Tree Diversity in Three Northeastern U.S. states." *Arboriculture & Urban Forestry* 43 (1): 14. https://doi.org/10.48044/jauf.2017.001.

D'Amato, L., F. Bartoli, V. Savo, and G. Caneva. 2025. "Promoting Native Biodiversity: An Evaluation of Multifactorial and Bioclimatic Selection Criteria for Street Trees in Italian Cities." *Urban Forestry & Urban Greening* 107: 128784. https://doi.org/10.1016/j.ufug.2025.128784.

Dowtin, A. L., and I. B. Hunt. 2025. "Use of the Tree Diversity Reporting Index (TDRI) to Assess Variability in Urban Tree Diversity and Related Reporting Practices: A Michigan, USA Pilot Study." *Journal of Environmental Management* 380: 124760. https://doi.org/10.1016/j.jenvman.2025.124760.

Dümpelmann, S. 2025. "Tree Times: Urban Plants as Timekeepers and Seasonal Indicators." *Journal of Urban History* 51 (1): 48–60. https://doi.org/10.1177/00961442241260359.

Esperon-Rodriguez, M., R. Gallagher, C. Calfapietra, P. Cariñanos, C. Dobbs, A. A. Eleuterio, D. Esperon Rodriguez, et al. 2025. "Barriers and Opportunities for Resilient and Sustainable Urban Forests." *Nature Cities* 2 (4): 290–298. https://doi.org/10.1038/s44284-025-00212-2.

Esperon-Rodriguez, M., M. G. Tjoelker, J. Lenoir, J. B. Baumgartner, L. J. Beaumont, D. A. Nipperess, S. A. Power, B. Richard, P. D. Rymer, and R. V. Gallagher. 2022. "Climate Change Increases Global Risk to Urban Forests." *Nature Climate Change* 12 (10): 950–955. https://doi.org/10.1038/s41558-022-01465-8.

Fargione, J., D. L. Haase, O. T. Burney, O. A. Kildisheva, G. Edge, S. C. Cook-Patton, T. Chapman, et al. 2021. "Challenges to the Reforestation Pipeline in the United States." *Frontiers in Forests and Global Change* 4: 629198. https://doi.org/10.3389/ffgc.2021.629198.

Fernandez-Conradi, P., H. Jactel, A. Hampe, M. J. Leiva, and B. Castagneyrol. 2017. "The Effect of Tree Genetic Diversity on Insect Herbivory Varies with Insect Abundance." *Ecosphere* 8 (1): e01637. https://doi.org/10.1002/ecs2.1637.

Galle, N. J., D. Halpern, S. Nitoslawski, F. Duarte, C. Ratti, and F. Pilla. 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.

Hansen, O. K., P. Thomsen, and C. W. Rasmussen. 2014. "DNA Markers Provide Insight about Common Lime in Historical Plantings: An Example from the Royal Danish Gardens." *Urban Forestry & Urban Greening* 13 (3): 543–552. https://doi.org/10.1016/j.ufug.2014.04.001.

Hilbert, D. R., A. K. Koeser, M. Andreu, M. Clarke, G. Hansen, L. A. Roman, and M. Thetford. 2023. "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, D. R., A. K. Koeser, M. G. Andreu, G. Hansen, L. A. Roman, M. Thetford, and G. L. Thompson. 2023. "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.

Hirons, A. D., J. H. R. Watkins, T. J. Baxter, J. W. Miesbauer, A. Male-Muñoz, K. W. Martin, N. L. Bassuk, and H. Sjöman. 2021. "Using Botanic Gardens and Arboreta to Help Identify Urban Trees for the Future." *Plants, People, Planet* 3 (2): 182–193. https://doi.org/10.1002/ppp3.10162.

Iles, J. K., and A. M. Vold. 2003. "Landscape Tree Cultivar Preferences in Iowa, U.S." *Arboriculture & Urban Forestry* 29 (6): 331–336. https://doi.org/10.48044/jauf.2003.041.

Jump, A. S., and J. Peñuelas. 2006. "Genetic Effects of Chronic Habitat Fragmentation in a Wind-Pollinated Tree." *Proceedings of the National Academy of Sciences of the United States of America* 103 (21): 8096–8100. https://doi.org/10.1073/pnas.0510127103.

Kendal, D., C. Dobbs, and V. I. Lohr. 2014. "Global Patterns of Diversity in the Urban Forest: Is There Evidence to Support the 10/20/30 Rule?" *Urban Forestry & Urban Greening* 13 (3): 411–417. https://doi.org/10.1016/j.ufug.2014.04.004.

Kester, D. E. 1983. "The Clone in Horticulture." *HortScience* 18 (6): 831–837. https://doi.org/10.21273/HORTSCI.18.6.831.

Kinlock, N. L., D. W. Adams, and M. van Kleunen. 2023. "An Ecological and Evolutionary Perspective of the Historical U.S. Nursery Flora." *Plants, People, Planet* 5 (1): 146–159. https://doi.org/10.1002/ppp3.10336.

Koeser, A. K., D. R. Hilbert, D. H. Locke, C. B. Riley, and N. F. Sonti. 2026. "Increasing Urban Tree Diversity, Quality, and Abundance in the Chesapeake Bay Watershed: Challenges and Opportunities." *Arboriculture & Urban Forestry* 52 (1): 22–35. https://doi.org/10.48044/jauf.2025.035.

Laćan, I., and J. R. McBride. 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, V. I. 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, V. I., D. Kendal, and C. Dobbs. 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 (1108): 263–270. https://doi.org/10.17660/ActaHortic.2016.1108.34.

Love, N. L., K. Althaus, M. Esperon-Rodriguez, A. Ossola, J. Johns, C. Pawlak, B. Igić, M. Ritter, and J. Yost. 2025. "Genetic Diversity in Urban Forests and Their Potential Role in Conserving the World's Threatened Tree Species." *Annals of Botany*, *138*, 120–133. https://doi.org/10.1093/aob/mcaf238.

Ma, B., R. J. Hauer, H. Wei, A. K. Koeser, W. Peterson, K. Simons, N. Timilsina, L. P. Werner, and C. Xu. 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.

Martin, A. J., and T. M. Conway. 2025. "Historical Drivers of Street Tree Species Selection: A Comparative Archival Study of Canadian Prairie Cities." *Trees, Forests and People* 22: 101044. https://doi.org/10.1016/j.tfp.2025.101044.

MD DNR (Maryland Department of Natural Resources). 2023. "'Five Million Trees, Please': Maryland Rolls Out '5 Million Trees' Initiative." Accessed March 2024. https://news.maryland.gov/dnr/2023/06/01/five-million-trees-please-maryland-rolls-out-5-million-trees-initiative/.

MD DNR (Maryland Department of Natural Resources). 2025. "Tree-Mendous Maryland." Accessed September 21, 2025. Maryland DNR. https://dnr.maryland.gov/forests/Pages/treemendous/default.aspx.

Morgenroth, J., J. Östberg, C. C. Konijnendijk van den Bosch, A. B. Nielsen, R. J. Hauer, H. Sjöman, W. Chen, and M. Jansson. 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.

Muller, R. N., and C. Bornstein. 2010. "Maintaining the Diversity of California's Municipal Forests." *Arboriculture & Urban Forestry* 36 (1): 18–27. https://doi.org/10.48044/jauf.2010.003.

Nowak, D. J. 2012. "Contrasting Natural Regeneration and Tree Planting in Fourteen North American Cities." *Urban Forestry & Urban Greening* 11 (4): 374–382. https://doi.org/10.1016/j.ufug.2012.02.005.

Noy, C. 2008. "Sampling Knowledge: The Hermeneutics of Snowball Sampling in Qualitative Research." *International Journal of Social Research Methodology* 11 (4): 327–344. https://doi.org/10.1080/13645570701401305.

Pearse, W. D., J. Cavender-Bares, S. E. Hobbie, M. L. Avolio, N. Bettez, R. Roy Chowdhury, L. E. Darling, et al. 2018. "Homogenization of Plant Diversity, Composition, and Structure in North American Urban Yards." *Ecosphere* 9 (2): e02105. https://doi.org/10.1002/ecs2.2105.

Shobe, B. M., and M. Avolio. 2026. "Identification and Validation of Microsatellite Markers for Acer Rubrum." *Arboriculture & Urban Forestry* 52: jauf.2026.004. https://doi.org/10.48044/jauf.2026.004.

Sjöman, H., J. Morgenroth, J. D. Sjöman, A. Sæbø, and I. Kowarik. 2016. "Diversification of the Urban Forest—Can We Afford to Exclude Exotic Tree Species?" *Urban Forestry & Urban Greening* 18: 237–241. https://doi.org/10.1016/j.ufug.2016.06.011.

Sjöman, H., H. Watkins, L. J. Kelly, A. Hirons, K. Kainulainen, K. W. Martin, and A. Antonelli. 2024. "Resilient Trees for Urban Environments: The Importance of Intraspecific Variation." *Plants, People, Planet* 6 (6): 1180–1189. https://doi.org/10.1002/ppp3.10518.

Smallwood, N. L., and E. M. Wood. 2023. "The Ecological Role of Native-Plant Landscaping in Residential Yards to Birds during the Nonbreeding Period." *Ecosphere* 14 (1): e4360. https://doi.org/10.1002/ecs2.4360.

Sydnor, T. D., S. Subburayalu, and M. Bumgardner. 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.

The Morton Arboretum. 2025. "Urban and Community-Serving Nursery Project." Accessed September 21, 2025. The Morton Arboretum. https://mortonarb.org/plant-and-protect/urban-and-community-serving-nursery-project/.

Thompson, G. L., A. McCombs, and M. D. Jansen. 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.

US Census Bureau. 2020. "QuickFacts: Baltimore City, Maryland. United States Census Bureau." Accessed July 20, 2026. US Census Bureau. https://www.census.gov/quickfacts/baltimorecitymaryland.

Vineland Research and Innovation Centre. 2025. "Greening the Landscape Research Consortium." Accessed September 21, 2025. Vineland Research and Innovation Centre. https://www.vinelandresearch.com/research-programs/greening-the-landscape-research-consortium/.

Vogt, J., R. J. Hauer, and B. C. Fischer. 2015. "The Costs of Maintaining and Not Maintaining the Urban Forest: A Review of the Urban Forestry and Arboriculture Literature." *Arboriculture & Urban Forestry* 41 (6): 293–323. https://doi.org/10.48044/jauf.2015.027.

Warren, C. A. B, and T. X. Karner. 2015. *Discovering Qualitative Methods: Ethnography, Interviews, Documents, and Images*. New York, NY: Oxford University Press.

Williams, M. I., and R. K. Dumroese. 2014. "Assisted Migration: What It Means to Nursery Managers and Tree Planters." *Tree Planters' Notes* 57: 21–26.