SOCIETY & NATURAL RESOURCES
https://doi.org/10.1080/08941920.2023.2175285

Expanding Urban Tree Species Diversity in Florida (USA): Challenges and Opportunities for Practitioners

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ABSTRACT

While many practitioners and scholars understand the risks associated with low urban tree diversity, they often lack the ability to rectify this challenge on their own. The complex system of tree production and procurement is shaped by market pressures, nursery and site constraints, local governance, and differing professional objectives among those who grow, specify, and plant trees. To understand constraints to and opportunities for increasing urban tree diversity, we conducted a series of focus groups comprised of nursery growers, landscape architects, and municipal tree managers. Our results highlight a significant list of considerations and constraints to diversity, with some issues shared among green industries and some specific to growers or purchasers. In light of our findings, we outline actionable strategies for increasing urban tree diversity.

ARTICLE HISTORY
Received 14 June 2022
Accepted 4 January 2023

KEYWORDS
City trees; landscape design; nursery production; urban greenspace; urban forests

Introduction

Background

The "urban forest" is comprised of "all publicly and privately owned trees within an urban area—including individual trees along streets and in backyards, as well as stands of remnant forest" (Nowak et al. 2010). For decades, urban tree diversity has been a reoccurring topic of discussion among urban forest managers and scientists (Raupp, Cumming, and Raupp 2006; Miller, Hauer, and Werner 2015). In Europe and North America, much of the dialogue regarding species diversity was initially driven by the devastating impacts of Dutch elm disease (*Ophiostoma* spp.) which wiped out monocultures of elm (*Ulmus* spp.) street trees in the mid- and late-1900s (D'Arcy 2000; Raupp, Cumming, and Raupp 2006). More recently, interest in diversity has been renewed in North America as the emerald ash borer (*Agrilus planipennis*) has devastated areas

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Supplemental data for this article can be accessed online at https://doi.org/10.1080/08941920.2023.2175285.

where trees in the *Fraxinus* genus represented a significant portion of urban forests (USDA Animal and Plant Health Inspection Services: Emerald Ash Borer 2021; Clarke, Roman, and Conway 2020). As many of the most noxious pathogens are adapted to infect trees at the species or genera level, increasing tree diversity can potentially decrease the severity of infestations or, at a minimum, the proportion of an urban forest lost to a lethal threat (Hantsch et al. 2014; Raupp, Cumming, and Raupp 2006).

However, incorporating a greater variety of tree species into urban plantings is challenging. Urban tree growing conditions are often characterized as having minimal soil volumes, disrupted hydrological cycles, and human-caused tree damage (Roloff 2016). Yet intensively-managed urban planting sites can also afford some beneficial conditions for trees, including more consistent access to water through irrigation, less competition with other tree canopies, and plant health interventions when pests or diseases do arrive (Miller, Hauer, and Werner 2015). Trees touted as strong performers in urban landscapes are tolerant of stressful growing conditions while also being low maintenance (Roman and Eisenman 2022), leading to over-reliance on a few "tried and true" species.

Lack of availability of different tree species is potentially the greatest limiting factor in efforts to diversify urban forests (Petter et al. 2020a). Trees can take 5–15 years to grow to suitable sizes for use in urban plantings (Warren 1990; Burcham and Lyons 2013). This presents a challenge for nursery growers, who must anticipate future market demand when planning out their stock. While growers may have interest in growing underutilized tree species—that is, species that are adaptable to the region, yet make up only a minimal portion of the urban forest (Hilbert et al. 2022)—it is often economically safest (at least in the short-term) to produce popular species that have an established market.

In an effort to break this self-perpetuating cycle, some cities and states have incorporated tree species diversity goals into their urban forest planning and have revised planting lists to include less-common species (e.g., Northrop et al. 2013; Davey Resource Group 2018). Acknowledging that the addition of a species to a preferred planting list does not guarantee its availability, a few municipalities have created their own nurseries to grow lesser-produced trees, although this strategy is not common (Hauer and Peterson 2016). On the other hand, other municipalities have joined together to leverage their buying power and initiate successful contract growing arrangements with area nurseries. For example, in the Chicago Metropolitan Areas (USA), the Suburban Tree Consortium lobbied with the West Central Municipal Conference to successfully extend the length of time municipalities could enter into contractual relationships with area nurseries to 10 years. This policy change provided nurseries with the time needed to grow trees to specification (Miller, Hauer, and Werner 2015). Likewise, when New York City undertook its MillionTreesNYC initiative, annual street tree plantings increased by 14,000 trees. To quickly secure enough trees meeting quality standards and desired diversity, New York City Parks and Recreation (NYCDPR) created long-term tree procurement contracts with several nurseries (Stephens 2010; Miller, Hauer, and Werner 2015).

The aforementioned examples stress the centrality of human decisions in shaping urban forests (Avolio et al. 2018; Roman et al. 2018). While nursery availability is often cited as a limitation to diversification efforts (Conway and Vander Vecht 2015),

consumer demand plays a significant role in determining what growers produce. Urban tree species selection is influenced by esthetic preferences, desired ecosystem services, ease of maintenance, and availability (Kendal, Williams, and Williams 2012; Shakeel and Conway 2014; Conway and Vander Vecht 2015; Gillner et al. 2016; Avolio et al. 2018; Roman and Eisenman 2022). The actors who select and plant trees for public property or new developments—including municipal arborists and foresters, landscape architects, and landscape contractors—may also be required to adhere to local codes, selection guidelines, and planting requirements. Each layer of selection decision (e.g., nursery, design, management) further limits the pool of potential species available for use in urban areas.

Tree Diversity in Florida (USA)

While mostly spared from many of the larger infestations that have plagued the more temperate regions of North America (e.g., Dutch elm disease, emerald ash borer), there is the potential for Florida's urban centers to experience a disturbance of similar magnitude. In recent years, citrus greening (*Candidatus* spp.; Alvarez et al. 2016) has significantly impacted a wide range of citrus (*Citrus* spp.) crops, both in agricultural and residential settings. Similarly, many of Florida's landscape palms have been under pressure from the invasive pathogens lethal yellowing (proposed as "*Candidatus* Phytoplasma palmae"; Bahder and Helmick 2018) and lethal bronzing (taxonomy ongoing; Bahder and Helmick 2019). In Florida's natural lowland habitats, laurel wilt (*Raffaelea lauricola*) has devastated redbay (*Persea borbonia* (L.) Spreng.; Mayfield, Fraedrich, and Merten 2019). This same disease threatens avocado trees (*Persea americana* Mill) in residential yards and commercial orchards. Considering these pathogens and stresses from climate change, urban forestry professionals in Florida have supported trials of underutilized species to expand the potential pool of plantable taxa (Hilbert et al. 2022).

Florida is known for its diversity of flora (Nelson 1994) and is part of the North American Coastal Plain biodiversity hotspot (Noss et al. 2015). Inventories of public and private trees in major cities throughout the state, however, show that trees in the genus *Quercus* often make up a large portion of urban species by quantity (Koeser unpublished data; Escobedo et al. 2009; Escobedo et al. 2011; Empke et al. 2012; Landry et al. 2018). The dominance of *Quercus* can be problematic if serious diseases or pests come to Florida, such as oak wilt (*Ceratocystis fagacearum*). Furthermore, the state is rapidly urbanizing, with developed land quickly replacing agricultural lands and native ecosystems (Carr and Zwick 2016; Nowak and Greenfield 2018), and oaks continue to be one of the favorite choices for urban tree plantings. Based on current patterns of urban growth and development in Florida, urban forests could become a dominant land type in the state in the next 50–100 years (Carr and Zwick 2016). The diversification of Florida's urban forests is critical to enable these human-dominated systems to withstand inevitable disturbances and pests.

In this study, we focused on the perceptions, attitudes and experiences of green industry professionals in relation to urban tree diversity throughout the state of Florida. Specifically, we focused on growers and purchasers, whose decision-making processes

are central to the species palettes used in planted urban landscapes. To better understand the challenges associated with urban tree diversity in Florida, we sought to (1) discern the reasons behind the limited selection of tree species available in the sizes and quantities sought by regular purchasers, and (2) determine how the major actors in the purchasing relationships have attempted to address the cycle of limited species availability and associated low diversity. With its extensive green industry and rapid urbanization, Florida is a compelling state to investigate these research objectives.

By addressing these objectives, growers and purchasers can be better supported in efforts to diversify their stock or selections. Understanding this problem can also help to identify direct actions that policy makers could take to support green industry professionals who seek to diversify their tree selections.

Methods

Study Scope

Florida is the third most populous state in the USA, and 91.3% of its residents live in urban areas (Florida Department of Transportation 2021a, 2021b). The climate of north and central Florida is humid subtropical, while south Florida has a mix of tropical monsoon, tropical rainforest, and drier tropical savannah climates (Beck et al. 2018). There are approximately 15.2 million publicly-owned trees in the state of Florida, and urban forestry is a major industry, with an output of approximately USD $8.40 billion in 2017 (Hodges and Court 2019). We focused on large-scale tree producers in the state (e.g., the wholesale tree growers of both field-grown and containerized trees), as well as those who regularly purchase trees in large quantities (e.g., municipal tree managers and landscape architects who design large developments and planting projects).

Focus Group Design

We conducted a focus group study comprised of practitioners involved in the large-scale production and purchasing of trees in Florida to gain insights regarding the limited palette of tree species available and planted, and the perceptions and attitudes of key players toward increasing the supply of diverse tree species.

We purposefully created focus groups that included (1) growers, (2) municipal tree managers and (3) landscape architects. Each focus group meeting was designed to have a mix of at least two of each green industry professional from the three categories. Given the complexity of the topic, we chose a smaller, mixed focus group design to generate discussion between participants in the green industry and allow individuals ample time to share their perspectives, experiences, and ideas (Breen 2006; Krueger and Casey 2015). We also wanted even representation of the state's major horticultural regions in our study (Figure 1).

First, we compiled lists of potential participants by using professional references from urban forestry colleagues and examining board memberships of professional organizations related to the target participants (e.g., Florida Chapter of the American Society of Landscape Architects; Florida Urban Forestry Council; and Florida Nursery, Growers and Landscape Association). The three lists included 26 growers, 16 municipal tree

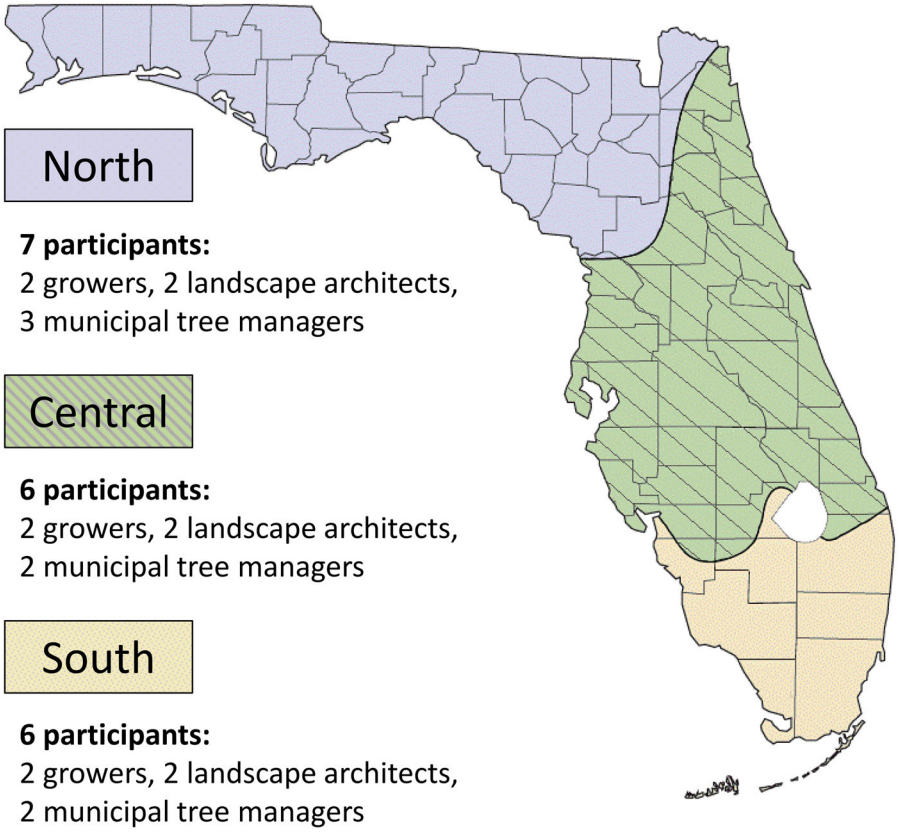

Figure 1. Map of the horticultural regions of Florida, USA, with the numbers and types of green industry professionals represented in the focus groups. Adapted from UF/IFAS (2021).

managers, and 15 landscape architects and were organized by region. Growers were also organized by production method (i.e., field-grown and container-grown). Finally, we randomly contacted professionals from each list until we met our recruitment goal. We initially contacted potential participants by email, then followed up with a phone call as needed to fill each focus group session. We contacted 14 growers, 10 municipal tree managers, 13 landscape architects. As a token of our appreciation, we offered all participants a tree identification book for their time and efforts. Nineteen individuals participated in the study, with an overall recruitment rate of 51% (Figure 1). The University of Florida Institutional Review Board approved our recruitment strategy, focus group methods, data management protocol, and token of appreciation (book) prior to the start of the study.

We held three 90-min meetings during April and May 2021. Meetings were conducted virtually using video conferencing software (Zoom Video Communications, Inc., San Jose, California, USA). Each meeting was facilitated by the same two members of the research team, one of whom acted as the main facilitator, and the other co-facilitated and took notes. Methods SOM 01 in the Supplementary Materials provides the focus group questions. For most questions, we tried to replicate flipchart note taking by typing and displaying participant responses in real-time using the whiteboard function

of the Zoom conferencing software. At the end of the meeting, we summarized what we believed were the main themes raised during the session and allowed the participants to modify these as they deemed necessary. We recorded the three meetings, and transcripts were generated automatically using the conferencing software. After each meeting, the facilitators debriefed to discuss the meeting notes and major take-aways regarding the methods and data collected.

Data Analysis

Our analysis was conducted following the guidelines and best practices established by Krueger and Casey (2015). Auto-generated transcripts were read in their entirety while watching the video recordings to correct any transcription errors. Once the transcriptions were verified, the video recordings of the groups were watched again so notes could be made on any instances where participants emphasized certain points, which were determined based on changes in dialogue intensity or other cues that may have been missed in the transcription process. Coding was carried out using qualitative data analysis software (Quirkos 2.4.1, Quirkos, Edinburgh, Scotland). We used an inductive and deductive coding approach in which the focus group protocol provided foundational questions for discussion and the conversational dialogues also guided the creation of new codes as they pertained to the research objectives (Table 1). Through coding, themes were identified and additional research annotations regarding frequency, extensiveness, participant perception of importance, and researcher inferences were added to the text. Themes were grouped according to research objectives, and the resulting themes and patterns were visualized within the software. This process was conducted by one member of the research team, then coding was confirmed separately by another member.

Results and Discussion

Participant Background

Many participants had experience in more than one sector of the green industry. For example, several of the wholesale tree growers also had current or prior experience in landscape contracting. Participants' years of professional experience in the green industry ranged from 4 to over 40 years. Viewpoints from North, Central, and Southern Florida were represented (Figure 1).

As an introductory question, we asked participants to list the tree species they sell, purchase, or select most frequently (see Table SOM 01). The species *Quercus virginiana* Mill. (southern live oak) and *Lagerstroemia indica* (L.) Pers. (crapemyrtle) were mentioned most frequently by both tree growers and purchasers in all three groups. One grower noted, "The live oak, statewide, is probably the most planted tree under production, and most tree farms probably have 50% of their production based around that one species." This observation is not surprising given that *Q. virginiana* is abundant in natural areas and is one of the most common species in urban tree inventories throughout the state (Koeser unpublished data; Escobedo et al. 2009; Escobedo et al. 2011; Empke et al. 2012; Landry et al. 2018). Drawing on the survey data published by Hauer and

Table 1. Primary coding frames for quantitative analysis of transcripts of focus groups comprised of wholesale tree growers, landscape architects, municipal arborists and urban foresters from Florida, USA.

Questions	Coding options (themes)	Number of times a participant response was coded as the theme
Factors Influencing Production	Climate	4
	Demand and sales	22
	Diversity	2
	Growth rate	4
	Personal preference	1
	Pests and pathogens	2
	Production ease	7
	Recommendations	1
	Regulations	1
	Risk	11
	Tree success	1
Factors Influencing Purchasing	Availability	7
	Budget/costs	5
	Clients/residents	5
	Climate	7
	Convenience	2
	Diversity	3
	Education	2
	Growth rate	3
	History/cultural values	3
	Maintenance level	5
	Pests and pathogens	5
	Politics	1
	Production method	1
	Recommendations	2
	Regulations	12
	Site conditions	21
	Tree function	30
	Tree size	7
	Tree success	5
Constraints to Expanding Selection	Availability	5
	Budget/costs	1
	Clients/residents	4
	Growth rate	6
	History/cultural values	4
	Production ease	3
	Politics	3
	Production method	2
	Regulations	15
	Site conditions	5
	Tree size	6
Opportunities for Expanding Selection	Availability	2
	Contract growing	11
	Collaboration	19
	Education	19
	Experimentation	3
	Interactive database	3
	Marketing	7
	Regulations	19
	Tree function	2
	Tree giveaway	2
	Tree size	5
	Underutilized trees	4

Participants were asked questions relating to their experiences with tree species selections and diversifying the pallet of trees available for use in urban areas in Florida. The "Questions" were the preliminary codes created through deductive coding before analyzing the transcripts based on the main research questions. The "Coding Options" were created inductively while analyzing the transcripts and were the main themes. The last Column notes the number of times a participant response was coded as a certain theme within the context of the Questions.

Peterson (2016) and Ma et al. (2020) for comparison, we found that 15 of the 19 responding Florida cities listed *Q. virginiana* as one of their six most abundant species. Furthermore, respondents to a follow up question ($n = 10$) noted the species constituted 41.8% of their cities' urban forests, on average. Oaks in general (*Quercus* spp.) accounted for 53.4% of existing trees among the respondents. In contrast, crapemyrtle, a non-native species, was listed as one of the most abundant species in eight cities with a maximum relative abundance of 17% (Hauer and Peterson 2016; Ma et al. 2020).

We then asked the participants to explain their decision-making and factors they consider when selecting which trees to produce, plant or recommend for planting. Table 1 outlines the primary coding frames for the analysis of their responses.

Factors Influencing Tree Selection by Growers

When growers were asked to explain their species selection decision-making process, responses largely fell into the categories of (1) market demand and sales, (2) production ease and (3) growth rate. Growers highlighted market demand and sales more frequently than any other factors. For example, all growers said historical sales records are reviewed when selecting which trees to grow each year.

Other studies have similarly found consumer demand to be a leading factor in nursery stocking (Polakowski, Lohr, and Cerny-Koenig 2011, Conway and Vander Vecht 2015). However, our grower respondents expressed a willingness to adapt current inventory to meet the needs of purchasers. For example, species like the slower-growing *Podocarpus macrophyllus* (Thunb.), are commonly sold as hedge plants in small containers. As a tough, relatively pest free species, its slow growth rate makes it a desirable candidate for designers and urban foresters looking to plant in sites with limited above and belowground space. One grower suggested that other growers could look at the underutilized trees being discussed by purchasers and researchers and cultivate part of their existing inventory into tree forms to "try to stimulate that market".

In addition, these conversations regarding demand and sales overlapped most often with discussions of tree uniformity, and several growers emphasized that purchasers should be more accepting of variation in the size and structure within a given species.

Growers frequently discussed how a desire for production ease can limit the diversity of species being grown. One grower explained how the number of different species being produced can affect efficiency as follows:

> You don't want to have too many different varieties of trees that require different requirements because it makes your production much harder. So, a lot of growers decide they only want to grow five varieties of trees to simplify their production. And then you have some growers that like to have a lot of diversity. We like to have a little more diverse palette, so we decided to grow maybe 20 to 25 different species of trees.

A second grower followed up on this point later in the discussion when asked about how they might respond to the appearance of a major pest or pathogen by saying this:

> That scenario is why we grow 25 different species of trees. We try to keep live oak percentage as low as we can … I think if something were to come along and wipe out live oak, we would just immediately start growing more of the other species that we already have found to be successful.

These conversations highlight some of the complexity of the decision-making process growers go through when considering how to maximize production, minimize expenses, and minimize risk.

Growth rate was another frequently noted factor in determining which tree species to produce, in part because trees with similar growth rates are easier to care for in a tree farm or nursery setting. Several growers shared examples of how they "are incentivized by the market to find fast-growing trees." For example, one grower had produced two cultivars of crapemyrtle and found that "an eight-foot 'Catawba' is about four years old, and no one wants to pay any more for that than an eight-foot 'Muskogee' that's a year-and-a-half old." While fast growth rates were generally seen as being advantageous during production, one grower noted that this also shortened one's timeframe for selling a tree. If the market for trees slowed or was flooded with a particular species, a grower could easily be left with trees too large to harvest or sell.

Factors Influencing Tree Selection by Purchasers

When we asked landscape architects and municipal tree professionals what they considered when making tree selection decisions, the most frequently and extensively discussed factors included municipal tree lists, tree ordinances, municipal codes, utility setback rules, and other regulations (coded under the theme "regulations"). Other studies support the importance of municipal tree lists in tree selection decisions. In a survey of municipal tree managers in the Pacific Northwest, USA (Petter et al. 2020b), 24 of the 70 respondents agreed with the statement "my city's street tree list strongly influences what I plant." Similarly, a study of the procurement decisions of municipal arborists from the North-eastern and Mid-Atlantic USA found that 81.2% of the trees purchased by interviewees had been selected from an approved species list (Burcham and Lyons 2013).

Other factors more commonly associated with tree selections, such as site conditions and requirements (Petter et al. 2020a, 2020b), the function of the tree in the landscape (Conway and Vander Vecht 2015; Petter et al. 2020a), and mature tree size (Petter et al. 2020a, 2020b) were discussed frequently by purchasers in each focus group, but not nearly to the same extent as the role of regulations. When discussing tree function, purchasers focused on the design of the planting site and noted esthetics, as well as the environmental benefits of trees like shade and habitat creation.

The theme of tree uniformity was discussed with moderate frequency by purchasers in each group, and it appeared to have slightly different implications for them than for the growers. Whereas growers frequently discussed uniformity within a single species, the designers and municipal arborists and foresters discussed uniformity across different species in order to serve a function within a planted landscape. For example, designers discussed the importance of uniform appearance in certain landscapes when the goal is to have a more formal urban design and to create a certain "feel" for users. One landscape architect had this to say on the subject:

> … I think, especially if we're specifically talking street trees, you know, even though horticulturally- and diversity-wise it might be better to have six different street trees down one street, it's not going to look the way that maybe you would want it to look to accomplish whatever urban design feel you're going for … we design to what the site is and what we want

> to accomplish on that site. I think being mindful of diversity is really important, but also the aesthetics of an urban place and the function of the place is very important.

The importance of esthetics and trees' function in the landscape show up in similar studies in different parts of North America. For example, Conway and Vander Vecht (2015) studied species selection decisions in Toronto, Canada, and found that site conditions, appearance and function were most important to landscape architects. In a survey that targeted municipal tree managers and arborists in the Pacific Northwest, USA, esthetics was listed as important (Petter et al. 2020a, 2020b).

Constraints to Expanding Tree Species Diversity

Participants shared constraints to diversifying the tree species available for urban plantings (Table 1), and their responses tended to focus on regulations, planting site conditions, historical and cultural values of the community, tree size, tree availability, and client or resident desires.

Based on their comments in the focus group discussions, growers are open to growing underutilized trees, but only if purchasers want them. These two participants summed up their interpretation of the problem with this exchange:

> … you want to plant fringetrees [*Chionanthus virginicus* L.] and other stuff and they're not available. And they're not available because nobody [specifies] them, and nobody [specifies] them because they're not available. You know it's the same Catch-22.

> Yeah, I was just about to say it's just a feedback loop where, you know, certain groups and companies want a certain tree, so nurseries grow more of that. And the only thing that's available are those trees … it's a negative feedback loop, and you only end up with a certain amount of trees.

The limited availability of species and associated purchasing feedback loop have been noted in other studies of urban tree selection and procurement (e.g., D'Amato et al., 2002; Sydnor et al. 2010; Petter et al. 2020a). When a certain species cannot be found in a desired size or quality, purchasers will often select a different species—even if it is less suitable to the site (Burcham and Lyons 2013). Conway and Vander Vecht (2015) found this to be particularly true for landscape architects in their Toronto, Canada study.

While some of purchasers in our study were open to experimenting with underutilized species, particularly urban foresters who carry out tree giveaways, others were hesitant—demonstrating how tree availability and purchaser familiarity can work against efforts to diversify the urban forest. As related by one landscape architect:

> … we don't really have as much luxury to, I'll say, experiment … because it's not our money, you know, we're working for a client … success rate is very important, how something's going to look is very important to a lot of clients …

Again, we see the overall appearance of the trees and the landscape, as well as the success of the tree, as noteworthy factors when making species selection decisions.

Opportunities for Expanding Tree Species Diversity

Despite the challenge of making more tree species available, participants touched on several opportunities for expanding tree species diversity (Table 1). One of the most

widely discussed opportunities was education about the importance of tree species diversity. Participants mentioned that self-education on this topic is vital, as diversity is not always baseline knowledge for individuals in their respective fields. One landscape architect had this to say:

> As a landscape architect, there's very little taught in the schools regarding trees and arboriculture … probably one of the best things I ever did was become an arborist. It changed the way I do things.

Participants also discussed the importance of working with higher education institutions, extension agents, and professional organizations to better educate the public about tree diversity. Several municipal arborists and foresters recommended educating policy makers on tree species diversity and how it relates to climate change and the threat of devastating diseases and pests. Other studies have similarly pointed out the importance of educating tree stakeholders, particularly those who are not professional arborists, on why urban tree diversity is important (Conway and Vander Vecht 2015; Petter et al. 2020a).

Many participants expressed continued collaboration and "crossover engagement" between the different green industry professional groups as an important opportunity. As one participant put it, "I don't think you can solve this problem without, you know, really creating that collaboration across the entire chain." This topic of collaboration spurred a lot of back-and-forth dialogue in each group. One participant thought it would be "empowering" to better understand the factors that go into each other's decision-making processes, particularly the city codes and ordinances that frequently drive what purchasers can plant in urban areas. They also discussed the benefit of having a web application where growers could see what is being selected for by designers and, alternatively, designers could see what is available from growers (without disclosing confidential information). By sharing this information, growers would have a chance to step in and suggest alternative tree species they have available that may not be as frequently used by designers or other purchasers. Several purchasers shared an openness to discussing alternatives to their usual species choices in designs and plantings. Growers also discussed the importance of working with other growers, when possible, to coordinate efforts to introduce underutilized species. Unlike earlier research on this topic (Polakowski, Lohr, and Cerny-Koenig 2011; Conway and Vander Vecht 2015), we found the nursery growers in our study were aware of the problem of low tree species diversity and why it is significant, which could make Florida's green industry more amenable to incorporating underutilized species.

A few other opportunities were noted. Participants shared that green industry professionals need to be involved with tree ordinance meetings and other policy-making conversations as this type of collaboration could result in more flexible urban tree policies. Many were eager to share species they think are underutilized (Table SOM 02). Finally, purchasers shared a willingness to accept smaller trees from nurseries, when appropriate to the planting site or design, as it can be a challenge finding some underutilized trees in larger caliper or container sizes. Table 1 lists these and other themes which were applied to potential solutions.

During discussions of contract growing, growers shared that they are not at full production capacity and stated "if we had somebody that wanted to partner with us and

become a tree farmer, meaning actually contract grow and give us money up front to take some of that risk, we could add to that." It was noted that contract growing would not affect their normal production; rather it would be seen as an add-on to existing speculative sales on the open tree market. Having the capacity and willingness to engage in long-term contacts is something growers could advertise more explicitly to customers, particularly regular customers who are more eager to incorporate underutilized species into their plantings, such as municipalities.

One municipal arborist in the group shared that they are already doing this on a small-scale with a partnering nursery, and it has been essential to their ability to incorporate a diversity of trees into their landscape. Another participant pointed out that, "[they] may also really need the input from municipal purchasing and procurement divisions [to understand] what is the financial and legal model that municipalities can use to be able to contract grow or participate in a [consortium] with public funds."

Strategies for Expanding Urban Tree Species Diversity

Building directly from stakeholders' comments in our focus groups, here we suggest seven strategies that could be implemented to assist with expanding urban tree species diversity.

1. *Engage in contract growing.* When a need for underutilized trees is not being met, some municipalities have created nurseries or worked directly with growers to communicate their desired needs.These relationships are not always formalized by contracts, but rather, through sustaining strong working relationships (B Dick, personal communication). They can also look to contract growing models from other locations (e.g., the Suburban Tree Consortium in the Chicago metropolitan area) to initiate similar arrangements with growers.
2. *Reexamine approved species lists.* Tree lists, which are often codified at the city or county level (e.g., Northrop et al. 2013; Davey Resource Group 2018), influence which trees can and cannot be planted on public and sometimes private property. These measures are popular in the United States, with 70% of municipalities having approved tree lists for their public spaces (Hauer and Peterson 2016). Local governments generate approved planting lists as a means of limiting undesirable species (e.g., given invasiveness or associated disservices) and encouraging the use of locally-adapted and desirable species (e.g., natives, large-growing shade trees, etc.). Unfortunately, local growers who sell primarily to clients that are bound to these regulations have no incentive to experiment with promising unlisted species. Moreover, growers may simply gravitate to the smaller proportion of fast-growing, more familiar approved species. A less limiting approach would be to create a list of plants to be avoided given their overabundance or undesirable traits.
3. *Incentivize the use of less common trees through relaxed development criteria.* In the United States, 60% percent of municipalities require tree planting in new parking lots and 68% of municipalities require tree planting in new developments (Hauer and Peterson 2016). In Florida, 89% of municipalities have both of

these provisions (Koeser et al. 2021). Often landscaping codes specify the size and number of species required for a given project. Our respondents noted that giving additional "credit" for underused species (e.g., allowing smaller materials to be planted than is normally required) could reduce some of the pressures to produce and specify fast-growing species.

4. *Reexamine planting stock requirements.* In Florida, many municipalities and state-regulated planting designs require trees to meet a standard of quality based on the Florida Grades and Standards for Nursery Plants, a codified system meant to facilitate clear communication between buyers and sellers of plants in the state of Florida (Florida Department of Agriculture and Consumer Services 2015). Finding underutilized urban tree species, particularly native understory trees, can be challenging—especially when one is looking for specimens that have been grown and pruned in the nursery to meet the highest specification standards (i.e., "Florida Fancy"). Such underutilized native trees are typically grown as shrubs for restoration projects, which have a separate set of standards in which tree form and structure is not prioritized like it is for urban landscape trees (Florida Department of Agriculture and Consumer Services 2015).
5. *Pay based on time required to produce a tree, not stock size.* It is standard practice to buy and sell nursery stock based on size (AmericanHort 2014). However, the costs associated with growing urban landscape trees are largely a factor of production time. This disconnect can make slow-growing trees commercially unviable. Other nursery systems avoid this issue by specifying trees based on age. When reforesting natural areas in North America, seedlings are often priced based on the years spent in a greenhouse or seedbed and the years grown outdoors in a transplant bed (Grotta, Ahrens, and Bennett 2019). Typical heights, stem calipers, and root lengths can still be provided for reference, but the purchasing decision is informed by the effort associated with producing the tree.
6. *Use an interactive database to share tree species being grown, specified, or sought after*. The exchanges between growers and buyers in our focus group suggests the potential to create and maintain a web application that would allow purchasers to see which species are available, growers to see which species are desired, and both sides to have easier conversations about inventory. For example, this could be a venue for growers to add notes about certain underutilized species in their existing inventory that could be viable alternatives to more commonly sought-out species. Municipal arborists and foresters can maintain open communication with growers to clarify which tree species are desired and when substitutions are appropriate (Sydnor, Subburayalu, and Bumgardner 2010).
7. C*ontinue research, education, and transdisciplinary collaborations to increase tree species diversity*. While a call for more research and education runs the risk of seeming cliché in an academic research article, findings from past works bear out this need (Lohr 2013; Petter et al. 2020b). For researchers, there is the opportunity to identify and test uncommon trees for use in urban areas, something that is an ongoing avenue of research around the world (Roman et al. 2015; McPherson, Berry, and van Doorn 2018; Sjöman, Hirons, and Bassuk 2018). Participants in this study shared a need for more understory and small-

stature trees, as well as salt-tolerant trees for use in coastal areas that are already dealing with saltwater intrusion from sea level rise. More research is also needed to understand how the species composition of urban forests compare to adjacent non-urban areas in different regions (Nitoslawski and Duinker 2016; Spotswood et al. 2021). Supply chain researchers and economists can delve deeper into the challenges growers have in predicting market demand, the risk involved in introducing underutilized species, and opportunities for incentives. Social science research on plant selection and esthetic preferences can help guide the introduction of underutilized trees into urban plantings, particularly in places where residents have strong connections to certain trees or landscapes because of the history or culture of the place (Roman et al. 2018).

Conclusion

Our findings provide insights into the human dimensions of urban forest systems. Within these mixed focus groups, the different professionals appeared to broadly understand of the constraints of other members, while also expressing support for continued cross-industry conversations and collaboration.

There are limitations to this research. The results of focus groups are not intended to be generalized to a larger population, but instead capture a snapshot of what these particular participants shared during the discussions and any insights that can be applied to the larger problem (Galindo-Gonzalez and Israel 1992). We chose to focus on buyers who purchase or select trees in large quantities, which meant a focus on those planting on public property. Residential yards and other private property comprise a significant portion of the urban forest (Nguyen et al. 2017), so future research could focus on residential buyers and their impact on the tree market and urban forest composition (e.g., Pearce, Davison, and Kirkpatrick 2015).

The themes and major findings of this study are in line with those from surveys of green industry professionals in other regions (Burcham and Lyons 2013; Conway and Vander Vecht 2015; Petter et al. 2020a, 2020b). More people are living in urban areas than ever before (UN 2018), and discussions of the livability of cities are increasing, along with efforts to make cities more sustainable using green infrastructure. Urban forests are at the forefront of many of these discussions (Pearlmutter et al. 2017), so it is essential that the trees that are planted in cities will have the best chance at survival under the pressure of inevitable stressors.

Acknowledgments

We thank Mr. Ben Bolusky and Dr. Taylor Clem for participant recruitment suggestions. We also thank Dr. Paul Monaghan for early feedback on study design. Finally, we thank the participants in this group for their willingness to share their experiences and opinions on this important green industry topic. 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. An early version of this manuscript was published as part of a graduate thesis titled “Improving Urban Forest Species Diversity in Florida” (Hilbert 2021).

Ethical Approval

This study was approved by the University of Florida Institutional Review Board (IRB #IRB202100862).

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