doi:10.20944/preprints202205.0205.v1

Article

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

Deborah R. Hilbert[1]*, Andrew K. Koeser[1], Michael Andreu[2], Mysha Clarke[2], Gail Hansen[3], Lara A. Roman[4] and Mack Thetford[5]

[1] Department of Environmental Horticulture, IFAS, University of Florida – Gulf Coast Research and Education Center, Wimauma, FL, USA
[2] School of Forest, Fisheries, and Geomatics Sciences, University of Florida, Gainesville, FL, USA
[3] Department of Environmental Horticulture, IFAS, University of Florida, FL, USA
[4] USDA Forest Service, Northern Research Station, Philadelphia Field Station, Philadelphia, PA, USA
[5] Department of Environmental Horticulture, IFAS, University of Florida – West Florida Research and Education Center, Milton, FL, USA
*Corresponding author: dhilbert@ufl.edu

Abstract: While many practitioners and experts understand the risks associated with low urban tree diversity, they often lack the ability to rectify issues they encounter on their own. The current system of tree production and procurement is complex – shaped by market pressures, nursery and site constraints, local governance, and differing professional objectives among those who grow, specify, and plant trees. To understand this complexity as well as constraints to- and opportunities for increasing urban tree diversity, we conducted a series of focus groups comprised of nursery growers, landscape architects, and urban foresters. Our results highlight a significant list of considerations and constraints to diversity (both shared among green industries and some specific to growers or purchasers). More importantly, in discussing our findings we outline actionable strategies for increasing urban tree diversity.

Keywords: city trees; landscape design; nursery production; urban greenspace

1. Introduction

1.1. 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 et al. 2006; Miller et al. 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 oft-repeated monocultures of elm (*Ulmus* spp.) street trees in the mid-and late-1900s (D'Arcy 2000; Raupp et al. 2006). More recently, interest in diversity has been renewed in North America as the emerald ash borer (*Agrilus planipennis*) has devastated areas where trees in the Fraxinus genus represented a significant component of urban forests (USDA 2021; Clarke et al. 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 et al. 2006).

Incorporating a greater variety of tree species into urban plantings can be a challenge. Growing conditions in urbanized areas 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 et al. 2015). In fact, some urban areas foster a greater tree species richness than adjacent peri-urban and rural lands (Padoa-Schioppa and Canedoli 2017), though many species may be present in low numbers or in isolation.

With a significant portion of urban forest regeneration linked to intentional planting efforts, the unavailability of different tree species is potentially the greatest limiting factor in this effort (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 they 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—it is often 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 where they can 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 et al. 2015). Likewise, when New York City undertook its MillionTreesNYC initiative, annual street tree plantings increased by 14,000 trees. To quickly secure enough trees in the right quality and standards, New York City Parks & Recreation (NYCDPR) created long-term tree procurement contracts with several nurseries (Stephens 2010; Miller et al. 2015).

To understand the ecology of urban forests, including tree diversity, human decisions cannot be ignored (Avolio et al. 2018). While nursery availability is often cited as a limitation (Conway and Vander Vecht 2015), consumer demand plays a significant role in determining what growers produce. Research has shown that urban tree species selection is influenced by aesthetic preferences, desired ecosystem services, ease of maintenance, and availability (Kendal et al. 2012; Shakeel and Conway 2014; Conway and Vander Vecht 2015; Gillner et al. 2016; Avolio et al. 2018). Those planting trees for public property or new developments, such as 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.

1.2. Tree Diversity in Florida (USA)

While largely spared from many of the larger infestations (e.g., Dutch elm disease, emerald ash borer) that have plagued the more temperate regions of North America, 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 backyard 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 the State's natural lowland habitats, laurel wilt (*Raffaelea lauricola*) has devastated redbay (*Persea borbonia* (L.) Spreng.; Mayfield et al. 2019). This same disease threatens avocado trees (*Persea americana* Mill) in backyard and commercial orchards. While all the above-mentioned diseases are each destructive in their own right, the species affected have been minor contributors to Florida's urban forests (Koeser unpublished data; Escobedo et al. 2009; Escobedo et al. 2011; Empke et al. 2012; Landry et al. 2018).

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*). This is even more concerning given that 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) and the species makeup of these human-dominated environments should be diverse to withstand inevitable disturbances.

To better understand the challenges associated with urban forest tree diversity, it is important to understand why there is only a limited selection of tree species available in the sizes and quantities needed by regular purchasers. Furthermore, we must determine how the major actors in the purchasing relationships address the cycle of limited species availability and associated low diversity of urban forests. By addressing these key research questions, growers and purchasers may be better supported in efforts to diversify their stock or selections. Understanding this problem could also provide direct actions that policy makers could take to support the green industry professionals looking to diversify their tree selections. With its extensive green industry and rapid urbanization, Florida can serve as an informative location to investigate these research questions and increase our understanding about the problem at large.

1.3. Study Objectives and Justification

For this study, we conducted qualitative research to increase our understanding about the constraints and opportunities for Florida tree growers and purchasers regarding the expansion of urban tree species diversity. Specifically, 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 in this supply chain toward increasing the supply of diverse tree species. Focus groups are a useful way to delve into complex problems in urban forest systems and to generate new ideas based on peoples' perspectives and experiences (Breen 2006; Krueger and Casey 2015).

2. Methods

2.1. Study Scope

In this study, we focused on the perceptions, attitudes and experiences of green industry professionals throughout the state of Florida (USA). 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).

2.2. Focus Group Design

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 16 May 2022 doi:10.20944/preprints202205.0205.v1

We purposefully created focus groups that included 1.) growers, 2.) municipal tree managers and 3.) landscape architects. First, we compiled a list 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). For the growers, we compiled a list of potential participants and organized it by region and production method (i.e., field-grown and container-grown). Second, we randomly organized all the potential contacts within each region. There were not enough potential participants in the lists of municipal tree managers and landscape architects to do a random selection, so we contacted all potential participants. Third, each focus group meeting was designed to have a mix of at least two of each green industry professional from the three categories. A different set of participants were included in each meeting.

We contacted potential participants by email initially and followed up with a phone call as needed to fill each focus group session. As a token of our appreciation, we offered all participants a tree identification book for their time and efforts. 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 (Krueger and Casey 2015). 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-minute meetings during April and May 2021. Meetings were conducted virtually using video conferencing software (Zoom, 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. Appendix A provides the focus group questions and protocol. 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 focus group 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.

2.3. Data Analysis

Our analysis was conducted following the guidelines and best practices established by Kreuger & Casey (2015). The 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. Patterns such as frequency and extensiveness, as well as areas of overlap among coded text were examined.

3. Results & Discussion

 doi:10.20944/preprints202205.0205.v1

3.1. Participant Background

There were 19 participants total for the 3 focus groups, with a recruitment rate of 51%. 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 (Fig. 1).

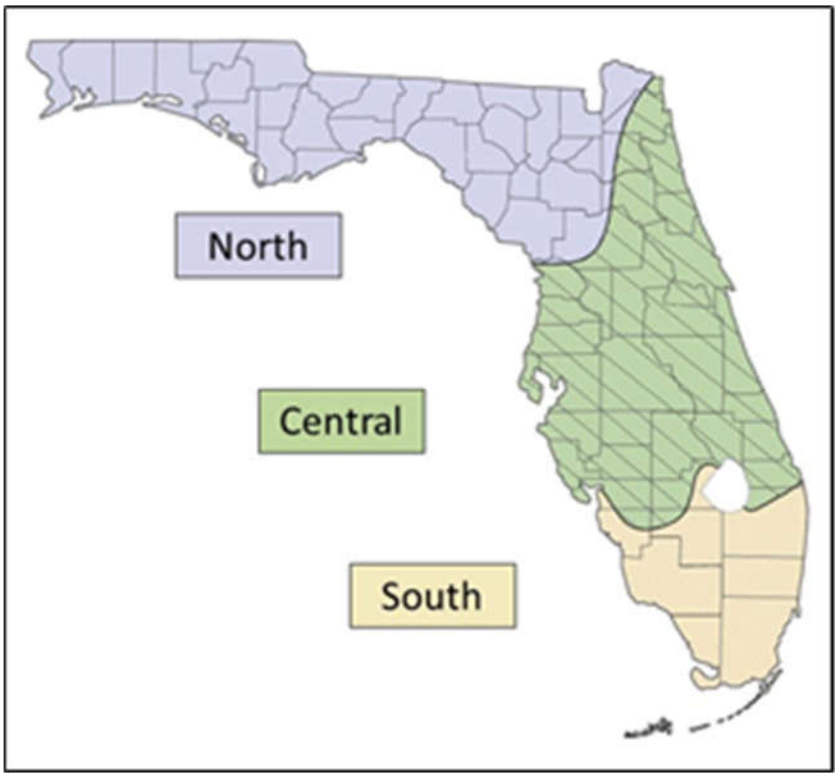

Figure 1. Map of the horticultural regions of Florida. Adapted from UF/IFAS (2021).

As an introductory question, we asked participants to list the tree species they sell, purchase, or select most frequently (Appendix B summarizes these responses). The species *Quercus virginiana* Mill. (i.e., southern live oak) and *Lagerstroemia indica* (L.) Pers. (i.e., 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 that one species." This observation is not surprising given that southern live oak (*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 Peterson (2016) and Ma et al. (2021) for comparison, we found that 15 of the 19 responding Florida cities listed southern live oak 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. 2021).

We asked the participants to explain their decision-making and important factors that 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.

3.2. Factors Influencing Tree Selection by Growers

When growers were asked to explain their species selection decision-making process, the responses largely fell into the categories of 1) market demand and sales, 2) production ease and 3) growth rate. Growers highlighted the importance market demand and sales more frequently than any other factors. For example, all of the 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 et al. 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.) Sweet 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. 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," as one grower put it.

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. 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 "Groups" were the preliminary codes created through deductive coding before analysing the transcripts. The "Coding Options" were created inductively while reading the transcripts.

Groups	Coding Options
Factors Influencing Production	Climate Demand and sales Diversity Growth rate Personal preference Pests and pathogens Production ease Recommendations Regulations Risk Tree success
Factors Influencing Purchasing	Availability Budget/costs Clients/residents Climate Convenience Diversity Education Growth rate History/cultural values Maintenance level Pests and pathogens Politics Production method Recommendations Regulations Risk Site conditions Tree function

	Tree size Tree success
Constraints to Expanding Selection	Availability Budget/costs Clients/residents Growth rate History/cultural values Production ease Politics Production method Regulations Risk Site conditions Tree size
Opportunities for Expanding Selection	Availability Contract growing Collaboration Education Experimentation Interactive database Marketing Regulations Tree function Tree giveaway Tree size Underutilized trees

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.

3.3. 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 factors more commonly associated with tree selections such as site conditions and requirements, the function of the tree in the landscape, and mature tree size 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 aesthetics, 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."

3.4. Constraints to Expanding Tree Species Diversity

Participants shared constraints to diversifying the tree species available for urban plantings (Table 1). The idea of market maturity in the Florida tree industry was brought up by one grower who has been involved in the industry for decades. When asked about the potential for contract growing, they had this to say:

"… maybe 20 years ago, you actually heard a little bit of that…people would go to a nursery and say, "I want you to grow 1000 of this for me." [Now that the industry has matured] it's almost like we're Walmart or Amazon in that people literally will call the day before, and you know, want trees the next day… You know, we're not making widgets in a factory. You can't just ramp up production."

The challenges of consumers expecting large quantities of trees to be available at short notice (coded as "convenience") ties back to many of the constraints mentioned by growers, which unsurprisingly revolve around keeping their businesses operating in a competitive industry.

In addition to this extremely short turn around, the growers also noted the level of specificity associated with purchases has increased. The same grower went on to note:

"…and it's not just 'give me a magnolia.' It's 'give me magnolia that's 14 feet tall and eight feet wide and has two foot of clear trunk and is this particular cultivar.' So there's just all those variables."

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

 doi:10.20944/preprints202205.0205.v1

"…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."

While some of respondents were open to experimenting with new species, others were hesitant – demonstrating how availability and 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..."

3.5. 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. They 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.

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 participants shared an openness to discussing underutilized alternatives to their usual designs and plantings. Growers also discussed the importance of working with other growers, when possible, to coordinate efforts to introduce 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 (Appendix C). 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/container sizes. Table 1 lists these and other the themes which were applied to potential solutions.

During discussions of contract growing, growers shared that they are not at full production capacity and "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."

3.6. Strategies for Expanding Urban Tree Species Diversity

Building off the results of the focus group discussions, we have laid out 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 their own nurseries or worked directly with growers to communicate their desired needs, although these relationships are not always formalized by contracts but sustained by strong working relationships (B Dick, personal communication). Such relationships between nurseries and regular customers like municipalities are key to ensuring trees are available in the types, quantities and specifications needed for urban plantings. 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. *Re-examine the use of 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 quite 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. *Be less rigid with planting stock requirements.* In Florida, many municipalities and state-regulated planting designs require trees to meet a certain 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; Hilbert personal conversation).

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, especial when selling to the uninitiated. 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 et al. 2019). For example, a 2+1 seedling is a three-year-old seedling that has spent two years in a greenhouse and one year in a transplant bed (for a total of three years in production). 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*. There is also 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 place 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 et al. 2010).
7. C*ontinue research, education, and collaboration efforts 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; Petters 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 et al. 2018; Sjöman et al. 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 needs to be done 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 and the risk involved in introducing underutilized species. There may be an opportunity for incentives to encourage the production and use of underutilized trees. Social science research on plant selection and aesthetic 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).

There is also 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 place for growers to add notes about certain underutilized species in their existing inventory that could be viable alternatives to more commonly sought-out species. Those in educational and leadership roles can also provide guidance to policy makers who may not understand the importance of urban tree diversity.

4. Conclusion

The results above provide insights into the human dimensions of the urban forest ecosystem, particularly for scientists who study urban forests as socio-ecological systems (Vogt 2020). Many parts of the globe are experiencing a shift in land use and associated plant communities as urban areas grow and climates change (Song et al. 2018). These

 doi:10.20944/preprints202205.0205.v1

urban areas often possess different patterns and degrees of species diversity compared to undeveloped areas, particularly in highly built-up areas of a city (Grimm et al. 2008; McDonald et al. 2020; Spotswood et al. 2021).

Moreover, this study provided a structured qualitative approach to better understand the perceptions, attitudes, experiences and ideas of green industry professionals regarding urban tree availability and diversification. Within these mixed focus groups, the different professionals appeared understanding of the constraints that each member operated under. Furthermore, participants were supportive of the idea of continued cross-industry conversations and collaboration. Based on the focus group discussions and other research on this topic, some of the potential avenues to increasing the diversity of tree species available for urban plantings in Florida include education, cross-industry meetings and collaboration, and regulatory changes.

Although our study provide useful insights about urban tree diversity, there are several 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 2017). We chose to focus on buyers who are purchasing or selecting trees in large quantities, which meant a focus on those planting on public property. Residential yards and other private property make up a significant portion of the urban forest (Nguyen et al 2017), so there is the opportunity for more studies to focus on these groups of buyers and their impact on the tree market and urban forest composition (e.g., Pearce et al. 2015).

The themes from this study and major findings 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 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.

Conflicts of Interest: The authors declare no conflict of interest.

References

AmericanHort. 2014. American Standard for Nursery Stock (ANSI Z60.1). 109p. https://cdn.ymaws.com/americanhort.site-ym.com/resource/collection/38ED7535-9C88-45E5-AF44-01C26838AD0C/ANSI_Nursery_Stock_Standards_AmericanHort_2014.pdf

Alvarez, S., E., Rohrig, D. Solís, and M. H. Thomas. 2016. Citrus greening disease (Huanglongbing) in Florida: Economic impact, management and the potential for biological control. *Agricultural Research* 5:109-118. https://doi.org/10.1007/s40003-016-0204-z

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

Bahder, B. W., and E. E. Helmick. 2018. Lethal Yellowing (LY) of Palm. *EDIS*. PP-222. 8 p. https://edis.ifas.ufl.edu/publication/pp146

Bahder, B. W., and E. E. Helmick. 2019. Lethal Bronzing Disease (LBD). *EDIS*. PP-243. 3 p. https://edis.ifas.ufl.edu/publication/pp146

Beck, H. E., N. E. Zimmermann, T. R. McVicar, N. Vergopolan, A. Berg, and E. F. Wood. 2018. Present and future Köppen-Geiger climate classification maps at 1-km resolution. *Scientific Data* 5:180214. https://doi.org/10.1038/sdata.2018.214

Breen, R. L. 2006. A practical guide to focus-group research. *Journal of Geography in Higher Education* 30 (3):463-475. https://doi.org/10.1080/03098260600927575

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

Carr, M. H., and P. D. Zwick. 2016. Technical Report: Florida 2070 Mapping Florida's Future – Alternative Patterns of Development in 2070. Gainesville (FL, USA): Geoplan Center at the University of Florida. 41 p. http://1000friendsofflorida.org/florida2070/table-of-contents/

Clarke, M. K., L. A. Roman, and T. M. Conway. 2020. Communicating with the public about emerald ash borer: Militaristic and fatalistic framings in the news media. *Sustainability* 12 (11):4560. https://doi.org/10.3390/su12114560
Conway, T. M., and J. V. 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
D'Arcy, C. J. 2000. Dutch elm disease. *The Plant Health Instructor*. St. Paul (MN, USA): The American Phytopathological Society. [Accessed 2021 June 21]. https://www.apsnet.org/edcenter/disandpath/fungalasco/pdlessons/Pages/DutchElm.aspx
Davey Resources Group, Inc. 2018. Growing with Trees: Tallahassee Urban Forest Master Plan. Kent (OH, USA): Davey Resource Group, Inc. 142 p. https://www.talgov.com/place/pln-urbanforestry2.aspx
Empke, E. K, E. Becker, J. Lab, R. Hinkle, F. Escobedo, and B. Iannone. 2012. Orlando, Florida's Urban and Community Forests and Their Ecosystem Services. *EDIS*. 2012. https://edis.ifas.ufl.edu/publication/fr358
Escobedo, F., S. Varela, C. Staudhammer, B. Thompson, J. Jarratt, and B. Iannone. 2009. Pensacola and Southern Escambia County, Florida's Urban Forests. *EDIS*. 2009. https://edis.ifas.ufl.edu/publication/fr293
Escobedo, F., J. Klein, M. Pace, H. Mayer, S. Varela, B. Iannone. Miami-Dade County's Urban Forests and Their Ecosystem Services. *EDIS*. 2011(8). https://doi.org/10.32473/edis-fr347-2011
Florida Department of Agriculture and Consumer Services. 2015. Florida Grades and Standards for Nursery Plants 2015. 5th edition. Tallahassee (FL, USA): Florida Department of Agriculture and Consumer Services. FDACS-P-02036. 165 p. https://www.fdacs.gov/About-Us/Publications/Plant-Industry-Publications
Florida Department of Transportation. 2021a. Urbanized Area Population Estimates. Tallahassee (FL, USA): FDOT Forecasting Trends Office. 2 p. https://www.fdot.gov/planning/demographic
Florida Department of Transportation. 2021b. Urban Cluster Population Estimates. Tallahassee (FL, USA): FDOT Forecasting Trends Office. 2 p. https://www.fdot.gov/planning/demographic
Galindo-Gonzalez, S., and G. D. Israel. 1992. Using Focus Group Interviews for Planning or Evaluating Extension Programs. *EDIS*. https://edis.ifas.ufl.edu/publication/PD036
Gillner, S., M. Hofmann, A. Tharang, and J. Vogt. 2016. Criteria for species selection: Development of a database for urban trees. In: Roloff A, editor. *Urban Tree Management: For the Sustainable Development of Green Cities*. 1st Edition. Chichester (West Sussex, UK): John Wiley & Sons, Ltd. p. 196-220.
Grimm, N.B., D. Foster, P. Groffman, J. M. Grove, C. S. Hopkinson, K. J. Nadelhoffer, D. E. Pataki, and D. P. C. Peters. 2008. The changing landscape: Ecosystem responses to urbanization and pollution across climatic and societal gradients. *Frontiers in Ecology and the Environment* 6 (5):264–272. https://doi.org/10.1890/070147
Grotta, A., G. Ahrens, and M. Bennett. 2019. Selecting and buying quality tree seedlings. EC 1196 16p. https://catalog.extension.oregonstate.edu/sites/catalog/files/project/pdf/ec1196.pdf
Hantsch L., S. Bien, S. Radatz, U. Braun, H. Auge, and H. Bruelheide. 2014. Tree diversity and the role of non-host neighbour tree species in reducing fungal pathogen infestation. *The Journal of Ecology* 102 (6):1673-1687. https://dx.doi.org/10.1111%2F1365-2745.12317
Hauer, R. J., W. D. Peterson. 2016. Municipal Tree Care and Management in the United States: A 2014 Urban & Community Forestry Census of Tree Activities. Stevens Point (WI, USA): University of Wisconsin – Stevens Point. Special Publication 16-1. College of Natural Resources, University of Wisconsin – Stevens Point. 71 pp.
Hodges, A.W., and C. D. Court. 2019. Economic Contributions of Urban Forestry in Florida in 2017. Gainesville (FL, USA): University of Florida IFAS Economic Impact Analysis Program. Sponsored Project Report to the Florida Department of Agriculture and Consumer Services – Florida Forest Service. 37 p. https://fred.ifas.ufl.edu/extension/economic-impact-analysis-program/publications/2017-urban-forestry-in-florida/
Kendal, D., K. J. H. Williams, and N. S. G. Williams. 2012. Plant traits link people's plant preferences to the composition of their gardens. *Landscape and Urban Planning* 105 (1-2):34–42. https://doi.org/10.1016/j.landurbplan.2011.11.023
Koeser, A. K., R. J. Hauer, E. E. Downey, D. R. Hilbert, D. C. McLean, M. A. Andreu, and R. J. Northrop. 2021. Municipal response to state legislation limiting local oversight of private urban tree removal in Florida. *Land Use Policy* 105:105398. https://doi.org/10.1016/j.landusepol.2021.105398
Krueger R. A., and M. A. Casey. 2015. Focus Groups: A Practical Guide for Applied Research. 5th edition. Thousand Oaks (CA, USA): SAGE Publications, Inc. 280 p.
Landry, S., A. K. Koeser, R. Northrop, D. McLean, G. Donovan, M. Andreu, and D. Hilbert. 2018. City of Tampa Tree Canopy and Urban Forest Analysis 2016. Tampa, FL: City of Tampa, Florida.
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
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: Finding and implications in the United States. *Urban Forestry & Urban Greening* 56:126826. https://doi.org/10.1016/j.ufug.2020.126826
Mayfield, A.E., S. W. Fraedrich, and P. Merten. 2019. Laurel Wilt. Atlanta (GA, USA): USDA Forest Service Southern Research Region, State and Private Forestry, Southern Region. Pest Alert R8-PR-01-19. 2 p.
McDonald R. I., A. V. Mansur, F. Ascensão, M. Colbert, K. Crossman, T. Elmqvist, A. Gonzalez, B. Güneralp, D. Haase, M. Hamann, et al. 2020. Research gaps in knowledge of the impact of urban growth on biodiversity. *Nature Sustainability* 3:16–24. https://doi.org/10.1093/biosci/biaa155

McPherson, E. G., A. M. Berry, and N. S. van Doorn. 2018. Performance testing to identify climate-ready trees. *Urban Forestry & Urban Greening* 29:28-39. https://doi.org/10.1016/j.ufug.2017.09.003
Miller, R. W., R. J. Hauer, and L. P. Werner. 2015. *Urban Forestry: Planning and Managing Urban Greenspaces*. 3rd edition. Long Grove (IL, USA): Waveland Press, Inc. 560 p.
Nelson, G. 1994. *The trees of Florida: a reference and field guide*. 1st edition. Sarasota (FL, USA): Pineapple Press, Inc. 284 p.
Nguyen, V. D., L. A. Roman, D. H. Locke, S. K. Mincey, J. R. Sanders, E. Smith Fichman, M. Duran-Mitchell, and S. Lumban Tobing. 2017. Branching out to residential lands: Missions and strategies of five tree distribution programs in the U.S. *Urban Forestry & Urban Greening* 22:24-35. https://doi.org/10.1016/j.ufug.2017.01.007
Nitoslawski S. A., and P. N. Duinker. 2016. Managing tree diversity: A comparison of suburban development in two Canadian cities. *Forests* 7 (6):119. https://doi.org/10.3390/f7060119
Northrop, R.J., K. Beck, R. Irving, S. M. Landry, and M. G. Andreu. 2013. City of Tampa Urban Forest Management Plan. 1st edition. Tampa (FL, USA): City of Tampa. 66 p. https://www.tampa.gov/document/2013-urban-forest-management-plan-68531
Noss R. F., W. J. Platt, B. A. Sorrie, A. S. Weakley, D. B. Means, J. Costanza, and R. K. Peet. 2015. How global biodiversity hotspots may go unrecognized: lessons from the North American Coastal Plain. *Diversity and Distributions* 21: 236-244. https://doi.org/10.1111/ddi.12278
Nowak D.J., S.M. Stein, P. B. Randler, E. J. Greenfield, S. J. Comas, M. A. Carr, and R. J. Alig. 2010. Sustaining America's Urban Trees and Forests. Newtown Square (PA, USA): USDA Forest Service Northern Research Station. General Technical Report NRS-62. 27 p.
Nowak D. J, and E. J. Greenfield. 2018. US Urban forest statistics, values, and projections. *Journal of Forestry* 116 (2):164–177. https://doi.org/10.1093/jofore/fvx004
Padoa-Schioppa E., and C. Canedoli. 2017. Urban Forest Biodiversity. In: Ferrini F, Konijnendijk van den Bosch CC, Fini A, editors. *Routledge Handbook of Urban Forestry*. 1st edition. New York City (NY, USA): Routledge. P. 123–136.
Pearce L. M., A. Davison, J. B. Kirkpatrick. 2015. Personal encounters with trees: The lived significance of the private urban forest. *Urban Forestry & Urban Greening* 14 (1):1-7. https://doi.org/10.1016/j.ufug.2014.11.003
Pearlmutter D, Calfapietra C, Samson R, O'Brien L, Ostoić SK, Sanesi G, del Amo, R. (editors). 2017. The Urban Forest: Cultivating Green Infrastructure for People and the Environment. New York City (NY, USA): Springer. 351 p.
Petter B., P. Ries, A. D'Antonio, and R. Contreras. 2020a. A tree selection survey of Tree City USA designated cities in the Pacific Northwest. *Arboriculture & Urban Forestry* 46 (5):371–384. https://doi.org/10.48044/jauf.2020.027
Petter B, P. Ries, A. D'Antonio, and R. Contreras. 2020b. How are managers making tree species selection decisions in the Pacific Northwest of the United States? *Arboriculture & Urban Forestry* 46 (2):148–161. https://doi.org/10.48044/jauf.2020.011
Polakowski, N. R., V. I. Lohr, and T. Cerny-Koenig. 2011. Survey of wholesale production nurseries indicates need for more education on the importance of plant species diversity. *Arboriculture & Urban Forestry* 37 (6): 259-264. https://doi.org/10.48044/jauf.2011.033
Raupp, M. J., A.B. Cumming, and E. C. Raupp. 2006. Street tree diversity in Eastern North America and its potential for tree loss to exotic borers. *Arboriculture & Urban Forestry* 32 (6): 297-304. https://doi.org/10.48044/jauf.2006.038
Roman, L. A., L. A. Walker, C. M. Martineau, D. J. Muffly, S. A. MacQueen, and W. Harris. 2015. Stewardship matters: Case studies in establishment success of urban trees. *Urban Forestry & Urban Greening* 14:1174–1182. https://doi.org/10.1016/j.ufug.2015.11.001
Roman, L. A., H. Pearsall, T. S. Eisenman, T. M. Conway, R. T. Fahey, S. Landry, J. Vogt, N. S. van Doorn, J. M. Grove, D. H. Locke, et al. 2018. Human and biophysical legacies shape contemporary urban forests: A literature synthesis. *Urban Forestry & Urban Greening* 31:157-168. https://doi.org/10.1016/j.ufug.2018.03.004
Roloff, A. 2016. Urban trees: Features and requirements. In: Roloff A, editor. *Urban Tree Management: For the Sustainable Development of Green Cities*. 1st Edition. Chichester (West Sussex, UK): John Wiley & Sons, Ltd. p. 15-19.
Shakeel, T., and T. M. Conway. 2014. Individual households and their trees: Fine-scale characteristics shaping urban forests. *Urban Forestry & Urban Greening* 13:136–144. https://doi.org/10.1016/j.ufug.2013.11.004
Sjöman, H., A. D. Hirons, and N. L. Bassuk. 2018. Improving confidence in tree species selection for challenging urban sites: a role for leaf turgor loss. *Urban Ecosystems* 21:1171–1188. https://doi.org/10.1007/s11252-018-0791-5
Song, X-P., M. C. Hansen, S. V. Stehman, P. V. Potapov, A. Tyukavina, E. F. Vermote, and J. R. Townshen. 2018. Global land changes from 1982 to 2016. *Nature* 560:639–643. https://doi.org/10.1038/s41586-018-0411-9
Spotswood, E. N., E. E. Beller, R. Grossinger, J. L. Grenier, N. E. Heller, and M. F. J. Aronson. 2021. The biological deserts fallacy: Cities in their landscapes contribute more than we think to regional biodiversity. *BioScience* 71 (2):148–160. https://doi.org/10.1093/biosci/biaa155
Stephens, M. 2010. Tree procurement contracts: New York City's quest for amazing trees. *City Trees: The Journal of The Society of Municipal Arborists* May/June 2010:10-12.
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.
USDA Animal and Plant Health Inspection Services: Emerald Ash Borer. 2021. Riverdale (MD, USA): USDA-APHIS. USDA-APHIS-PPQ-EAB. https://www.aphis.usda.gov/aphis/ourfocus/planthealth/plant-pest-and-disease-programs/pests-and-diseases/emerald-ash-borer. [Accessed 2021 June 21].
Vogt, J. 2020. Urban Forests as Social-Ecological Systems. In: Goldstein MI, DellaSala DA (editors). *Encyclopedia of the World's Biomes*. Amsterdam (NL): Elsevier. p. 58-70. https://doi.org/10.1016/B978-0-12-409548-9.12405-4
Warren, K. 1990. Commercial production of deciduous tree cultivars. In: Proceedings of the seventh conference of the Metropolitan Tree Improvement Alliance, Lisle (IL, USA): Morton Arboretum. p. 67-70.

 doi:10.20944/preprints202205.0205.v1

Appendix A

Focus Group Questions

Opening question:

1. Tell us your first name, which sector of the landscape industry you work in (don't name the company), how long you've been in the industry, and tell us what urban tree diversity means to you.

Introductory question:

2. Next, we want to hear what the top 3 species are that you grow/sell, select or plant.

   Follow-ups: Does anything about these lists surprise you? Why or why not?

Key questions:

3. Could those of you who grow trees take us through the steps that you go through when you are deciding on which trees to grow?

   Follow-ups: What do those of you who purchase trees think about these responses?

4. For those that purchase trees for local governments, can you take us through the steps that you go through when deciding which trees to plant? What factors do you consider?

5. For the landscape architects: can you take us through the steps that you go through when deciding which trees to plant? What factors do you consider?

   Follow-ups: Is there anything about these responses that surprise you? Do you have any questions for the group?

6. If you had the power, what is one thing that you would change to make it easier to sell or procure new species?

7. Pretend you can sell or procure any species you want (that can grow in Florida). What is one unusual species or cultivar of tree you would choose?

   Follow-ups: Explain why you chose that species. Does anything surprise your about what others are listing? Do you have any questions?

Ending questions:

8. Based on today's conversation, we think the major points that were brought up were…How well does this summary capture what was said here?
9. Remember, the purpose of this study is to understand the constraints and opportunities for expanding tree species diversity in Florida urban areas. With that purpose in mind, is there anything that we should have talked about but didn't? Is there anything that you have thought of that we didn't discuss?

Back-up questions (if time allowed or additional follow-ups were needed)

1. What is the first thing that comes to mind when you hear the phrase "urban tree species diversity?"
2. Imagine that a disease makes the most common species you grow or use become totally unsellable. What could be done to diversify the types of trees that are available?
3. Think back to a time when you considered growing or purchasing/planting species that are not commonly available. Did you encounter any barriers or challenges in doing so?
4. For the growers: Do you have a success or failure story about an uncommon species that you added to your inventory? Can you take us through your experience with this change in inventory?
5. For the growers: How many years out do you have to plan, and do the steps change based on how far out you must decide? Does growth rate factor in?

 doi:10.20944/preprints202205.0205.v1

Appendix B

Table B-1. The most produced, purchased, or specified trees by quantity according to focus group participants in Florida. Participants included wholesale tree growers, landscape architects, and municipal arborists and foresters. Trees are listed by alphabetical order.

Most commonly produced/sold trees	Most purchased or specified
• *Acer rubrum**	• *Acer rubrum*
• *Ilex* spp.	• *Bulnesia arborea*
• *Juniperus virginiana*	• *Bursera simaruba*
• *Lagerstroemia indica,*	• *Caesalpinia granadillo*
• *Livistonia* spp.	• *Chionanthus virginicus*
• *Magnolia grandifolia*	• *Clusia rosea*
• *Phoenix sylvestris*	• *Coccoloba diversifolia*
• *Quercus nuttallii*	• *Conocarpus erectus*
• *Quercus shumardii*	• *Elaepcarpus decipiens*
• *Quercus virginiana*	• *Fraxinus americana*
• *Taxodium* spp.	• *Fraxinus pennsylvanica*
• *Ulmus alata*	• *Lagerstroemia indica*
	• *Magnolia virginica*
	• *Pinus elliottii*
	• *Pinus palustris*
	• *Prunus angustifolia*
	• *Quercus austrina*
	• *Quercus shumardii*
	• *Quercus virginiana*

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 16 May 2022 doi:10.20944/preprints202205.0205.v1

	• *Roystonea regia* • *Sabal palmetto* • *Swietenia mahagoni* • *Taxodium distichum* • *Ulmus chinensis Allee*™ • *Ulmus alata* • *Veitchia montgomeryana* • Various edible fruit trees for north Florida

 doi:10.20944/preprints202205.0205.v1

Appendix C

Table C-1. Underutilized tree species shared by focus group participants in Florida. Participants included wholesale tree growers, landscape architects, and municipal arborists and foresters. Underutilized refers to species that are adaptable to the region, yet make up only a minimal portion of the urban forest. Notes are based directly on comments made by the participants.

Species Name	Common Name	Notes from Meetings
Acca sellowiana	pineapple guava	Need more in tree form
Avicennia germinans	black mangrove	For use in flooded, coastal areas; adjust to sea level rise
Bulnesia arborea	verawood	na
Bursera simaruba	gumbo limbo	na
Calophyllum inophyllum	beach calophyllum	na
Cassia fistula	cassia	na
Citharexylum spinosum	fiddlewood	na
Clusia rosea	pitch apple, autograph tree	na
Eugenia foetida	Spanish stopper	Need more in tree form
Eugenia rhombea	red stopper	Need more in tree form
Ficus citrifolia	shortleaf fig	na
Gymnanthes lucida	crabwood, oysterwood	na
Ilex vomitoria	yaupon holly	Need more in tree form
Khaya senegalensis	African mahogany	na
Laguncularia racemosa	white mangrove	For use in flooded, coastal areas; adjust to sea level rise
Lyonia ferruginea	rusty lyonia, stagger bush	Need more in tree form
Myrcianthes fragrans	Simpson's stopper	na
Pinus elliottii var. densa	densa slash pine	na
Podocarpus macrophyllus	yew podocarpus	Need more in tree form
Ulmus alata	winged elm	na
Vaccinium arboreum	sparkleberry, farkleberry	na
Viburnum obovatum	Walter’s viburnum	Need more in tree form
Acca sellowiana	pineapple guava	Need more in tree form
Avicennia germinans	black mangrove	For use in flooded, coastal areas; adjust to sea level rise