An Evaluation of Tree Procurement and Acquisition Strategies for Urban Planting[1]

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Abstract

Cities increasingly plant trees for the numerous benefits they provide to communities. Tree health and structure at planting affect their growth and development and the long-term accumulation of important environmental, economic, and social benefits. Consequently, it is important to procure and acquire high quality trees from commercial suppliers. In order to characterize the range of experience with tree procurement, a qualitative study was conducted to document this important urban forest management process in the Northeastern and Mid-Atlantic United States. Semi-structured interviews were conducted with 11 municipal arborists to obtain primary information about tree procurement and acquisition, and the data collected were evaluated to summarize the state of knowledge about this process. The data suggest three main components comprise tree procurement, including establishing needs and requirements, evaluating and assigning suppliers, and managing commercial relationships. During 2008, participants in this study collectively planted over 26,000 trees from 132 woody taxa. Although participants described similar tree planting needs, they adopted markedly different approaches to buying them from and interacting with commercial suppliers. The results illustrate similarities and differences in tree procurement among participants and establish a framework for further research and discussion.

Index words: procurement, nursery production, tree planting, urban forestry.

Significance to the nursery industry

Nurseries will benefit from a detailed understanding of municipal arborists' tree planting needs, supplier evaluation methods, and trade relations management. In this study, participants mostly preferred medium-sized, 5.1–6.4 cm (2–2.5 in) caliper, field-grown trees sold as balled in burlap stock. Collectively, they planted Japanese zelkova (*Zelkova serrata*), honey locust (*Gleditsia triacanthos* var. *inermis*), and pin oak (*Quercus palustris*) most frequently during 2008. However, each of the cities adopted a uniquely distinct mechanism to evaluate potential suppliers and manage ongoing commercial relationships. Nurseries fluent with these municipal tree procurement policies and procedures may engender better, more productive trade relations.

Introduction

Over the past several decades, populations have steadily migrated from rural towards urban areas, and a majority of people worldwide now resides in cities (30, 56). This population shift will result in a concentration of resources towards urban development and, in many places, an enfranchisement of urban greenery. Throughout history, trees were incorporated into urban landscapes to strengthen the aesthetics, power, or cultural traditions of a place (36). Today, many continue this tradition with an appreciation for the environmental, economic, and social benefits conferred by trees onto the communities in which they are planted (34, 45, 55). Numerous studies have demonstrated this positive impact of trees on energy and carbon dioxide conservation, air quality, urban hydrology, noise reduction, ecological stability, landscape spaces, medical and psychological health, real estate values, economic development, and community well being (12). In short, trees are one of the most equitable and cost-effective ways to make cities more livable.

These tangible benefits of urban forests have motivated individuals, organizations, and municipal governments to embark on ambitious urban tree planting initiatives across the United States. A 2008 survey reported that 47% of cities created specific goals to increase the total number of trees managed within their public landscapes (7). New York City, for example, developed plans to integrate one million new trees into the city's five boroughs by 2030 (6). Although many small, short-lived or invasive trees, such as tree of heaven (*Ailanthus altissima*) and staghorn sumac (*Rhus typhina*), can naturally thrive and regenerate in urban areas, the systematic and coordinated tree planting by cities ensures that suitable trees grow in communities where they are most needed (44).

While cultivating and managing an urban forest, municipal arborists coordinate and execute numerous operational, financial, and administrative processes. They identify spaces for planting, obtain trees from nurseries, oversee installation, conduct maintenance activities, and remove dead or dying specimens (39). Among these, tree procurement and acquisition from commercial nurseries is especially important. Commercial nurseries propagate, grow, and distribute the trees used for planting in cities, and this production process has important consequences on the vitality and resilience of trees in the landscape. Nursery production methods, for example, can modify tree root morphology and architecture, which in turn affects tree growth, survival, stability, and drought stress several years after planting in the landscape (18, 20, 21, 22, 23, 28). Formative tree pruning in the nursery can similarly alter canopy architecture and weaken the attachment strength of branches, especially when these grow relatively large compared to the trunk (19). There are also several problems resulting from the misuse of product packaging materials, including synthetic burlap, wire baskets, labels, and trunk wraps, that have injurious effects on trees after planting (51). These operational practices of commercial nurseries are of great interest to many municipal arborists.

[1]Received for publication March 5, 2013; in revised form April 12, 2013.

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In addition, nursery supply contributes significantly to urban forest population dynamics. In the past, a heavy, often exclusive reliance on a small number of species and narrow genetic base contributed to the proliferation of species-specific health problems, and several pest and disease outbreaks have caused the widespread loss of commonly planted trees. In 1971, for example, approximately 45% of Chicago's public trees were reported as American elms (35, 49); and this relatively large portion of Chicago's urban forest was significantly reduced after the introduction and spread of Dutch elm disease (11, 52, 57). In recognition of this risk, many have promoted increasing species diversity in the urban forest as a safeguard against tree pest and disease outbreaks (3, 13). However, the supply of trees may not always meet consumer demand for greater diversity (10, 17, 48, 54).

Literature on the U.S. domestic landscape tree nursery trade is generally sparse, but there is some empirical evidence of this market's unique attributes (27). Overall, landscape tree market activity is comparatively small both in terms of the total value of outputs and participants. In 2009, deciduous shade and flowering tree sales ($903.7 million) corresponded to 7.7% of the total value of all horticultural specialty crop sales (41). This figure represented a 17% decrease in the total value of shade tree sales compared with that reported in 1998 after adjustment for inflation (40, 41). During the same ten year period, the number of nurseries growing these trees increased by only 1.5% to a total of 7,661 producers, at slightly more than one third of all horticulture specialty crop operations nationwide (40, 41). In the decade before 2009, the shade tree market experienced a sizeable decrease in output and nominal increase in producers, while overall horticultural specialty crop sales increased by 10% to over $11.6 billion (41).

In addition to occupying a relatively small market, commercial nurseries face a number of other significant challenges. The shade tree crop cycle required to bring landscape trees into market is unusually prolonged, lasting between 10 and 15 years (59). This extended production period, in particular, makes it difficult for producers to accurately forecast demand and respond to short term changes in the market, and uncertainty about the future often results in landscape tree surplus or scarcity, both of which were experienced during recent periods of economic recession and growth (16). As a result, producers faced with uncertain sales projections deliberately avoided significant changes at times to their crop schedules to limit risk exposure (16, 58). In combination with long production cycles, significant startup and operating expenses impose slow returns on investment for new and existing producers. Capital investments and fixed costs for a four-hectare ground bed production system were estimated at over $1.2 million in 2010, and annual operating and production costs for 20,000 red maple liners on 128.8 m^2 within the same nursery would cost an additional $86,111.76 per year (33).

Conversely, many cities buying trees are confronted by equally formidable challenges. In comparison with other agricultural commodities, limited public information is available about landscape tree price and quality. The lack of commonly accepted grades and standards impairs the ability of both producers and consumers to establish a fair price based on specific quality criteria, and instead, subjective quality criteria are inconsistently applied by buyers (32). Current national standards for nursery stock establish a basic framework for terms and measurements, with only a small number of local and regional markets providing supplementary descriptive guidelines for quality characteristics (1, 15). In addition, price information is substantially less reliable for landscape trees without being openly traded on exchanges (43).

Overall, the shade tree market is fundamentally important in supplying trees for use in cities, and the outcomes of this economic interaction between cities and commercial nurseries have important consequences on long term tree health and stability. However, it is unclear how the dynamic interaction between nurseries and cities can be structured to minimize uncertainty and maximize utility for all participants. In order to provide information on this topic, a qualitative study was initiated to investigate and characterize tree procurement and acquisition practices by cities. Qualitative research methods have often been used to investigate the depth, complexity, and comprehension of anthropogenic processes. In contrast with quantitative methods, these techniques seek to explore a phenomenon by focusing on human perceptions of an issue about which relatively little is known, and this is a useful way to characterize the state of knowledge surrounding tree procurement for urban planting. McLean et al. (38), in particular, promoted the suitability of these methods in building a broader comprehension of the urban forest and its management. Specifically, this study sought answers for these research questions:

- What kinds of trees are needed for urban planting?
- Where do cities obtain trees for planting?
- How are these trees purchased?
- What challenges are encountered during this transaction?

Materials and Methods

In this study, semi-structured interviews were conducted with recruited municipal arborists in order to obtain first-hand information about tree procurement and acquisition. These participants were purposefully selected based on the relevance of their professional responsibilities and practical experience, and they were selected from organizations with diverse financial resources, staff sizes, organizational structures (i.e. private non-profits and municipal governments), and recognized experience in tree procurement. The study was restricted geographically to the 11 states (Connecticut, Delaware, Massachusetts, Maryland, Maine, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont) and one district (Columbia) comprising the Northeast and Mid-Atlantic regions of the United States. A stratified, biased sampling strategy was employed to select one participant per state or district for inclusion in the study.

A standard set of questions was developed for interviews. This set consisted of open-ended questions about the organization in which the participant was employed and their professional experiences related to the main research questions (Table 1). The questions asked were the same for each participant, and a protocol was used to guide the conversation and ensure the inclusion of key topics. However, an adaptable interview format was adopted to allow questions to be asked in any order for the discussion to proceed naturally. An emphasis was placed on encouraging the participants to reconstruct their own professional experiences within the subject of each question. Occasionally, the responses

Table 1. Tree procurement and acquisition questions asked during semi-structured interviews with municipal arborists.

1. What kinds of trees are needed for urban planting (e.g. sizes, root packages, species)?
2. Have you established specific and/or broad guidelines for tree planting?
3. How do you plant trees?
4. With whom do you interact to purchase shade trees?
5. How are suppliers evaluated and awarded?
6. How are shade trees purchased from a source?
7. How is this transaction structured?
8. Can you consistently buy enough shade trees to meet your planting needs?
9. Have you consistently sourced shade trees with adequate quality characteristics?

were probed to elicit greater details using requests for more specifics or examples.

The same individual conducted all interviews with each municipal arborist to minimize subjective interviewer bias or inconsistencies. Interviews were recorded on a digital voice recorder and subsequently transcribed into written form. Pertinent sections of interview transcripts were extracted, reviewed, and summarized for ease of comparison.

At the same time, basic information was collected to construct a general profile of the organization in which each participant worked, including its mission, structure, capacity, and civic role(s). Topically relevant electronic records and documents, such as contractual agreements and technical specifications, were collected from each organization, with permission, to provide additional context for the organization's tree procurement and acquisition approach (Table 2). In addition, firsthand observations were made of the tree procurement and acquisition process, or distinct elements thereof, in a natural setting alongside the participant to construct a broader narrative of the phenomena. Field notes of general observations and experiences were recorded during these site visits. The interviews and observations were performed in person and occurred mostly over one day at the participant's workplace during 2008. All participants were issued a four-digit numeric identifier for accurate record keeping, and the identities of participants, as well as their associated organizations, remained completely confidential.

Qualitative data analysis. The various sources of qualitative data were organized into groups according to their origin. Broadly according to the procedure outlined by Creswell (9), all transcribed data, field notes, and documents were reviewed for initial overall meaning by identifying common phrases and ideas among participants. Divergent views were also recorded by recognizing contrasts, irregularities, or conflicts among participants. Following this initial review, a detailed coding process was used to separate and organize the topics and ideas into meaningful categories, with similar categories clustered together and organized into main themes. Theme syntax was derived from first hand phrases and terms originally expressed by participants. Particular attention was given to any concept identified by participants as meaningfully related to some aspect of tree procurement and acquisition. The coding results were subsequently used as a framework for reporting and discussing observed variation among participants. A detailed narrative of the settings encountered and observed during the study and the interconnected themes observed among programs was constructed. Direct quotations of statements by participants were chosen to illustrate commonly held ideas and beliefs. Finally, the qualitative findings were used to infer important conclusions about the current state of tree procurement and acquisition by cities.

Results and Discussion

Semi-structured interviews were conducted with 11 municipal arborists responsible for tree planting by non-profit organizations and local governments in the Northeast and Mid-Atlantic United States. These participants were recruited from metropolitan areas with at least 50,000 residents in Connecticut, Delaware, Maine, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont, and the District of Columbia. Six of the participants worked for organizations incorporated and funded as private non-profits and the remaining five worked for local municipal governments. All of the organizations considered tree planting to be a major part of their mission and civic roles. Participants interviewed during the study held managerial positions within their respective organizations and were responsible for overseeing human and financial resources to realize annual tree planting goals. Firsthand observations were made of directly related processes, including the assessment and preparation of new tree planting spaces, installation of trees in new and existing spaces, and inspection of trees recently delivered or planted. In compiling and reviewing all collected data, three major themes repeatedly surfaced in various forms from numerous sources as being important process components of tree procurement and acquisition, including establishing needs and requirements, evaluating and assigning suppliers, and managing commercial relationships.

Component One: Establishing needs and requirements. The initial phase of tree procurement involved determining the types and quantity of trees needed for planting. The interviewed arborists indicated they most often purchased medium sized, 5.1–6.4 cm (2–2.5 in), caliper trees for their needs. This size range was chosen as the most suitable based on observations that smaller trees did not withstand abuses typical of urban environments, such as vandalism or mechanical damage, and larger trees experienced greater transplant stress with slower growth and higher overall mortality rates. Participants often conveyed a perception that this size range struck a balance between these competing practical concerns. Gilman et al. (24) reported supporting evidence that large [9.3 cm (3.7 in) caliper] trees grew slower

Table 2. Tree procurement and acquisition information and documents collected from municipal arborists.

Name of organization
Organizational chart
Mission statement
Annual report
Tree planting records
Urban forest management plan
Guidelines, regulations, and specifications:
Approved species list
Site assessment checklist
Nursery tree production specifications
Tree planting specifications
Supplemental brochures and materials

after transplanting than small [6.8 cm (2.7 in) caliper] trees. However, other authors have demonstrated the confounding influence of many nursery production processes towards the reduced vigor of large transplanted trees, including damage afflicted on these often genetically inferior, slower growing trees during preceding harvests as faster growing trees are removed for distribution (53).

Commercially, the desired caliper sizes were more readily available as field-grown stock sold with balled and burlapped root systems, and participants reported that most of their trees were purchased with this root packaging. Although these medium-sized field grown trees were demanded most frequently, there was some variability in the tree caliper sizes and root packages sought by participants. For example, some shared their preference for smaller trees sold as container grown or bare root stock when working with volunteers for tree planting. These trees were simply easier to physically handle by community members. Several participants believed bare root trees, in particular, represented a cheap, convenient alternative to traditional balled and burlapped root systems, and some independent reports have demonstrated similar transplant success rates between these two root packaging methods when bare root systems are handled according to established procedures (5, 31).

> *We've honed in on medium sized,* 4.4–5.1 cm (1.8 – 2.0 in)*, balled and burlapped trees, and for us the size is really great, especially working with volunteers. It's a slightly smaller root ball size, and it's easier to work with. We're reluctant to go beyond* 6.4 cm (2.5 in) *because our forklift machine can't handle something that big. There's also some good science on the tree caliper size and transplant establishment period. So, we're ideally looking at trees between* 4.4–6.4 cm (1.8–2.5 in). –Participant 1004

Based on collected records, an average of 81.2% (SD 9.8) of all trees purchased by participants in 2008 were selected from a list of pre-approved species. These lists were created to publicly identify and endorse tree species tolerant of common biotic and abiotic stresses using information gathered from past experience and historical records. The lists encouraged individuals to consult the organization's institutional experience with the species most well adapted to local planting conditions and heed recommendations to match a species to site conditions. The convergence of trees on these lists with those actually planted illustrates the practical approach most participants adopted towards species selection; it also suggests that these lists are valuable predictive estimates of the tree species that will be required by cities for planting in the future.

> *We do have a recommended list of street trees, and it's divided into categories according to their mature size. So that's the starting point whenever we try to get a new tree planted. So, we look around at a site* [and] *if there are overhead wires, we're going to select from the small tree list. If it's wide open and there's enough… space to put a large tree that would always be the preference.* –Participant 1005

Collected organizational records revealed that more than 45% of the trees purchased by cities were members of the rose (Roseaceae), beech (Fagaceae), and elm (Ulmaceae) plant families. The most frequently purchased species included Japanese zelkova (*Zelkova serrata*), honey locust (*Gleditsia triacanthos* var. *inermis*), and pin oak (*Quercus palustris*) (Fig. 1). Several of these species were reported as frequently sold by nurseries in the Northeastern U.S. twenty years ago, including pin oak (*Quercus palustris*), red maple (*Acer rubrum*), little leaf linden (*Tilia cordata*), and honey locust, suggesting a sustained demand for their use in the landscape (46, 59). The species used most by participants were typically fast-growing generalists adaptable to a wide range of environmental conditions (50). In contrast, participants planted some other species comparatively less than in previous years, including ash (*Fraxinus* sp.) and callery pear (*Pyrus calleryana*). These species were used less frequently after serious risks to the health of individual trees or stability of landscapes were realized. For example, the emerald ash borer (*Agrilus planipennis*), an exotic phloem-feeding beetle, has killed millions of ash trees native to the United States, and many cities are not planting new ash trees in anticipation of this continued insect pressure (47).

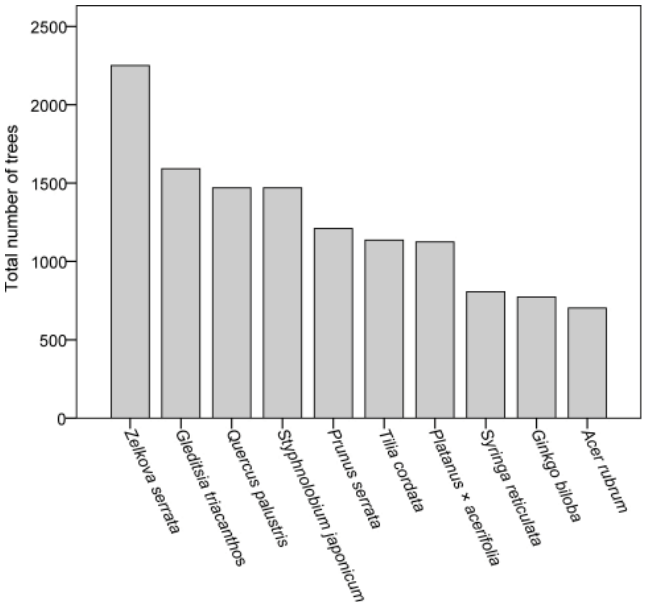

Fig. 1. During 2008, the 11 participants in this study collectively planted over 26,000 trees from 132 woody taxa, and these frequency counts represent the ten species most often planted.

Although there was marked similarity in the types of trees purchased by participants, there were substantial differences in the total number of trees purchased during 2008. Trees purchased by these organizations during the same period ranged between 44 and 21,025 with a mean of 2,639 trees (SD 6,479) and median (25 to 75%) of 683 trees (Fig. 2). Similar reports about discrete shade tree purchases by individual cities have heretofore not been published. Compared with sales data collected the following year (2009), these ten cities collectively acquired a small fraction (<0.1%) of all landscape trees sold nationally (41). One survey similarly reported that American cities collectively purchased 4.05 million trees annually between 1991 and 1996, and these sales accounted for, on average, 3.7% of domestic shade tree sales during the same period (42). According to the same survey, the propor-

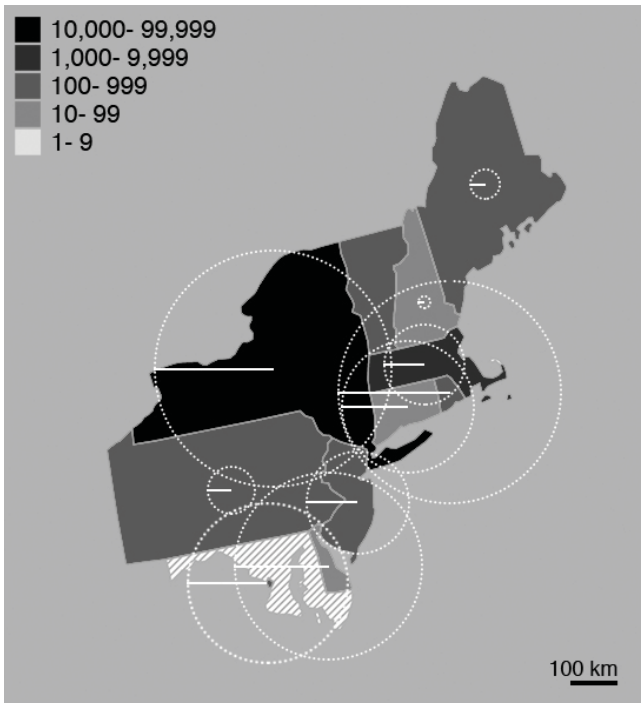

Fig. 2. The five color-coded exponential categories display the wide variation in the number of trees purchased for planting among the participants, and the circle radii similarly reveal differences in the mean distance between buyers and sellers.

tion of nursery demand sustained by cities was significantly smaller than that of other consumer categories, including garden centers (31.5%), contractors (24.7%), re-wholesalers (17.9%), and general merchandisers (15.4%) (42).

Overall, participants described considerably similar tree planting needs and requirements among the cities included in this study. This convergence was largely evident in the markedly similar tree sizes, root packages, and species demanded by participants. Although this study's restricted geographic range likely belies greater disparity in tree planting needs at the national (or international) level, these results highlight a number of features common among the tree planting needs and requirements of several large cities in the Northeast and Mid-Atlantic United States. These common features, if stable across time, could serve as the basis of an accurate demand profile for this unique market segment.

Component Two: Evaluating and assigning suppliers. After establishing their needs, participants indicated the second component of tree procurement was the evaluation and selection of commercial suppliers. Trees were procured by cities primarily through direct trade with wholesale nurseries. Occasionally, they were purchased from intermediaries, such as re-wholesalers or brokers, who maintained connections to a larger network of buyers and sellers than typically available to individual participants. Less commonly, landscape contractors purchased trees on behalf of cities in the course of providing tree-planting services. Collectively, these varied transactions comprised the latter stages of the supply chain delivering landscape trees to cities, while propagators and liner nurseries (i.e. 'primary growers') contributed to the earlier stages of this process by reproducing and growing young, small trees (Fig. 3). Each participant recounted using a very unique set of downstream supply chain components to acquire trees, and these combinations resulted in trees being harvested, handled, transported, and stored in equally distinct ways.

> *In my program, we have a guy… that is a middleman between all of these growers and our program. We don't have to pay him because the nurseries will. He generally gives me a list of what's available each season from the twenty or so nurseries with which he's familiar. We then select trees from that list based on availability.* –Participant 1015

In order to engage these commercial sources, participants developed distinct mechanisms to select and award responsibility to various suppliers for delivering these trees. The mechanisms provided a consistent basis for transactions within a broader exchange relationship, and they were variously employed to ensure buyers received the best value for goods. In total, three distinct assignment mechanisms were used to acquire shade trees for planting, including direct purchasing, negotiated acquisition, and open competitive bidding. Direct purchases accepted a noncompetitive price from vendors for a relatively small amount of trees. The negotiated acquisition process relied on a series of proposals and counterproposals to establish a price mutually agreeable

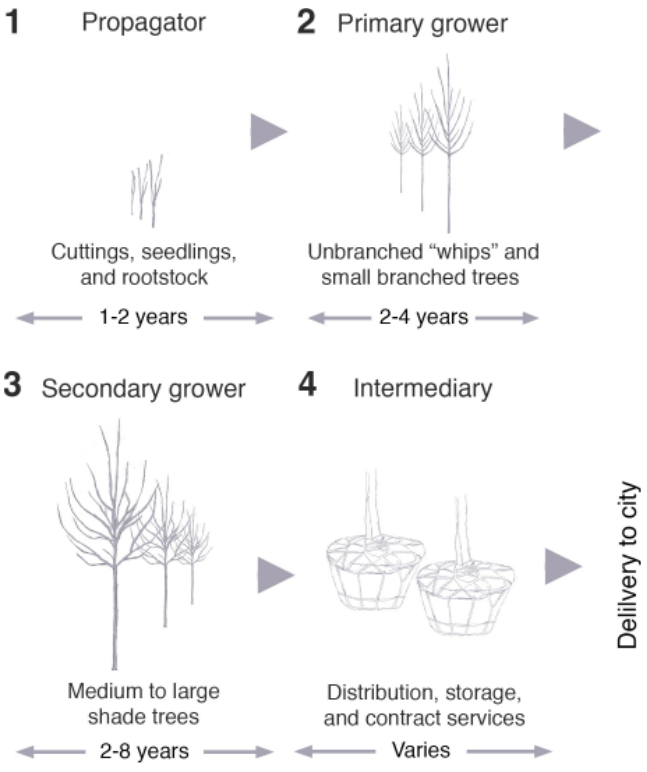

Fig. 3. The landscape tree supply chain, as described by participants, consisted of four major components, including propagators, primary growers, secondary growers, and intermediaries; participants described numerous intermediaries involved in the tree procurement and acquisition process, including brokers, re-wholesalers, and landscape contractors.

to the buyer and seller for a predetermined amount of goods. Open competitive bidding identified the lowest price offered by sellers on a competitive basis in response to a formal solicitation for a fixed amount of goods. This approach, in particular, was used preferentially by all government agencies as a means to promote transparent, fair competition and reduce fraudulent or corrupt transactions (14). Until this point, existing research has mostly described the source of transactions in the nursery sector (e.g. telephone, in-person, and mail orders) rather than the means by which an offer is selected among all available (29).

> *The way we get trees is that we put out a contract for 'x' number of trees that we think is going to be around this price… and the awarded contractor is then responsible for sourcing, planting, watering, and maintaining them for two years… So, the contractor gets to decide which nursery he would like to use, and I'll generally get to go out and tag the specific trees to be delivered.* –Participant 1022

Participants worked most often with sellers located in close proximity to their communities; the average distance between buyers and sellers was 176.8 km (SD 168.6) (Fig. 2). These nearby suppliers likely provided the lowest transportation costs. Guo et al. (27) reported that trade volume significantly increased with shorter distances between buyers and sellers of nursery and greenhouse crops. Cheng et al. (8) similarly reported greenhouse and nursery firms clustered around urban areas had higher production output as they capitalized on their proximity to growing markets. These short delivery distances also allowed participants to minimize the handling period and effort required to maintain trees during harvest, storage, and shipping. Among participants, buyers purchased trees from between one and three sellers with a mean of two (SD 1). However, it is not immediately clear whether participants used a limited range of suppliers due to a scarcity of qualified firms or some other reason(s).

In general, there have been relatively few evaluations of the comparative utility of supplier evaluation and assignment mechanisms (2). However, it is known that open competitive bidding performs relatively poorly when seeking complex goods and services, when few bidders are available, or prioritizing quality characteristics (2, 4, 37). Some of these conditions could be periodically encountered during shade tree procurement, including a scarcity of qualified bidders. A review of private-sector construction contracts signed between 1995 and 2001 reported more than 43% were awarded using negotiations while only 18% used open competitive bidding, and these figures were 1 and 97%, respectively, for public sector contracts awarded during the same period (2). These findings suggest a clear distinction exists between public and private sector evaluation and assignment mechanisms. Although negotiations may allow cities more flexibility to coordinate and communicate with shade tree suppliers and leverage their market expertise before making a commitment, government regulations strongly favoring the use of open competitive bidding will likely restrict immediate changes to these policies.

In contrast with the broadly similar types of trees sought by participants, there was marked dissimilarity in their approach to selecting among available suppliers. Although most participants utilized direct purchasing when acquiring a relatively small amount of trees, they diverged between two separate mechanisms when acquiring large quantities of trees: negotiated acquisition and open, competitive bidding. However, it is not possible to discern which approach described in this study consistently delivered adequate goods at a competitive price.

Component Three: Managing commercial relationships. The third component of tree procurement described by participants involved managing the outcomes of existing commercial relationships. Trade between these buyers and sellers, or their agents, was structured administratively in different ways to enforce predictability during commercial interaction. Individual transactions occurring under an awarded contract were consistently supported by standard purchasing documents, including purchase orders, delivery notices, and invoices, to record their occurrence for internal accounting and regulatory requirements. In addition to basic commercial regulation by the state, many participants used legal contracts to set up a trade relationship and resolve problems encountered during the exchange. In these cases, legal reciprocity was desired by cities in response to the many sources of uncertainty in the landscape tree market. The contracts were often established to clearly outline the specific responsibilities of participants, contingency plans for unforeseeable circumstances, consequences of nonperformance, and enforceability of terms. In these contracts, arborists frequently specified basic shade tree quality characteristics that detailed requirements for tree health, root structure, and canopy architecture. These contracts allowed participants to control specific, important aspects of nursery operational and cultural practices during production, harvest, storage, and shipping.

> [With this contract] *we'll be dictating what trees we'll need and when they'll be delivered. So, this is all about control over what we're after and getting what we want. All the way down to the number of trees per season, exactly to what specifications they should be grown, how high they should be limbed up, what the canopy should look like, and what the root ball should look like. This formal contractual obligation requires, with very strict terms, the products these nurseries will be providing.* –Participant 1011

In contrast, many other participants conducted trade with nurseries mostly through personal relationships in which a combination of trust, ethics, and social norms were used to enforce predictable behavior among participants. In these cases, shade tree quality attributes were developed by nurseries to match municipal arborists' expectations displayed in the course of their commercial relationship. Although contracts are common in many trades, some have reported the ability of certain socio-economic institutions to compensate or substitute for the protection of legal and financial institutions when they are not practically available. Greif (26), for example, demonstrated the historical importance of professional reputations in conveying commercial predictability to trading partners. Relationship-based commerce may specifically appeal to those involved in shade tree procurement when verbal agreements contain flexibility that reduces risk for everyone. For example, as disease outbreaks, natural disasters, or unpredictable weather cause a party to

default on some of its earlier promises, these dynamic personal relationships can easily adjust to maintain productive outcomes (43).

> *We actually entertained the idea of contract growing* [with a nursery] *for a while, but it eventually came back to a gentleman's agreement. We came up with a list of common trees they could grow in sufficient quantities while still servicing their other customers. There was nothing in writing or formal between the two of us. You know, they bring us down for steaks every once in a while. They come up to visit, and we take them out for steaks. It works and it's been great.* –Participant 1004

In fact, even those commercial relationships regulated by legal contracts similarly benefited from strong personal relationships. These personal connections offered a platform for buyers and sellers to exchange information and address issues over the long term, often outside the timeframes and scope of work governed by contracts. Participants repeatedly suggested they believed it was important to support businesses that understood and demonstrated values similar to their own. The enduring relevance of these relationships demonstrates the continued importance of social institutions in business relationships (25). However, it will be important for organizations to develop and continuously adapt an administrative framework to ensure that these relationships accumulate positive benefits while mitigating the risk of collusion.

> *We found out really that these contracts aren't about growing trees. They're about building relationships. It's about building trust with the nurseries so they have a consistent, steady consumer and we get what we want in steady, quality products.* –Participant 1011

Comparatively, the participants adopted strongly divergent approaches to managing commercial relationships, ranging from highly regulated legal contracts to informal personal relationships. The selected strategy often corresponded closely with the supplier evaluation and assignment mechanism used by participants. Participants assigning vendors through open, competitive bidding often relied on contracts to oversee an exchange of promises while others utilizing negotiations frequently depended on personal relationships.

Within these commercial relationships, participants described several challenges commonly encountered during tree procurement. The limited availability of certain tree species at a given size, in particular, hindered attempts to suitably match trees with planting site characteristics. These supply shortfalls usually resulted in changes or variations to planting designs and allowed less suitable species to be installed at a particular site. Participants believed these changes complicated their attempts to improve the urban forest's structure and composition over time. Sydnor et al. (54) attempted to quantify the frequency and severity of these disparities by comparing nursery supply with shade tree demand from cities in the state of Ohio, and they found deficient nursery supply for 33 separate species during 2010. Clearly, this is an important issue confronting municipal arborists and further research is warranted on both its occurrence and consequences. The prolonged, 10–15 year shade tree production period could partially explain the limited extent to which nurseries may adjust available supply to accommodate short-term or seasonal changes in demand (59). Although participants reportedly made requests to nurseries to increase the availability of certain species, they believed the shade tree market offered little incentives for nurseries to focus on the needs of a relatively small consumer segment. In addition to supply shortfalls, some participants also reported a frustration with a lack of commonly accepted tree quality grades and standards defining tree health, root structure, and canopy architecture.

> *I would say on average, we came up with a species list between 50 and 60 tree species for each individual season and a contract of about 800 trees. In the end, the proportion of the time that the nurseries carried exactly what we desired, without species substitutions, and specified was about 60% of the time. Then we probably would have taken a few species that weren't to specification, smaller or wounded trees, for another 10% of our desired target. So really, that extra 30% is what we're trying to resolve.* –Participant 1011

In order to address some of these perceived shortcomings, a few of the participants attempted to assert greater control over upstream portions of the landscape tree supply chain. This vertical integration gave cities more room to influence planning decisions and production techniques at these stages and alter resultant outcomes in their favor. For example, one participant entered into a nine-year contractual agreement with several wholesale nurseries in which the annual output, growing practices, and harvesting techniques were clearly specified to match the participant's requirements. Another participant assumed greater control of the supply chain by purchasing small trees directly from primary growers and cultivating them at an in-house nursery facility. Similar instances of vertical integration in the nursery industry have been reported in other distribution channels leading to mass-market retail centers (43). These structural changes were facilitated by the increasing clout of large retailers as sales concentrated through their businesses, but a similar concentration is unlikely among cities purchasing trees for urban planting. However, it will be important to identify the factors giving rise to these changes, especially among cities, to assert more control over the supply chain and further improve the cost-benefit ratio of tree planting investments.

> *Well, we decided to start our own nursery to provide access to tree species we couldn't find elsewhere and have greater control over tree quality. We also needed trees that were acclimated to our local climate. Now we control every step of the process in growing a tree for our city.* –Participant 1025

The experience of tree procurement for planting in urban areas has been documented in this study, and the entire process was organized into three major components based on the information obtained from research participants. Although participants in this study required similar trees for urban planting, they adopted markedly different approaches to acquiring them from commercial nursery suppliers. The decisions made and strategies enacted within each of the described components may have consequences on the long-term health and stability of landscape trees, and it will be

important for further research to identify the tree procurement and acquisition approach providing superior outcomes, both in terms of the price and quality of trees.

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