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Massachusetts Urban Forest Diversity: Insights from an Undergraduate Service Learning Course

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Abstract. Background: Conventional volunteer pools can generate labor for citizen science activities, but opportunities also exist to involve and incorporate student populations into meaningful data collection exercises and service learning initiatives. This is especially relevant in urban and community forestry, where land managers are charged with maintaining inventory records of tree populations in order to inform management and policy decisions but often operate without adequate capacity to maintain high quality and updated data. Previous research has shown that trained undergraduate students have the ability to meet this need and also benefit from service learning opportunities. Methods: As part of an undergraduate capstone course in urban forestry at the University of Massachusetts Amherst (the state land grant university), undergraduate student researchers worked with local land managers to collect urban tree inventory data from municipalities throughout the state. Data were aggregated to assess statewide and subregional urban tree taxonomic and size diversity, then evaluated against previously published research about statewide urban and street tree populations to signal the legitimacy of using undergraduate student data to supplement formal research. Results: Findings from this study show that the incorporation of trained undergraduate natural resource students can serve as a form of citizen science that productively contributes to urban forest management practices—namely urban tree inventory efforts. Conclusions: Students can yield useful empirical data that may inform conclusions and supplement more intensive urban tree inventory protocols at broader scales.

Keywords. Civic Science; Community Science; Land Grant University; Species Composition; Undergraduate Research; Urban Tree Inventory.

INTRODUCTION

Urban forests are the trees, plants, and associated ecosystems on streetscapes as well as in public parks, private residential properties, and forested natural patches in cities, towns, and suburbs (Miller et al. 2015; Johnson et al. 2020). These ecosystems provide a suite of environmental, social, and economic benefits (Endreny 2018; Mei et al. 2021). However, urban trees face many challenges, including soil compaction, exposure to pollution, lack of growing space, diseases and insect pests, and construction (Scharenbroch et al. 2017; Roman et al. 2022). As a result, urban tree loss in the United States (US) has been occurring at a rate of 36 million urban trees annually (the equivalent of 175,000 acres), with a total urban tree canopy cover decline of about 1.0 percentage point from 2009 to 2014 (Nowak and Greenfield 2018).

Urban tree inventories are critical components for the successful management of urban forests (Bond 2013; Klobucar et al. 2020). An urban tree inventory is the systematic collection of measurements of individual urban trees that typically includes attributes like stem diameter, species, height, crown width, location, and health condition rating (Miller et al. 2015) and may be used to help estimate tree growth or determinants of tree removal (Esperon-Rodriguez et al. 2023). Data about individual trees can be aggregated across larger geographies to assess conditions related to urban forest systems, like overall tree species composition and size class. Without current data from inventories and assessments, urban and community forest managers and other decision-makers may be challenged to effectively monitor variables that maximize ecosystem service provision, mitigate hazards, and develop informed policies and management strategies, such as achieving desirable future tree species diversity goals (Klobucar et al. 2020).

A variety of stakeholders engage in contemporary urban and community forest assessment and inventory activities, including researchers, private contractors, government agencies, and citizen or civic volunteers (e.g., Bloniarz and Ryan 1996; Fazio 2015; Elton et al. 2022). The involvement of volunteer or other less formally trained personnel represents an important paradigm shift from traditional approaches to urban forest assessments and inventories, which were typically conducted by agency specialists (i.e., staff) and professional contractors. Volunteers now account for a small but important (5%) amount of municipal tree care performed in the US (Hauer et al. 2018), and specific initiatives have included high profile volunteer street tree inventory initiatives in large cities (Bloniarz and Ryan 1996; Johnson et al. 2018). These individuals are often motivated by intrinsic and extrinsic factors including altruism, environmental stewardship, the opportunity for social interaction, and the opportunity to gain new skills (Vogt and Fischer 2017; Roman et al. 2020; Elton et al. 2022). While conventional volunteer pools may generate desirable candidates for citizen science activities, ample opportunity may also exist to involve and incorporate student populations through service learning initiatives (Bringle and Hatcher 2007; Cowett and Bassuk 2012).

Service learning is a pedagogical approach usually involving student populations that incorporates community-based experience, academic learning objectives, and intentional reflection into the learning process (Gelmon et al. 2018). At colleges and universities, service learning typically involves a 3-way partnership between the academic unit, the community (e.g., government agency, civic association, nongovernmental organization), and the student. Service learning and citizen science have the potential to enhance undergraduate education through inquiry-based learning and data collection, research opportunities, and class projects (Oberhauser and LeBuhn 2012). Students in forestry and other natural resource or environmental studies programs have shown to benefit from experience-based learning activities with increased motivation and confidence, development of professional skills, integrated forms of knowledge, and enhanced sense of place (Ward 1999; Hix 2015; Watkins and Poudyal 2021). Undergraduate students at the University of Massachusetts Amherst indicated that they appreciated the "immersive, hands-on experience" of urban forestry field work service learning projects (Harper et al. 2021). Student-led data collection has been shown to enhance learning while also serving broader management needs (Gelmon et al. 2018).

Integrating ecological monitoring into undergraduate courses is not new (e.g., Hitchcock et al. 2021), and service learning also has the potential to help address important gaps in urban forest data. Though the importance of an urban forest inventory is widely recognized—83% of US communities have an inventory—only 41% of urban tree inventories are current (Hauer and Peterson 2016). Many barriers exist for communities to conduct an urban tree inventory and include the costs associated with data collection and management as well as the technical expertise to operate and maintain inventory software (Berland et al. 2019). Urban forest managers in under-resourced cities and towns are often tasked with making management and operational decisions with substantial limitations related to inventory data, personnel, and a paucity of scientific knowledge (Harper et al. 2017; Lass and Harper 2023).

In this study, we bridge the opportunity to assess connections between college student learning with management needs in urban and community forestry. The goal of this research is to assess tree diversity in Massachusetts, USA, by comparing statewide urban tree data collected by undergraduate university student researchers to professional statewide assessments (Cumming et al. 2006; Cowett and Bassuk 2020) and using that comparison as a reflection to discuss the potential broader application of student-led inventories, particularly at land grant universities (LGU).

We asked the following research questions:

What is the relative taxonomic composition, diversity, and size class distribution of urban forest trees across Massachusetts?

What is the extent of management-relevant regional variation across relative taxonomic composition, diversity, and size class distribution?

How do these student-collected data—and the affiliated findings—compare to conclusions based on other data collected by professionals?

MATERIALS AND METHODS

Study Area

Massachusetts is located in the Northeastern USA and is part of the Southern New England region (Figure 1). The state's climate is humid continental

(Köppen Dfb), with warm, humid summers and cold, snowy winters. Massachusetts was dominated by forests prior to European colonization and is currently categorized as the 11th most-forested state (Oswalt et al. 2019). As of 2019, about half of the state is classified as deciduous, evergreen, or mixed forested land cover (Dewitz and US Geological Survey 2021). Central and transition hardwood forests prevail (dominated by *Quercus* (oak) species), followed by Northern hardwood forests (dominated by *Fagus grandifolia* (American beech), *Betula alleghaniensis* (yellow birch), and *Acer saccharum* (sugar maple)(de la Crétaz et al. 2010). Between 2000 and 2010, Massachusetts experienced a 3.8% expansion in urban land, totaling 38% of all land area. This raised the state to the third-highest percentage of urban land in the continental US, and by 2060, it is projected that 60% of land in Massachusetts may be classified as urban (Nowak and Greenfield 2018).

Average urban tree canopy cover in Massachusetts' municipalities is 43.5% (Nowak and Greenfield 2008), and there is a statewide goal to increase urban tree canopy cover and increase urban forest diversity and age class to improve resilience (Cardwell et al. 2020). Urban forests dominated by a few tree species are notoriously susceptible to widespread tree loss from even a single disturbance, like an invasive pest or a weather-related event (Clapp et al. 2014). Several larger cities in Massachusetts, like Cambridge, have developed comprehensive urban tree canopy cover

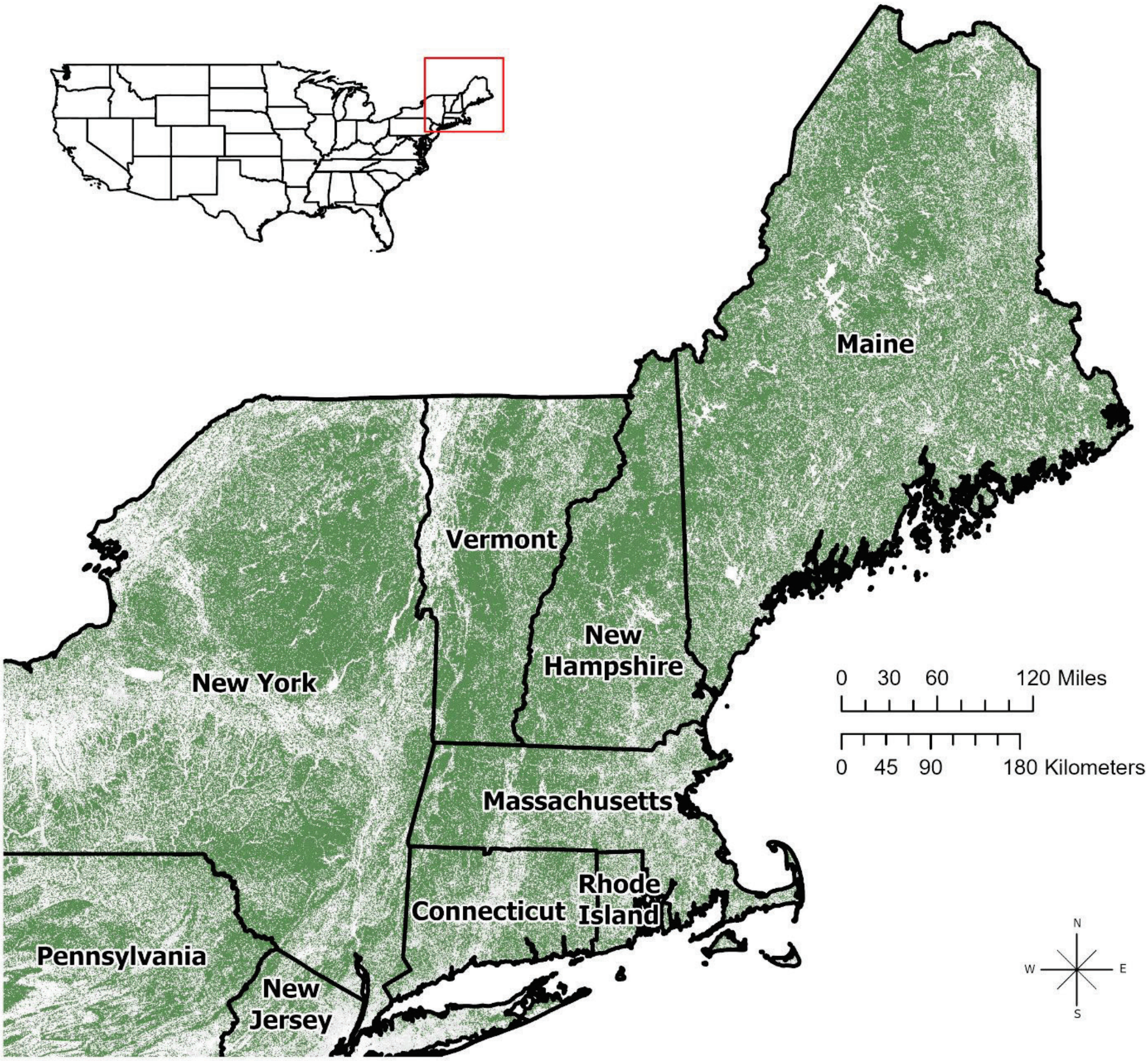

Figure 1. Context of the Massachusetts forested land cover in Southern New England and the Northeastern USA (data based on 2021 USA NLCD Tree Canopy Cover).

assessments across public and private lands (Cardwell et al. 2020); many municipalities have also engaged in formal research for various issues, including pest invasions and the discovery of the Asian longhorned beetle (*Anaplophora glabripennis*) in Worcester (Elton et al. 2022), tree planting initiatives in midsized towns (Breger et al. 2019; Commonwealth of Massachusetts 2023; Healy et al. 2023), localized gas leaks near Boston (Schollaert et al. 2020), and tree conflicts with utilities (Doherty et al. 2000). However, many municipalities lack up-to-date tree data—as of 2011, 70% of Massachusetts cities and towns did not have a complete or partial urban tree inventory (Freilicher 2010; Rines et al. 2011; Shifley et al. 2012).

Data Collection

Data collection for the present study occurred between 2016 and 2022 as part of a capstone undergraduate urban forestry course at the University of Massachusetts Amherst; further description of the general student population and their training are discussed in the Appendix. Participating students conducted a sample tree inventory (Bond 2013) in a Massachusetts city, town, or other US Census designated place. Each student collected data for approximately 100 urban trees, including genus, species, and DBH (stem DBH, approximately 1.37 m) of each tree. As in other studies of urban tree inventories across multiple municipalities, this study relied on a nonrandom, convenience sample methodology (Cowett and Bassuk 2017; Koch et al. 2018; Love et al. 2022). Students were authorized by the instructor to independently select their participating municipality from a wide geographic spread of communities (Table 1). Given that nearly 70% of incoming UMass Amherst undergraduate students are from Massachusetts (Rose 2024), we expect that this geographic spread is reflective of students' hometowns across the state. Prior to field work, students were encouraged to contact the municipal tree warden for guidance related to community inventory needs. While a majority of the students don't typically receive a return communication from the municipal tree warden, the students do present the opportunity to elicit professional input on what trees might be measured.

When undertaking field work, students were expected to sample only public-facing trees in planted urban landscapes (e.g., street and neighborhood park trees, not residential trees or natural forested patches). The student-led inventories that form the basis for this study were screened for inclusion based on data quality and completeness by the second author (see Table 1 and the Appendix for further information).

Analytic Strategy

R Studio (R Foundation for Statistical Computing, Vienna, Austria) was used for statistical analysis and

Table 1. Overview of the data used in this study. MA DCR (Massachusetts Department of Conservation and Recreation).

MA DCR urban and community forestry administrative region	Sampling region (Cumming et al. 2006)	Total number of cities and towns	Total number of trees
Eastern	Boston area	4	403
	Cape Cod	4	393
	North Shore	9	950
	South Shore	5	508
	Subtotal	**22**	**2,254**
Central-western	Berkshires	13	1,291
	Central	8	817
	Subtotal	**21**	**2,108**
	Grand total	**43**	**4,362**

data visualization, including the R packages "psych" (Revelle 2017), "tidyverse" (Wickham et al. 2019), and "ggplot2" (Wickham 2016). For each research question, we calculated and reported summary statistics (weighted mean, standard error) or frequency/percentage proportions and graphs.

To answer the first research question and establish a baseline of comparison, taxon abundance and diversity of the top 10 reported species, genus, and family were first reported as a weighted mean, where:

Weighted Mean = (N / P) × M
N = total number of places (total or regional) that reported a taxon;
P = total number of places (total or regional);
M = arithmetic mean percentage for the community reported taxon.

Tree diversity was assessed by the "10-20-30" rule at each taxonomic level (Santamour 1990; Ma et al. 2020), whereby a species should not compose more than 10% of a sample, a genus should not compose more than 20% of a sample, and a family should not compose more than 30% of a sample. This management guideline is widely used in urban forest management to discourage overreliance on fewer tree species, because such monocultures increase urban forest vulnerability to pest and disease outbreaks (Laćan and McBride 2008; Roman et al. 2018).

Relative size class distributions were assessed by DBH. Diameter measures were converted to centimeters from inches, and tree size was categorized into 8 size classes following Cowett and Bassuk (2020), ranging between 0 to 15.2 centimeters (0 to 6 inches) and 106.7+ centimeters (42+ inches). Size class assessment is an important component of tree population sustainability, demonstrated through a sufficient quantity of young (small size) trees to offset factors like tree mortality (larger size trees)(Hilbert et al. 2019). Graphical detection of a "reverse J" shape demonstrates a descending distribution of smallest to largest size classes and population distributions with a "hump" in the midsized DBH classes often suggest an unsustainable, aging tree population (McPherson and Kotow 2013).

To address the second research question and have the greatest relevance for statewide practitioners, regional variation of tree composition, diversity, and size class distribution was assessed by summarizing the data through the Massachusetts Department of Conservation and Recreation (MA DCR) Urban and Community Forestry Program administrative regions (see Table 1). In the MA DCR regions, sample locations within Worcester County and west were classified as the central-western region, and all sample locations east of Worcester County were classified as the eastern region. The aforementioned methods were replicated across both regions, and analysis of the variance (ANOVA) compared DBH mean differences between regions. Tukey's Honest Significant Difference test was used to assess the significance of any regional differences detected, and results are reported with the F-statistic, degrees of freedom, and P-value.

The third research question was addressed by comparing the results of this undergraduate university student-led data collection study to related assessments of Massachusetts' urban forests, published in a federal Government Technical Report (Cumming et al. 2006) and a peer-reviewed publication (Cowett and Bassuk 2020). Cumming et al. (2006) established a sample of random sampling monitoring plots to test sampling methods and estimate the health and structure of urban street trees; in total, Cumming et al. (2006) assessed 1,124 trees from 296 sampling plots (m = 3.89; sd = 0.38 trees per plot) across 6 sampling regions between the Massachusetts Urban and Community Forestry Program administrative regions. Cowett and Bassuk (2020) assessed species diversity and size classes of street trees using a nonrandom sample of 30 municipal tree inventories across Massachusetts, where 10 inventories were obtained from the Central-Western region and 20 inventories were obtained from the Eastern part of the state. In total, Cowett and Bassuk (2020) assessed 213,845 urban trees (m = 7,128 per inventory).

RESULTS

Statewide Patterns of Diversity and Abundance

Species, Genus, Family Composition

Our sample of urban tree inventories from 43 cities and towns across Massachusetts identified 127 urban tree species representing 63 genera and 32 families (Figure 2). The number of tree records for both MA DCR Forestry Administrative Regions were comparable (Eastern n = 2,254; Western n = 2,108; total n = 4,362).

The weighted means of the 10 most common species ranged between 0.3% and 11.5%. Norway maple *(Acer platanoides*, weighted mean 11.5%) was the most abundant species and exceeded Santamour's

10% rule for species (Appendix Table S1). The second most abundant species, sugar maple (*Acer saccharum*, weighted mean 8.4%) and red maple (*Acer rubrum*, weighted mean 8.3%), did not surpass Santamour's 10% rule for species.

The most abundant urban tree genus in Massachusetts was maple (*Acer* spp.), which comprised a weighted mean of 38.4% and exceeded Santamour's 20% rule for genus (Appendix Table S2). The next most abundant genus, oak (*Quercus* spp., weighted mean 12.6%) and pine (*Pinus* spp., weighted mean 5.9%), did not exceed Santamour's 20% rule for genus. The most abundant urban tree family was the maple family (*Aceraceae*, weighted mean 38.4%) (Appendix Table S3) and was the only family to exceed Santamour's 30% rule for families.

Relative Size Class Distribution

Overall, a clear, descending, reverse J-shaped profile can only be detected in the largest size classes (> 45.7 to 61.0 cm [> 17.9 to 24 in]), because too few trees could be categorized in the smallest size class (0 to 15.2 cm [0 to 6 in])(Figure 3). Among the 10 most prevalent urban tree species, genera, and families, none of the distributions reveal a clear, descending, reverse J-shaped profile from smallest to largest DBH sizes (Appendix Figures S1-S3), and most have larger overall means (Appendix Tables S4-S6), suggestive of a tree population with imbalanced age classes across taxonomic levels.

Moreover, the relative size class distributions across taxa are somewhat inconsistent. For example,

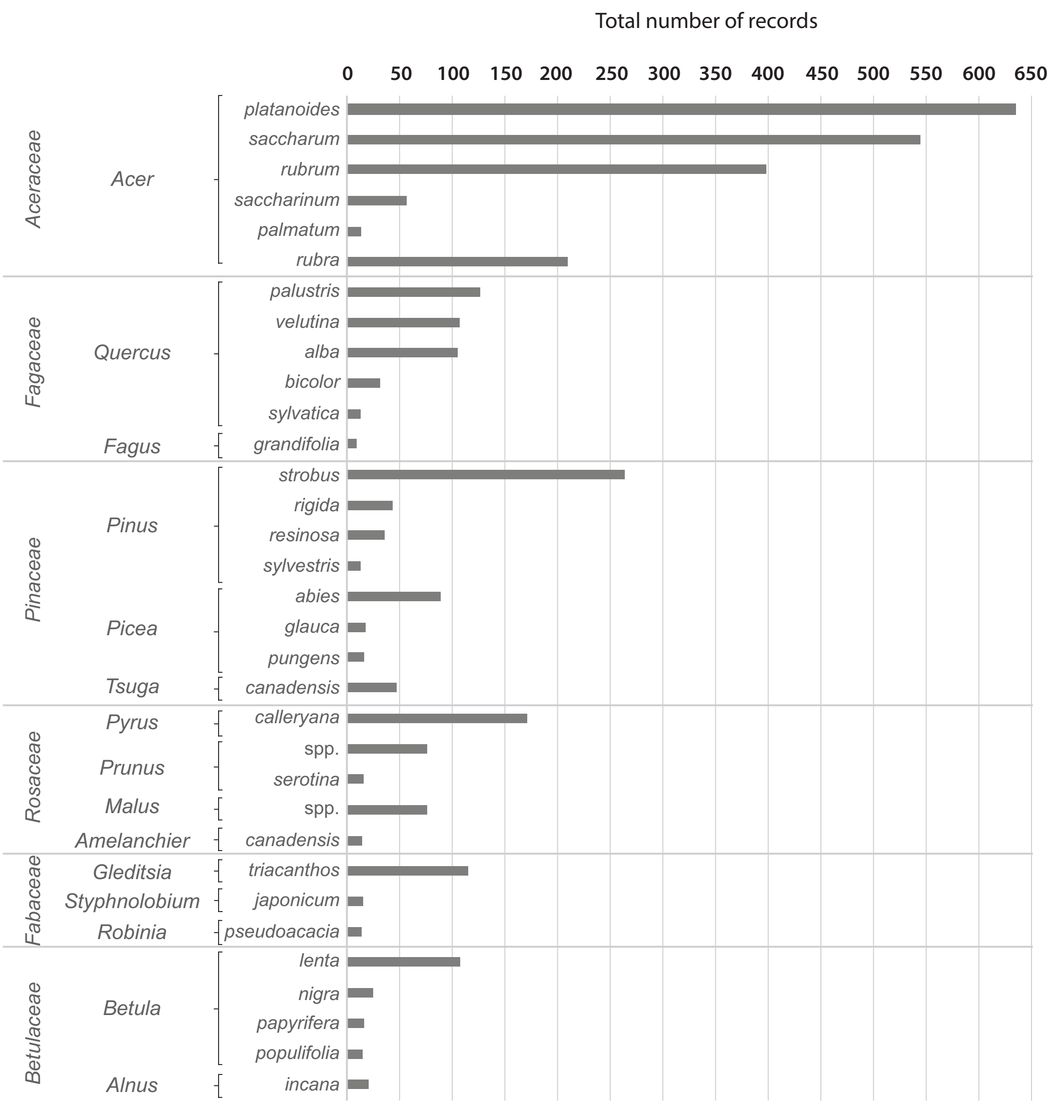

Figure 2. Summary of most common records by family, genus, and species.

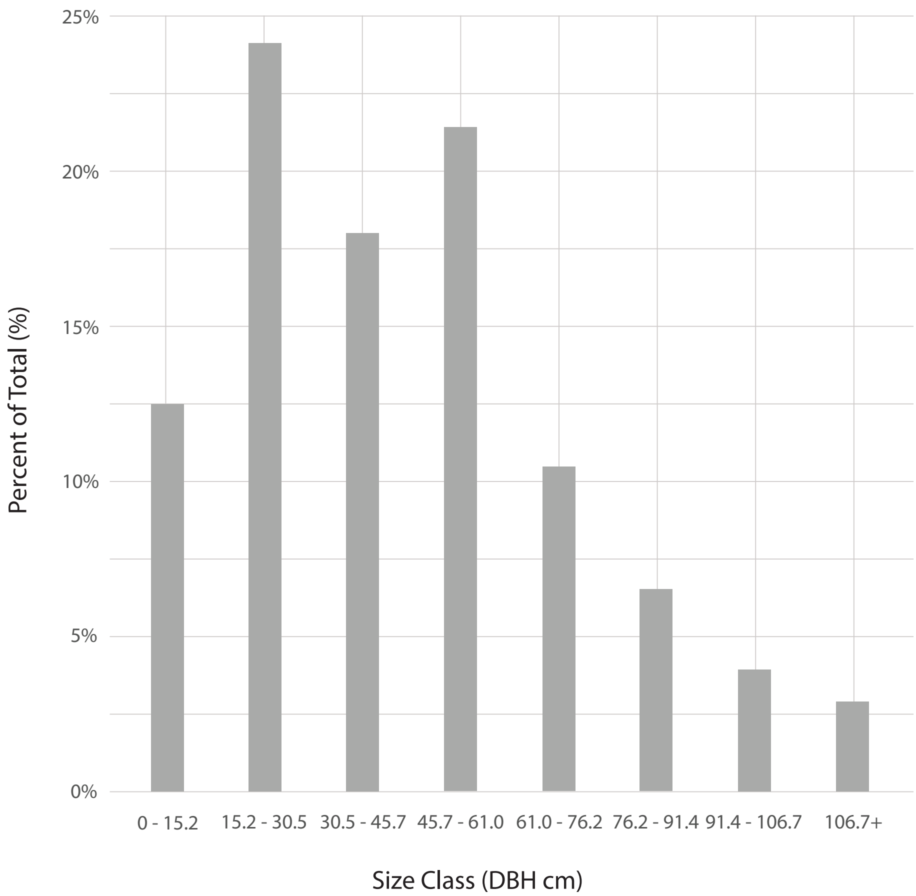

Figure 3. The relative size class distribution of urban trees in this sample.

the distributions of Norway maple (*A. platanoides)*, sugar maple (*A. saccharum)*, and red maple (*A. rubrum)*, the top 3 most prevalent tree species, reveal humps in the midsized DBH classes (Appendix Figure S1); the top 2 most prevalent genera (*Acer* spp. *and Quercus* spp*.)* and families (*Aceraceae* and *Fagaceae)* also are clustered at midsized age classes (Appendix Figure S2).

Diversity and Abundance Patterns Between Regions

Species, Genus, Family Composition

Across the 22 cities and towns of Eastern Massachusetts, a total of 104 urban tree species representing 54 genera and 26 families were found, compared to the 21 cities and towns of Western Massachusetts, where a total of 86 species representing 46 genera and 27 families were found (Appendix Tables S7-S12).

In Eastern Massachusetts, the most abundant species ranged between 1.5% and 13.6% (weighted mean), and Norway maple (*A. platanoides*; weighted mean = 13.6%) was the most common and exceeded Santamour's 10% rule. The urban trees of Western Massachusetts had a wider range of species abundance, between 0.8% and 20.9% (weighted mean), and unlike Eastern Massachusetts, sugar maple (*A. saccharum*; weighted mean 20.9%) and red maple *(A. rubrum*; weighted mean 11.4%) were most abundant and exceeded Santamour's 10% rule for species.

The most abundant genus in both Eastern and Western Massachusetts was maple (*Acer* spp.) and exceeded Santamour's 20% rule for genera in both regions (weighted mean = 28.3% and 49.1%, respectively). While the most abundant urban tree family in both Eastern and Western Massachusetts was also maple (*Aceraceae),* it only exceeded Santamour's 30% rule in Western Massachusetts (weighted mean = 28.3% and 49.1%, respectively).

Relative Size Class Distribution

Trees inventoried in Western Massachusetts (mean 50.61 cm, SD 30.59 cm) were determined to be significantly larger than those in Eastern Massachusetts (mean 41.12 cm, SD 25.76 cm)($F(1, 4360) = 123.30$, $P < .001$). *Acer rubrum* in Eastern Massachusetts was, on average, smaller (mean 35.1 cm, SD 23.9 cm), while those in Western Massachusetts were found to be significantly larger (mean 44.7 cm, SD 28.2 cm) ($F(1, 397) = 12.31$, $P < .001$) and were mostly located within the 45.7-cm to 61.0-cm size class. Other species more prevalent in Western Massachusetts were also on average larger than the same species in Eastern Massachusetts, including *Pinus strobus* (mean 51.8 cm, SD 22.6 cm and mean 43.4 cm, SD 22.6 cm, respectively)($F(1, 262) = 8.62$, $P = 0.004$) and *Quercus rubra* (mean 65 cm, SD 24.9 cm and mean 50.5 cm, SD 20.8 cm, respectively)($F(1, 208) = 19.91$, $P < .001$). Of the most prevalent genera and families, Western Massachusetts was determined to have significantly larger *Acer* ($F(1, 1671) = 52.90$, $P < .001$); *Pinus* ($F(1, 364) = 18.84$, $P < .001$)*; Aceraceae* ($F(1, 1671) = 52.90$, $P < .001$); and *Pinaceae* ($F(1, 560) = 5.57$, $P < .001$) compared to Eastern Massachusetts (see Appendix Tables S13-S18 and Appendix Figures S4-S9).

Comparison to Other Published Assessments

Lastly, results were assessed for compatibility and alignment between undergraduate university student data collection and other formal assessments of Massachusetts urban tree taxonomic diversity, abundance, and size class distributions, including municipal street tree inventories (Cowett and Bassuk 2020) and a baseline inventory and monitoring assessment (Cumming et al. 2006)(Table 2).

Overall, findings from this undergraduate student initiative largely align with conclusions from previous studies. In present and past studies, *A. platanoides* is consistently most abundant in Massachusetts followed by *A. rubrum*; at the level of genera, *Acer* spp. is also most dominant. The presence of oaks (*Quercus* spp.) as the second most prevalent genus is also consistent between this study and previous

Table 2. Summary of the data comparison between the present study, Cowett and Bassuk (2020), and Cumming et al. (2006).

Pattern of interest	Previous finding	Current finding	Explanation for discrepancy/ difference
Species of highest prevalence	Dominance of *Acer platanoides* and *Acer* spp. in statewide urban tree species and genus composition (Cumming et al. 2006; Cowett and Bassuk 2020)	Dominance of *Acer platanoides* and *Acer* spp. in statewide urban tree species and genus composition	Consistent with findings from past research in Massachusetts, as well as nearby states (CT, NY, NJ, PA)
Second most prevalent species	*Acer rubrum* was the second most prevalent urban tree species and *Quercus* spp. was the second most prevalent urban tree genus (Cumming et al. 2006; Cowett and Bassuk 2020)	*Acer saccharum* and *Acer rubrum* were the second most prevalent urban tree species and *Quercus* spp. was the second most prevalent urban tree genus	Consistent with findings from past research in Massachusetts (where *Acer saccharum* ranked third most abundant)
	The second most abundant species and genera (*Acer rubrum* and *Quercus* spp., respectively) were slightly lower in Cowett and Bassuk (2020) than in Cumming et al. (2006)	The prevalence of the second most abundant species and genera (*Acer rubrum* and *Quercus* spp., respectively) more closely matched Cowett and Bassuk (2020) than Cumming et al. (2006)	May indicate differences in sampling methodology and data collection, or may represent structural change and future population dynamics over time
Size class distribution	Most *Acer platanoides* and *Acer* spp. fall within smaller DBH classes (Cumming et al. 2006; Cowett and Bassuk 2020)	Most *Acer platanoides* and *Acer* spp. fall within midsized DBH classes	Young/small *Acer platanoides* and *Acer* spp. are less prevalent
	In the smallest DBH class (0 to 15.2 cm [0 to 6 in]), *Acer rubrum*, *Pyrus calleryana*, and *Malus* spp. are the first, second, and third most prevalent urban tree species (Cowett and Bassuk 2020)	In eastern Massachusetts only, *Betula lenta* far exceeds others as the most prevalent species in smallest DBH class (0 to 15.2 cm [0 to 6 in]), followed by *Acer rubrum* and *Pyrus calleryana*	May indicate new population dynamics in specific regions of the state

publications. *Pinaceae,* as one of the most common tree families, is consistent between the present study and previous reports but has interesting species-level differentiation. For example, Cumming et al. (2006) highlight the prevalence of pitch pine (*Pinus rigida*), while this study identifies the prevalence of eastern white pine (*P. strobus)* across both regions of the state.

Across taxa, the trees of this study are consistently larger in size than those of Cowett and Bassuk (2020) and Cumming et al. (2006). As the most abundant taxa are increasing, the present study identifies an increase in new, younger, ornamental species (e.g., *Betula lenta*) that may potentially signal a shift in urban forest composition over the long-term and/or anomalies based on nursery stock availability.

Unlike previous assessments, these findings show a regional difference between disease and insect pest-prone taxa across the state, including the prevalence of white ash (*Fraxinus americana)* and eastern hemlock *(Tsuga canadensis)* in Western Massachusetts and the prevalence of the now invasive Callery pear (*Pyrus calleryana*) in Eastern Massachusetts (Appendix Tables S7-S8)(Young 2023). Additionally, this study found trees in Western Massachusetts to be significantly larger in DBH but with less species- and genus-level diversity than trees in Eastern Massachusetts.

DISCUSSION

As demonstrated by the findings in this undergraduate-led data collection initiative, American LGUs and the Cooperative Extension system are uniquely positioned to leverage and collaborate with undergraduate students in environmental monitoring and formal research. Systematic methodologies exist to inventory and monitor urban trees over time (Roman et al. 2020) and there is an expansive need to survey, record, and collect consistent data with standardized methods in urban and community forestry (Morgenroth and Östberg 2017).

We see the present undergraduate university student-led initiative from the University of Massachusetts as a complement to a model piloted at Cornell University, which connects skills-based training with larger data collection needs. In 2002, Cornell University piloted a program titled the Student Weekend Arborist Team (SWAT)(Cowett and Bassuk 2012). The SWAT program was designed specifically to meet the capacity needs of smaller, inadequately resourced communities that often lacked personnel, funding, and the baseline data needed to generate community forest management plans. Student participants were paid an $80 stipend for each day worked and also earned one academic credit to complete a half-day training session that included both classroom and hands-on instruction. The SWAT program has not only generated urban forest management-related capacity for underserved municipalities, but participating students also reported a greater confidence in their ability to identify trees, as well as to work as part of a team (Cowett and Bassuk 2012).

The formal involvement of undergraduate students in urban forestry and experience-based, service learning activities—like that demonstrated by the methodology of this study—has the potential to broaden engagement and to include greater numbers of historically marginalized groups in STEM degree programs. It may also help to focus the professional trajectory and long-term stewardship behaviors of students during the developmental stages of their career and more broadly support social and economic diversity in the urban and community forestry sector (Kuhns et al. 2004; Postles and Bartlett 2018; Westphal et al. 2022).

This study also highlights an important opportunity for urban forestry academic researchers and the broader communities of practice to learn more about student learning of technical arboriculture and urban forestry skillsets. While volunteer groups remain an important component of many urban forestry programs (e.g., Harper et al. 2018), sustaining a workforce requires informal and formal education opportunities for wage-earning professionals who are sometimes, though inconsistently, introduced to urban forestry and arboriculture during their undergraduate education (O'Herrin et al. 2018).

Undergraduate student learning may be explored through different modes of literacy evaluation, focusing on bioliteracy (the understanding and application of scientific topics), data literacy (understanding data collection, analysis, and visualization), and numeracy (understanding numeric measurements, scales, and units). Precedential studies in urban forestry education may be worth revisiting for new research undertakings; for example, McPherson (1984) found that 70% of industry professionals believe that undergraduate arboriculture and urban forestry students need to have at least 6 months of supervised field experience prior to entering the workforce, in spite of the varying skills expected of these separate professions (Table 3). Each of these skills represent different areas of knowledge learning outcomes from university courses and may be taught through different pedagogical strategies that optimize student learning—and the combinations and depth of research questions that consider the needs of different learners, differing student backgrounds, different teaching methods, and different topics could yield important information for the productivity of these industries and the well-being of individuals in the workforce.

In addition to student-related impacts, our findings also point to important natural resource management considerations collected via citizen or civic science. The dominance of the maple family, genus, and species in municipalities of the Northeastern US is not surprising (e.g., Ma et al. 2020), since maples have been a common replacement for urban elm trees (*Ulmus* spp.) following the introduction and proliferation of Dutch elm disease in previous decades (Cumming et al. 2006). This finding does, however, reinforce that the installation of new urban (nonmaple) trees may positively contribute to the diversity and resilience of tree populations within Massachusetts' municipalities (Elton et al. 2020), statewide management regions (Cumming et al. 2006), and multistate regions like the Northeastern US (Doroski et al. 2020). The abundance of white pine (*Pinus strobus*) is also of note as it is susceptible to both pest pressure and structural failure (Wyka et al. 2018; Mcintire et al. 2021), and efforts to diversify urban forests could include a broader palette of coniferous species (Clapp et al. 2014). Though Santamour's 10-20-30 rule is a widely recognized, simple metric through which to view urban forest diversity, many researchers continue to advocate more stringent or nuanced planting guidelines (Laćan and McBride 2008; Clapp et al. 2014; Ball and Tyo 2016). Advancing both understanding and potential inclusion

Table 3. Examples of skills taught across urban forestry and arboriculture classes based on 8 syllabi, with modern concepts and terms added in parentheses (McPherson 1984; Elmendorf et al. 2005). CODIT (Compartmentalization of Decay In Trees).

Examples of skills taught in urban forestry classes:		
• arboriculture	• shade tree commissions	• funding
• tree benefits and values	• tree (urban forest) management plans	• conflict resolution
• street and park (urban) tree inventory	• tree evaluation and removal	• public relations
• street (community) tree and other ordinances	• work planning and budgeting	• volunteer management
• land use planning and regulation	• utility forestry	• preserving trees during development
Examples of skills taught in arboriculture classes:		
• tree identification	• CODIT and hazard (risk) tree evaluation	• tree removal
• tree biology (anatomy)	• diagnosis	• chainsaw operations and safety
• plant selection and planting techniques	• tree appraisal	• cabling and bracing
• soils, fertilizing, and plant relations	• ropes, knots, and hitches	• lightning protection
• pruning young and mature trees	• tree climbing	• tree protection during development
• chipper and truck operations and safety	• safety	• transplanting larger trees

of other guidelines is an important urban forest management consideration.

Our results suggest that volunteer data collection efforts alongside trained, university undergraduate students have the potential to generate accurate results and to supplement a more intensive urban tree inventory protocol at minimal cost to the local community. Numerous scholars and urban forestry practitioners have identified and discussed the importance of performing an urban forest inventory at the community level (e.g., Fischer et al. 2007; Ma et al. 2020). Urban forest inventories are a common management and assessment gap, and in the absence of current urban tree-related data, urban foresters may be forced to make management decisions about their urban natural resources with substantial knowledge limitations (Harper et al. 2017). While national and state-wide funding may provide capacity to manage urban forest resources at the regional and statewide-level, budget limitations, personnel costs, and inflation have continued to adversely impact urban forest management and operations at the local level (Healy et al. 2023). This study also contributes to the utility of civic or citizen science for cataloging components of urban nature (Hawthorne et al. 2015; Duchesneau et al. 2021).

This study is not without limitations. Researchers have conducted detailed evaluations to assess student learning outcomes from civic engagement and service learning initiatives in natural resources. Carr et al. (2011) studied the geospatial student learning outcomes of undergraduate forestry and natural resource students, finding that geospatial learning was below intended outcomes and that the assessment informed curricula improvement. Thompson and Licklider (2011) found student-generated concepts maps, illustrating conceptual hierarchies and connections among course topics, to be an effective model of assessment in an undergraduate urban forestry class. Though the undergraduate student-led urban forest inventory initiative was not designed to evaluate student learning beyond successful completion of the tree inventory, it could be considered a contributory citizen science undertaking, by which data was collected using systematic protocols that allow a high degree of student agency; however, the present study did not investigate how participants utilize and experience and make meaning of their involvement (e.g., Diprose et al. 2022)—an ample arena for future research given the pressing need to broaden (Lass and Harper 2023) and diversify (Chhin and Dahle 2024) the urban forestry workforce and the opportunity to accelerate student appeal to urban forestry professions (O'Herrin et al. 2018). Additional student assessments from the urban forest inventory initiative would build understanding and further inform updates to course curriculum.

While data collected from the present study was qualitatively screened by the course instructor, previous studies from urban and community forestry citizen science literature have explicitly engaged in data quality assessment. Volunteer geographic information has, for example, used validated citizen science data (e.g., controlled and approved on the basis of evidence, expert judgment, or knowledge rules) to supplement tree inventories and enable the mapping of allergenic tree species abundance (Dujardin et al. 2022). Other urban forestry research has evaluated data quality errors between samples collected by experts and less experienced personnel, like volunteers (Bloniarz and Ryan 1996), field crews (Roman et al. 2017), and boy scouts (Hallett and Hallett 2018). Long-term monitoring and tree inspections have also been studied and developed with volunteers and citizen scientists in mind (e.g., Vogt and Fischer 2017; Roman et al. 2020). Findings have consistently revealed a moderate-high consensus between expert and less experienced personnel, especially if course-level determinations are acceptable. Similar assessments that formally examine the quality of data from the undergraduate student-led urban forest inventory initiative would inform assignment (and course-related) curriculum updates. Findings may also apply beyond the classroom and inform data collection and tree monitoring programs in other municipalities.

Considerations of the nonrandom sample of municipalities selected by the students is also a limitation of this study. Since multicity analyses are subject to the willingness of collaborative partners for data sharing, and the existence of recent inventory data, it is not uncommon to have a sampling bias in comparable urban forest inventory analyses (e.g., Cowett and Bassuk 2017; Koch et al. 2018; Love et al. 2022). In other words, the nonrandom sampling that occurred in our study is a widespread challenge in urban forestry research. In the context of a university course, an approach to overcome this limitation would be to randomly assign a municipality to each student.

It is important to consider that this undergraduate university student-led sample urban forest inventory is not designed to formally inform some of the more nuanced aspects of urban forest management potentially included in a more expansive, professional urban forest inventory report (Morgenroth and Östberg 2017). For instance, student-derived recommendations related to the inspection and mitigation of urban trees for risk (of failure) should be reviewed with a tree risk assessment qualified (TRAQ) arborist. This is a clear example as to how an undergraduate student researcher cannot replace a trained, skilled arborist, or a professionally conducted urban tree inventory.

Additionally, data collected via convenience sample is not without limitation, including bias, error, and validity. Though there is precedence of informing useful conclusions from data that has been derived from a convenience sample in the natural resources sector (Day 1994; Etikan et al. 2016; Lass and Harper 2023), other data collection protocols might also be considered. These may include deliberately randomized samples that would better statistically reflect the nature of the community's urban forest and sampling beyond current limitations (i.e., 100 trees) to include greater numbers of trees per community as well as the collection of more attributes. The incorporation of virtual data-collection methods with undergraduate students may also be worthy of further exploration.

CONCLUSIONS

Undergraduate student-led urban forest data collection efforts yielded findings that largely align with conclusions from previous literature in relation to statewide urban tree taxa abundance, diversity, and size class distributions. Management-relevant differences between species and genus-level diversity as well as disease and pest-prone taxa emerged, especially in subregions across the state. Key areas for future research might emphasize experimentation with approaches to data collection, formal assessment of student learning outcomes, and formal data quality validation. With an ever-increasing demand on local budgets and the continuous need for current urban tree-related data, the incorporation of trained undergraduate natural resource student volunteers into urban forest management practices—namely urban tree inventory efforts—may yield useful data that will inform conclusions and supplement more intensive urban tree inventory protocols at broader scales.

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Appendix.

Further comments on data used in this study.

Duplicate inventories between the same towns and those featuring inaccuracies were not included in this assessment; examples of inaccuracies included reports with misidentified trees or trees that were not measured correctly. After collating the reports, several additional steps were taken to organize the data. First, one report contained data for 387 unique trees, and the *sample* function (without replacement) in R Studio (R Foundation for Statistical Computing, Vienna, Austria) was used to randomly select 100 trees and match the sample sizes from other reports. Next, the genera and species names were standardized and coded by taxonomic level (family, genus, species) using the PLANTS Database (NRCS 2022). In cases when the species was unknown and only the genus and family could be coded, the abbreviation "spp." was inserted in place of the specific epithet to indicate that the value could not be determined and should be excluded from the aggregate count of species names.

Further comments on participating students.

The following description is provided to anecdotally characterize the undergraduate students responsible for data collection in this study; precise data about the students was beyond the scope of this study and presents an opportunity for future research.

The undergraduate students that gathered data for this study participated in 'Community Forestry' (NRC 310). This is a skills-based capstone course undertaken by upper class undergraduate students, largely from the BS in Natural Resource Conservation (NRC) major or related majors, who have participated in courses like field ecology, GIS, botany, or soil science. Urban Forestry & Arboriculture is an area of concentration for NRC undergraduate students.

Students of NRC 310 have commonly worked for commercial tree care companies or interned for a federal, state, or municipal natural resources agency (i.e., USDA Forest Service, state agencies like the Department of Conservation and Recreation, or local parks departments). Many students have also graduated from Massachusetts Agricultural Technical High Schools, where they participated in precollege coursework and obtained hands-on experience in urban forestry and arboriculture. Others have had experience operating specialized urban forestry and arboriculture equipment including chainsaws, chippers, hand-pruners, and diameter-tapes, as well as performing hands-on tasks like pruning and tree identification.

Some NRC 310 students may be limited to course-related experiences that include plant and soil sampling, using GPS units, or obtaining field measurements. To address this knowledge gap, early in the semester students are divided into groups and assigned team captains that are individuals with extensive experience in urban forestry/arboriculture; in these groups they practice obtaining tree measurements and identification as part of the course. The final project from which data for this study was collected is called "the urban forest inventory and management plan" and is central to the course experience. To carry out this assignment, students develop the ability to successfully identify trees, use specialized tools, and systematically record and store data independently and alongside their peers over the course of the semester.

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Supplemental tables and figures.

Table S1. The relative abundance of the 10 most common species of urban trees in this sample.

Scientific name	Common name	Total (number, percent)	Weighted mean (percent)	Standard error of mean
Acer platanoides	Norway maple	637, 14.6%	11.5%	3.0
Acer saccharum	Sugar maple	544, 12.5%	8.4%	3.8
Acer rubrum	Red maple	399, 9.1%	8.3%	1.4
Pinus strobus	Eastern white pine	264, 6.1%	3.9%	1.8
Quercus rubra	Northern red oak	210, 4.8%	3.1%	1.4
Pyrus calleryana	Callery pear	172, 3.9%	1.8%	2.4
Quercus palustris	Pin oak	128, 2.9%	1.4%	1.8
Gleditsia triacanthos	Honeylocust	115, 2.6%	1.0%	2.1
Quercus velutina	Black oak	109, 2.5%	1.0%	1.6
Betula lenta	Sweet or black birch	109, 2.5%	0.3%	15.2
	Cumulative abundance	2687, 61.5%		

Table S2. The relative abundance of the 10 most common genera of urban trees in this sample.

Scientific name	Common name	Total (number, percent)	Weighted mean (percent)	Standard error of mean
Acer	Maple	1,673, 38.4%	38.4%	3.4
Quercus	Oak	592, 13.6%	12.6%	2.2
Pinus	Pine	366, 8.4%	5.9%	1.9
Betula	Birch	178, 4.1%	2.1%	4.1
Pyrus	Pear	172, 3.9%	1.8%	2.4
Picea	Spruce	134, 3.1%	1.9%	0.8
Tilia	Linden	134, 3.1%	1.6%	1.4
Gleditsia	Locust	115, 2.6%	1.0%	2.1
Fraxinus	Ash	112, 2.6%	1.3%	0.9
Prunus	Flowering fruit	102, 2.4%	1.5%	1.0
	Cumulative abundance	3,578, 82.2%		

Table S3. The relative abundance of the 10 most common families of urban trees in this sample.

Scientific name	Common name	Total (number, percent)	Weighted mean (percent)	Standard error of mean
Aceraceae	Maple	1,673, 38.4%	38.4%	3.4
Fagaceae	Oak/beech	625, 14.3%	13.7%	2.2
Pinaceae	Pine	561, 12.9%	10.5%	1.9
Rosaceae	Rose	385, 8.8%	7.8%	1.9
Betulaceae	Birch	203, 4.7%	2.6%	3.9
Fabaceae	Pea	154, 3.5%	1.9%	1.7
Tiliaceae	Jute	134, 3.1%	1.6%	1.4
Oleaceae	Olive	114, 2.6%	1.4%	0.8
Cupressaceae	Cypress	107, 2.5%	1.0%	1.6
Ulmaceae	Elm	93, 2.1%	0.9%	1.1
	Cumulative abundance	1,190, 92.9%		

Table S4. Summary of the 10 most common species of urban trees by DBH. DBH (diameter at breast height).

Scientific name	Common name	Mean (cm)	Standard deviation (cm)	Mean (in)	Standard deviation (in)
Acer platanoides	Norway maple	49.8	19.3	19.6	7.6
Acer saccharum	Sugar maple	62.2	31.2	24.5	12.3
Acer rubrum	Red maple	41.1	27.2	16.2	10.7
Pinus strobus	Eastern white pine	48.3	22.9	19.0	9.0
Quercus rubra	Northern red oak	58.9	24.4	23.2	9.6
Pyrus calleryana	Callery pear	26.4	13.7	10.4	5.4
Quercus palustris	Pin oak	57.7	41.9	22.7	16.5
Gleditsia triacanthos	Honeylocust	34.7	18.8	13.7	7.4
Quercus velutina	Black oak	51.1	26.9	20.1	10.6
Betula lenta	Sweet or black birch	18.8	5.8	7.4	2.3

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Table S5. Summary of the 10 most common genera of urban trees by DBH. DBH (diameter at breast height).

Scientific name	Common name	Mean (cm)	Standard deviation (cm)	Mean (in)	Standard deviation (in)
Acer	Maple	52.3	27.9	20.6	11.0
Quercus	Oak	57.2	30.5	22.5	12.0
Pinus	Pine	45.9	21.6	18.1	8.5
Betula	Birch	20.8	10.2	8.2	4.0
Pyrus	Pear	26.4	13.7	10.4	5.4
Picea	Spruce	52.3	24.9	20.6	9.8
Tilia	Linden	43.2	20.3	17.0	8.0
Gleditsia	Locust	34.8	18.8	13.7	7.4
Fraxinus	Ash	51.8	26.9	20.4	10.6
Prunus	Flowering fruit	36.1	25.4	14.2	10.0

Table S6. Summary of the 10 most common families of urban trees by DBH. DBH (diameter at breast height).

Scientific name	Common name	Mean (cm)	Standard deviation (cm)	Mean (in)	Standard deviation (in)
Aceraceae	Maple	52.3	27.9	20.6	11.0
Fagaceae	Oak/beech	57.9	32.3	22.8	12.7
Pinaceae	Pine	47.8	22.9	18.8	9.0
Rosaceae	Rose	26.9	18.5	10.6	7.3
Betulaceae	Birch	19.8	10.2	7.8	4.0
Fabaceae	Pea	34.5	20.3	13.6	8.0
Tiliaceae	Jute	43.2	20.3	17.0	8.0
Oleaceae	Olive	51.3	26.9	20.2	10.6
Cupressaceae	Cypress	27.7	25.4	10.9	10.0
Ulmaceae	Elm	37.8	26.4	14.9	10.4

Table S7. The relative abundance of the 10 most common species of urban trees in the Eastern Massachusetts sample.

Scientific name	Common name	Total (number, percent)	Weighted mean (percent)	Standard error of mean
Acer platanoides	Norway maple	397, 17.6%	13.6%	5.4
Acer rubrum	Red maple	147 6.5%	5.6%	1.4
Pyrus calleryana	Callery pear	138, 6.1%	3.1%	3.8
Pinus strobus	Eastern white pine	110, 4.9%	2.7%	3.0
Gleditsia triacanthos	Honeylocust	107, 4.7%	2.6%	2.6
Betula lenta	Sweet or black birch	104, 4.6%	0.6%	29.7
Quercus palustris	Pin oak	94, 4.2%	1.9%	3.5
Quercus rubra	Northern red oak	87, 3.9%	2.5%	1.5
Tilia cordata	Littleleaf linden	80, 3.5%	1.6%	3.0
Quercus velutina	Black oak	72, 3.2%	1.5%	2.1
	Cumulative abundance	1,336, 59.2%		

Table S8. The relative abundance of the 10 most common species of urban trees in the Western Massachusetts sample.

Scientific name	Common name	Total (number, percent)	Weighted mean (percent)	Standard error of mean
Acer saccharum	Sugar maple	488, 23.1%	20.9%	5.1
Acer rubrum	Red maple	252, 12.0%	11.4%	2.3
Acer platanoides	Norway maple	240, 11.4%	9.2%	2.2
Pinus strobus	Eastern white pine	154, 7.3%	2.6%	2.2
Quercus rubra	Northern red oak	123, 5.8%	3.9%	2.4
Picea abies	Norway spruce	62, 2.9%	1.8%	1.1
Quercus alba	White oak	51, 2.4%	1.2%	2.2
Fraxinus americana	White ash	48, 2.3%	0.9%	1.6
Tsuga canadensis	Eastern hemlock	39, 1.9%	0.9%	0.7
Malus spp.	Apple spp.	37, 1.8%	0.8%	1.2
	Cumulative abundance	1,494, 70.9%		

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Table S9. The relative abundance of the 10 most common genera of urban trees in the Eastern Massachusetts sample.

Scientific name	Common name	Total (number, percent)	Weighted mean (percent)	Standard error of mean
Acer	Maple	639, 28.3%	28.3%	4.6
Quercus	Oak	339, 15.0%	13.7%	2.9
Pinus	Pine	174, 7.7%	4.9%	3.0
Betula	Birch	140, 6.2%	3.1%	8.2
Pyrus	Pear	138, 6.1%	3.1%	3.8
Gleditsia	Locust	107, 4.7%	2.6%	2.6
Tilia	Linden	104, 4.6%	2.7%	2.3
Prunus	Flowering fruit	79, 3.5%	2.2%	1.6
Platanus	Plane	71, 3.1%	1.9%	1.0
Picea	Spruce	48, 2.1%	1.0%	1.1
	Cumulative abundance	1,839, 81.3%		

Table S10. The relative abundance of the 10 most common genera of urban trees in the Western Massachusetts sample.

Scientific name	Common name	Total (number, percent)	Weighted mean (percent)	Standard error of mean
Acer	Maple	1,034, 49.1%	49.1%	4.1
Quercus	Oak	253, 12.0%	11.4%	3.3
Pinus	Pine	192, 9.1%	6.9%	2.4
Picea	Spruce	86, 4.1%	3.3%	1.2
Fraxinus	Ash	74, 3.5%	2.0%	1.4
Malus	Apple	45, 2.1%	1.0%	2.0
Tsuga	Hemlock	39, 1.9%	0.9%	0.7
Betula	Birch	38, 1.8%	0.9%	0.9
Thuja	Cypress	34, 1.6%	0.3%	4.2
Pyrus	Pear	34, 1.6%	0.7%	1.2
	Cumulative abundance	1,829, 86.8%		

Table S11. The relative abundance of the 10 most common families of urban trees in the Eastern Massachusetts sample.

Scientific name	Common name	Total (number, percent)	Weighted mean (percent)	Standard error of mean
Aceraceae	Maple	639, 28.3%	28.3%	4.6
Fagaceae	Oak/beech	359, 15.9%	15.2%	3.0
Rosaceae	Rose	265, 11.8%	10.2%	3.3
Pinaceae	Pine	238, 10.6%	7.2%	3.3
Betulaceae	Birch	146, 6.5%	3.8%	7.0
Fabaceae	Pea	141, 6.3%	4.3%	2.3
Tiliaceae	Jute	104, 4.6%	2.7%	2.3
Platanaceae	Plane	71, 3.1%	1.9%	1.0
Ulmaceae	Elm	64, 2.8%	1.2%	1.9
Cupressaceae	Cypress	48, 2.1%	0.8%	2.1
	Cumulative abundance	2,075, 92.0%		

Table S12.The relative abundance of the 10 most common families of urban trees in the Western Massachusetts sample.

Scientific name	Common name	Total (number, percent)	Weighted mean (percent)	Standard error of mean
Aceraceae	Maple	1,034, 49.1%	49.1%	4.1
Pinaceae	Pine	324, 15.4%	14.6%	2.3
Fagaceae	Oak/beech	266, 12.6%	12.0%	3.3
Rosaceae	Rose	120, 5.7%	5.2%	1.6
Oleaceae	Olive	74, 3.5%	2.0%	1.4
Cupressaceae	Cypress	59, 2.8%	1.2%	2.6
Betulaceae	Birch	57, 2.7%	1.4%	1.9
Tiliaceae	Jute	30, 1.4%	0.7%	0.8
Ulmaceae	Elm	28, 1.3%	0.6%	0.7
Juglandaceae	Walnut	25, 1.2%	0.3%	1.5
	Cumulative abundance	2,017, 95.7%		

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Table S13. Summary of the 10 most common species of urban trees in Eastern Massachusetts by DBH. DBH (diameter at breast height).

Scientific name	Common name	Mean (cm)	Standard deviation (cm)	Mean (in)	Standard deviation (in)
Acer platanoides	Norway maple	47.8	16.8	18.8	6.6
Acer rubrum	Red maple	35.1	23.9	13.8	9.4
Pyrus calleryana	Callery pear	29.5	12.4	11.6	4.9
Pinus strobus	Eastern white pine	43.4	22.6	17.1	8.9
Gleditsia triacanthos	Honeylocust	35.3	18.8	13.9	7.4
Betula lenta	Sweet or black birch	19.3	5.6	7.6	2.2
Quercus palustris	Pin oak	59.2	46.2	23.3	18.2
Quercus rubra	Northern red oak	50.5	20.8	19.9	8.2
Tilia cordata	Littleleaf linden	41.7	19.8	16.4	7.8
Quercus velutina	Black oak	51.1	26.9	20.1	10.6

Table S14. Summary of the 10 most common species of urban trees in Western Massachusetts by DBH. DBH (diameter at breast height).

Scientific name	Common name	Mean (cm)	Standard deviation (cm)	Mean (in)	Standard deviation (in)
Acer saccharum	Sugar maple	62.5	31.8	24.6	12.5
Acer rubrum	Red maple	44.7	28.2	17.6	11.1
Acer platanoides	Norway maple	52.6	22.9	20.7	9.0
Pinus strobus	Eastern white pine	51.8	22.6	20.4	8.9
Quercus rubra	Northern red oak	65.0	24.9	25.6	9.8
Picea abies	Norway spruce	60.7	25.7	23.9	10.1
Quercus alba	White oak	66.5	25.4	26.2	10.0
Fraxinus americana	White ash	26.9	49.8	10.6	19.6
Tsuga canadensis	Eastern hemlock	51.8	24.6	20.4	9.7
Malus spp.	Apple spp.	22.6	11.2	8.9	4.4

Table S15. Summary of the 10 most common genera of urban trees in Eastern Massachusetts by DBH. DBH (diameter at breast height).

Scientific name	Common name	Mean (cm)	Standard deviation (cm)	Mean (in)	Standard deviation (in)
Acer	Maple	46.2	21.6	18.2	8.5
Quercus	Oak	52.8	32.3	20.8	12.7
Pinus	Pine	40.9	20.3	16.1	8.0
Betula	Birch	20.8	8.9	8.2	3.5
Pyrus	Pear	29.5	12.4	11.6	4.9
Gleditsia	Locust	35.3	18.8	13.9	7.4
Tilia	Linden	45.5	20.1	17.9	7.9
Prunus	Flowering fruit	39.1	26.4	15.4	10.4
Platanus	Plane	44.5	29.5	17.5	11.6
Picea	Spruce	43.7	23.1	17.2	9.1

Table S16. Summary of the 10 most common genera of urban trees in Western Massachusetts by DBH. DBH (diameter at breast height).

Scientific name	Common name	Mean (cm)	Standard deviation (cm)	Mean (in)	Standard deviation (in)
Acer	Maple	56.1	30.5	22.1	12.0
Quercus	Oak	63.0	27.2	24.8	10.7
Pinus	Pine	50.5	21.6	19.9	8.5
Picea	Spruce	57.4	24.6	22.6	9.7
Fraxinus	Ash	48.8	24.9	19.2	9.8
Malus	Apple	22.1	11.0	8.7	4.3
Tsuga	Hemlock	51.8	24.6	20.4	9.7
Betula	Birch	20.3	14.5	8.0	5.7
Thuja	Cypress	20.1	21.8	7.9	8.6
Pyrus	Pear	14.0	10.9	5.5	4.3

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Table S17. Summary of the 10 most common families of urban trees in Eastern Massachusetts by DBH. DBH (diameter at breast height).

Scientific name	Common name	Mean (cm)	Standard deviation (cm)	Mean (in)	Standard deviation (in)
Aceraceae	Maple	46.2	21.6	18.2	8.5
Fagaceae	Oak/beech	53.3	33.0	21.0	13.0
Rosaceae	Rose	30.2	19.1	11.9	7.5
Pinaceae	Pine	41.1	21.1	16.2	8.3
Betulaceae	Birch	20.6	8.9	8.1	3.5
Fabaceae	Pea	35.3	20.6	13.9	8.1
Tiliaceae	Jute	45.5	20.1	17.9	7.9
Platanaceae	Plane	44.5	29.5	17.5	11.6
Ulmaceae	Elm	39.9	26.4	15.7	10.4
Cupressaceae	Cypress	32.8	22.6	12.9	8.9

Table S18. Summary of the 10 most common families of urban trees in Western Massachusetts by DBH. DBH (diameter at breast height).

Scientific name	Common name	Mean (cm)	Standard deviation (cm)	Mean (in)	Standard deviation (in)
Aceraceae	Maple	56.1	30.5	22.1	12.0
Pinaceae	Pine	52.3	23.1	20.6	9.1
Fagaceae	Oak/beech	63.8	30.2	25.1	11.9
Rosaceae	Rose	19.3	14.2	7.6	5.6
Oleaceae	Olive	48.8	24.9	19.2	9.8
Cupressaceae	Cypress	23.4	26.9	9.2	10.6
Betulaceae	Birch	17.5	12.7	6.9	5.0
Tiliaceae	Jute	34.8	19.3	13.7	7.6
Ulmaceae	Elm	34.5	26.2	13.6	10.3
Juglandaceae	Walnut	49.3	30.5	19.4	12.0

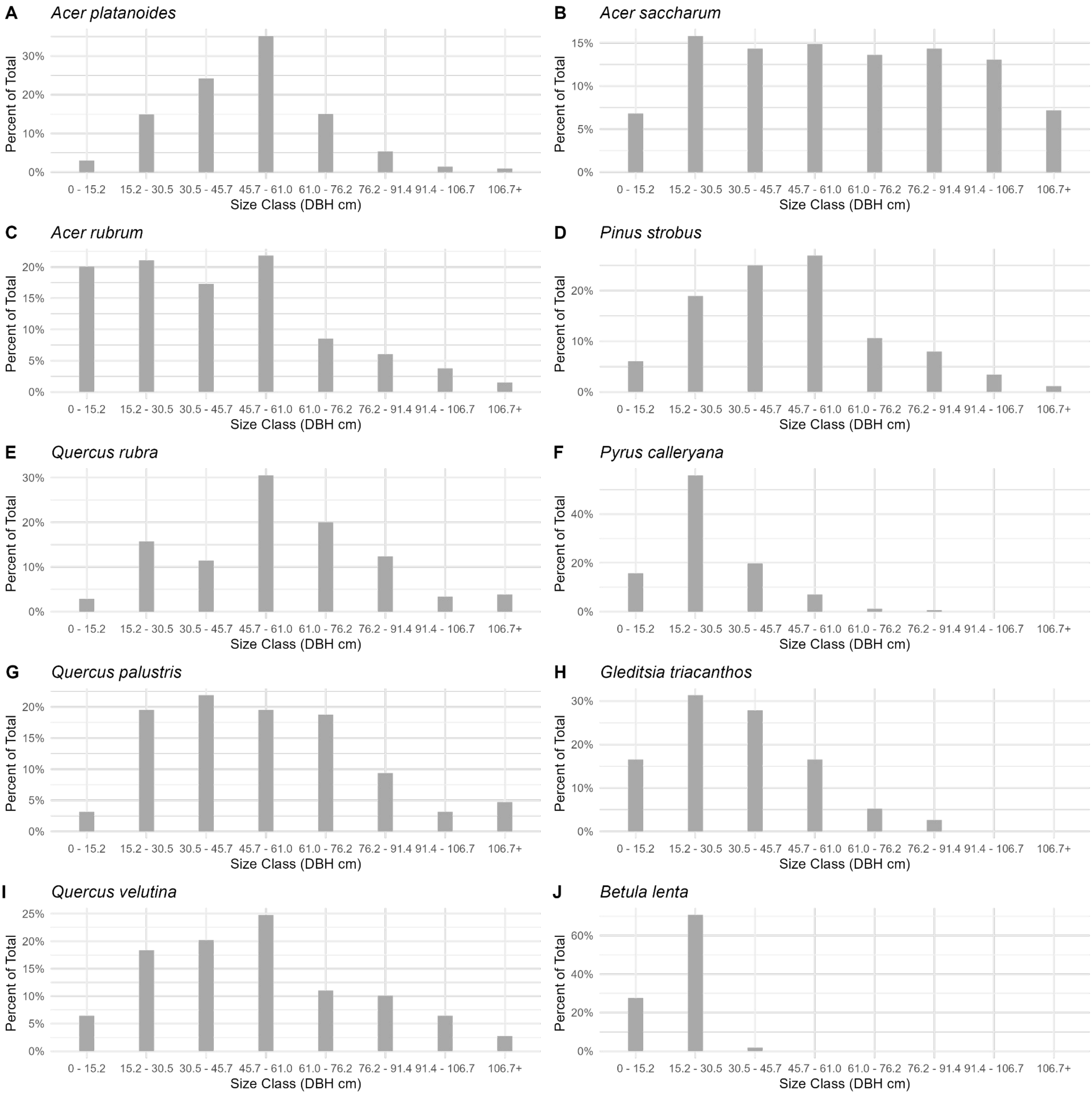

Figure S1. The relative size class distribution of the 10 most common species of urban trees in this sample.

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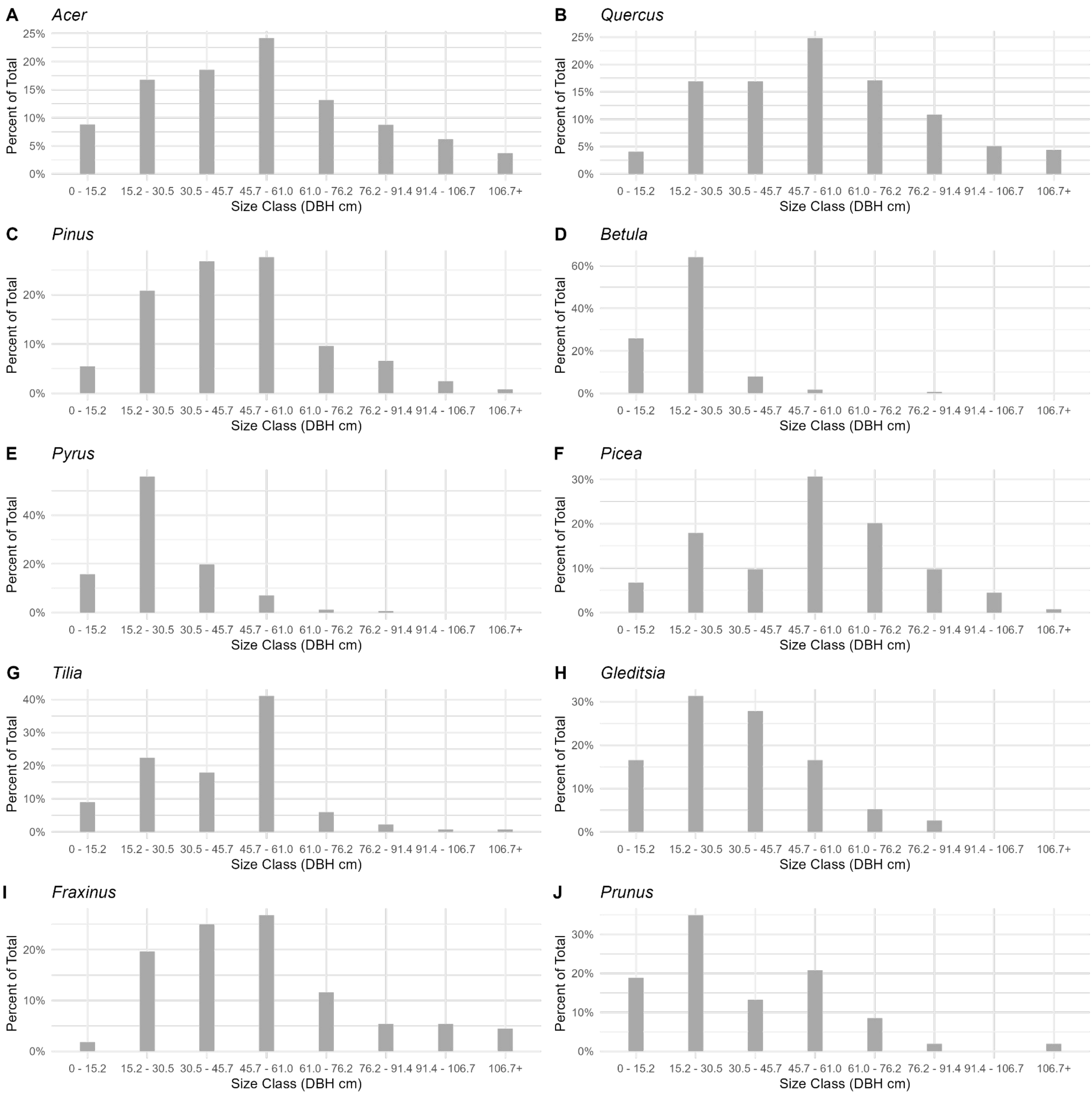

Figure S2. The relative size class distribution of the 10 most common genera of urban trees in this sample.

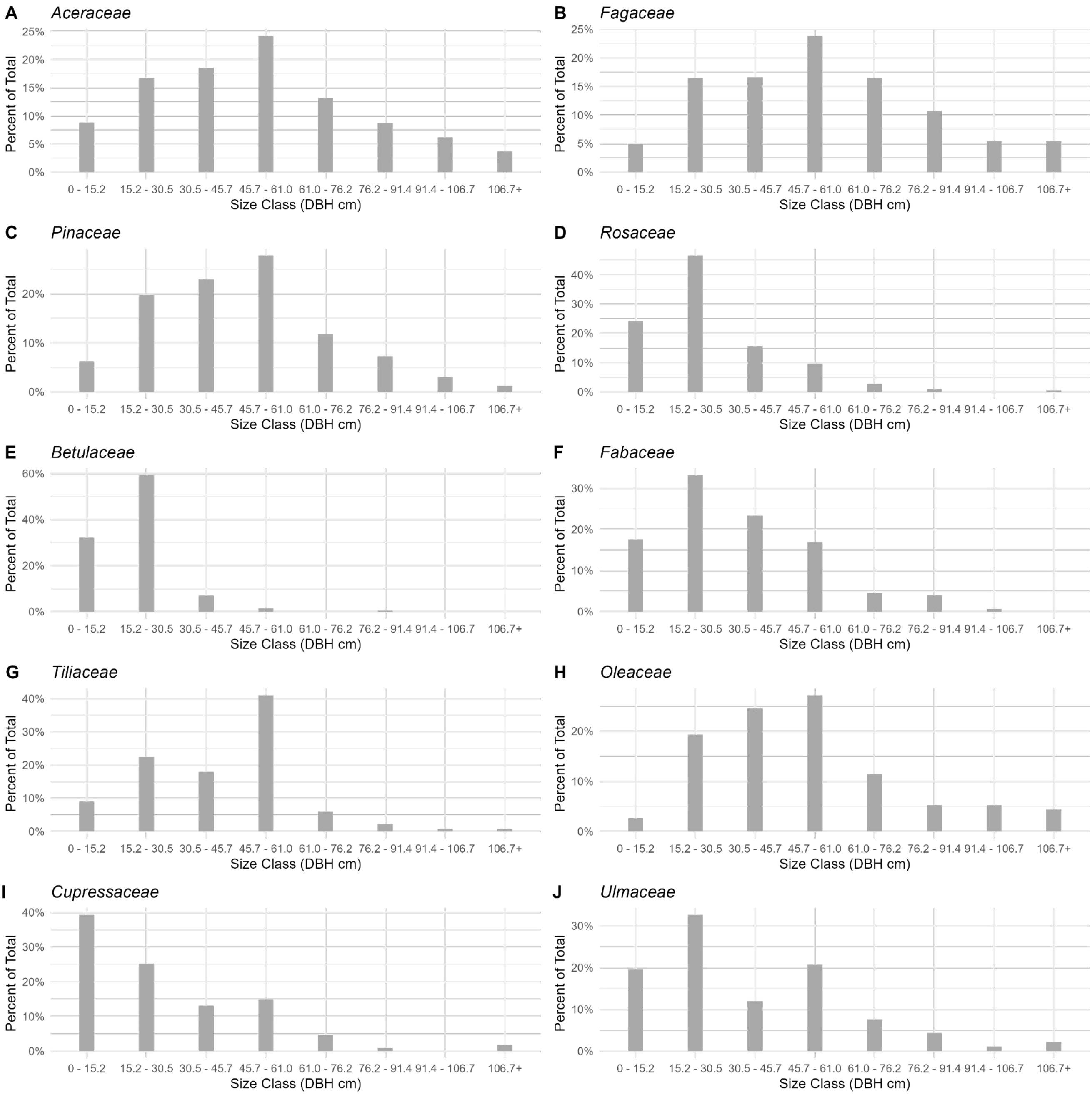

Figure S3. The relative size class distribution of the 10 most common families of urban trees in this sample.

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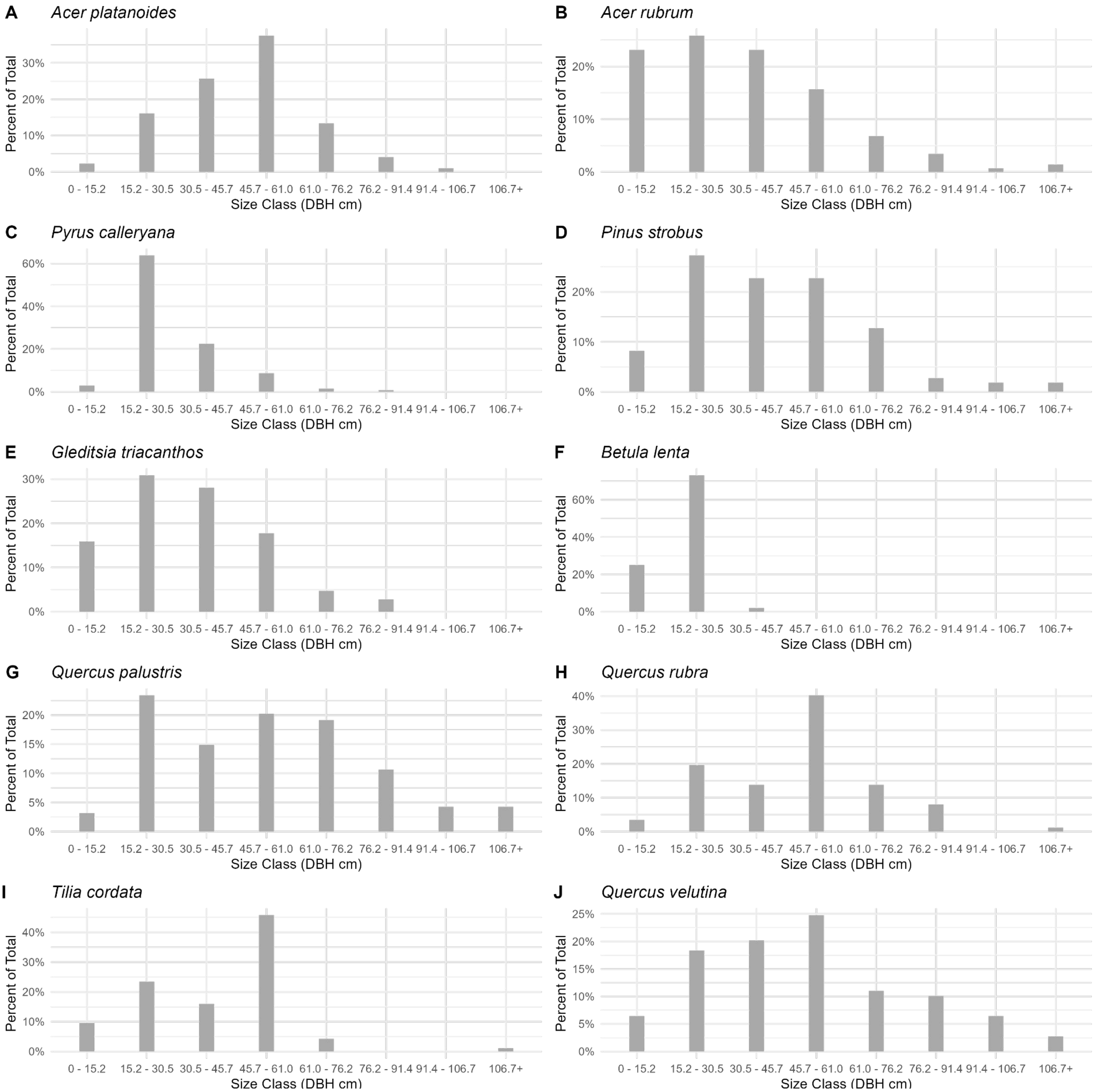

Figure S4. The relative size class distribution of the 10 most common species of urban trees in the Eastern Massachusetts sample.

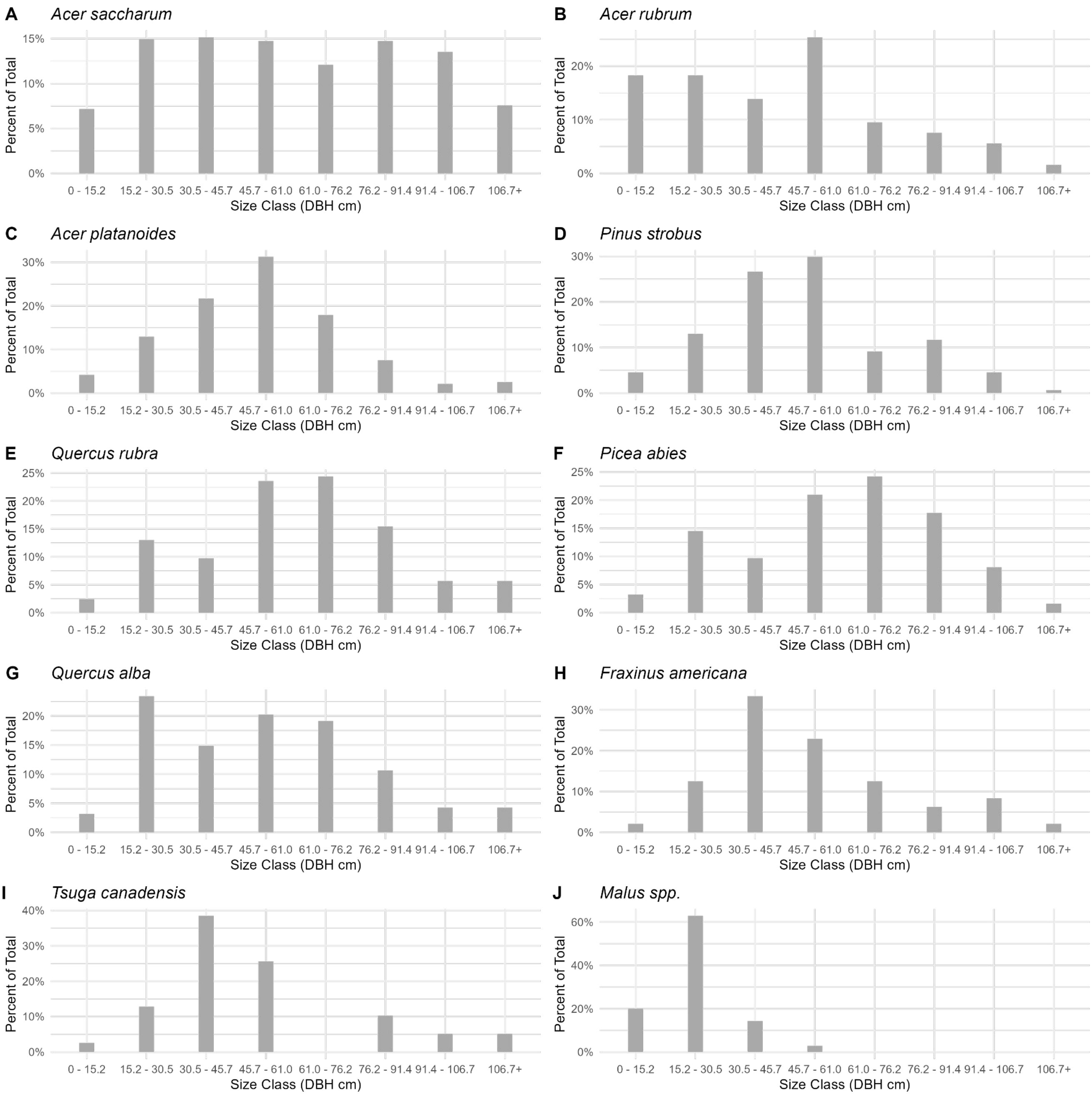

Figure S5. The relative size class distribution of the 10 most common species of urban trees in the Western Massachusetts sample.

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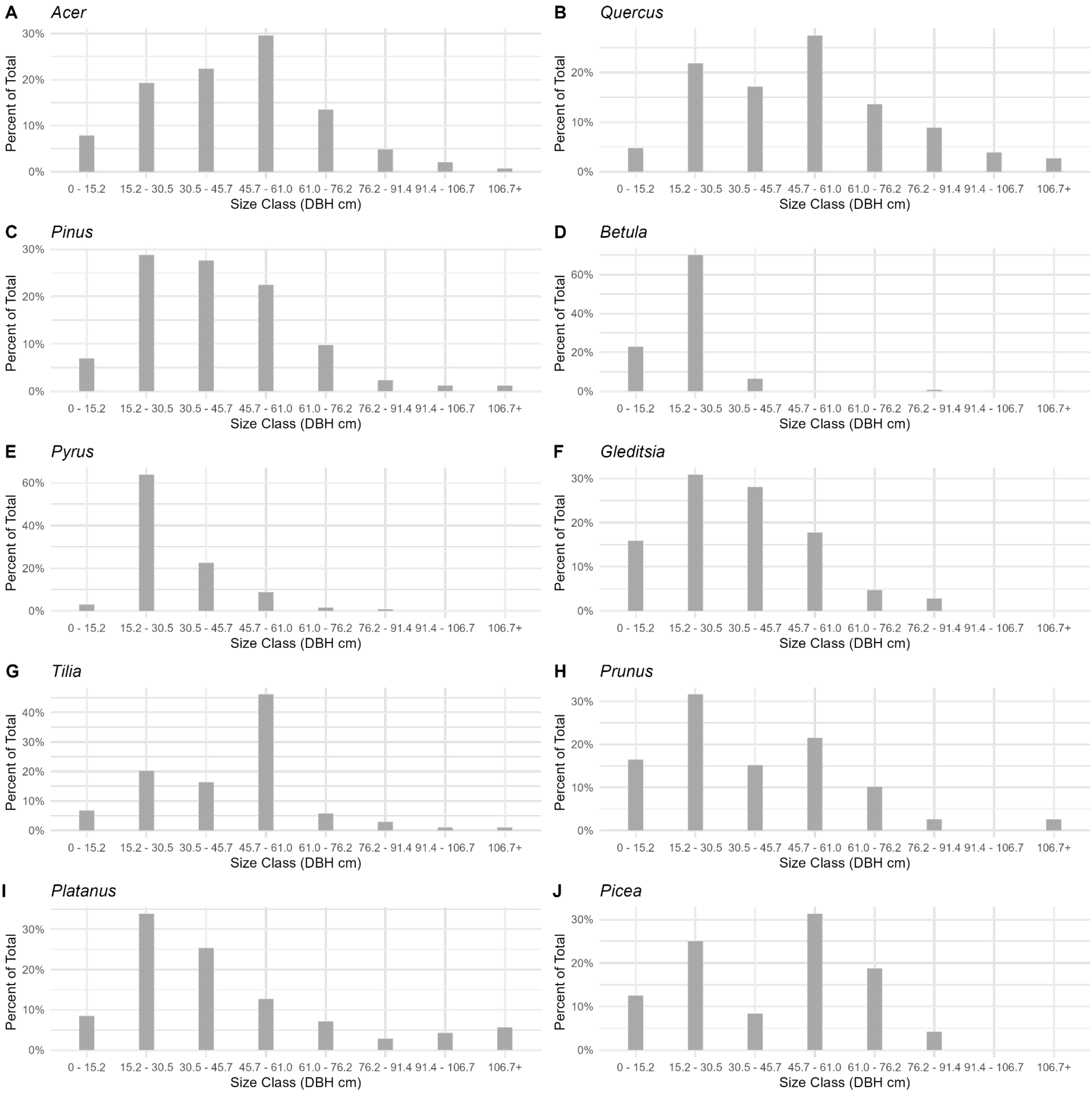

Figure S6. The relative size class distribution of the 10 most common genera of urban trees in the Eastern Massachusetts sample.

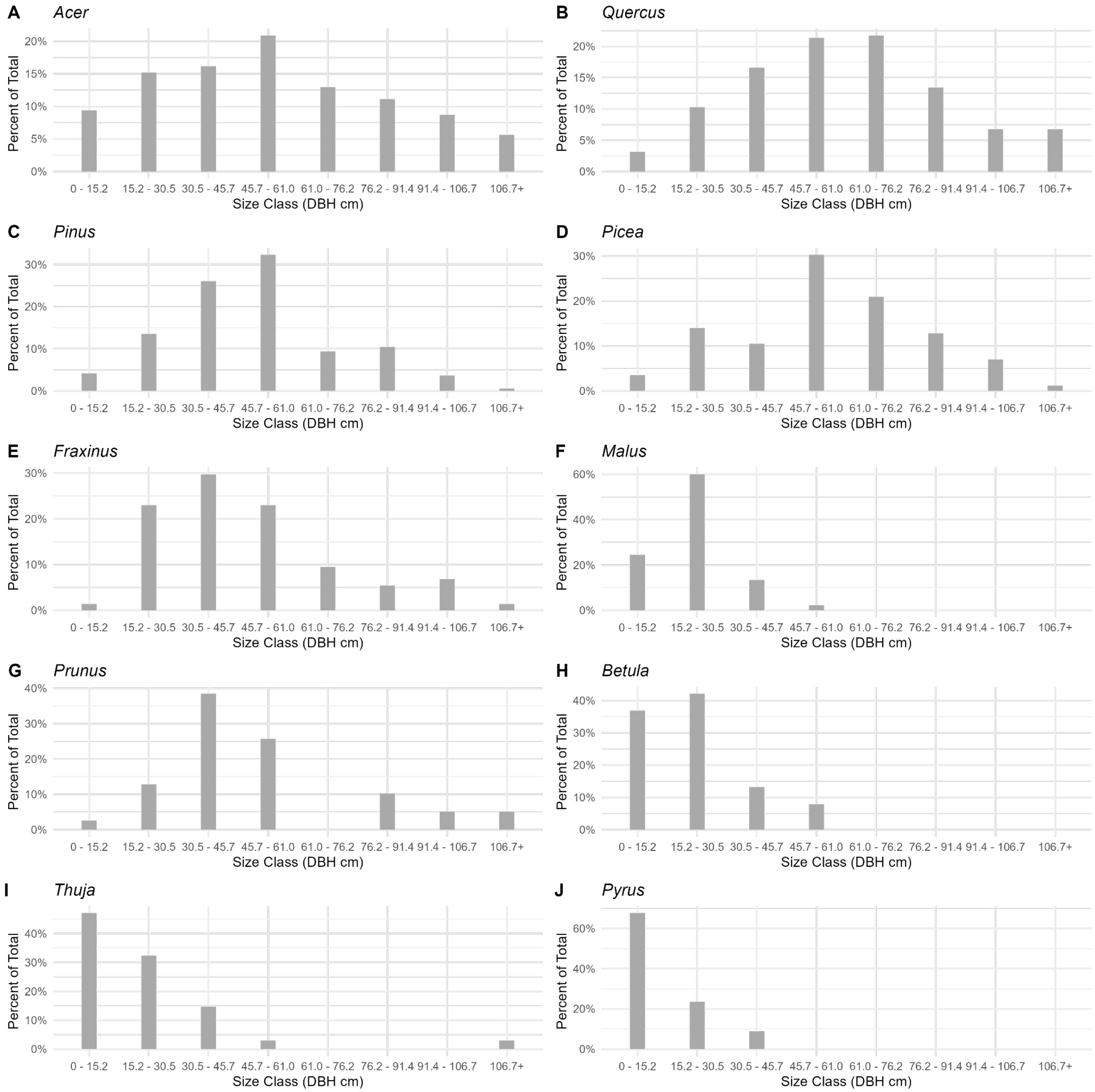

Figure S7. The relative size class distribution of the 10 most common genera of urban trees in the Western Massachusetts sample.

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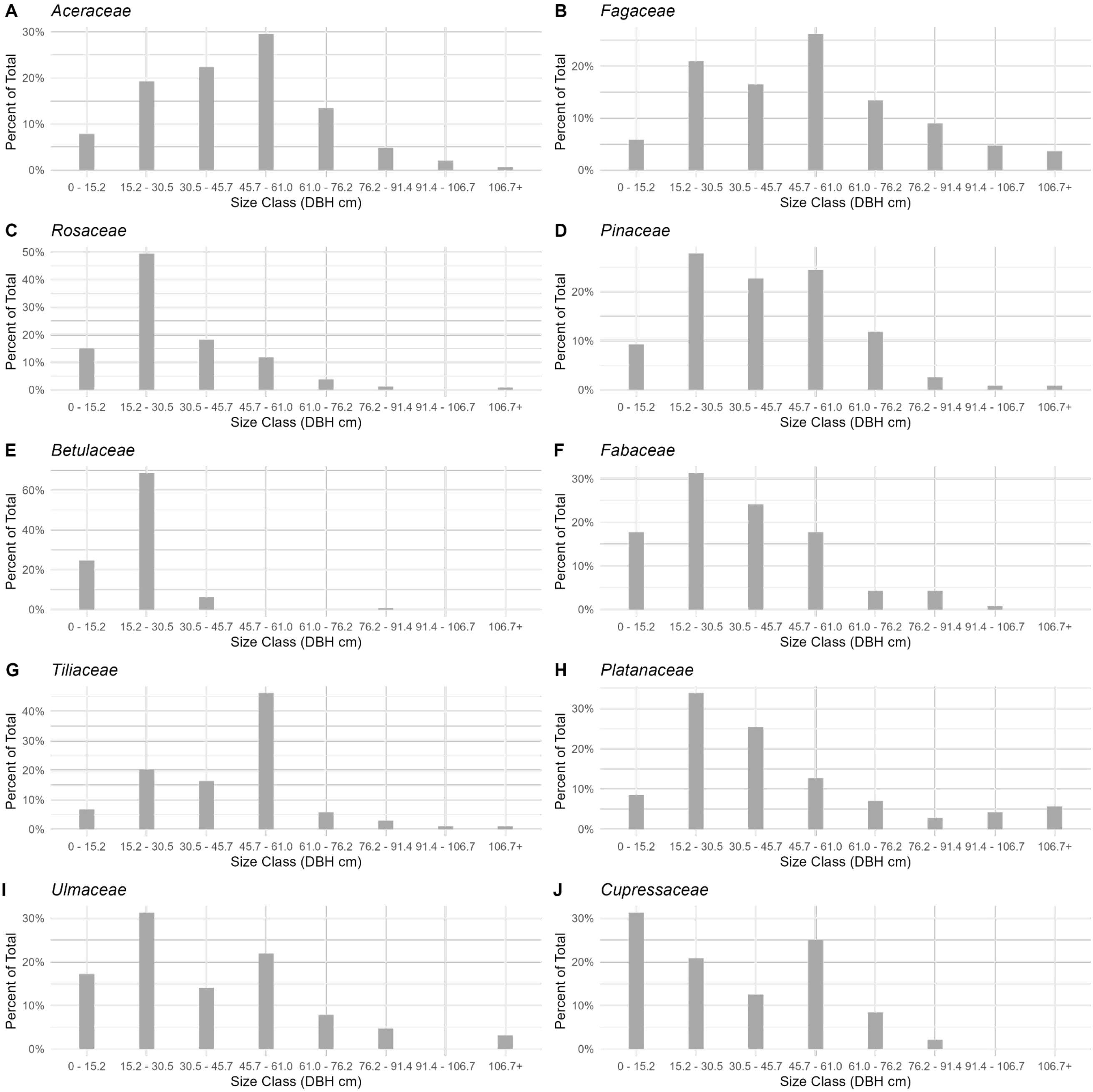

Figure S8. The relative size class distribution of the 10 most common families of urban trees in the Eastern Massachusetts sample.

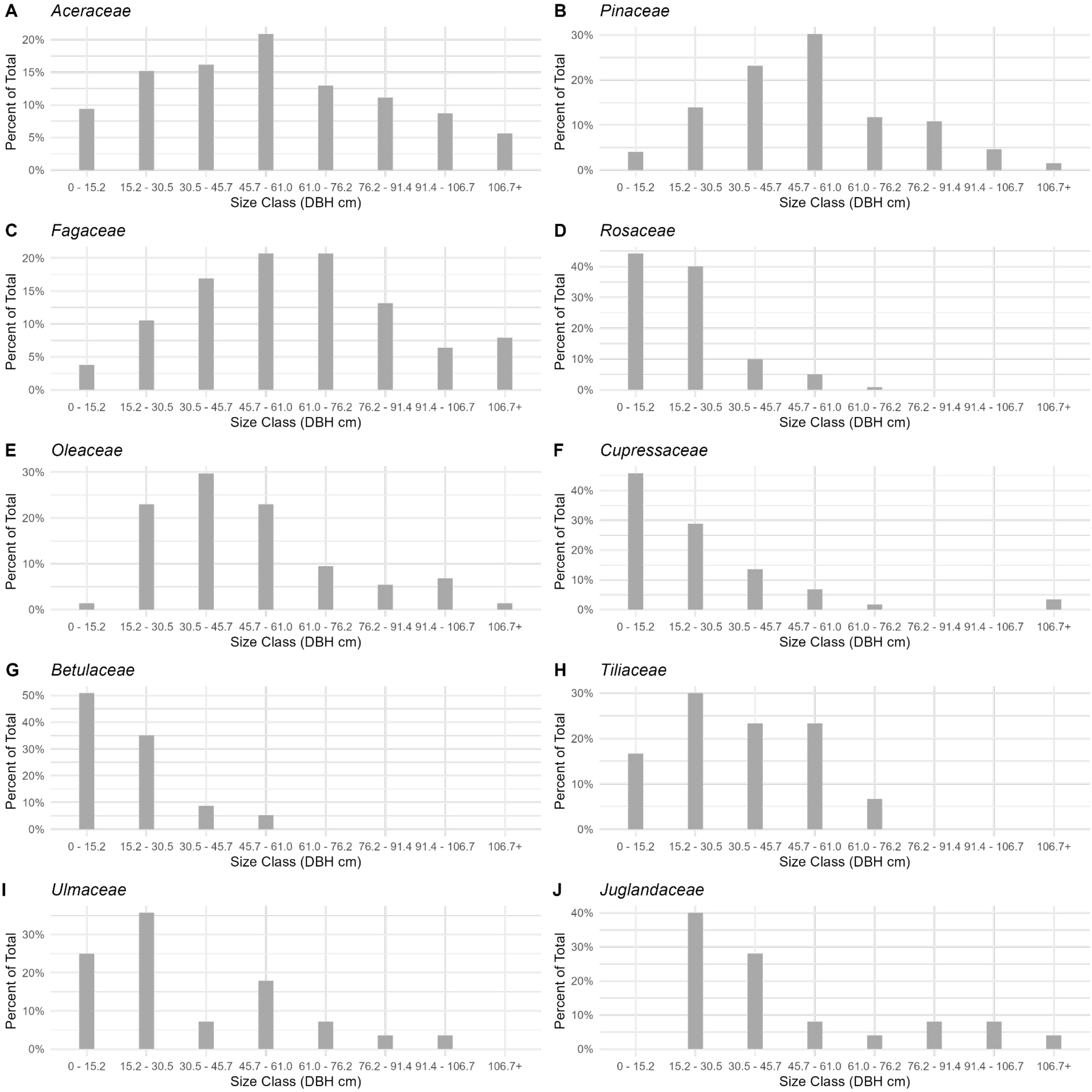

Figure S9. The relative size class distribution of the 10 most common families of urban trees in the Western Massachusetts sample.