



Taking Stock: The Current State of Urban Forestry Education at International Institutions of Higher Education

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Abstract. Background: Urban forestry has evolved over the past 50 years, growing into a distinct profession with expanding global initiatives and increasing funding. This paper examines the state of urban forestry education, analyzing current programs, competencies, and educational approaches. Methods: We conducted a Delphi survey with urban forestry educators. The survey, distributed to educators in multiple countries, gathered data on teaching contexts and competencies. We then collected, described, and analyzed case studies from a diverse range of programs. Results: Survey responses from 34 educators reveal diverse teaching backgrounds and subjects taught. The results show diverse competencies in areas such as urban forest management, environmental science, and community engagement. We also present 6 case studies showcasing innovative educational approaches, reflecting the field's potential for future development. The case studies highlight varied educational models, from massive open online courses (MOOC) to specialized degrees, showcasing different approaches to curriculum and delivery. Key findings include a wide range of teaching topics and competencies, reflecting both the interdisciplinary nature of urban forestry and emerging educational trends. Conclusions: This study examines the evolving landscape of urban forestry education. The discipline's diversity is evident in the broad range of topics covered, from arboriculture to urban planning to human health. Urban forestry emerges as a nimble, transdisciplinary discipline with deep roots in forestry. We highlight the need for a cohesive, well-defined curriculum to advance the profession and educational standards.

Keywords. Competencies; Curriculum; University; Urban Forestry.

INTRODUCTION

Urban forestry has evolved over the last half-century as a distinct profession with a substantial body of knowledge and practice (Ferrini et al. 2017; Hauer et al. 2017; O'Herrin et al. 2020). Urban forestry and urban greening initiatives around the world are expanding in response to critical challenges around climate change, biodiversity conservation, and public health. In 2023, the Biden-Harris administration announced over 1 billion USD in grants for increasing access to urban forests in American cities (USDA 2023). The United Nations Economic Commission for Europe put forward the Trees in Cities Challenge in 2019 to increase urban forests in northern

hemisphere countries across Europe, North America, and Central Asia, which has resulted in over 70 cities pledging to plant more trees (UNECE 2023). The Arbor Day Foundation's Tree Cities of the World program has reached 200 cities in 20 countries (Arbor Day Foundation 2024). Research in urban forestry is also expanding rapidly, with 3 disciplinary journals, *Arboriculture & Urban Forestry*, *Urban Forestry & Urban Greening*, and the *Arboricultural Journal* (subtitled the *International Journal of Urban Forestry*), all gaining impact in recent years. Jobs in the sector are also expanding and diversifying, driven by increased government and private sector funding (Eisenman et al. 2024). Most recently, the Society of

American Foresters launched a professional credential in Urban and Community Forestry. Similarly, a nonprofit professional group, the Society of Municipal Arborists, expanded its mission and changed its name to the Urban and Community Forestry Society in 2023, to acknowledge and more strongly support the growing professionalization of urban forestry (UCFS 2023). This was very recently strengthened by the announcement of the re-naming of the Municipal Specialist Credential as the Urban Forest Professional Credential. In Canada, the Forest Professional Regulators of Canada (FPRC) introduced a new Urban Forestry Standard (Standard 8C)(FPRC 2024).

Growth in societal relevance and professional practice of urban forestry has spurred education and training opportunities and programs in urban forestry (Vogt et al. 2016). It is therefore timely for urban forestry educators to take stock of how we are educating our students in the 2020s. What competencies are students learning? How are students being educated? What type of students are we educating? To help answer these questions, 2 international Urban Forest Educators Symposia (UFES) were convened in recent years, one in 2019 at the Morton Arboretum, near Chicago, Illinois, USA, and one in 2023 at the University of British Columbia in Vancouver, BC, Canada. Each brought together educators to present their respective courses and programs, showcase best practice in teaching, and discuss curricular development. Currently, urban forestry programs are an intermixture of curriculum offerings, which may be due to the specializations of the academic faculty and/or based on historical legacies of curriculum, research foci, and/or integration with other degree programs. To a different extent, urban forestry topics and elements are being integrated into current teaching curricula of existing programs such as forestry, landscape architecture, engineering, and environmental conservation. For example, in the United States, there are a variety of approaches to urban forestry programs, such as stand-alone programs resulting in a specific certificate or degree to coursework or as part of allied disciplines such as horticulture, landscape architecture, and plant sciences (Vogt et al. 2016). Taking stock of current international education at both UFES, themes emerged that helped define urban forestry as a distinct discipline, consistent with the findings by others (O'Herrin et al. 2020; Martin et al. 2024). The authors acknowledge that UFES participants were

primarily from North America, Europe, and Australia, limiting the truly global scope of this work. More work is needed to extend the scope to other countries and regions educating in urban forestry, particularly since much urban forestry research and interest is occurring in Asia, Africa, and Central and South America.

This paper focuses on urban forestry and arboriculture curriculum in higher education. Numerous studies have examined urban forestry and/or arboriculture curricula (Andresen and Williams 1975; McPherson 1984; Hildebrandt et al. 1993; Andersen et al. 2002; Elmendorf et al. 2005; Konijnendijk and Randrup 2005; Wiseman et al. 2011; Baumeister 2014; Miller 1994; Vogt et al. 2016). Programs have emerged and curriculum has changed since these studies. Previous studies share some specific knowledge domains commonly included in urban forestry education. For example, Elmendorf et al. (2005) found that tree care topics were prioritized over more broad topical areas. Vogt et al. (2016) note that elements from disciplines such as biology, ecology, and forestry are included in curriculum, while other areas, such as economy, social sciences, planning, design, and engineering, are recognized but not comprehensively included in urban forestry curricula. However, some programs have a focus on social sciences and humanities, including design and governance approaches in their curricula (UBC 2024). Martin et al. (2024) showed that urban forestry professionals rely on a variety of formal education and informal knowledge exchange to gain a wide range of professional competencies, with the latter broad range reflecting the generalist typecast often placed on urban forestry professionals. As Dahle et al. (2020) note, "it can often be difficult for professionals and educators to effectively communicate what exactly is meant when one uses the term urban forester." Professions closely allied to urban forestry include arboriculture, landscape architecture, horticulture, ecology, and forestry, all of which have clear professional certifications and educational pathways. The need for urban forestry to have a greater professional identity and credentials is well argued elsewhere (O'Herrin et al. 2023), although how this is then linked to education programs and curriculum is not always clear. Further investigation into connections between professional bodies and education is warranted, and beyond the scope of our study.

There is growing interest in urban forestry education and employment, and yet perceptions of urban forestry as a career path remain subdued (O'Herrin et al. 2018). Past studies have identified a broken career ladder in urban forestry, with few entry-level positions (O'Herrin et al. 2020; Day et al. 2022). Bardekjian (2016) found that urban foresters have often moved from field to office work as their careers advance. This signals a potential need for re-training or higher education opportunities to facilitate more standardized urban forestry training. Dahle et al. (2020) note that the required skills will change as urban foresters advance up the career ladder. Currently, participants in the urban forestry workforce come from a range of education programs (O'Herrin et al. 2020). The historical lack of a dedicated urban forestry professional credential, coupled with a lack of formal educational requirements as seen in allied credentials, may signal that formal education is not critical for a successful career in urban forestry (O'Herrin et al. 2020). Furthermore, as the profession solidifies (O'Herrin et al. 2023), core competencies, learning outcomes, and disciplinary boundaries are emerging.

This paper presents urban forestry as a continually evolving discipline with distinct contributions to knowledge built over the past half-century, with professional ties going back a century and more. We present evidence of the growing expansion of urban forestry education in a range of modalities, discuss the current competencies taught, describe case studies of leading educational programs, and discuss what makes urban forestry a unique area of education and practice. We also discuss what is missing in urban forestry education: clear disciplinary boundaries and competencies across educational programs. Taking stock of where urban forestry education currently sits, we identify opportunities for future pathways and opportunities.

METHODS

To understand the current state of urban forestry education, we used a Delphi survey with urban forestry educators, and analysed case studies of existing urban forestry programs. Data collected has been supplemented by the knowledge and experiences of the educators authoring this paper.

Delphi Survey

The Delphi survey was used to gather information from urban forest educators. A Delphi survey collects

data from individuals considered experts on a specific topic (Barron et al. 2016). For the purposes of this study, educators who are currently delivering, or who have delivered, urban forestry content in higher education programs are considered experts. A call for participation in the study was distributed by email in February 2023 to academics teaching in urban forestry programs in Canada, the United States, Europe (Germany, Italy, United Kingdom, Sweden, and Spain), China, and Australia. Recipients were also encouraged to sign up for a 2-day Urban Forestry Educators Symposium (UFES) hosted online and in-person at the University of British Columbia in Vancouver, Canada in April 2023. The same invitation was also sent to participants from an earlier UFES held at the Morton Arboretum in Lisle, Illinois, USA in 2019. Recipients were encouraged to share the survey with educator colleagues. This snowball approach to response collection resulted in the survey being shared on various electronic mailing lists in Europe and the United States. Round one of the Delphi survey included a series of both open and closed questions relating to the educational background, current teaching context, and questions designed to elicit a range and ranking of competencies for graduates of urban forestry programs.

Two open-ended survey questions asked participants to list competencies for urban forestry students, while closed-ended questions asked participants to rank a list of twenty-six knowledge domains connected to urban forestry and to score proposed learning objectives. The domain list was generated from multiple sources (Baumeister 2014; Vogt et al. 2016), and the author team consolidated this list through an iterative coding process, ensuring a comprehensive yet manageable collection of knowledge domains. Similar to Vogt et al. (2016), we combined similar domains when the entire team agreed it was reasonable to do so. For example, we combined urban ecology and urban biodiversity into a single domain.

There were 38 responses to the survey, with 89% of survey responses complete. Four completed two or fewer questions and were not included in the results. We analysed results from the 34 semi-complete surveys. Only half of the survey participants answered some open-ended questions requiring longer responses.

Survey Participants

Of the 34 participants, most (33) taught at higher education institutions in North America, Europe, and

Australia. We also collected information about participants' education background to understand how the educators were themselves educated. Given a historical paucity of higher degree programs specific to urban forestry (Baumeister 2014), we felt this information could help illustrate some of the existing trends. The results show (Figure 1) that 21% of participants were educated in forestry, with urban forestry, environmental science/studies/affairs, and geography also being represented. The interdisciplinary nature of urban forestry was evident, with 35% of respondents presenting more than one discipline as part of earning their degree(s).

We then asked participants what level of students they teach (Table 1). Most of our experts teach at the undergraduate level, with 10 also teaching at the post-graduate level. One participant is not currently teaching as they shifted job roles in academia.

Nearly half of respondents (14 participants) taught in academic programs with 4-year degrees. One third also taught graduate programs in Urban Forestry (10 participants). The remaining 5 participants came from 2-year programs such as diploma, associate, or certificate programs.

Table 1. Academic level of teaching for study participants who responded to this question (30 responses). Many participants taught at both the undergraduate and graduate level.

Academic level of teaching	Frequency (#)
Diploma/certificate/associate degree (1 to 3 years)	5
Bachelor degree (4 years)	14
Graduate	10
None	1

Case Studies

We asked the survey participants to provide case studies of recent innovations in urban forestry education. These were selected from survey participants and from presentations given at the second UFES in April 2023. Six are presented below. The 6 were chosen to represent a range of modalities across the spectrum of potential educational offerings, spanning from a handful of courses within a degree to a full Masters degree.

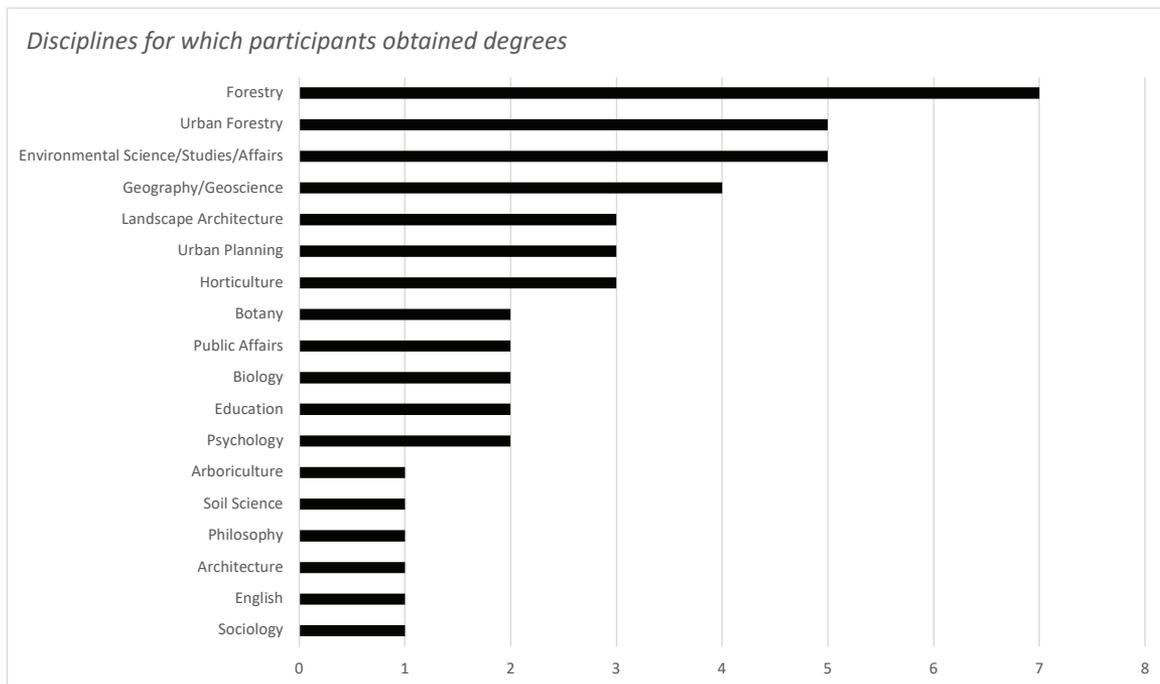


Figure 1. Disciplines from which study participants obtained a degree. Most participants listed multiple degrees. All responses (34 participants, 46 degrees) are included, including both undergraduate and post-graduate degrees.

RESULTS: THE CURRENT STATE OF URBAN FORESTRY EDUCATION AND TRAINING

Delphi Survey

The Delphi approach provided details on what is taught within urban forestry programs, as reported by 34 urban forestry educator participants. Participants in the study included educators from international institutions with at least some teaching responsibilities in urban forestry ranging from a part- (e.g., a course) to a full-time allocation of teaching or program leadership. Competencies that urban forestry students should possess were also compiled through a ranked list of competencies.

Survey participants and educators currently teach urban forestry-related courses or units of study, which are grouped into 25 categories (Figure 2). The figure shows a wide range of knowledge areas that are taught. A variety of courses were presented with teaching occurring in urban forestry (16%), arboriculture (11%), dendrology (7%), urban ecology and biodiversity (7%), and a combined urban forestry/landscape and ecosystem management theme (7%).

An interesting comparison emerged between the list of courses taught (Figure 2) and the list of

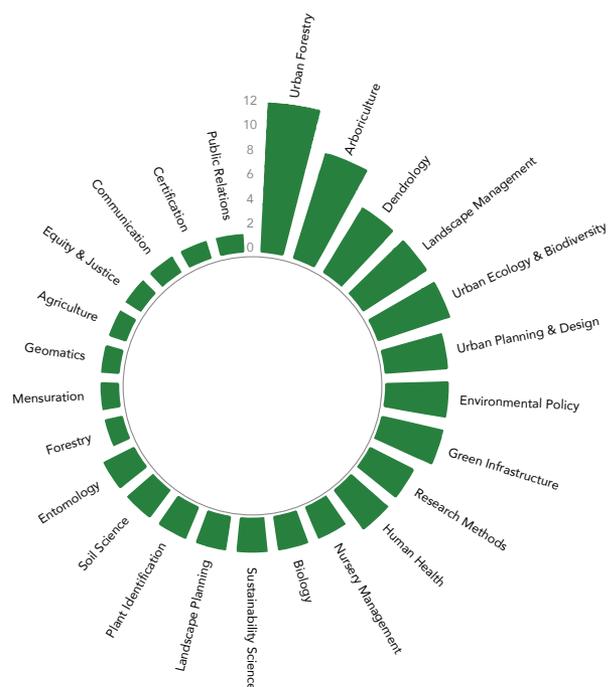


Figure 2. Courses, subject, and/or units of study taught by study participants. The figure presents open-ended responses to the question “List the courses/subjects/units of study that you teach.” All survey responses are included, and many participants wrote multiple courses or units of study taught.

knowledge domains, technical competencies, and generic competencies elicited from the open-ended survey question that asked about competencies of urban forestry graduates (Table 2). For example, dendrology is an often-taught course, but only one participant included it in their self-generated list of competencies. Anecdotally, we note that dendrology and woody plant courses can be taught outside urban forestry programs, such as in botany or horticulture departments. Many participants wrote of generic competencies such as community engagement, report writing, and knowledge of professional practice, but did not report teaching these competencies themselves.

Creating lists of knowledge domains and competencies was informative for our study, which focuses on identifying and prioritizing the most important and central bodies of knowledge for urban forestry. From the generated list of 26 related knowledge domains (Table 2), we asked participants to rank the top 5. Arboriculture (ranked first by 5 participants), urban ecology (ranked first by 4 participants), ecosystem services (ranked first by 3 participants), climate change resilience (ranked first by 3 participants), and communications and engagement (ranked first by 2 participants) were the top-ranked knowledge domains. These were followed by environmental politics, botany, environmental justice, urban planning, geomatics, and human health and well-being.

Case Studies

Here we provide 6 case studies representing a spectrum of urban forestry educational programs. The first is a hybrid academic-praxis partnership that produced a Massive Open Online Course (MOOC) developed by a European project (Table 3). The second, third, and fourth demonstrate urban forest teaching within a traditional four-year degree (Depaul, Virginia Tech, and Southern). The fifth is a post-graduate certificate (OSU). Finally, the sixth is an online graduate degree (University of British Columbia [UBC]). Our goal here is to show diverse examples of curriculum content, delivery style, and approach in urban forestry education. These are limited to our perspectives from North America and Europe.

Uforest

Officially titled “European Alliance on Interdisciplinary Learning and Business Innovation for Urban Forests Project,” the Uforest project was a 3-year Knowledge Alliance project co-funded by the Erasmus+

Table 2. Knowledge domains, technical competencies, and generic competencies listed by study participants as competencies for urban forestry graduates in response to the question: 'In 50 words or less, please write the competencies you would expect a student graduating with a degree in urban forestry to have obtained.' Numbers in parentheses represent the number of responses for each competency.

Knowledge domains	Technical competencies	Generic competencies
Environmental science (4)	Urban forest management (15)	Community engagement (7)
Urban ecology (4)	GIS and spatial tools (9)	Report writing and communications (5)
Climate change (4)	Tree identification (7)	Professional practice (3)
Ecosystem services (4)	Tree risk assessment (3)	Data analysis and interpretation (3)
Tree growth and function (3)	Tree inventories (3)	Conflict resolution (2)
Socio-ecological (3)	Ecosystem assessment (2)	Governance (2)
Arboriculture (2)	Mensuration tools (2)	Strategic planning (2)
Sustainability (2)	Tree valuation (1)	Research methods (2)
Ecology (2)	Characterize structure and function of the urban forest (1)	Coding in R/R-Studio (or equivalent platform) (1)
Pathology (2)	Proper tree planting; (1)	Budget (1)
Botany, tree biology, anatomy (2)	Diagnosis of abiotic, insect, and diseases (1)	Study design (1)
Socio-cultural (2)	CODIT (e.g., tree wounding response)(1)	Problem solving (1)
Environmental justice (2)	Proper pruning cuts (1)	Knowledge transfer (1)
Environmental psychology (1)		
Soil science (1)		
Hydrology (1)		
Dendrology (1)		
Entomology (1)		
Environmental biophysics (1)		
Finance (1)		
Economics (1)		
Biostatistics (1)		
Building and construction dynamics (1)		
Green infrastructure (1)		
Engineering (1)		

Table 3. Case studies of urban forestry higher education across a spectrum of learning opportunities.

Name	Institution	Country	Year of inception	Approach	Delivery mode	Students in 2023	Faculty	Faculty expertise	Core curriculum	Focus
Nature in the city: turning knowledge into urban forestry practice (MOOC)	Uforest alliance	European project, funded by the European Union	2023	Open, free online course in urban forestry	Online	1024	16	Urban planning; urban forestry; and management; socio economic studies; forest ecology; forest management; forestry mapping	History, planning and design, ecology, socioeconomic, governance and community engagement, entrepreneurship	Broad introduction to urban forestry practice
Urban forestry courses	DePaul University	USA	2016	Focused urban forestry courses within a degree	In-person	16 to 20 per class every other academic year	1	Environmental Science and Studies	Social-ecological systems, urban forest, management, tree inventory, urban forest practicum (field trips/labs with professionals)	Basic urban forestry skills and project-based learning
Urban forestry emphasis within forestry major	Virginia Tech	USA	1999	Urban forest specialization within undergraduate forestry major	In-person	12	6	Forest resources and environmental conservation; landscape architecture; geomatics; soil science; horticulture; tree physiology	Arboriculture, silviculture, dendrology, forest ecology, remote sensing and field inventory, policy, planning, and management	Professional preparation for urban foresters and arborists that integrates scientific theory and management best practices with a foundation of natural resources stewardship and sustainability

Table 3 continued on next page

Table 3. Continued.

Name	Institution	Country	Year of inception	Approach	Delivery mode	Students in 2023	Faculty	Faculty expertise	Core curriculum	Focus
Bachelor of science in urban forestry	Southern University	USA	1992	Stand alone program	In-person	20-30	8	Urban forestry/ ecophysiology and climate change, forest ecology and environmental science, GIS and remote sensing, urban forest management, entomology and pathology, ecology and tree biology	General science, arboriculture	
Graduate certificate in urban forestry	Oregon State University	USA	2014	Post-graduate urban forestry courses	Online	30	3	Urban forestry, forest ecosystems and society, fisheries, wildlife, and conservation sciences	Planning, policy, management, green infrastructure leadership	Advanced skills in planning, policy, management, and leadership
Master of urban forestry leadership	University of British Columbia	Canada	2021	Course-based masters degree	Online	18	8	Design, governance, environmental justice, urban ecology	Governance, arboriculture, assessment, management	Advanced skills in leadership, management, and assessment

Programme of the EU. The project concluded in December 2023. Among other products, the Uforest project developed an E-learning course, a MOOC “Nature in the City: Turning Knowledge into Urban Forestry Practice,” and the specialization Course “Greening Your City: Develop Your Urban Forestry Project,” reserved for students of different degree programs from the 4 Uforest partner universities: Politecnico di Milano in Italy, Brasov University in Romania, Trinity College Dublin in Ireland, and Universitat Autònoma de Barcelona in Spain.

The program’s Basic MOOC attracted global learners across 7 interdisciplinary weeks and remains accessible online. It was built as an introduction to urban forestry for learners from other disciplines. It is delivered in an online, self-directed format with 5 modules, requiring 50 hours of study. The 5 modules are taught by a group of international experts participating in Uforest include: History of Urban Forestry, Urban Forest Planning and Design, Urban Forest Ecology, Socioeconomics: Governance and Community Engagement, and Entrepreneurship and Innovation. Students had an option to apply for an additional project-based “capstone” course, which was offered in 2023. The capstone was attended by 95 global students from a wide range of disciplinary backgrounds, further emphasizing the initiative’s broad impact and commitment to advancing urban forestry knowledge and practice.

Urban Forests as a Single Course Leading to Career Outcomes

Students at DePaul University (Chicago, Illinois) can take the “Urban Forests as Social-Ecological Systems” course within the Environmental Science Bachelor of Science, Environmental Studies Bachelor of Arts, or Master’s of Science in Environmental Science degrees. Students enroll in the course in their upper years as an undergraduate student or within their master’s program (the course is cross-listed). The course is taught for 15 to 20 students every-other year. It is the only explicitly urban forest-related class in the DePaul Environmental Science and Studies curriculum. It is delivered over a 10-week quarter, in-person, in twice-weekly 90-minute lectures plus a weekly 3-hour field component. The class was designed and is taught by a faculty whose BA, MS, and PhD degrees are in environmental science but whose scholarship is and has always been entirely within the field of urban forestry. The course focuses on the social-ecological

systems (SES) perspective as applied to urban forestry, emphasizing the many dimensions of the trees/forests, growing environment, human community, and management that impact urban forest outcomes. Especially, the class teaches basic skills in urban forest management through an applied project where students design and conduct street tree or park tree inventories in small groups. Field component experiences center on skills such as tree identification, tree inventory, pruning, planting, arboricultural science, community engagement, plant health care, and climbing. Field experiences are facilitated in collaboration with professionals including arborists from tree care companies in the private sector, city foresters from several different departments of local municipalities, local urban greening nonprofits, and the Morton Arboretum.

While most would not consider a single urban forestry course to be a true “program” in any real sense, situated in the right kind of educational environment, a single urban forestry class can lead to a career in the field. At DePaul this single urban forestry class is situated in a department where degree programs that have an explicitly urban focus: urban ecology, restoration and conservation, urban environmental justice run as themes through many courses in the curriculum. Several faculty have urban ecological and urban forestry-related research agendas in which students can complete mentored research projects that often involve conducting tree inventories and examining this data in concert with spatial data such as tree canopy cover and census demographics and socio-economics. In particular, students who have taken the “Urban Forests as Social-Ecological Systems” course since 2016 have progressed to jobs in the urban forestry sector, or have gone on to graduate-level urban forestry/urban greening research.

Bachelor of Science in Forestry with Urban and Community Forestry Emphasis

A specialized urban forestry curriculum is offered at Virginia Tech (Blacksburg, VA, USA) within a 4-year undergraduate degree program—the Bachelor of Science in Forest Resources and Environmental Conservation. The degree program includes 4 majors that span the biophysical and socioeconomic aspects of studying, managing, and conserving forest resources. The forestry major comprises 3 emphasis areas (specializations)—2 of which focus on traditional aspects of rural forest management and timber production. The third specialization is urban and community

forestry. All students in the forestry major take a common core of degree courses and major courses, which results in about one-third of the curriculum in each specialization comprising coursework specific to that emphasis area. The forestry program holds both the forestry and urban forestry accreditations of the Society of American Foresters.

The urban and community forestry curriculum is multi-disciplinary and focuses on the stewardship and management of trees and forests in urban and periurban areas. Courses are intentionally drawn from allied academic disciplines such as geography, horticulture, landscape architecture, and urban planning, to name a few. This range of course offerings provides students with true interdisciplinary choices to build the educational pathway for their future career goals. Students enrolled in the curriculum are mostly traditional students (matriculating directly from high school) who grew up in suburbs of Virginia's 3 major metropolitan areas: Northern Virginia, Greater Richmond, and Hampton Roads. Students who tend to gravitate toward the curriculum are those interested in hands-on environmental stewardship that connects directly with landscapes and communities in urban areas.

The curriculum has been crafted to align with 3 prevalent career pathways commonly taken by graduates of the program: the tree care industry, governmental agencies, and nonprofits. To accommodate these pathways, general knowledge domains are defined in the curriculum and several approved courses are listed under each domain. Students then choose a suite of courses that fulfil the knowledge domains while catering to their specific interests and professional aspirations. Regardless of career pathway, the curriculum ensures competency in 4 core areas: (1) forest biology and ecology, (2) resource measurement and assessment, (3) resource planning and management, and (4) communication and collaboration.

Curriculum coursework is delivered in a traditional model of in-person lectures and labs that meet 1 to 3 hours per week in a classroom setting. Almost all instruction is delivered by doctorate-holding faculty who are subject matter experts in the course content. Experiential learning is emphasized throughout the curriculum by way of field labs, practicums, and recitations so that students learn a variety of technical and soft skills that are readily transferrable to the workforce. Practicing urban foresters and arborists

routinely contribute to experiential learning activities as guest instructors.

In addition to the urban and community forestry emphasis of the forestry major, Virginia Tech also provides an urban and community forestry minor, which comprises core courses in arboriculture, urban forest management, dendrology, and forest ecology. The minor is commonly pursued by students in allied majors such as horticulture, landscape architecture, and urban planning who desire specialized knowledge about trees in built environments to complement their primary expertise.

Bachelor of Science in Urban Forestry, Southern University

The Bachelor of Science in Urban Forestry was established by Southern University in 1992. It was the United States' first stand alone urban forestry degree, and was developed with the Louisiana Board of Regents and USDA Forest Service. Southern University is recognized in the United States as a Historically Black College/University. The urban forest program provides a comprehensive education for managing urban and community forests while providing a strong foundation for pursuing advanced studies in various specialized areas. Specialized areas include: urban forest management, forest ecology, ecosystem assessment, arboriculture, urban hydrology, tree physiology and anatomy, urban tree entomology and pathology, GIS applications, urban soil and wetland science, among others.

The department also offers minors in GIS Applications, Urban Forestry and Arboriculture, Urban Forest Science or Management, and Urban Agriculture and Community Garden Development. In December 2020, the program became the first Urban Forestry Bachelor's Degree in the United States to receive accreditation from the Society of American Foresters (SAF). This accreditation signifies that the program meets the quality standards established by the profession, affirming its standing as a leader in urban forestry education.

Oregon State University Graduate Certificate in Urban Forestry

The Oregon State University (OSU) Graduate Certificate in Urban Forestry can be earned as a stand-alone online professional certificate, or as part of a Master of Natural Resources degree. The program attracts students from across the United States, Canada, and

internationally. Approximately 30 students are active in the program at any one time, and 77 certificates have been awarded as of 2024. Students in the program come from 3 distinct groups: (1) people presently working in urban forestry and looking to advance in the field, (2) people working in fields adjacent to urban forestry such as horticulture, landscape architecture, or public works, and (3) career changers looking to move into the urban forestry field. The age range of students in the program is typically 25 to 65, and approximately 55% are women, minorities, or people from under-represented groups.

Oregon State University's 18 to 20 credit certificate focuses primarily on urban forest planning, policy, and management, with additional coursework on urban forest leadership, data analysis, and green infrastructure. The asynchronous online courses are taught in 10-week modules that include online discussions, individual papers, and group projects. The program makes extensive use of simulated learning activities and place-based analytical assessments. Students also complete a capstone study of their own design. Program level learning outcomes are focused on helping students (1) analyse and assess specific challenges, opportunities, conflicts, issues, and trends associated with complex urban forest planning, policy, and management situations, (2) apply critical thinking skills and program assessment concepts to urban forestry governance, community engagement, leadership, and interdisciplinary contexts, and (3) synthesize and integrate biological and social science concepts in a capstone project designed to address a specific urban forestry situation, issue, or problem.

Master of Urban Forestry Leadership at the University of British Columbia

The Master of Urban Forestry Leadership (MUFL) is an online graduate degree offered by the University of British Columbia's Faculty of Forestry. It was designed to meet the evolving needs of urban forestry professionals worldwide. Launched in 2021, the program aims to provide advanced education for professionals already working in urban forestry and adjacent industries, or professionals looking for a career change into urban forestry. Following feedback from early cohorts, MUFL has evolved to include a part-time delivery model over 2 years to allow for mature students to balance work and study effectively.

The degree consists of a set of 10 courses covering a range of advanced urban forestry topics. It is 1 of 4

professional masters programs offered at UBC, which each follow a set of courses culminating in a capstone project or internship. Core courses in MUFL focus on urban forest approaches, governance, benefits and assessment, strategic planning, and arboriculture. Students engage in a mix of coursework, including classes in transdisciplinary communication and diverse knowledge systems. Nearly one-third of the program is dedicated to an independent research project on a topic of professional interest. For their research project, students have engaged in qualitative methods such as surveys and focus groups, quantitative field studies, and advanced geomatic exercises to explore a wide range of urban forestry challenges. The program is currently a candidate for accreditation with the Society of American Foresters.

A small cohort of students are admitted once per year (up to 30), allowing for more personalized instruction and enhanced peer collaboration. Most are mid-career professionals looking to enhance their skills or change careers. The program's close-knit setting fosters a strong sense of community as well as professional connections with peers and professionals that last beyond program completion. Peer-learning, international guest seminars from diverse leading urban forest experts, and interdisciplinary learning activities ensure that students are exposed to the most up-to-date research, challenges, and opportunities in urban forestry. Though offered online, the program provides an optional international field experience, offering firsthand insights into best practices from around the world and the ability to socialize with the peer cohort. Students from the program have gone to work in various environments, ranging from local government to education to arboricultural settings.

DISCUSSION

Two key themes emerged through examining the format and content of the selected programs and courses compared to the survey results. The first theme is that urban forestry is not taught in a universal modality. The second theme is that content within programs is diverse. Through these themes came forth a unifying trend: urban forestry is emerging as a nimble, diverse, transdisciplinary discipline with strong roots in forestry and tree-related sciences.

A Discipline Rooted in Forestry

Urban forestry, arboriculture, and forestry were the top 3 educational backgrounds for urban foresters in

the study by Dahle et al. (2020). Urban forestry emerged from forestry faculties and departments, leaving a legacy that continues to impact the profession today (Andresen and Williams 1975; Andersen et al. 2002). Vogt et al. (2016) found that many programs continue to be housed within traditional forestry or natural resource units. Urban forestry programs, from our perspective, are not connected to their forestry roots as much as they could be. Forestry is a discipline of long-term, holistic thinking of the sustainable management of complex ecosystems. Yet, there is perception that urban forestry thinking focuses on a single tree, or a single stand, with little successional planning of the type commonly practiced in ‘traditional’ forestry (Piana et al. 2021). Standing firmly with the discipline from which our name is aligned could open possibilities in discourse that expands the view of urban forest management and governance.

Conversely, urban forestry has much to offer to the discipline of forestry. A growing percentage of people trained in forestry are working in urban or suburban landscapes. Traditional forestry can learn from urban challenges such as invasive species, climate change adaptation, and multi-cultural community engagement. An appreciation of urban forestry’s strong alignment with human communities, environmental justice, and competencies in transdisciplinary communication and community engagement could expand the scope of existing forestry programs. As urban forestry looks to build flexible, diverse, and transdisciplinary programs, it could provide new pathways for forestry education and opportunities for cross-fertilization between both disciplines.

A Nimble Discipline

Urban forestry is emerging as a nimble discipline. We define nimble as an ability to rapidly innovate and successfully manage change. For urban forestry education, this means an ability to quickly shift to new modalities, approaches, and areas of focus without major disruptions. The case studies reveal that education programs in urban forestry have shifted to delivery across a spectrum of modalities and through a range of approaches based on context. Bachelor programs in urban forestry in North America date back to 1975, though they are still relatively small in number (Vogt et al. 2016; O’Herrin et al. 2018). Programs encountered during our descriptive program review, Delphi survey, and the 2 UFES revealed a range of offerings

for a diverse group of students. Education is currently delivered in open accessible online platforms, courses and specialties within degrees, 2- and 4-year undergraduate programs, and professional graduate programs that are offered online. Education in general is evolving to be more flexible to meet changing student requirements (Imran et al. 2023) and it appears that urban forestry is following this trend. Online education is one example to reach broader groups of students facing travel as a barrier, whether domestic or international students. Three of our case studies have used online learning to reach international students. One, an open platform, has reached 1,024 students across the world to participate in their 7-week program, demonstrating the demand for urban forestry training from a global student body. It appears that flexibility in delivery mode could be a key future direction for urban forestry education. For example, in the United Kingdom, many urban forestry students have studied foundation, bachelor and masters degrees in arboriculture and urban forestry through part-time, distance learning alongside their work commitments (Johnston and Hirons 2012).

The case studies and diversity of responses in the survey reveal that urban forestry education must be flexible to include topics and issues appropriate to the academic and/or socio-political and governance contexts in which programs are embedded. Programs also differ in the institutional resources available to deliver an urban forestry curriculum. Therefore programs tend to shape the curriculum around the inherent strengths of instructors, the institution, or they forge partnerships to fill gaps in resources. Examples include partnering with urban forestry professionals to provide guest lectures on specialized topics or provide training on technical skills; this can expand the curricular and topical offerings beyond the capabilities of full-time academic faculty. Because urban foresters must be responsive to the socio-cultural, as well as bio-ecological contexts in which they practice, urban forestry programs likewise find their curriculum ever-evolving to address emerging topics such as climate-ready trees and tree canopy equity (Table 2). Current issues such as climate change resilience, biodiversity loss, and dynamic human-nature interactions are knowledge domains that emerged from our study that were not central in previous studies (Vogt et al. 2016; Egerer and Suda 2023). The nimbleness of urban forestry as a discipline relies in part on the diversity of its areas of focus.

A Diverse Discipline

The urban forestry educators participating in the survey listed 25 unique courses/subjects/units taught. The list of competencies an urban forestry graduate should demonstrate was even longer at 51 unique knowledge domains and skills listed through the survey. Nearly 20 years ago, Elmendorf et al. (2005) found that tree care topics were prioritized over more broad topical areas. In Elmendorf's review (2005), competencies included: "arboriculture, tree benefits and values, tree and park inventory, street tree ordinance, shade tree commissions, tree management plans, tree evaluation and removal, work planning and budgeting, funding, conflict resolution, public relations, volunteer management, land use planning, preserving trees and utility forestry" (Baumeister 2014). Comparing this list to our survey, there is much overlap. Elmendorf's review did not mention urban ecology or ecosystem services, which may suggest a shift over the past 2 decades toward recognizing urban forests as critical ecosystems rather than simply landscape amenities. Vogt et al. (2016) noted that disciplines such as biology, ecology, and forestry are included in urban forestry curricula, while other areas are recognized but not comprehensively included. One example is human health which was in the top 10 reported courses taught (Figure 2), but not prioritized in the case studies' areas of focus (Table 3).

The skills and competencies required to design, plant, manage, maintain, and preserve trees in cities are broad. However, a curriculum should not include an exhaustive list of competencies without much thought of what is best to achieve. Rather we must work as a community to define and bound the discipline of urban forestry. As O'Herrin et al. (2020) state, "for expert management of urban forests to become the new norm, expertise must be defined." In comparing the list of courses taught to the core curriculum of the selected case studies (Table 3), some interesting patterns emerge that could give insight into defined expertise. Arboriculture, commonly taught by survey participants, was only listed as core curriculum by 2 case studies. This could be due to the fact that many students entering advanced degrees in urban forestry have experience in arboriculture. Exact percentages of students entering urban forestry higher education following work in arboriculture would be useful to know for future research. Dendrology, green infrastructure, and design were missing in the case study

priorities. Management, planning, ecology, and policy were all mentioned by at least one case study. Future studies should begin to prioritize competencies required for urban forestry professionals. However, we caution against narrowing definitions and requirements too tightly, as the diversity reflected in the educators, courses, and competencies are also a unique strength of urban forestry (Miller et al. 2015).

A Transdisciplinary Discipline

Many previous studies have noted the multi-, inter-, and transdisciplinary approach of urban forestry (Deneke 1978; Konijnendijk and Randrup 2005; Baumeister 2014; Miller et al. 2015; Vogt et al. 2016; Dahle et al. 2020). Multidisciplinary approaches combine theories, knowledge, and skills from multiple academic disciplines. Interdisciplinary approaches also leverage insights from various fields but emphasize integration, aiming to foster a comprehensive understanding that transcends disciplinary confines and engages with communities (Nassauer 2023). We feel that transdisciplinary approaches best define the current state of urban forestry education. Transdisciplinary approaches go beyond interdisciplinary approaches to include perspectives of nonacademic knowledge holders, such as local residents, indigenous groups, practitioners, and policymakers. We argue that approaches used within established disciplines including, for example, ecology, urban planning, landscape architecture, and arboriculture do not train students in the competencies needed to effectively manage urban forests at the ecosystem level (Kenney 2003). The social aspects of urban forestry stand out as unique from related fields, with the exception of landscape architecture. For example, 'stakeholder communication and engagement' was selected as a key knowledge domain of urban forestry by our educational respondents. This aspect of working with local residents requires specific training in communications, real-world challenges, and problem solving, all key to employment in this sector. While educators aspire to transdisciplinary approaches, work remains to fully integrate this into education programs. This challenge is shared with the discipline of landscape architecture (Nassauer 2023).

A recent survey revealed that interpersonal skills were lacking in newly hired urban forestry employees (Dahle et al. 2020). Students involved in a field-based internship in urban forestry were surveyed with 80% responding that they used the skills and

knowledge gained from the internship experience in their current professional role (Scanlan et al. 2021). In a recent study, undergraduate students in an urban forestry program highly valued the ‘experiential learning’ elements in their degree and felt it increased their capacity for urban forest management (Martin 2024). The course at DePaul University outlined above (3.3.2) is an ideal case study demonstrating an applied, field-based approach to education that exemplifies transdisciplinary education.

The diversity of the educational backgrounds of urban forestry educators (Figure 1) provide a strong foundation for interdisciplinary collegiality. O’Herrin et al. (2020) similarly note a strong base for interdisciplinary research that has yet to be fully capitalized upon. Interestingly, Dahle et al. (2020) note that a key skill of urban foresters is their proficiency in multidisciplinary collaboration. Working at the interface of multiple disciplines (Dahle et al. 2020), urban forestry practitioners have developed skills that could be taught in higher education to prepare graduates to operate within the interdisciplinary and multifaceted reality of urban built environments.

Gaps in Urban Forestry Education

Clear disciplinary boundaries and competencies across educational programs are currently missing in urban forestry education. The case studies reveal a diverse range of competencies taught across a range of educational levels (Table 3). Across all professions, there is a need to achieve consensus on minimal expectations of competency across agreed-upon knowledge domains. This standardization provides the safeguards needed by society to distinguish between individuals qualified and unqualified to practice in a profession. Likewise, standards help establish disciplinary boundaries between allied professions that converge in the urban space. Having such boundaries ensures that professional expertise is deployed efficiently and protects the investment made by professionals in their specialized education and training from devaluation by unqualified practitioners. Yet progress toward consensus on urban forestry education has remained elusive. In the United States, a specialized accreditation standard for urban forestry programs has been promulgated by the Society of American Foresters (SAF) since 2008. Programmatic accreditation is a voluntary, peer-reviewed process conducted by non-governmental organizations to ensure the quality of

higher education programs. Academic programs choose to participate in this detailed evaluation regularly to confirm they meet established standards.

SAF’s urban forestry accreditation currently includes six universities. By contrast, over 50 universities possess 1 or more of the ‘traditional’ accreditations offered by SAF, which began in 1935. Why are there not more accredited urban forestry programs? Is this because urban forestry is a more recently formed discipline? The answer is no doubt complicated and beyond the scope of this paper but a worthy focus of future research.

While the disciplinary diversity that underpins urban forestry programs is an inherent strength for nimbleness and creativity in addressing urban challenges, the lack of a long-established singular professional organization that shares in stewardship of the urban forestry body of knowledge presents a challenge for advancing the urban forestry profession and gaining the credibility and salience afforded to allied professions operating in the urban space. The recent change in focus of the newly re-named Urban and Community Forestry Society (formerly the Society of Municipal Arborists) presents an opportunity to solidify this stewardship. Similarly, the recently launched Certified Urban and Community Forester Credential™ by the SAF provides opportunities for industry alignment. Finally, a major gap in this paper is participation from more global perspectives. The growing research and interest in urban forestry in Asia, Africa, and Central and South America demonstrates potential demand for more training in these locations. Future research should include urban forestry training and education in these places to ensure the discipline of urban forestry can build a globally shared understanding of effective higher education.

CONCLUSION

Urban forestry continues to emerge as a nimble, diverse, transdisciplinary discipline with strong roots in tree and forest science. As a discipline, urban forestry needs a high-quality, intentional, distinct, and collaborative curriculum, with educators who can deliver this curriculum, to guide the process of training the next generation of practitioners, scholars, and policy makers. There are certainly needs for regional differences in urban forestry education. However, urban forestry currently lacks a clear and cohesive vision that sets it apart from other disciplines. The findings

from our study highlight the diversity required in an urban forestry curriculum. A range of approaches will continue to be required based on various student needs, including formal higher education, continuing education, and urban forestry as part of other programs. The courses and topics identified in this paper provide the foundation for future studies that examine the needs of urban forest academics, practitioners, politicians, and the general public, leading to clearly defined boundaries that prompt the widespread recognition of urban forestry as a unique and distinct academic discipline.

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