Received: 5 June 2024 | Revised: 22 November 2024 | Accepted: 25 November 2024

DOI: 10.1002/ecs2.70120

ECOSPHERE
AN ESA OPEN ACCESS JOURNAL

ARTICLE

Socio-Ecological Systems

Aligning urban forest management actions with urban sustainability goals: A multi-city expert elicitation

Corinne G. Bassett[1] | Susan D. Day[1] | Cecil C. Konijnendijk[1,2] | Lara A. Roman[3] | Victoria Hemming[1]

[1]Faculty of Forestry, University of British Columbia, Vancouver, British Columbia, Canada

[2]Nature-Based Solutions Institute, NBSI-Dutch Office, Zeist, The Netherlands

[3]USDA Pacific Southwest Research Station, Riverside, California, USA

Correspondence
Corinne G. Bassett
Email: cgbass@student.ubc.ca

Funding information
Social Sciences and Humanities Research Council of Canada, Grant/Award Number: 890-2020-0069

Handling Editor: Laura López-Hoffman

Abstract

City leaders are setting ambitious plans to achieve critical urban sustainability goals such as reducing urban heat, mitigating flooding during storms, and conserving biodiversity, and increasingly rely on urban forests as a key nature-based solution to such challenges. Current paradigms of urban forest management typically prioritize goals like increasing tree canopy cover that are often viewed as proxies for increased ecosystem service provision, in a general sense. However, urban foresters, the professionals with responsibility to manage urban forests, are increasingly faced with the complex challenge of managing for new goals related to ecosystem services, biodiversity, or people–nature relationships, as cities increasingly set goals centered on such outcomes, without robust guidelines to follow. We ask: How can urban foresters align their street tree management actions with specific urban sustainability goals? We conducted a structured expert elicitation of urban forest professionals in three cities: Vancouver, British Columbia, Canada; Honolulu, Hawaiʻi, United States; and Washington, DC, United States. A socio-ecological lens was used to examine urban foresters as agents of change in urban ecosystems. Participants assessed the impacts of 40 direct management actions on five goals: (1) canopy cover increase and tree risk reduction, (2) urban heat reduction, (3) people–nature relationships, (4) wildlife habitat, and (5) stormwater interception and infiltration. While certain actions (e.g., in the mature tree maintenance phase) were selected as needed to advance every goal, experts identified numerous actions which aligned with one or several goals, but not all. Preplanting actions, specifically site selection and species selection, presented the greatest opportunities to advance specific goals, suggesting that aligning this phase with city sustainability goals is critical. Participants were highly confident in being able to advance all goals through street tree management, but were more confident in being able to advance the goals of increasing canopy cover while reducing tree risk and of mitigating urban heat, possibly because these goals more closely align with traditional canopy cover goal setting. This research underscores the necessity of considering site-level ecosystem management actions to advance strategic sustainability goals, while also revealing the complexity of the role and responsibilities of professionals who manage urban ecosystems.

KEYWORDS
decision science, ecosystem management, multiobjective management, participatory research, tree planting, urban ecology

INTRODUCTION

The rapid growth of cities in the United States and Canada over the last half century, as well as globally, demands urgent action to conserve urban nature to achieve sustainability goals for the wellbeing of urban residents (Colding et al., 2020; Seto et al., 2012). The fields of urban ecology and urban sustainability are likewise rapidly developing as linked disciplines of research and practice needed to inform action in cities' complex networks of social, ecological, and built infrastructure systems (Frantzeskaki et al., 2021; Wu, 2014). Urban forests are often defined as the communities of trees and associated vegetation in urban areas (Konijnendijk et al., 2006). They are socioecological systems characterized by complex human–nature interactions which can alter both the biophysical structure of vegetation, and services and disservices to communities, such as heat mitigation, stormwater interception, and wildlife habitat provision (Roy et al., 2012; Vogt, 2024). The social and cultural benefits of urban forests, many derived from people–nature relationships, can also be important drivers of stewardship and conservation, though they often elude quantification efforts (Chan et al., 2016; Nesbitt et al., 2017). Managing urban forests for such benefits requires skilled application of both general and context-specific knowledge, including understanding the impacts of management strategies on specific ecosystem services and the spatial and temporal scale of that service provision, all of which have been identified as crucial research needs (McPhearson et al., 2016). Previous research indicates that urban foresters—important change agents and knowledge holders in urban socioecological systems through their role influencing urban forest management (O'Herrin et al., 2023)—largely focus their efforts on maximizing tree canopy while minimizing disservices as a blanket approach to provisioning ecosystem services (Walters & Sinnett, 2021). However, there is reason to believe that urban forest management actions differ in their impacts on different ecosystem services, and understanding these differences is critical to successful multiobjective management. In this study, we present a multicity, scenario-based expert elicitation to identify points of influence for a key agent of change in urban ecosystems, in our case, urban foresters, to align decision-making with urban sustainability goals.

The many challenges and needs of urban areas necessitate a multiobjective approach to ecosystem management (Almeter et al., 2018; Hale et al., 2015). In multiobjective management, it is important to first define objectives, identify management options, and characterize the effect of management options on each objective in order to eventually assess tradeoffs (Bradford & D'Amato, 2012). In the United States and Canada, many cities are adopting broad arrays of goals related to climate adaptation and human health (Turner et al., 2022), resilience (Fitzgibbons & Mitchell, 2019), and other advances in the field of urban sustainability science which promote strong connections between people and urban ecosystems (Frantzeskaki et al., 2021). These goals encompass efforts to increase ecosystem services, such as those that urban forests provide to humans, to mitigate ecosystem disservices, and even to recognize the relationships between people and place that are required for urban sustainability, adding to the complexity of the task that urban foresters are tasked with. Multiobjective management of urban forests for urban sustainability requires deliberate consideration of this broader array of goals and the identification of suitable management options for such goals.

In urban forestry, management options vary along a gradient of intensity from urban forested natural areas, which are often managed at the stand level, to street trees or individual trees in yards or parks, which are often intensively managed at the individual tree level (Vogt, 2020). Management of these individual trees focuses primarily on tree survival and health (Hauer & Peterson, 2016) and is characterized by cycles of human-led planting, care, and then removal. Though cities expressly point to urban forests as a critical tool for achieving these goals (Croeser et al., 2021), urban foresters lack support, evidence, and capacity to tailor their management accordingly (Davies et al., 2017; Roy et al., 2017). Urban foresters must already weigh many layers of complexity in making each decision. Furthering multiple urban sustainability goals through management of urban forests requires identifying clear links between specific urban forest management actions and specific urban sustainability goals, as well as identifying possible tradeoffs, to support urban foresters in an already nearly impossible balancing act.

Advances in research on this topic include characterizing the effects of different urban forest types (e.g., street trees vs. parks) on different ecosystem services (Elliott et al., 2020) or effects of urban forest management actions on single ecosystem service goals, such as which species should be selected to improving air quality, heat mitigation, or stormwater mitigation (Dowtin et al., 2023; Eisenman et al., 2019; Rahman et al., 2020). Most of the research on urban forest management and ecosystem services has focused on actions within the planning and design phase of the urban tree management cycle (Almeter et al., 2018; Bodnaruk et al., 2017), but there is a pressing need to examine effects of actions throughout the full street tree management life cycle on the diverse range of urban sustainability goals cities are adopting (Figure 1). Lack of understanding of needs and costs of the full tree life cycle has been found to be a limiting factor to improved urban forest management, identified as a barrier to community participation in tree planting (Riedman et al., 2022) and to increased investment by municipalities (Koeser, Vogt, et al., 2016). Overall, there is a scarcity of research examining the full tree life cycle, and to the best of our knowledge, there are no prior studies linking multiple ecosystem services to management decisions throughout the tree life cycle.

Crucially, decisions made later in the cycle can also affect both ecosystem services and disservices. For example, decisions in the mature tree maintenance and end of life phases can affect not only the risk trees pose to people and property within their fall zones, but also affect their contribution to wildlife habitat (Fröhlich & Ciach, 2020; Figure 2a,b). Analyses of the carbon footprint of urban trees, which examine the climate change mitigation potential of urban trees from beginning to end of the life cycle, have shown different emissions from management actions in different phases (McPherson et al., 2015; Petri et al., 2016). To understand the full scope of potential influence of an actor within a system, it is important to consider the impacts of all of their potential actions, in this case, all direct site-level actions needed for urban forest management to help achieve urban sustainability goals. The stakes are high for urban foresters making these decisions, as direct management actions (e.g., tree planting, pruning, and removal) make up significant portions of municipal urban forestry budgets (Hauer & Peterson, 2016) and have potential to affect human health and wellbeing. Understanding these links can affect how we align actions with broader sustainability goals and could influence the allocation of resources towards using urban trees as a solution for such challenges. Additionally, as not all actions will result in the same outcomes everywhere, there is a need for multicity research which can compare differences in needs between different contexts to understand which management recommendations can be generalizable and which are context dependent (McPhearson et al., 2016).

In urban forestry research, time and resources are significant barriers to conducting a field-based, multicity study which could compare the effects of a multitude of management options available on multiple goals. Expert elicitation is frequently used in many fields, including conservation and natural resources management, to answer and understand research questions where data are absent or insufficient and where conducting field experiments may not be feasible due to time or resources (Martin et al., 2012). Such methods have also been used to elicit expert judgment on the outcomes of management interventions on complex systems, generating results that can inform policy and decision-making (Kehoe et al., 2021; Schindler et al., 2014; Singh et al., 2017).

By looking at urban foresters as an agent of change within urban socioecological systems, our broad aim is to investigate the influence of site-level ecosystem management decisions on advancing sustainability goals. Specifically, our research question is: how can urban foresters align their street tree management actions with specific urban sustainability goals?

To address this question, we set the following research objectives:

1. Determine if suites of actions needed for typical urban forest management goals (i.e., canopy cover and risk mitigation) differ from those needed for other urban sustainability goals.
2. Identify which direct actions are linked with which specific urban sustainability goals.
3. Identify points of influence in the street tree management cycle where urban foresters could advance specific urban sustainability goals.

In this study, we selected three metro areas in the United States and Canada and conducted an expert elicitation to address these objectives. As part of expert elicitation, we also ascertained the degree of certainty that participants held in their responses and underlying reasons for certainty. We discuss possible tradeoffs and synergies in managing for urban sustainability goals, including those framed as ecosystem services and disservices, and how findings could inform generalizable and context-specific management recommendations.

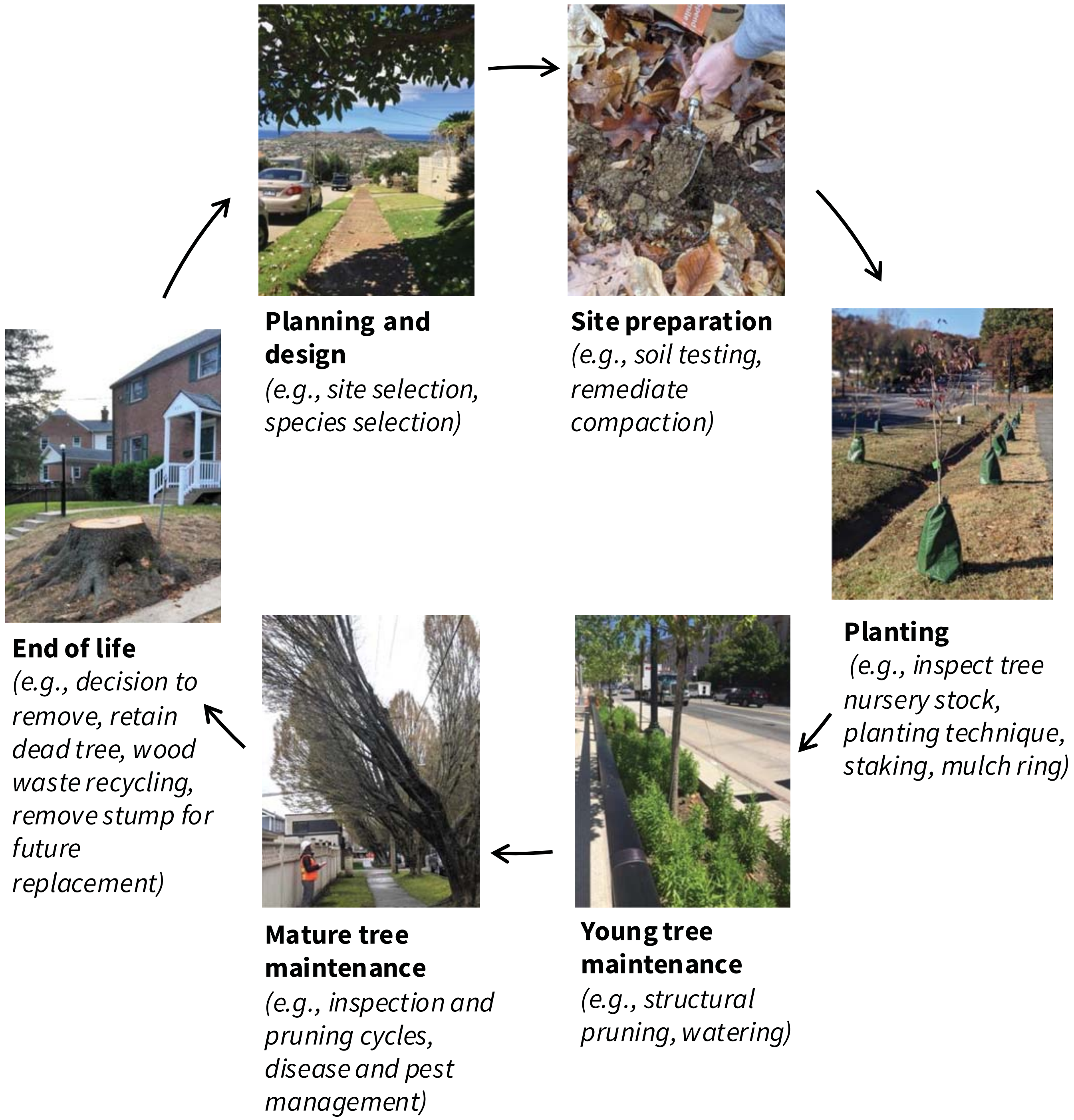

FIGURE 1 Phases of the street tree management life cycle (photo credits: Corinne Bassett).

METHODS

Approach

We applied a Delphi approach, wherein expert participants independently answer a set of questions, participate in a discussion-based calibration process, then individually revise their estimates following the discussion (Figure 3). Our method was inspired by the structured steps outlined in the IDEA protocol (Hemming et al., 2018) but differed in that our study had qualitative aims (e.g., Cawson et al., 2020). Though expert knowledge can be both biased and limited (Morgan, 2014), following principles of structured elicitation, such as those described in the IDEA protocol (Hemming et al., 2018), can help improve accuracy of results, identify and mitigate biases, and qualify results by assessing confidence of the experts in their elicited judgments. We took a qualitative

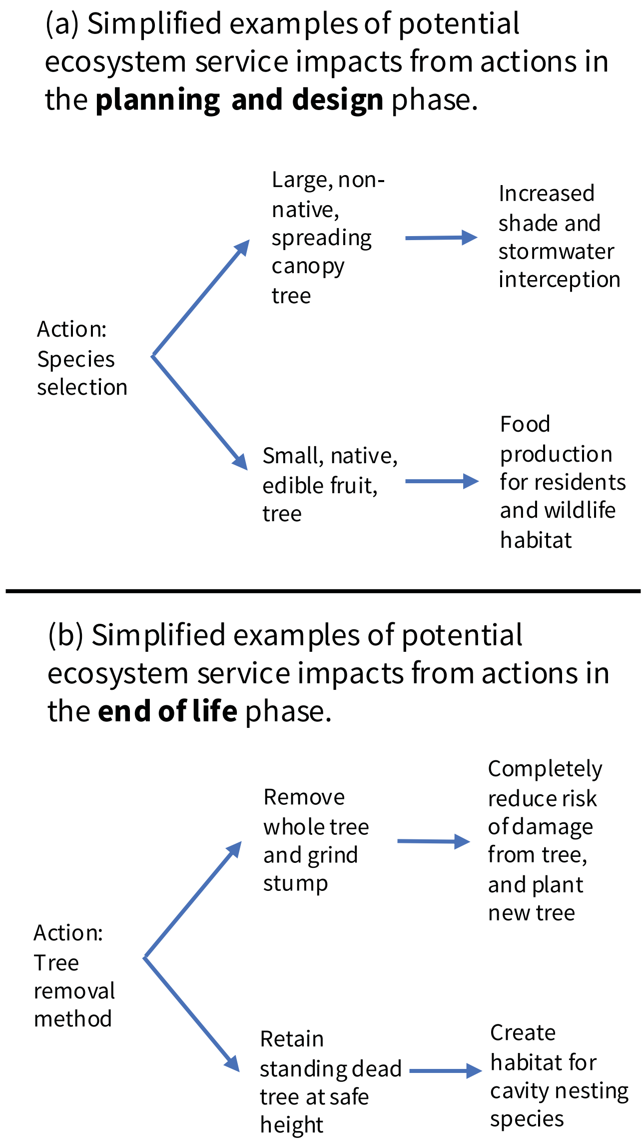

FIGURE 2 Simplified examples of how actions throughout the street tree management life cycle present opportunities to affect different ecosystem services, at the (a) planning and design phase and (b) end of life phase.

approach because of the nature of the research questions to establish links or isolate key factors, and because qualitative elicitation is often a necessary precursor to a quantitative elicitation (French, 2022). We used scenarios in this qualitative elicitation because they can elicit creativity and overcoming of "real world" obstacles, provide mutual ground for productive discussion and identification of new connections, and enable creative visioning about the future (Wollenberg et al., 2000). This study was part of Street Tree Futures, a multiyear research-practice partnership based at the University of British Columbia and advised by a committee of researchers and urban forestry practitioners from institutions and organizations with reach in the United States and Canada.

Metro areas and participants

To respond to the need to produce knowledge which could generate both generalizable and context-specific recommendations, we selected metro areas with three contrasting climatic and ecological characteristics, yet, which shared similar streetscape forms within their regions. Vancouver, British Columbia, Canada, is situated within the Pacific maritime climate and temperate rainforest, characterized by rainy winters and warm, dry, summers (Beck et al., 2018). The metropolitan area (referred to as Metro Vancouver) includes 23 local authorities, with a total population of 2.64 million and land area of 2878 km^2 (Statistics Canada, 2023). Washington, DC, USA, is situated within the temperate eastern deciduous forest, characterized by hot, humid, summers (Beck et al., 2018). The metropolitan area (referred to as the National Capital Region) includes the city of Washington, District of Columbia, two counties in the state of Maryland, and five counties and four cities in the state of Virginia, with a total population of 5.22 million and land area of 6063 km^2 (US Census Bureau, 2023). Honolulu, Hawaiʻi, United States, is a tropical city with zones spanning from tropical savannah to arid and hot (Beck et al., 2018). The City and County of Honolulu is a city-county merger representing the entire island of Oʻahu with a total population of 995,638 and land area of 1545 km^2 (US Census Bureau, 2022). Importantly, the urban forestry professionals and arborists in these three metro areas are united by training and experience, credentials, professional organizations, such as the International Society of Arboriculture, and linked North American paradigms of urban forest management (Day et al., 2022). Members of the study team had extensive connections with the professional communities in these metro areas, allowing for successful identification of experts and knowledge of local contexts.

Pre-elicitation

In the pre-elicitation phase, steps consisted of developing and defining (1) research questions, (2) scenario context and assumptions, (3) goals, (4) list of direct management actions, followed by (5) creating and testing the questionnaire, and (6) recruiting eligible participants. The steps in this phase were conducted in consultation with the Street Tree Futures project's committee of researchers and practitioners (Figure 3).

In developing the scenario context and assumptions (Figure 4), particular care was taken to develop a hypothetical streetscape that allowed for the answering of the research question, and that would be salient, credible,

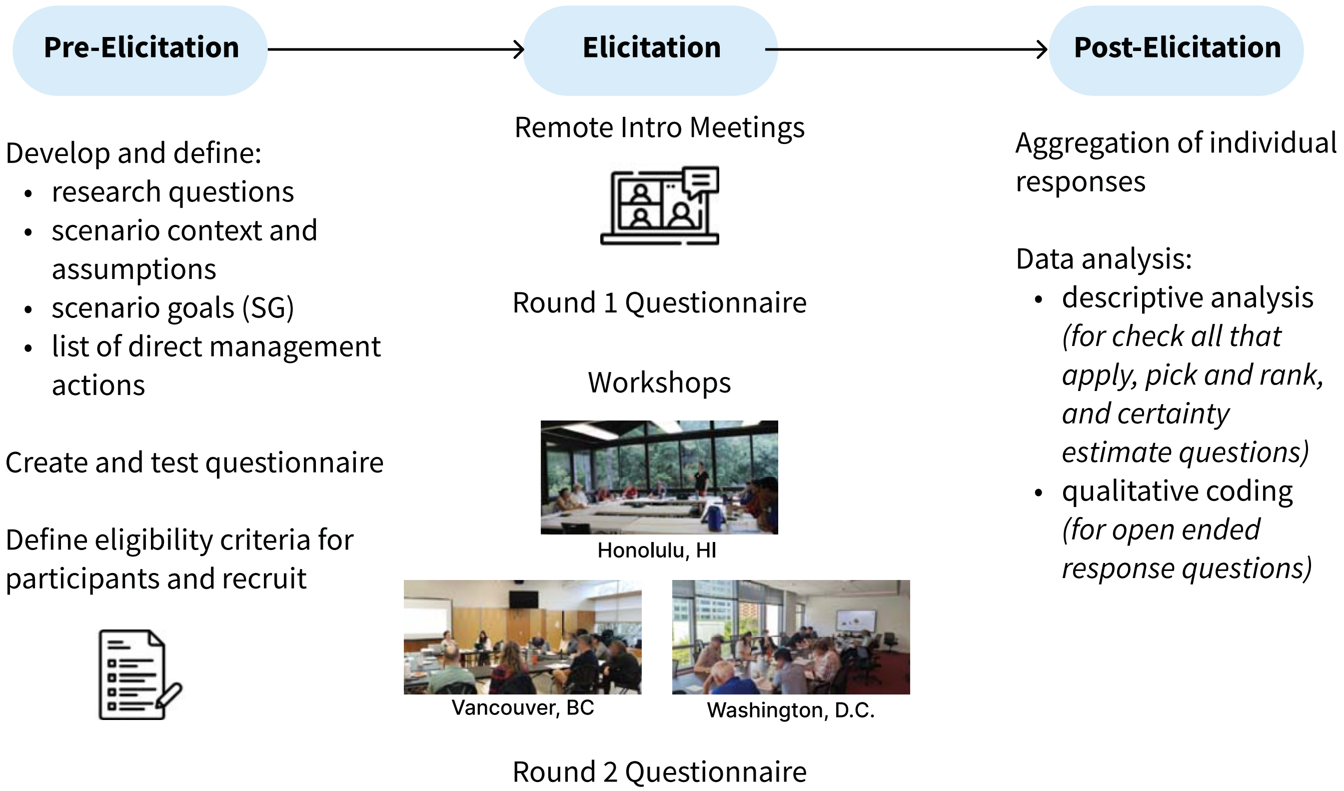

FIGURE 3 Overview of multicity structured expert elicitation method for a qualitative elicitation. Photographs sized to obscure faces and protect the identity of participants (photo credits: Chanel Yee, Corinne Bassett; icons: Flaticon.com).

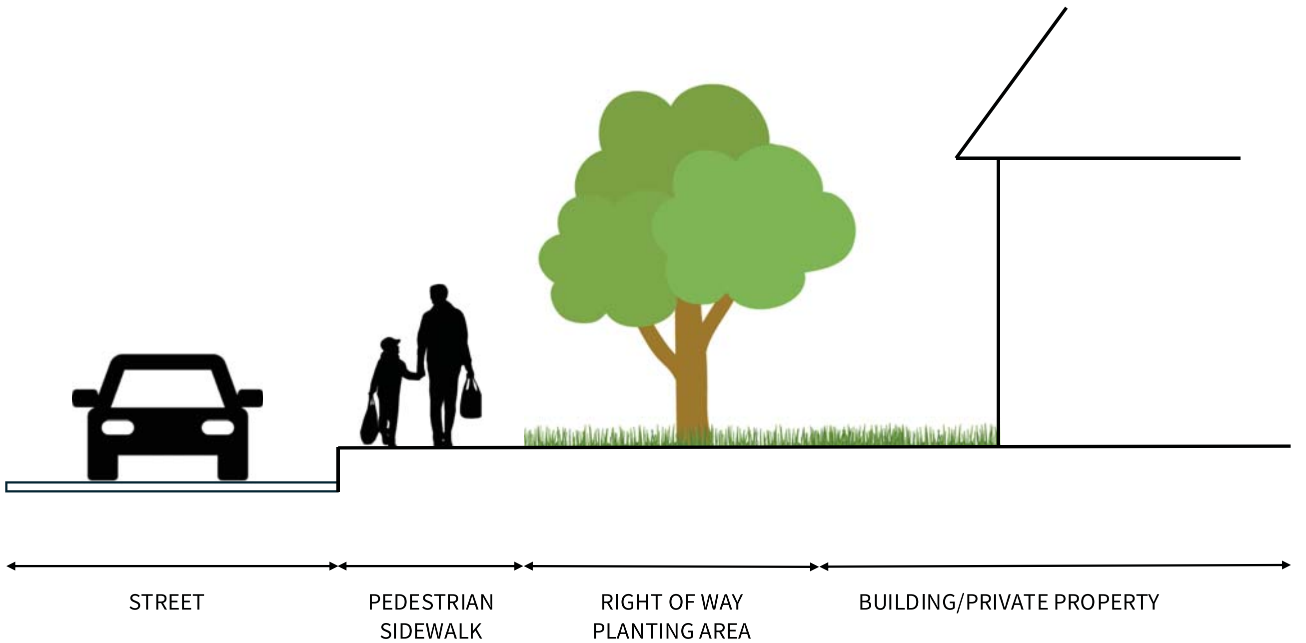

FIGURE 4 Hypothetical streetscape scenario (icons: Flaticon.com, Canva.com). Participants answered questions about direct management actions needed to advance five different goals within the following context and assumptions: “Imagine yourself as a manager responsible for planning all street tree management on a hypothetical street in your region for the next 20 years. The street has a sidewalk and low-rise development, with buildings that are approximately 1–3 stories tall. In this mostly perfect world, you have full control over the trees adjacent to the sidewalk. Within these scenarios, you should assume the following will be true: (1) Each action you select is in comparison to not doing the actions at all; (2) Actions will be performed according to industry standard; (3) Trees will not be removed by events such as vandalism, new construction, extreme storms, or pest invasions; (4) Newly planted trees will be watered through establishment and as needed for survival; (5) Urban form will not change (street, pavement, buildings will remain the same with reasonable maintenance); (6) Species planted will be adapted for any change in hardiness zone projected in 20 years due to climate change.”

and legitimate to urban foresters across the United States and Canada, for future application of results (Rounsevell & Metzger, 2010). The scenario assumptions were designed to create a "mostly perfect world," removing sources of uncertainty that are threats to basic tree survival. This included the removal of ecological threats, such as invasive pests, and social threats such as vandalism or mower damage, to allow the isolation of factors upon which urban foresters have the most control.

The hypothetical streetscape is characterized by a plantable public right-of-way, in which the urban forester has authority to plant and manage trees, bordered by a public pedestrian sidewalk and privately owned low-rise development. This street form is found in all three metro areas. It was critical to choose a form that represented a "sweet spot" between the typical constraints urban foresters face, so that the scenario was close to real life circumstances, and parameters that gave participants ample space and authority, so they could exercise many different management options in considering the sustainability goals. There can be significant variations in streetscape designs, which can have a major influence on the types and sizes of trees that can be grown. This is primarily due to limitations in both above and belowground space, as well as the authority to manage trees based on property lines and municipal codes. Additionally, the placement of sidewalks also plays a role in the way residents interact with street trees.

The steps of selecting management goals and generating a list of direct management actions were informed by results from a prior study wherein semi-structured interviews were conducted with urban foresters working at municipalities across the United States and Canada to understand their street tree management priorities and strategies to align direct management actions with ecosystem service goals (Bassett, 2024a). We developed our suite of goals following common principles in scenario development, such as adhering to a decision-making context that is sufficiently familiar to participants that they will be able to provide constructive inputs, but choosing conditions that are flexible and distinct enough to stimulate creativity and critical thinking, including the crafting of scenarios with somewhat "extreme outcomes" to free participants from real world constraints (Wollenberg et al., 2000).

Each goal was developed to consist of a thematic title and a specific management objective (Box 1). Critically, each goal represented a qualitative target to advance towards with benefits relevant to residents of the street in question. Though trees can provide services at many spatial scales (e.g., the benefit of food provision at a local scale vs. benefit of climate change mitigation at a global scale), the goals were designed to keep the scale of benefit provision constant between scenarios. Goal 1 Canopy and Risk Reduction was designed to represent the typical priorities of municipal urban forestry programs—to increase canopy cover and reduce risk from falling branches or whole trees. "Tree risk rating" refers to results of a Level 2 Risk Assessment following the International Society of Arboriculture's Best Management Practices for Tree Risk Assessment, which assigns a risk rating of low, moderate, high, or severe, after consideration of likelihood of failure, likelihood of impact, and consequences of impact, and is a widely known industry standard in arboriculture and urban forestry (Koeser, Hauer, et al., 2016). While the first goal (shorthand: Canopy and Risk) was developed to represent a typical or "business as usual" type goal, the subsequent four goals (shorthands: Heat, People–Nature, Wildlife, and Stormwater) were developed to represent important priorities often featured in

BOX 1

Expert elicitation participants were asked the same set of questions about each of the goals shown. Each goal consists of a thematic title and a specific management objective.

Goal 1. Canopy and Risk Reduction: Increase canopy coverage, while keeping tree risk rating for all trees to moderate (or lower).

Goal 2. Urban Heat Reduction: Pedestrians are able to walk comfortably during the hottest time of day during the hot season.

Goal 3. People–Nature Relationships: Residents develop a strong and personal connection with trees on this street.

Goal 4. Wildlife Habitat: Increase the abundance and diversity of species of native wildlife who use these street trees for habitat.

Goal 5. Stormwater Interception and Infiltration: This street can experience a storm with no stormwater runoff.

city sustainability plans and which could require contrasting management strategies when compared with Canopy and Risk. Additionally, Heat, Wildlife, and Stormwater, represent goals fitting a typical definition of ecosystem services wherein ecosystems provide services to humans in a unidirectional relationship, while People–Nature represents a relational approach to urban sustainability, wherein people and nature are united through more reciprocal and irreplaceable relationships.

The questionnaire consisted of five questions, asked for each of the five goals. In the first question, "Which actions are needed to significantly advance each scenario's goal above all other goals?" participants considered a suite of 40 direct street tree management actions, which were intended to constitute actions an urban forester could take throughout the street tree management life cycle. This suite of actions was developed by first constructing an initial list from results of interviews with urban foresters (Bassett, 2024a) and from the literature on urban forest management (Lilly et al., 2022; Miller et al., 2015). Then, direct actions deemed as required by policy, such as notifying utilities prior to digging, and actions obviously required for tree survival in all scenarios such as watering, were removed from the list and added to the set of scenario assumptions. The final list of actions was reviewed by members of the Street Tree Futures research and practice advisory committees. To ensure that the choice to not select an option was intentional and not indicative of a missing value, participants were required to check at least one action or "None of these options" per phase. The second question, "Are there direct actions not listed and not referenced in the assumptions that must be performed in order to advance this goal?" was open-ended and the only non-required question. In the third question, "Within the assumptions of this scenario, if all of your selected actions were taken, how certain are you that this goal could be significantly advanced in 20 years?" participants indicated their response by dragging a slider on a horizontal scale of 0%–100%. The slider was labeled with 0% as "With the actions I selected, I do NOT believe this goal will be significantly advanced in 20 years," 50% as "Coin toss," and 100% as "With the actions I selected I believe this goal WILL be significantly advanced in 20 years." In the fourth question, "What are the main reasons for your level of certainty?" participants wrote brief open-ended responses. In the fifth question, "Which actions present the greatest opportunities to advance each scenario's goal?", participants were asked to pick up to three actions from a list populated with the actions they had selected in the first question and drag them into a box in ranked order of importance to the goal. The questionnaire was hosted on Qualtrics, Version July 2023, Provo, UT. The final questionnaire (Appendix S1) underwent several iterations of testing by study team members and external urban forest professionals. Research ethics approval was obtained through the University of British Columbia Behavioural Research Ethics Board (Approval Certificate H22-02863).

We aimed to recruit participants with significant expertise related to street tree management and urban forest ecosystem services, who as a group would represent a diversity of perspectives and experiences on these topics. As the professional identities of those who manage and influence the management of urban trees is varied and multidisciplinary (O'Herrin et al., 2020), and individuals communicate their expertise through the use of credentials from several disciplines (Day et al., 2022), we did not require any specific professional or academic credentials as signifiers of expertise. We asked prospective participants to self-define their eligibility to participate based on the following criteria: (1) interested in and knowledgeable of diverse benefits of trees or ecosystem services, (2) significant experience with street tree management, (3) currently in role where they manage or inform management of street trees in the city's metro area, and (4) two or more relevant credentials (professional credentials or degrees).

Initial letters of contact with attached project overviews were sent via email to participants at key urban forestry organizations in each city who met the above eligibility criteria. Contacts were also asked to recommend other eligible individuals in their metro area, who the project team then also reached out to. A target was set to recruit 10–15 participants per city, with a minimum of eight participants, based on recommendations from the IDEA Protocol (Hemming et al., 2018) and evidence that there are only minimal gains from having groups larger than 6–12 in size (Cooke & Goossens, 2004; Rowe & Wright, 2001). Participants were not given monetary incentives, but benefits to participation described in recruitment included networking with their peers and documentation of participation to receive credit towards maintaining professional credentials.

The final participant totals for each cohort were as follows: Vancouver, BC ($n = 11$), Washington, DC, ($n = 11$) and Honolulu, HI ($n = 9$). Participants' years of experience in urban forestry ranged from 3 to 49, with an average of 15 years and a median of 12 years. Of the participants, 77.4% ($n = 24$) were ISA Certified Arborists, 74.2% ($n = 23$) held the ISA Tree Risk Assessment Qualification, and 90.3% ($n = 28$) held a relevant professional credential other than an academic degree. Participants reported their highest level of education completed as PhD 12.9% ($n = 4$), master's degree, 35.5% ($n = 11$), bachelor's degree, 45.2% ($n = 14$), associate's degree 3.2% ($n = 1$), and high school diploma 3.2%

($n = 1$). Over all 31 participants, 16 self-identified as male, 14 self-identified as female, and 1 preferred not to disclose.

Elicitation

The elicitation consisted of online introduction meetings, completion of the questionnaire (Round 1), in-person workshops, and a final completion of the same questionnaire (Round 2), all of which took place from June to September 2023. The same elicitation method was followed in each of three metro areas and participants were informed of the existence of the other two areas, but cohorts were managed and conducted independently from each other. The identities and opinions of participants were only shared within each city cohort. All materials, such as recruitment and informational materials, were the same for each city. The same introductory presentation was given to each cohort and included an overview of the study's purpose and methods and a demonstration questionnaire. To retain the independence of participants prior to completing the first questionnaire, participants were given opportunities to ask questions related to definitions of terms and the study logistics but were asked to not discuss anything that might give away their expert opinions on the subjects at hand. Participants were emailed the questionnaire immediately upon the ending of the meeting and were asked to complete it as soon as possible, or within 2 weeks at the latest. In-person workshops were scheduled to occur within 1–2 months of the introduction meetings. The Washington, DC, metro area workshop had to be rescheduled to 2.5 months after the introduction meeting because of an extreme windstorm which required most of the participants to attend to emergency clean-up efforts.

Prior to the in-person workshops, reports of results of the Round 1 questionnaires were produced and shared via email with each cohort prior to the in-person workshops. Participants were each assigned and informed of their random codename (e.g., "HNL_1," "DC_1," or "YVR_1") and responses were only identified via codename in each city's report, so that each participant could locate their own Round 1 responses in relation to the rest of the group, while still retaining their anonymity.

The primary goals of the workshops were to discuss the questions of the Round 1 questionnaire and in doing so, investigate sources of uncertainty, clarify ambiguous terms, and explore underlying reasonings behind participants' responses to Round 1. Importantly, the goal of discussions was not to force or even work towards consensus, but rather to share knowledge between participants and improve collective responses in the final Round 2 questionnaire. Facilitators centered the workshop discussions on the first and fifth questions of the questionnaire—the actions *needed* and presenting the *greatest opportunity* to advance each goal. Participants were instructed to consider their selected actions as part of a management program that would be implemented regularly throughout the hypothetical 20-year time span. Facilitators promoted critical thinking through tactics such as probing assumptions underlying statements and use of "coherence checks," such as asking participants to consider counterfactuals (e.g., "if this action wasn't taken, could this goal still be advanced?") (Rowe & Wright, 2001).

The lead author took on the role of facilitator and led participants through discussions first of the overall scenario context and assumptions, followed by a deep dive into each of the five goals of the questionnaire (Box 1). The discussion of each goal was structured as follows: independent reflection, small group discussion (groups of three), full group discussion, and final independent reflection. This structure was designed to mitigate "anchoring bias"—the phenomena where group-based decision-making tends to be overly influenced by the first idea or information presented prior to making a judgment (Furnham & Boo, 2011)—by allowing all participants to reflect and take notes, prepare to share them with the group, then share in small groups, a greater number of ideas were encouraged and shared. Participants also changed seats so that the composition of the small groups were different for each discussion round. Research assistants aided with notetaking throughout the workshops.

In final reflection, participants were encouraged to take as specific notes as possible in their workbooks to assist them in completing the Round 2 questionnaire at the end of the day. Notes were also taken during discussion by the research team. Participants were also asked to complete an optional, anonymous survey to share any reflections on their experience in the study.

Post-elicitation

Following expert elicitation methodology, the Round 2 questionnaire was treated as the final results of the elicitation. Overall, a descriptive and comparative approach to analysis was deemed most appropriate for this primarily qualitative and categorical data, especially given the interdependencies between responses to check-all-that-apply and ranked choice questions, and because while participants filled out the questionnaires privately, the discussion phase of the elicitation was designed for participants within cohorts to learn and influence each other's final answers. We calculated descriptive statistics (e.g., frequencies, percent in favor) and created graphical visualizations (e.g., heat maps, summary tables, and box plots) using IBM SPSS Statistics, version 29, and R Statistical Software, version 4.3.0 (R Core Team, 2023).

Additional direct management actions offered by participants in the second question were consolidated into consistent language and summarized (more details in Appendix S2: Table S1). In the fourth question, reasons for certainty described by participants for each scenario were coded following an inductive and deductive process (Tracy, 2019). This process began with a round of open coding from a full reading of all responses, after which a set of codes were developed to describe the main reasons for certainty and uncertainty. All responses were then coded deductively using this set of codes, with only one code assigned to each response per list of certainty or uncertainty codes (see *Results*, Table 2). For example, the response "Soil remediation aids tremendously in stormwater management" (YVR_12) was only assigned the certainty code of "Belief actions will advance goals," while another response "We can manage for some wildlife like song birds on the street but most wildlife is going to need a forest or at least a forest patch" (DC_13) was assigned a certainty code of "Belief actions will advance goals" and an uncertainty code of "Street trees limited in advancing goals." In instances where multiple reasons for certainty or uncertainty were given, only the most prominent was chosen to represent that response.

RESULTS

Overall, we found notable differences in management actions seen as needed to advance the five goals. There was also high agreement in responses across metro areas, with notable exceptions for certain actions and goals. Results are qualified by participants' certainty ratings, which were on the whole very positive, but showed highest certainty in being able to advance Canopy and Risk, and least certainty in being able to advance People–Nature.

Actions needed to significantly advance each goal

Overall, the need for direct management throughout the street management cycle to "significantly advance each scenario's goal above all other goals" (as phrased in the questionnaire) was strongly supported (Table 1). Certain actions were seen as needed for all or some goals, while others were only needed for one goal. Suites of actions considered as needed for Canopy and Risk appear to be more similar to Heat and Stormwater than People–Nature and Wildlife. There is indication of a possible tradeoff when actions were selected as needed for only one or some goals but not all; however, we did not ask about negative relationships between actions and goals. Below, we breakdown results of the questionnaire's first question by management phase (Table 1) and include descriptions of these results for each metro area (for full results by metro area, see Appendix S3: Table S1).

Space tree planting sites by…

Almost all 31 participants selected "siting trees in every available planting space" as needed to advance Canopy and Risk, Heat, Wildlife, and Stormwater. Participants were split between all options for tree spacing on People–Nature and varied by metro area. For People–Nature, participants from DC still mostly selected "siting trees in every available planting space" as needed, while none from Honolulu and only two from Vancouver did.

Plant species with *x* characteristic

Across all species characteristics, there was most agreement among all participants that planting species of "large mature size" was needed to advance Canopy and Risk, Heat, and Stormwater. This was followed by needing to plant species with "aesthetic interest—flowers, foliage, bark, etc." and "cultural significance to residents" for People–Nature, and "native to region" and "food source to native wildlife" for Wildlife. For People–Nature, more participants identified "native to region," "food source to native wildlife," and "edible food for humans" as needed, notably with participants in Honolulu slightly more likely to select "native to region" and "edible food for humans," and DC more likely to select "edible food for humans." Only one participant each from DC and Vancouver selected palm trees for the People–Nature goal; they were not selected as needed for any other goals by the rest of the participants.

Plant trees that are of *x* species mix

There was widespread agreement that planting a "variety of species within previously selected characteristics" was needed to advance all five goals. "Variety of species by size (small, medium, large)" had moderate support, mostly due to more selections from Honolulu participants. Almost no participants thought it was needed to plant "no variety in species (i.e., all same species)" to achieve any of the five goals.

TABLE 1 Aggregated responses from all three metro areas ($N = 31$ participants) to the question "Which actions are needed to significantly advance each scenario's goal above all other goals?", in the context of each hypothetical streetscape scenario and assumptions.

		Percentage of participants					
Phase	**Direct management action**	**1. Canopy and risk**	**2. Heat**	**3. People-nature**	**4. Wildlife**	**5. Storm water**	**Min–max range**
Planning and design	Space tree planting sites by…						
	Siting one tree for every building	19.4	6.5	38.7	6.5	9.7	32.2
	Siting trees in every available planting space	**93.5**	**100.0**	32.3	**93.5**	**96.8**	67.7
	None of these options	0.0	0.0	35.5	6.5	0.0	35.5
	Plant species with *x* characteristic						
	Native to region	19.4	9.7	38.7	**83.9**	6.5	77.4*
	Edible food (humans)	3.2	0.0	54.8	3.2	0.0	54.8
	Food source to native wildlife	6.5	3.2	48.4	**87.1**	0.0	87.1*
	Aesthetic interest—flowers, foliage, bark, etc.	6.5	0.0	**96.8**	6.5	0.0	96.8*
	Cultural significance to residents	9.7	0.0	**96.8**	3.2	3.2	96.8*
	Drops leaves seasonally (deciduous)	22.6	25.8	9.7	35.5	25.8	25.8
	Retains leaves year-round (evergreen)	22.6	25.8	12.9	35.5	54.8	41.9
	Small mature size	38.7	22.6	32.3	45.2	35.5	22.6
	Medium mature size	61.3	61.3	32.3	48.4	58.1	29.0
	Large mature size	**100.0**	**96.8**	29.0	54.8	**100.0**	71.0
	Spreading or vase shaped growth habit	**80.6**	**80.6**	12.9	32.3	54.8	67.7
	Columnar or pyramidal shaped growth habit	22.6	12.9	9.7	19.4	19.4	12.9
	Round or oval growth habit	67.7	48.4	12.9	29.0	35.5	54.8
	Palm species	0.0	0.0	6.5	0.0	3.2	6.5
	None of these options	0.0	0.0	0.0	0.0	0.0	0.0
	Plant trees that are of *x* species mix						
	No variety in species (i.e., all same species)	0.0	0.0	3.2	0.0	3.2	3.2
	Variety of species by size (small, medium, large)	25.8	25.8	35.5	54.8	41.9	29.0
	Variety of species within previously selected characteristics	**87.1**	**90.3**	**90.3**	**93.5**	**83.9**	9.6
	None of these options	6.5	6.5	6.5	0.0	6.5	6.5
Site preparation	Remediate soil compaction	**93.5**	**93.5**	71.0	**87.1**	**100.0**	29.0
	Test soil and amend accordingly	67.7	58.1	54.8	41.9	61.3	25.8

(Continues)

TABLE 1 (Continued)

Phase	Direct management action	Percentage of participants: 1. Canopy and risk	2. Heat	3. People-nature	4. Wildlife	5. Storm water	Min–max range
	None of these options	3.2	0.0	19.4	12.9	0.0	19.4
Planting	Inspect nursery stock quality	**100.0**	**93.5**	**83.9**	74.2	74.2	25.8
	Stake for stability	51.6	32.3	51.6	29.0	29.0	22.6
	Add mulch ring with berm	45.2	48.4	51.6	45.2	61.3	16.1
	Prune root ball prior to planting	22.6	19.4	19.4	16.1	19.4	6.5
	None of these options	0.0	0.0	12.9	6.5	3.2	12.9
Young tree maintenance	Perform structural pruning for young trees	**100.0**	**80.6**	**87.1**	45.2	71.0	54.8
	Maintain mulch ring	38.7	38.7	54.8	38.7	67.7	29.0
	None of these options	0.0	9.7	6.5	22.6	3.2	22.6
Mature tree maintenance	Prune on a cycle (once every 5–7 years)	51.6	35.5	45.2	6.5	25.8	45.1
	Prune by resident request	9.7	3.2	**87.1**	6.5	6.5	83.9*
	Prune in response to storm damage	58.1	29.0	67.7	16.1	22.6	51.6
	Prune for clearance	41.9	29.0	58.1	6.5	12.9	51.6
	Prune deadwood	45.2	25.8	58.1	12.9	19.4	45.2
	Prune as needed to mitigate risk	**100.0**	45.2	64.5	32.3	22.6	77.4*
	Assess for plant health care needs and treat accordingly	71.0	67.7	67.7	48.4	61.3	22.6
	None of these options	0.0	12.9	0.0	35.5	29.0	35.5
End of life	Remove trees when invasive non-native species (even if healthy)	6.5	0.0	6.5	29.0	0.0	29.0
	Remove trees when tree risk assessment rating exceeds moderate risk level	74.2	25.8	51.6	12.9	12.9	61.3
	Remove trees when declining and likely to die within inspection cycle	67.7	51.6	51.6	16.1	45.2	51.6
	Remove trees when completely dead	67.7	**87.1**	**77.4**	32.3	**80.6**	54.8
	Retain standing snags at safe height	3.2	0.0	12.9	54.8	6.5	54.8
	Retain stumps	0.0	0.0	3.2	29.0	19.4	29.0
	None of these options	3.2	6.5	3.2	9.7	9.7	6.5

Note: Min–max range is the difference between the min and max percentage across all five goals for that action, where a higher value indicates an action was highly needed to advance one goal but not another. (An asterisk indicates a min–max range over 75, highlighting actions presenting potential tradeoffs between goals.) Values over 75% appear in boldface to highlight instances of high agreement.

Site preparation

There was widespread agreement on the need to "remediate soil compaction" to advance all goals, especially Canopy and Risk, Heat, and Stormwater. About half of participants thought it was needed to "test soil and amend accordingly," with no notable differences by metro area or goal.

TABLE 2 Coded responses to each participant's open-ended responses to the question "What are your main reasons for certainty?" ($N = 31$ participants).

Code	Frequency of participants: 1. Canopy and risk	2. Urban heat reduction	3. People-nature relationships	4. Wildlife habitat	5. Stormwater interception and infiltration
Certainty codes					
Belief actions will advance goal	22	20	12	16	16
Experience	4	4	0	5	0
Scenario assumptions removed sources of uncertainty	3	2	0	1	0
Education	0	0	1	0	1
Subtotal	29	26	13	22	17
Uncertainty codes					
Complex/difficult	4	1	5	1	3
Street trees limited in advancing goal alone	0	0	3	5	5
Environmental factors	3	2	0	4	3
Need for indirect actions	0	1	8	0	0
Not enough information or knowledge	0	1	2	2	4
Social factors	1	0	6	0	0
Factors specific to their metro area	0	0	0	3	0
More scientific research needed	0	1	0	0	0
Subtotal	8	6	24	15	15

Note: Each response was assigned one certainty code and/or uncertainty code that most reflected their response. Subtotals for each goal reflect the number of participants who expressed certainty and/or uncertainty in their response. Responses in which the participant wrote "N/A" or similar, were coded as "N/As" and omitted from this table.

Planting

There was widespread agreement on the need to "inspect nursery stock quality" prior to planting, however fewer participants from Vancouver selected this for Wildlife and Stormwater. Approximately half of participants selected "add mulch ring with berm" for all goals, due mostly to participants from Vancouver who nearly unanimously selected it for all goals. Almost no participants from Honolulu selected "add mulch ring with berm" for any goal (in the Honolulu workshop, participants described the current quarantine on moving mulch or wood chips to prevent the spread of the invasive coconut rhinoceros beetle).

Young tree maintenance

There was widespread agreement on the need to "perform structural pruning" during young tree maintenance, across all goals except for Wildlife. Like in the Planting phase, "maintain mulch ring" was favored across goals much more by participants from Vancouver than DC and Honolulu.

Mature tree maintenance

Mature tree maintenance needs varied across goals and metro areas, with pruning related actions being selected as needed more for Canopy and Risk and People–Nature than for the other scenarios. "Prune on a cycle (once every 5–7 years)" received almost no selections from Honolulu participants, for any goal. All three workshops included at least some discussion of resident interest in pruning of trees on their street, and the opportunities that arose for engaging with residents while inspecting and pruning trees.

End of life

Reasons to initiate removal varied across goals, with reasons related to risk management selected somewhat more for Canopy and Risk than for other goals. "Remove trees when completely dead" was selected as needed by most participants for all goals but Wildlife. For Wildlife, participants selecting "retain standing snags at safe height" and "retain stumps" were mostly from Vancouver, and some from DC, with only one from Honolulu. In the workshops, participants discussed the need to remove dead street trees to continue the street tree management cycle and plant new trees which could go on to provide more benefits.

Additional direct actions needed

Participants generally seemed to think that the list of direct actions included in the first question was comprehensive, based on the limited range in responses to the follow-up question asking if there were any additional direct actions needed for a particular goal that were not listed in the question or referenced in the assumptions (see Appendix S2: Table S1 for a complete list of responses). Of these, additional direct actions suggested for multiple goals included: interplant large trees with small understory trees (suggested for Canopy and Risk [$n = 1$], Wildlife [$n = 4$], and Stormwater [$n = 2$]) and plant species with characteristics such as high leaf area index (suggested for Heat [$n = 1$] and Stormwater [$n = 3$]). Notably, across all scenarios, participants from Honolulu stated a preference for pruning on a shorter cycle, such as 1–3 years, than the 5–7-year cycle specified in the original list, aligning with a discussion during the Honolulu workshop that most urban trees in Hawai'i grow too fast for a 5–7 cycle to result in safe conditions. Of the nine total Honolulu participants, eight wrote in this suggestion for Canopy and Risk.

Participants understood the scope of the study to include only direct, tree-based actions, however, answers to this open-ended question revealed how important participants believe indirect and non-tree-based actions to be in achieving certain goals. For People–Nature, many participants ignored the question parameters and wrote in detailed examples related to community engagement and education as needed to advance the goal ($n = 18$), which would be considered "indirect actions" and outside of the scope of this study. For Heat, Wildlife, and Stormwater, though not asked for, participants provided examples of non-tree direct actions they believed were also needed, such as changing the built infrastructure or changing the ground vegetation.

Certainty of advancing each goal and underlying reasons

Participants rated their certainty that their previously selected actions would "significantly advance each scenario's goal above all other goals" on a sliding scale of 0%–100% (Figure 5). For all five goals, the median certainty ratings were over 50%, indicating that on the whole, participants believed these goals could be significantly advanced with direct tree management. Considering all 31 participants, Canopy and Risk had the highest median certainty rating, 88%, while People–Nature had the lowest, 65%. Wildlife and Stormwater had the widest ranges between min and max rating (91% and 96%, respectively) and largest standard deviations (20.8 and 22.2, respectively). Certainty ratings showed more alignment by metro area for Canopy and Risk, Heat, and People–Nature. Participants from Honolulu had notably lower certainty ratings for Wildlife and Stormwater.

Across all goals, participants' reasons for their certainty ratings, given in an open-ended response question, mostly reiterated or described their belief that the actions they selected would advance the goal in question, coded as "Belief actions will advance goal." Some referenced their education or experience. A few said that the assumptions of the scenario parameters removed sources of uncertainty that would make them think a goal was less achievable in the real world, but that allowed them to have increased certainty within the hypothetical scenario. More responses in People–Nature were coded with reasons for uncertainty, in alignment with lower certainty ratings of being able to advance that goal with direct management alone (Table 2, Figure 5). There were not notable differences in frequencies of codes between participants of different metro areas.

Points of influence to advance each goal

Results indicate that each goal requires actions that are common across all goals, and actions that are unique to that goal. Specifically, there were actions presenting greater opportunity to influence specific goals, and management phases during which urban foresters could influence the advancement of goals by considering these actions (Table 3). "Siting trees in every available planting space" was the direct action ranked as presenting the greatest opportunity to advance most goals. In addition to receiving the most cumulative top three rankings, it received the most first place rankings of any action ($n = 17$ for Canopy and Risk, $n = 25$ for Heat, and $n = 17$ for Stormwater). Actions presenting the greatest opportunity to advance Canopy and Risk, Heat, and Stormwater, were broadly more in line with each other, while People–Nature and Wildlife each had different groupings of top ranked actions.

By phase, actions within the planning and design phase presented the greatest opportunity to advance specific goals. Within the planning and design phase, species

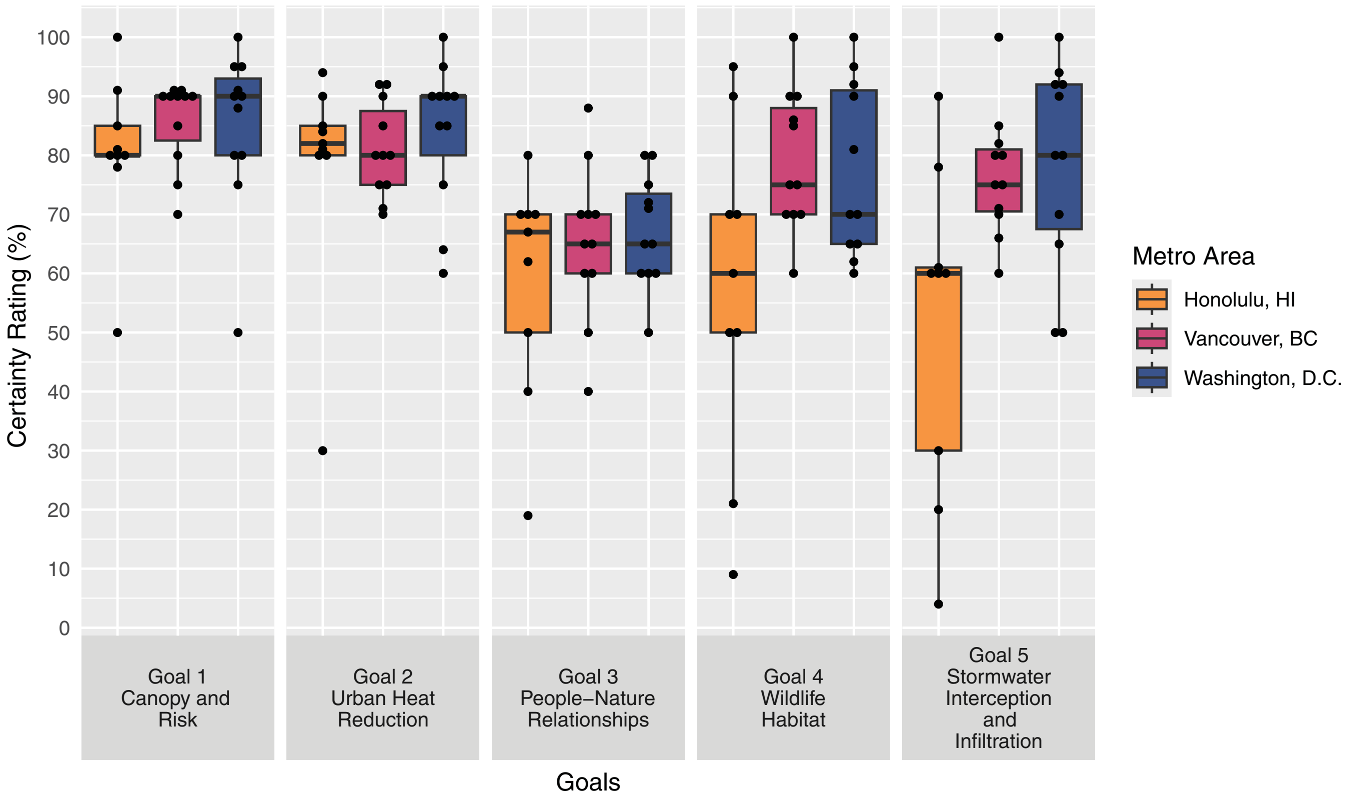

FIGURE 5 Box plots of certainty ratings (0%–100%) of participants grouped by goal and metro area, in response to the question "Within the assumptions of this scenario, if all of your selected actions were taken, how certain are you that this goal could be significantly advanced in 20 years?" All 31 participants answered this question for each goal, five times total. Each dot represents an individual participant's rating. The midlines of the boxplots are the median ratings, the ends of the whiskers are the minimum and maximum ratings, and the box limits are the upper and lower quartiles.

selection appeared to be the most important choice for urban foresters to influence goals in the hypothetical streetscape, as actions within "Plant species with *x* characteristic" received more rankings cumulatively than the "Space tree planting sites by…" and "Plant trees that are of *x* species mix" categories.

After comparing rankings for each action by metro area, cities were relatively aligned, with a few notable exceptions. Virtually all DC participants (91%) ranked "native to region" among the three most important actions for Wildlife, compared to only 22% of Honolulu participants and 36% of Vancouver participants. Meanwhile, 54% of Vancouver participants ranked "retain leaves year-round (evergreen)" for Stormwater, compared to 0% of DC participants and only 11% of Honolulu participants.

DISCUSSION

Certain goals are more aligned than others

Overall, we found strong evidence that street tree management actions can be aligned to substantially advance specific urban sustainability goals. In response to our first research objective, the results show that suites of actions needed for typical urban forest management goals (i.e., canopy cover and risk mitigation) have both broad overlap as well as notable differences from those needed for goals framed as specific urban sustainability goals. In particular, actions known to highly impact the survival of newly planted trees past the young tree maintenance phase (also known as the establishment phase), such as inspecting nursery stock prior to planting and performing structural pruning (Gilman et al., 2015; Ryder & Moore, 2013), were deemed essential nearly across the board. Though there was broad overlap in actions needed for most goals (Table 1), the actions presenting the greatest opportunity for each goal differed more starkly (Table 3). Specifically, we found strong evidence that actions needed to increase canopy cover while reducing tree risk (Canopy and Risk) aligned most with actions needed to mitigate urban heat (Heat) and increase stormwater interception and infiltration (Stormwater) (Tables 1 and 3). Most of these actions were also needed to foster people–nature relationships (People–Nature) and increase wildlife habitat (Wildlife), with notable exceptions related to selecting

TABLE 3 Direct street tree management actions assigned a top three ranking in response to the question "Which actions present the greatest opportunities to advance each scenario's goal?" across all participants ($N = 31$).

Phase	Direct management action	No. participants assigning a top three ranking: 1. Canopy and risk	2. Heat	3. People-nature	4. Wildlife	5. Stormwater	Total ranks for all goals, per action	Total ranks for all goals, per phase
Planning and design	Plant species with *x* characteristic							
	Large mature size	17	**19**	1	2	16	55	
	Food source to native wildlife	0	0	2	**24**	0	26	
	Aesthetic interest—flowers, foliage, bark, etc.	0	0	**23**	0	0	23	
	Cultural significance to residents	0	0	**22**	0	0	22	
	Spreading or vase shaped growth habit	4	9	0	0	6	19	
	Native to region	0	0	1	**16**	0	17	
	Retains leaves year-round (evergreen)	0	1	1	0	7	9	
	Space tree planting sites by…							
	Siting trees in every available planting space	23	**30**	3	20	27	103	
	Siting one tree for every building	2	0	3	0	1	6	
	Plant trees that are of *x* species mix							
	Variety of species within previously selected characteristics	3	9	4	**11**	7	34	
	Variety of species by size (small, medium, large)	3	**4**	3	3	2	15	329
Mature tree maintenance	Prune as needed to mitigate risk	**13**	1	2	0	0	16	
	Assess for plant health care needs and treat accordingly	4	4	2	2	1	13	
	Prune by resident request	0	0	**12**	0	0	12	41
Site preparation	Remediate soil compaction	6	6	2	4	**21**	39	39
Young tree maintenance	Perform structural pruning for young trees	**7**	4	1	1	1	14	14
Planting	Inspect nursery stock quality	**4**	2	1	0	0	7	7
End of life	Retain standing snags at safe height	0	0	0	**5**	0	5	5

Note: Each participant could pick and rank up to three actions per goal. One value is bolded per row/direct management action, indicating which goal that action presents the greatest opportunity to advance. Table is organized by listing phases in descending order of importance (i.e. total # of ranks for all goals, across actions of that phase). Nine actions which each received fewer than five total rankings across all goals were omitted from this table. Bold value indicates the highest value.

species characteristics and mature tree maintenance. Extensive literature strongly supports the alignment of increasing canopy cover with the provision of both the ecosystem services of heat mitigation (Alonzo et al., 2021; Krayenhoff et al., 2020) and stormwater interception and infiltration (Berland et al., 2017; Selbig et al., 2022). These are often united through studying the effect of increased leaf area index (Dowtin et al., 2023; Rahman et al., 2020), as also found in studies based on the commonly used i-Tree software, comprising a suite of tools for estimating urban forest ecosystem services developed by the USDA (Nowak, 2020). Nonetheless, despite these similarities, our evidence shows that managing for goals framed as changing ecosystem or biophysical structure (e.g., increasing canopy cover) requires different strategies compared with goals framed as ecosystem services or social-ecological relationships, and next look to an investigation of the specific actions which can cause these different outcomes.

Actions linked with specific urban sustainability goals

With respect to the second research objective, we find that some actions with the widest divergences in participant response were in planting species with specific characteristics needed for People–Nature (i.e., aesthetic interest or cultural significance) and Wildlife (i.e., native to region or a food source to native wildlife), which were selected for those goals alone (Table 1). On the whole, these results imply that aligning urban forest management with any of the other goals could miss the opportunities to advance People–Nature or Wildlife through planting species with these characteristics. For example, one could more quickly achieve a canopy cover goal through planting fast-growing non-native tree species, even though those trees may not be ecologically appropriate (Dickie et al., 2014). Multiobjective management requires deliberate choosing of actions that align with each goal at hand (Bradford & D'Amato, 2012).

Although we identified a suite of direct actions that aligns with each of the goals examined in this study, more research is required to fully develop management recommendations for specific urban sustainability goals. In some cases, experts identified barriers to implementing certain actions or gaps in research-based knowledge. In particular, they indicated relatively more uncertainty about People–Nature and Wildlife, which may mirror the complexity of the scientific literature on these topics, highlight needs for professional training, or perhaps illustrate inherent tradeoffs. For example, when considering People–Nature many participants in the workshops described that individual residents and diverse populations formed connections with many types of trees in ways that were difficult for them to predict. Experts related that fruit trees, for example, are often divisive—with some residents demanding more fruit trees and others demanding their removal. Literature on this subject has found that though the typical narrative aligns with most people liking trees with aesthetic or food production traits more, this can vary, as relationships people form with trees can be deeply personal and reflect a range of values, including those informed by cultural identity and personal past experiences, and influence perceptions of services and disservices (Barona et al., 2023; Fernandes et al., 2019). Nonetheless, the selection of many diverse actions (such as many different species characteristics and pruning strategies) by participants indicate a potential diversity of pathways to foster stronger relationships between residents and street trees. These results, that relationships between residents and trees on their street are different depending on the types of people and trees (and that urban foresters recognize this well), align with the growing body of literature on relational values (Chan et al., 2018), which puts forth that, like all relationships, people–nature relationships can change depending on the entities involved, and that one (e.g., person or tree) cannot be replaced without changing the relationship (Eyster et al., 2023). Literature on people–nature relationships is emerging as powerful area to understand human behavior and unlock pro-environmental behavior (Jax et al., 2018), and our results both contribute to this body of knowledge and indicate there is great opportunity for research which could inform further activation of tree stewardship and urban sustainability.

While People–Nature brought up questions related to serving diverse human populations, Wildlife required considering how to support diverse native wildlife populations. In the workshops, experts described many barriers to managing for habitat in the real world, even if within the parameters of the hypothetical scenario they believed that actions such as planting native species could support native wildlife. In Honolulu, participants expressed that it was so unlikely for native birds to be found on streetscapes that they were even hesitant to try to manage for this goal in the context of the hypothetical expert elicitation, especially combined with their experience that many native tree species fail to thrive in the typically poor and non-native soils along developed streets. Issues related to suitability of native species for streetscapes were also raised in Vancouver, but from a different angle. Though participants agreed planting native species could support native wildlife in general, participants also voiced concerns that the dominant tree species in native forests of Metro Vancouver include Douglas fir (*Pseudotsuga menziesii*), western red cedar (*Thuja plicata*), and western hemlock (*Tsuga heterophylla*), all of which can grow to exceptional heights and sizes (50–100 m), were not appropriate for most streetscapes because of their great needs for space and soil volume (British Columbia Ministry of Forests, 2024). It is also highly possible that participants only selected actions that they were familiar with. For example, discussion in the DC workshop revealed uncertainty among participants about the difference in annual stormwater interception ability between deciduous and evergreen trees, which could have influenced responses. This points to the need for more empirical research, and dissemination of such research on trait-based functions of urban trees (Dowtin et al., 2023; Farrell et al., 2022; Paquette et al., 2021). Thus, while our results describe actions which can be linked to specific goals in general, these results should be connected with other sources of evidence and knowledge of local social and ecological factors to inform practice. Finally, as research progresses on the tradeoffs between urban forest management actions and ecosystem services (e.g., Hutt-Taylor et al., 2024), there will be more opportunities to build off of the linkages established in this study, which relied on integrating the knowledge of practitioners (from their years of field experience, professional training, and education).

Points of influence for specific goal in the street tree management life cycle

With respect to our third research objective, we find actions in all phases of the street tree management cycle are needed no matter the goal at hand (e.g., street trees require active management), however participants identified actions in the planning and design phase as presenting the greatest opportunities to influence which goals are most advanced. There were also notable opportunities to advance goals later in the cycle that should not be ignored, such as increasing stormwater infiltration through site preparation actions like remediating soil compaction and reducing tree risk (i.e., minimizing an ecosystem disservice) through mature tree maintenance actions. That the planning and design phase had the actions considered the greatest opportunities for advancing specific urban sustainability goals was not surprising, especially given the amount of literature focusing on actions in this phase (e.g., Almeter et al., 2018; Bodnaruk et al., 2017; Esperon-Rodriguez et al., 2022). The results also show the high importance of species selection when siting options are limited, as the parameters of this study (linear streetside plantings) limited creativity in siting of trees in order to reduce variables. If this study were repeated in a different setting where practitioners could direct urban tree placement, such as yards, parks, institutions, we would expect site selection to present greater opportunities to advance goals, given the growing body of literature finding significant effects from modeling differences in ecosystem services such as heat regulation from site-level tree placement decisions (Abram et al., 2022; Hwang et al., 2015). Future management planning could benefit from considering the unique opportunities to influence different goals in different phases.

Untangling differences between contexts

We tried to anticipate as many differences in management needs between the three metro areas as possible in development of the study design to be able to assess actions with which all participants would be familiar. For example, we expected that appropriate street tree species would differ substantially between the three metro areas, and thus took a trait-based approach to the suite of species selection actions in the questionnaire. However, as anticipated, unexpected differences in context-based management needs still arose. One notable example clearly affected the study results for Canopy and Risk: while all 31 participants said it was needed to "prune as needed to mitigate risk," only 16 participants, none from Honolulu, said "prune on a cycle (5–7 years)" was needed. Meanwhile, eight out of nine Honolulu participants wrote in answers that pruning on a shorter cycle, such as 1–3 years, was needed to advance Canopy and Risk. This suggests that had the questionnaire been phrased differently, such as "pruning or inspecting trees on a locally appropriate cycle," 24 or more participants may have supported this action for Canopy and Risk. The recommendation to prune trees on an approximately 5-year cycle is widespread in temperate cities, and originates from seminal research from Milwaukee, Wisconsin, which determined this an optimal cycle length to reduce tree risk and overall maintenance costs (Miller & Sylvester, 1981). Inspection and pruning cycles are critical components of mature tree maintenance to identify health issues, promote strong tree architecture, and mitigate risk to residents from dead or dying tree parts, yet they are expensive and as a maintenance line item, do not receive as strong support from city leaders as do exciting tree planting initiatives (Koeser, Hauer, et al., 2016; Vogt et al., 2015). In sum, mature tree maintenance activities such as proactive inspection and pruning are essential to achieving most goals across all metro areas, with a notable exception for supporting wildlife habitat (likely specifically for species reliant on tree cavities, such as in Kane et al., 2015).

Although participating experts were broadly aligned on actions needed to achieve each of the goals, we identified differences across metro areas in certain key topics. We suspect these differences are a product of likely differences in local knowledge bases and training which interact with local social and ecological needs and conditions. For example, the ban in place at the time of writing on moving mulch in Honolulu due its ability to transport the invasive coconut rhinoceros beetle (*Oryctes rhinoceros*) not only rightly resulted in expert participants not recommending mulching, but based on discussions in the workshop, seemed to also be paired with less experience and knowledge of with the potential benefits of mulching compared to participants in DC and Vancouver. Similarly, all Vancouver participants recommended retaining standing snags for Wildlife (Appendix S3: Table S1.4), perhaps because of a movement in the professional tree care community of the Pacific Northwest to preserve habitat for cavity-nesting wildlife (French et al., 2020; Wildlife Dangerous Tree Committee of British Columbia, 2019), which seems not to have taken hold in DC. A comparable wildlife movement in the tree care community in Hawaii created guidelines for the only native bird species that is found to nest in street trees, manu-o kū (*Gygis alba*), which was reflected in the discussions and subsequent responses of the Honolulu participants (manu-o kū lays directly lays eggs in crooks of branches of street trees and does not seem to discriminate between trees based on nativity status) (Bassett et al., 2022; Liu et al., 2019). This idea of regional knowledge bases may be a factor in the varying certainty ratings between metro areas as well. For example, in the DC area, urban foresters are frequently involved in stormwater management discussions (perhaps in part due to region wide efforts to protect the Chesapeake Bay watershed, see Kimball et al., 2014), while urban foresters in Honolulu described being disconnected from stormwater management issues, due to barriers including disciplinary silos. However, though our results illuminate interesting and novel instances of difference between our included cities, we were overall relatively surprised at the high level of agreement in this study between participants of different metro areas.

Applications to multiobjective management for urban sustainability

We believe our study represents an important contribution towards the multiobjective management of urban forests for urban sustainability goals. Our results present a step forward in tailoring phase-specific management plans in multiobjective management of urban forests; however, this should be done with consideration for local factors, emerging literature on effects of management actions, and sustainability goals not included in this study. Additionally, despite being frequently reminded that this study was limited to direct street tree management actions, participants continuously pointed out many strategies to advance goals through indirect management actions, like fostering people–nature relationships through community outreach and education, or non-tree actions, like increasing stormwater retention capacity through engineered green infrastructure. This contributes to the idea that urban forest management cannot advance urban sustainability through trees alone, and that there are likely powerful benefits that could accrue when urban foresters connect with other disciplines, communities, and practices (ʻĀina of Kaʻōnohi et al., 2023; Campbell et al., 2022; Vogt et al., 2016). Our results should also thus be considered within the context of managing urban forests as complex socioecological systems within dynamic and changing urban areas.

Limitations

Overall, outcomes from expert elicitation as a method are limited by knowledge of the expert participants and common biases, which can include overconfidence and reliance on cognitive heuristics (Morgan, 2014). In constructing the elicitation, although we attempted to achieve a balance between asking questions that could open new areas of inquiry as well as match the knowledge of urban foresters, our participants themselves acknowledged significant differences in their depths of understanding on topics within the elicitation in workshop discussions and in the questionnaire (Table 2). The scope of our study was as comprehensive as possible in terms of inclusion of considered management actions and diversity of sustainability goals, within the limits of managing participant fatigue. We were also limited to subject areas we expected urban forest professionals to have a deep understanding of, which did not include emerging topics of importance such as the role of greenspace in human health (Pinto et al., 2022) or topics with considerable complexity and uncertainty in the literature, such as the relationship of trees and air quality (Eisenman et al., 2019). Because of this, study results could also serve to guide future science dissemination and professional education, for topics where expert knowledge may seem not to reflect the state of the science.

To meet the goal of generating results generalizable beyond the study metro areas, both goals and actions were framed broadly. Though our study design was limited to only three metropolitan areas, we also see this as a feature of the novelty of the study, as most expert elicitations either combine participants from many locations into one cohort, e.g., through virtual discussion processes, or are limited to considering a single location. This meant that despite careful adherence to consistent communications and facilitation procedures, participants from each cohort will have had different experiences in the influential discussion phase of the elicitation. Future research could more fully investigate factors identified within each of these metro areas to understand practices within a specific region and could investigate regions not included in this study. Using these results to inform practice and policy will require considering the assumptions within our hypothetical scenario, including but not limited to the considerable costs of individual tree management such as watering trees in establishment, threats from climate change and invasive pests undermining knowledge of suitable species, and limited soil volume and quality in most streets.

CONCLUSIONS

Our study offers a comprehensive, qualitative, evaluation of street tree management actions in relation to a selection of commonly targeted urban sustainability goals. We find that managing for widely adopted canopy cover goals could result in missed opportunities to advance other important sustainability goals and that there is more alignment in management approaches for certain goals than others. Additionally, it is critical to support the entire street tree management cycle in order to advance all goals using street trees, but recognize that each phase presents different opportunities to advance different goals. These findings can lay the foundation for future quantitative studies, such as through suggesting inputs for future modeling and highlighting areas to advance quantification efforts on the effects of management actions on outcomes, all of which can contribute to better assessment of tradeoffs to inform multiobjective management for urban sustainability (Bradford & D'Amato, 2012; Rounsevell & Metzger, 2010). Experts can be a valuable source of insights to inform practice, such as through evaluating management options (Hagerman & Satterfield, 2014), and to inform further research, such as identifying inputs for environmental modeling (Krueger et al., 2012). In this study, we found expert elicitation to be an expedient and fruitful exercise with positive benefits to the production of generalizable knowledge, and to the participants themselves, with strong potential for future use in (1) socioecological systems needing to be managed for many goals and (2) where a qualitative assessment of impacts is needed to provide a foundation for future quantitative research. Given changing cities and climates, it would not be possible to test the number of variables considered in this study in the field over a 20-year horizon. Still, the findings should be taken as a whole and integrated with local knowledge and emerging, relevant, research. We present evidence that site-level management decisions must be made deliberately to successfully use urban forests as a nature-based solution for urban sustainability goals.

ACKNOWLEDGMENTS

We sincerely thank the participants for their time and commitment to this study, as well as their work to steward urban forests and their cities. The lead author (Corinne G. Bassett) and Street Tree Futures project research assistants Chanel Yee and Angel Bao were supported in part by a Partnership Development Grant from the Social Sciences and Humanities Research Council of Canada. The lead author (Corinne G. Bassett) received a fellowship from the USDA Forest Service, Los Angeles Center for Urban Natural Resources Sustainability in 2020–2021, which supported the piloting of a survey that was an important precursor in the development of the research questions and methodology for this study. The findings and conclusions of this publication are those of the authors and should not be construed to represent any official USDA or US Government determination or policy.

CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest.

DATA AVAILABILITY STATEMENT

Data (Bassett, 2024b) are available from the University of British Columbia Research Data Collection on the Borealis data repository: https://doi.org/10.5683/SP3/L70OJY.

ETHICS STATEMENT

This study was approved by the Behavioural Research Ethics Board of the University of British Columbia (Approval Certificate H22-02863).

ORCID

Corinne G. Bassett https://orcid.org/0000-0002-5254-0688
Susan D. Day https://orcid.org/0000-0002-5184-1593
Cecil C. Konijnendijk https://orcid.org/0000-0003-4000-0622
Lara A. Roman https://orcid.org/0000-0001-5507-6406
Victoria Hemming https://orcid.org/0000-0003-3220-6161

REFERENCES

‘Āina of Ka‘ōnohi, A. K. Deluze, K. Enos, K. Mossman, I. Gunasekera, D. Espiritu, C. Jay, et al. 2023. “Urban ‘Āina: An Indigenous, Biocultural Pathway to Transforming Urban Spaces.” *Sustainability* 15: 9937.

Abram, L. Z., J. P. Keller, E. A. Tulanowski, and M. R. McHale. 2022. “From West to East: Tree Placement Differentially Affects Summertime Household Energy Consumption in a Semi-Arid City.” *Arboriculture & Urban Forestry* 48: 261–277.

Almeter, A., A. Tashie, A. Procter, T. McAlexander, D. Browning, C. Rudder, L. Jackson, and R. Araujo. 2018. “A Needs-Driven, Multi-Objective Approach to Allocate Urban Ecosystem Services from 10,000 Trees.” *Sustainability* 10: 4488.

Alonzo, M., M. E. Baker, Y. Gao, and V. Shandas. 2021. “Spatial Configuration and Time of Day Impacts the Magnitude of Urban Tree Canopy Cooling.” *Environmental Research Letters* 16: 084028.

Barona, C. O., C. Sonkkila, J. M. Baumann, C. G. Threlfall, D. F. Hochuli, R. A. Fuller, M. Davern, and S. J. Livesley. 2023. “The Role of Diverse Cultural Identities in the Perceived Value of Urban Forests in Melbourne, Australia, and Implications for Urban Ecosystem Research and Practice.” *Ecology and Society* 28: 3. https://ecologyandsociety.org/vol28/iss4/art3/

Bassett, C. G. 2024a. *Bridging Gaps in Urban Forest Management to Achieve Urban Sustainability Goals*. Vancouver, BC: University of British Columbia.

Bassett, C. G. 2024b. Data For “Aligning Urban Forest Management Actions with Urban Sustainability Goals: A Multi-City Expert Elicitation.” Borealis. V1. https://doi.org/10.5683/SP3/L70OJY.

Bassett, C. G., R. Gilpin, and K. Donohue. 2022. “Lessons Learned from Developing Best Management Practices for Urban Tree Care and Wildlife.” *Arboriculture & Urban Forestry* 48: 1–8.

Beck, H. E., N. E. Zimmermann, T. R. McVicar, N. Vergopolan, A. Berg, and E. F. Wood. 2018. “Present and Future Köppen-Geiger Climate Classification Maps at 1-km Resolution.” *Scientific Data* 5: 180214.

Berland, A., S. A. Shiflett, W. D. Shuster, A. S. Garmestani, H. C. Goddard, D. L. Herrmann, and M. E. Hopton. 2017. “The Role of Trees in Urban Stormwater Management.” *Landscape and Urban Planning* 162: 167–177.

Bodnaruk, E. W., C. N. Kroll, Y. Yang, S. Hirabayashi, D. J. Nowak, and T. A. Endreny. 2017. “Where to Plant Urban Trees? A Spatially Explicit Methodology to Explore Ecosystem Service Tradeoffs.” *Landscape and Urban Planning* 157: 457–467.

Bradford, J. B., and A. W. D’Amato. 2012. “Recognizing Trade-Offs in Multi-Objective Land Management.” *Frontiers in Ecology and the Environment* 10: 210–16.

British Columbia Ministry of Forests. 2024. “Tree Species Compendium.” Province of British Columbia. https://www2.gov.bc.ca/gov/content/industry/forestry/managing-our-forest-resources/silviculture/tree-species-selection/tree-species-compendium-index.

Campbell, L. K., E. S. Svendsen, M. L. Johnson, and S. Plitt. 2022. “Not by Trees Alone: Centering Community in Urban Forestry.” *Landscape and Urban Planning* 224: 104445.

Cawson, J. G., V. Hemming, A. Ackland, W. Anderson, D. Bowman, R. Bradstock, T. P. Brown, et al. 2020. “Exploring the Key Drivers of Forest Flammability in Wet Eucalypt Forests Using Expert-Derived Conceptual Models.” *Landscape Ecology* 35: 1775–98.

Chan, K. M. A., P. Balvanera, K. Benessaiah, M. Chapman, S. Díaz, E. Gómez-Baggethun, R. Gould, et al. 2016. “Opinion: Why Protect Nature? Rethinking Values and the Environment.” *Proceedings of the National Academy of Sciences of the United States of America* 113: 1462–65.

Chan, K. M. A., R. K. Gould, and U. Pascual. 2018. “Editorial Overview: Relational Values: What Are They, and What’s the Fuss About?” *Current Opinion in Environmental Sustainability* 35: A1–A7.

Colding, J., Å. Gren, and S. Barthel. 2020. “The Incremental Demise of Urban Green Spaces.” *Land* 9: 162.

Cooke, R. M., and L. H. J. Goossens. 2004. “Expert Judgement Elicitation for Risk Assessments of Critical Infrastructures.” *Journal of Risk Research* 7: 643–656.

Croeser, T., G. Garrard, R. Sharma, A. Ossola, and S. Bekessy. 2021. “Choosing the Right Nature-Based Solutions to Meet Diverse Urban Challenges.” *Urban Forestry & Urban Greening* 65: 127337.

Davies, H. J., K. J. Doick, M. D. Hudson, and K. Schreckenberg. 2017. “Challenges for Tree Officers to Enhance the Provision of Regulating Ecosystem Services from Urban Forests.” *Environmental Research* 156: 97–107.

Day, S. D., P. Ries, C. G. Bassett, P. E. Wiseman, and K. O’Herrin. 2022. “Support for a New Credential in Urban Forestry: Results from a Survey of Urban Forest Professionals.” *Urban Forestry & Urban Greening* 73: 127588.

Dickie, I. A., B. M. Bennett, L. E. Burrows, M. A. Nuñez, D. A. Peltzer, A. Porté, D. M. Richardson, M. Rejmánek, P. W. Rundel, and B. W. van Wilgen. 2014. “Conflicting Values: Ecosystem Services and Invasive Tree Management.” *Biological Invasions* 16: 705–719.

Dowtin, A. L., B. C. Cregg, D. J. Nowak, and D. F. Levia. 2023. “Towards Optimized Runoff Reduction by Urban Tree Cover: A Review of Key Physical Tree Traits, Site Conditions, and Management Strategies.” *Landscape and Urban Planning* 239: 104849.

Eisenman, T. S., G. Churkina, S. P. Jariwala, P. Kumar, G. S. Lovasi, D. E. Pataki, K. R. Weinberger, and T. H. Whitlow. 2019. “Urban Trees, Air Quality, and Asthma: An Interdisciplinary Review.” *Landscape and Urban Planning* 187: 47–59.

Elliott, R. M., A. E. Motzny, S. Majd, F. J. V. Chavez, D. Laimer, B. S. Orlove, and P. J. Culligan. 2020. “Identifying Linkages between Urban Green Infrastructure and Ecosystem Services Using an Expert Opinion Methodology.” *Ambio* 49: 569–583.

Esperon-Rodriguez, M., C. Ordoñez, N. S. van Doorn, A. Hirons, and C. Messier. 2022. “Using Climate Analogues and Vulnerability Metrics to Inform Urban Tree Species Selection in a Changing Climate: The Case for Canadian Cities.” *Landscape and Urban Planning* 228: 104578.

Eyster, H. N., T. Satterfield, and K. M. A. Chan. 2023. “Empirical Examples Demonstrate How Relational Thinking Might Enrich Science and Practice.” *People and Nature* 5: 455–469.

Farrell, C., S. J. Livesley, S. K. Arndt, L. Beaumont, H. Burley, D. Ellsworth, M. Esperon-Rodriguez, et al. 2022. “Can We Integrate Ecological Approaches to Improve Plant Selection for Green Infrastructure?” *Urban Forestry & Urban Greening* 76: 127732.

Fernandes, C. O., I. M. da Silva, C. P. Teixeira, and L. Costa. 2019. "Between Tree Lovers and Tree Haters. Drivers of Public Perception Regarding Street Trees and Its Implications on the Urban Green Infrastructure Planning." *Urban Forestry & Urban Greening* 37: 97–108.

Fitzgibbons, J., and C. L. Mitchell. 2019. "Just Urban Futures? Exploring Equity in "100 Resilient Cities."." *World Development* 122: 648–659.

Frantzeskaki, N., T. McPhearson, and N. Kabisch. 2021. "Urban Sustainability Science: Prospects for Innovations through a System's Perspective, Relational and Transformations' Approaches." *Ambio* 50: 1650–58.

French, B., R. Gilpin, and C. G. Bassett. 2020. *Should I Put A Sign On My Wildlife Habitat Snag?* Pacific Northwest Tigard, OR: International Society of Arboriculture Arbor Chat Series.

French, S. 2022. "From Soft to Hard Elicitation." *Journal of the Operational Research Society* 73: 1181–97.

Fröhlich, A., and M. Ciach. 2020. "Dead Wood Resources Vary across Different Types of Urban Green Spaces and Depend on Property Prices." *Landscape and Urban Planning* 197: 103747.

Furnham, A., and H. C. Boo. 2011. "A Literature Review of the Anchoring Effect." *The Journal of Socio-Economics* 40: 35–42.

Gilman, E. F., M. Paz, and C. Harchick. 2015. "Nursery Planting Depth, Mulch Application, and Root Pruning at Landscape Planting Affect Tree Health and Anchorage." *Arboriculture & Urban Forestry* 41: 75–87.

Hagerman, S. M., and T. Satterfield. 2014. "Agreed but Not Preferred: Expert Views on Taboo Options for Biodiversity Conservation, Given Climate Change." *Ecological Applications* 24: 548–559.

Hale, J., T. Pugh, J. Sadler, C. Boyko, J. Brown, S. Caputo, M. Caserio, et al. 2015. "Delivering a Multi-Functional and Resilient Urban Forest." *Sustainability* 7: 4600–4624.

Hauer, R. J., and W. D. Peterson. 2016. *Municipal Tree Care and Management in the United States: A 2014 Urban & Community Forestry Census of Tree Activities*. Stevens Point, WI: Special Publication, College of Natural Resources, University of Wisconsin – Stevens Point. 71 pp.

Hemming, V., M. A. Burgman, A. M. Hanea, M. F. McBride, and B. C. Wintle. 2018. "A Practical Guide to Structured Expert Elicitation Using the IDEA Protocol." *Methods in Ecology and Evolution* 9: 169–180.

Hutt-Taylor, K., C. G. Bassett, R. P. Kinnunen, B. Frei, and C. D. Ziter. 2024. "Existing Evidence on the Effect of Urban Forest Management in Carbon Solutions and Avian Conservation: A Systematic Literature Map." *Environmental Evidence* 13: 23.

Hwang, W. H., P. E. Wiseman, and V. A. Thomas. 2015. "Tree Planting Configuration Influences Shade on Residential Structures in Four U.S. Cities." *Arboriculture & Urban Forestry* 41: 208–222.

Jax, K., E. Furman, H. Saarikoski, D. N. Barton, B. Delbaere, J. Dick, G. Duke, et al. 2018. "Handling a Messy World: Lessons Learned When Trying to Make the Ecosystem Services Concept Operational." *Ecosystem Services* 29: 415–427.

Kane, B., P. S. Warren, and S. B. Lerman. 2015. "A Broad Scale Analysis of Tree Risk, Mitigation and Potential Habitat for Cavity-Nesting Birds." *Urban Forestry & Urban Greening* 14: 1137–46.

Kehoe, L. J., J. Lund, L. Chalifour, Y. Asadian, E. Balke, S. Boyd, D. Carlson, et al. 2021. "Conservation in Heavily Urbanized Biodiverse Regions Requires Urgent Management Action and Attention to Governance." *Conservation Science and Practice* 3: e310.

Kimball, L., P. Wiseman, S. Day, and J. Munsell. 2014. "Use of Urban Tree Canopy Assessments by Localities in the Chesapeake Bay Watershed." *Cities and the Environment (CATE)* 7: 9.

Koeser, A. K., R. J. Hauer, J. W. Miesbauer, and W. Peterson. 2016. "Municipal Tree Risk Assessment in the United States: Findings from a Comprehensive Survey of Urban Forest Management." *Arboricultural Journal* 38: 218–229.

Koeser, A. K., J. Vogt, R. J. Hauer, R. J. Northrop, and W. Peterson. 2016. "The Cost of Not Maintaining Trees: Findings and Recommendations from an International Symposium and Summit." *Arboriculture & Urban Forestry* 42: 377–388.

Konijnendijk, C. C., R. M. Ricard, A. Kenney, and T. B. Randrup. 2006. "Defining Urban Forestry – A Comparative Perspective of North America and Europe." *Urban Forestry & Urban Greening* 4: 93–103.

Krayenhoff, E. S., T. Jiang, A. Christen, A. Martilli, T. R. Oke, B. N. Bailey, N. Nazarian, et al. 2020. "A Multi-Layer Urban Canopy Meteorological Model with Trees (BEP-Tree): Street Tree Impacts on Pedestrian-Level Climate." *Urban Climate* 32: 100590.

Krueger, T., T. Page, K. Hubacek, L. Smith, and K. Hiscock. 2012. "The Role of Expert Opinion in Environmental Modelling." *Environmental Modelling & Software* 36: 4–18.

Lilly, S. J., C. G. Bassett, J. Komen, and L. Purcell. 2022. *Arborists' Certification Study Guide*, 4th ed. Atlanta, GA: International Society of Arboriculture.

Liu, A., K. Swindle, R. Downs, and E. VanderWerf. 2019. *Tree Care Guidelines and Best Practices for Manu-o-Kū Breeding Sites*. Honolulu, Hawaii: Aloha Arborist Association. 37 pp.

Martin, T. G., M. A. Burgman, F. Fidler, P. M. Kuhnert, S. Low-Choy, M. Mcbride, and K. Mengersen. 2012. "Eliciting Expert Knowledge in Conservation Science." *Conservation Biology* 26: 29–38.

McPhearson, T., S. T. A. Pickett, N. B. Grimm, J. Niemelä, M. Alberti, T. Elmqvist, C. Weber, D. Haase, J. Breuste, and S. Qureshi. 2016. "Advancing Urban Ecology toward a Science of Cities." *BioScience* 66: 198–212.

McPherson, E. G., A. Kendall, and S. Albers. 2015. "Life Cycle Assessment of Carbon Dioxide for Different Arboricultural Practices in Los Angeles, CA." *Urban Forestry & Urban Greening* 14: 388–397.

Miller, R. W., R. J. Hauer, and L. P. Werner. 2015. *Urban Forestry: Planning and Management of Urban Greenspaces*. Long Grove, IL: Waveland.

Miller, R. W., and W. A. Sylvester. 1981. "An Economic Evaluation of the Pruning Cycle." *Arboriculture & Urban Forestry* 7: 109–112.

Morgan, M. G. 2014. "Use (and Abuse) of Expert Elicitation in Support of Decision Making for Public Policy." *Proceedings of the National Academy of Sciences of the United States of America* 111: 7176–84.

Nesbitt, L., N. Hotte, S. Barron, J. Cowan, and S. R. J. Sheppard. 2017. "The Social and Economic Value of Cultural Ecosystem

Services Provided by Urban Forests in North America: A Review and Suggestions for Future Research." *Urban Forestry & Urban Greening* 25: 103–111.

Nowak, D. J. 2020. *Understanding i-Tree: Summary of Programs and Methods*. Madison, WI: U.S. Department of Agriculture, Forest Service, Northern Research Station General Technical Report NRS-200. 100 pp.

O'Herrin, K., C. G. Bassett, S. D. Day, P. D. Ries, and P. E. Wiseman. 2023. "Borrowed Credentials and Surrogate Professional Societies: A Critical Analysis of the Urban Forestry Profession." *Arboriculture & Urban Forestry* 49: 107–136.

O'Herrin, K., P. E. Wiseman, S. D. Day, and R. J. Hauer. 2020. "Professional Identity of Urban Foresters in the United States." *Urban Forestry & Urban Greening* 54: 126741.

Paquette, A., R. Sousa-Silva, F. Maure, E. Cameron, M. Belluau, and C. Messier. 2021. "Praise for Diversity: A Functional Approach to Reduce Risks in Urban Forests." *Urban Forestry & Urban Greening* 62: 127157.

Petri, A. C., A. K. Koeser, S. T. Lovell, and D. Ingram. 2016. "How Green Are Trees?—Using Life Cycle Assessment Methods to Assess Net Environmental Benefits." *Journal of Environmental Horticulture* 34: 101–110.

Pinto, L. V., M. Inácio, C. S. S. Ferreira, A. D. Ferreira, and P. Pereira. 2022. "Ecosystem Services and Well-Being Dimensions Related to Urban Green Spaces – A Systematic Review." *Sustainable Cities and Society* 85: 104072.

R Core Team. 2023. *R: A Language and Environment for Statistical Computing*. Vienna: R Foundation for Statistical Computing.

Rahman, M. A., L. M. F. Stratopoulos, A. Moser-Reischl, T. Zölch, K.-H. Häberle, T. Rötzer, H. Pretzsch, and S. Pauleit. 2020. "Traits of Trees for Cooling Urban Heat Islands: A Meta-Analysis." *Building and Environment* 170: 106606.

Riedman, E., L. A. Roman, H. Pearsall, M. Maslin, T. Ifill, and D. Dentice. 2022. "Why Don't People Plant Trees? Uncovering Barriers to Participation in Urban Tree Planting Initiatives." *Urban Forestry & Urban Greening* 73: 127597.

Rounsevell, M. D. A., and M. J. Metzger. 2010. "Developing Qualitative Scenario Storylines for Environmental Change Assessment." *WIREs Climate Change* 1: 606–619.

Rowe, G., and G. Wright. 2001. "Expert Opinions in Forecasting: The Role of the Delphi Technique." In *Principles of Forecasting: A Handbook for Researchers and Practitioners*, edited by J. S. Armstrong, 125–144. Boston, MA: Springer US.

Roy, S., J. Byrne, and C. Pickering. 2012. "A Systematic Quantitative Review of Urban Tree Benefits, Costs, and Assessment Methods across Cities in Different Climatic Zones." *Urban Forestry & Urban Greening* 11: 351–363.

Roy, S., A. Davison, and J. Östberg. 2017. "Pragmatic Factors Outweigh Ecosystem Service Goals in Street Tree Selection and Planting in South-East Queensland Cities." *Urban Forestry & Urban Greening* 21: 166–174.

Ryder, C. M., and G. M. Moore. 2013. "The Arboricultural and Economic Benefits of Formative Pruning Street Trees." *Arboriculture & Urban Forestry* 39: 17–24.

Schindler, S., Z. Sebesvari, C. Damm, K. Euller, V. Mauerhofer, A. Schneidergruber, M. Biró, et al. 2014. "Multifunctionality of Floodplain Landscapes: Relating Management Options to Ecosystem Services." *Landscape Ecology* 29: 229–244.

Selbig, W. R., S. P. Loheide, W. Shuster, B. C. Scharenbroch, R. C. Coville, J. Kruegler, W. Avery, R. Haefner, and D. Nowak. 2022. "Quantifying the Stormwater Runoff Volume Reduction Benefits of Urban Street Tree Canopy." *Science of the Total Environment* 806: 151296.

Seto, K. C., B. Güneralp, and L. R. Hutyra. 2012. "Global Forecasts of Urban Expansion to 2030 and Direct Impacts on Biodiversity and Carbon Pools." *Proceedings of the National Academy of Sciences of the United States of America* 109: 16083–88.

Singh, G. G., J. Sinner, J. Ellis, M. Kandlikar, B. S. Halpern, T. Satterfield, and K. M. A. Chan. 2017. "Mechanisms and Risk of Cumulative Impacts to Coastal Ecosystem Services: An Expert Elicitation Approach." *Journal of Environmental Management* 199: 229–241.

Statistics Canada. 2023. *Census Profile. 2021 Census of Population*. Ottawa: Statistics Canada.

Tracy, S. J. 2019. *Qualitative Research Methods: Collecting Evidence, Crafting Analysis, Communicating Impact*. Newark, NJ: John Wiley & Sons, Incorporated.

Turner, V. K., E. M. French, J. Dialesandro, A. Middel, D. M. Hondula, G. B. Weiss, and H. Abdellati. 2022. "How Are Cities Planning for Heat? Analysis of United States Municipal Plans." *Environmental Research Letters* 17: 064054.

US Census Bureau. 2022. "U.S. Census Bureau QuickFacts: Honolulu County, Hawaii." https://www.census.gov/quickfacts/fact/table/honolulucountyhawaii/PST045222.

US Census Bureau. 2023. "2020 Census Demographic Profile." https://www.census.gov/data/tables/time-series/demo/popest/2020s-total-cities-and-towns.html#v2022.

Vogt, J. 2020. "Urban Forests as Social-Ecological Systems." In *Encyclopedia of the World's Biomes*, edited by M. I. Goldstein and D. S. DA, 58–70. Amsterdam: Elsevier.

Vogt, J. 2024. "A Comprehensive Framework for Understanding Urban Forests as Social-Ecological Systems." *Arboriculture & Urban Forestry* 50: 427–469.

Vogt, J., B. C. Fischer, and R. J. Hauer. 2016. "Urban Forestry and Arboriculture as Interdisciplinary Environmental Science: Importance and Incorporation of Other Disciplines." *Journal of Environmental Studies and Sciences* 6: 371–386.

Vogt, J., R. J. Hauer, and B. C. Fischer. 2015. "The Costs of Maintaining and Not Maintaining the Urban Forest: A Review of the Urban Forestry and Arboriculture Literature." *Arboriculture & Urban Forestry* 41: 293.

Walters, M., and D. Sinnett. 2021. "Achieving Tree Canopy Cover Targets: A Case Study of Bristol, UK." *Urban Forestry & Urban Greening* 65: 127296.

Wildlife Dangerous Tree Committee of British Columbia. 2019. *Wildlife/Dangerous Trees assessor's Course Workbook: Parks and Recreation Sites Course Module*. Prince George, BC: BC Parks. 137 pp.

Wollenberg, E., D. Edmunds, and L. Buck. 2000. "Using Scenarios to Make Decisions about the Future: Anticipatory Learning for the Adaptive Co-Management of Community Forests." *Landscape and Urban Planning* 47: 65–77.

Wu, J. 2014. "Urban Ecology and Sustainability: The State-of-the-Science and Future Directions." *Landscape and Urban Planning* 125: 209–221.

SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

How to cite this article: Bassett, Corinne G., Susan D. Day, Cecil C. Konijnendijk, Lara A. Roman, and Victoria Hemming. 2024. "Aligning Urban Forest Management Actions with Urban Sustainability Goals: A Multi-City Expert Elicitation." *Ecosphere* 15(12): e70120. https://doi.org/10.1002/ecs2.70120