



## Original article

## Urban forest management and governance in Latin America and the Caribbean: A baseline study of stakeholder views

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## ABSTRACT

Cities in the Latin America and Caribbean (LAC) region and around the world are setting long-term greening goals that include planting more trees and increasing green cover. Research in LAC cities has mainly focused on biodiversity and vegetation, with little understanding of the mechanisms underlying the decisions through which stakeholders achieve urban greening. Exploring stakeholders' views about urban forest management and governance can provide us with an opportunity to identify needs and research gaps for urban greening and urban forestry in LAC. To our knowledge, there has never been a region-wide empirical study to capture these stakeholder views. Here we explore how stakeholders working in urban forestry in LAC, including governmental, and non-governmental professionals, define urban forests, and view management and governance issues as well as educational opportunities. We used an online survey based on a combination of open- and closed-ended questions. The survey was delivered to participants at the first two regional conferences on urban forests in LAC organized by the United Nations. We collected 91 responses from stakeholders working in 50 different cities of varying population sizes across 6 LAC bioregions. Most respondents considered parks, planted green corridors, street trees, and remnant forests in urban and peri-urban areas as components of urban forests. Stakeholder views on management and governance were divided in two distinct perspectives, one dominated by public participation issues, and another one related to operational issues. Most respondents considered operational and management tools for urban forests to exist in LAC cities, but they disagreed on the existence of inventories, long-term strategies, and ways for the public to engage in urban forestry. Responses also revealed that some educational opportunities, such as arboricultural certification, are still relatively scarce and in high demand in the region. This study provides a regional baseline and first insights into a more diverse view of urban forestry which could be enriched with more empirical studies in the future.

## 1. Introduction

Urban greening has been proposed as a promising pathway to support both the protection of ecosystems and biodiversity in and the improvement of wellbeing of urban communities (Ferrini and

Konijnendijk van den Bosch, 2017; van den Bosch and Sang, 2017; Wolf et al., 2020). A tangible and often dominant aspect of urban greening throughout the world are urban forests (Willis and Petrokofsky, 2017), defined here broadly as all the trees and associated vegetation in a city (FAO, 2016). Many Latin American and Caribbean (LAC) cities are

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setting long-term goals to retain and enhance urban forests, which includes planting more trees, maintaining and protecting existing trees, and overall increasing urban tree-canopy cover and number of trees (FAO, 2018).

While urban forest strategies advocate numerous benefits, their successful implementation is complex and depends on climatic and environmental as well as socio-economic factors. Moreover, a wide range of local, national, and regional stakeholders are usually involved in urban forest decision-making, so a crucial consideration is how governance plays out among these actors (Beatley, 2017; Sheppard et al., 2017). While some studies on urban forests in LAC cities have analyzed urban forest management, citizen values, and ecosystem services provision (Escobedo et al., 2006; Ordóñez and Duinker 2014; Dobbs et al., 2019; Ordóñez et al., 2020), to our knowledge, there is currently a lack of empirical, comparative, and region-wide understanding of how stakeholders participate in the urban forest governance process (Ordóñez et al., 2020). To date, most empirical studies on urban forest stakeholder views are based in the US, Europe, Canada, and Australia (Ordóñez et al., 2019). In addition, most of this literature has narrowly focused on the resources available to municipal governments, such as budgets and personnel, or operational decisions, such as tree-planting campaigns and tree species selection (Ordóñez et al., 2019), rather than focusing on the processes of decision-making among many stakeholders. This has limited our ability to recognize broader management and governance challenges and develop better insights into how stakeholders can facilitate more strategic, long-term urban forest decision-making.

Understanding stakeholder views on urban forestry can help develop insights on urbanization processes and urban greening in LAC. Urbanization in LAC is driven not only by economic opportunity and population growth as in other regions, but also by urban and rural development policies and complex geopolitical and historical legacies, including weak governance, rigid and overly intrusive government institutions, civil unrest, and abrupt social and economic crises, among others (Roberts 2005; Hardoy and Pandiella, 2009; Inostroza et al., 2013; United Nations, 2018). These processes have influenced urbanization and driven current urban challenges such as housing deficits, lack of social infrastructure, increased socio-economic inequality, and decreased quality of life for city residents living in poverty (Dobbs et al., 2018). Despite the attention given to greening in LAC cities, inequitable access to urban forests remains widespread (Arantes et al., 2021). Gaining a better understanding of the way in which urban forests are being prioritized, planned, and managed by stakeholders, and how these stakeholders work together, can inform strategies for improving urban forest governance and management, urban biodiversity conservation, urban green equity, and the quality of life of urban dwellers.

In this paper, we aim to address the gaps identified above by eliciting the views of urban forest stakeholders working in the LAC region regarding urban forest management and governance. Specifically, the objectives of the study are to explore stakeholder views on: (1) urban forest definitions and main components; (2) urban forest management and governance issues; and (3) availability of educational and training opportunities in urban forestry. We use a social science, explorative approach to establish a region-wide baseline understanding of such views, grounded in the lived experiences of the stakeholders. We also explored how the geographical and professional characteristics of stakeholders influence their views. We expect the insights of this study to enrich the global urban forest literature by incorporating the realities of a large, diverse, innovative, and highly urbanized region such as LAC.

## 2. Theoretical framework

This study builds on our current understanding of urban forest governance and urban forest management. Governance includes the collection of institutions, organizations, rules, and processes of collective decision-making that allow stakeholders to make decisions about

the environment and collectively owned natural resources (Folke et al., 2005; Lemos and Agrawal, 2006; Lockwood et al., 2010), including urban natural resources (Muñoz-Erickson et al., 2016) and urban forests (Lawrence et al., 2013). Management involves the process by which humans work with nature and use available institutional and/or organizational resources to implement activities and achieve a set of common objectives (Lackey, 1998), including those related to urban forests (Ordóñez & Duinker, 2013; Steenberg et al., 2019). By combining the framings of management and governance we can explore how urban forest stakeholders in LAC cities view the processes of collective decision-making, as well as how they view the process of setting and meeting objectives.

We defined a stakeholder as any individual, institution, or organization that influences, and is influenced by, the decisions or activities related to urban forests (Lawrence et al., 2013). Urban forests stakeholders include professionals and non-professionals working in governmental and non-governmental institutions and/or organizations, such as local governments (e.g., urban foresters, planners, engineers, etc.), private businesses (e.g., consultants and contractors), developers, community organizations, private and public landowners, and research institutions (i.e., applied researchers), among others.

The existing empirical research on the view of urban forest stakeholders is dominated by studies that identify their needs and challenges to design and implement urban forest strategies (e.g., Hill et al., 2010; Rines et al., 2011; Grado et al., 2013; Kirkpatrick et al., 2013; Young, 2013; Driscoll et al., 2015; Davies et al., 2017; see Ordóñez et al., 2019). Most of this literature explores how the internal operational characteristics (e.g., budgets, personnel, and the existence of strategic policies) of formal institutions, mostly local governments, can help these institutions meet their management objectives (Rines et al., 2011; Grado et al., 2013; Driscoll et al., 2015; similar studies in LAC cities include Fiedler et al., 2006; Tovar-Corzo, 2013; Locastro et al., 2017). While these issues are important to assess the state of urban forest management (Ordóñez and Duinker, 2013), there is a need to integrate governance issues and how these are being addressed. Some key themes that are related to governance, but are rarely integrated, include the development, implementation, and monitoring of strategies and policies (Grado et al., 2013; Young, 2013; Davies et al., 2017), trees on private urban lands (Ordóñez et al., 2021), climate change (Živojinović and Wolf-slehner, 2015), and biodiversity restoration, such as native tree species selection (Almas and Conway, 2016), among others.

Other key governance themes include professional capacity, political leadership, and public participation (Ordóñez et al., 2019). A key aspect of professional capacity is the availability of educational and training resources for professional stakeholders, such as professional education and certification (Hill et al., 2010; Rines et al., 2011; Driscoll et al., 2015). Empirical studies in some LAC cities based on the view of local government professionals indicate that, as a wider range of stakeholders come together to make collective decisions, the lack of equivalency in professional capacities hinders decision-making (e.g., Tovar-Corzo, 2013).

Political leadership relates to the general notion of how institutions dictate the management of collectively owned natural resources (Folke et al., 2005; Ostrom, 2005), including government institutions. This does not mean that the government is the only or most important stakeholder, or the only one who can provide leadership, but rather that it is a central stakeholder that can play a leading role in many circumstances. The literature notes how the political leadership provided by local governments has been important in providing resources to non-governmental organizations, and in facilitating stakeholder coordination (Kenward et al., 2011; Lawrence et al., 2013; Muñoz-Erickson et al., 2016; Devisscher et al., 2016; Gulrud et al., 2018). It is still unclear how political leadership is viewed in LAC urban forestry, where there is some indication of lack of transparency and trust towards local governments (Pineda-Guerrero et al., 2021).

Finally, governance researchers have shown that to successfully

**Table 1**  
Elements of the key survey questions used in this study.

| Objectives and topics (Source)                                                                                                                                                                           | Question and scale description [internal item code]                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Section 1:<br>Urban Forest Definitions<br>Ordóñez et al. (2020)                                                                                                                                          | What components do you think should be included in a definition of the urban forest? (List of 10 elements):<br>1. Street trees<br>2. Urban parks<br>3. Natural forests and woodlots around cities<br>4. Nature remnants in the city (wetlands, riparian forests, abandoned land, cliffs, etc.)<br>5. Planted green corridors in the city (along avenues and rivers, along bike trails, etc.)<br>6. Private gardens and lots<br>7. Lawn-covered playground<br>8. Green roofs, green walls, green bridges<br>9. Urban farms or agricultural areas<br>10. Other (open-ended)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| Section 2:<br>Views on Management and Governance<br>Hill et al. (2010); Rines et al. (2011), Grado et al. (2013), Kirkpatrick et al. (2013); Young (2013); Driscoll et al. (2015); Ordóñez et al. (2019) | How much do you agree/disagree with the following statements? The statements complete the sentence: "At present, in the city I work in/with, there is/are..." (Level of agreement (1–5) with 16 statements)<br>1. a plan or strategy with clear visions and objectives [UFG1]<br>2. an inventory of public trees (ideally georeferenced) [UFG2]<br>3. an inventory of private trees (ideally georeferenced) [UFG3]<br>4. political leaders that raise the profile of the urban forest and trees in the community [UFG4]<br>5. a list of appropriate species to plant [UFG5]<br>6. a system to monitor urban forests long-term [UFG6]<br>7. one team that coordinates decisions across departments influencing public trees [UFG7]<br>8. clear ordinances/regulations for urban trees [UFG8]<br>9. research partnerships with research institutions aimed at improving management of urban forests [UFG9]<br>10. adequate consultation and engagement with the community in decisions related to urban forests [UFG10]<br>11. trust among residents towards management agencies [UFG11]<br>12. adequate budget to manage the urban forest [UFG12]<br>13. technical maintenance plans to maintain forest health and manage risk (pruning, watering, fertilizing, etc.) [UFG13]<br>14. trained and certified human resources [UFG14]<br>15. sufficient education of the community about urban forests [UFG15]<br>16. plans to manage climate change-related hazards and other disturbances affecting the urban forest [UFG16] |
| Section 3:<br>Availability of Educational and Training Opportunities                                                                                                                                     | How much do you agree/disagree with the availability of the following educational activities? The items answer the question: "In the city where I work, there are..." (Level of agreement (1–5) with 4 statements)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |

**Table 1 (continued)**

| Objectives and topics (Source) | Question and scale description [internal item code]                                                                                                                                                               |
|--------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                | 1. certification programs for arborists [UFE1]<br>2. conferences and workshops on urban forestry [UFE2]<br>3. training on best practices [UFE3]<br>4. higher education programs relevant to urban forestry [UFE4] |

implement urban forest agendas, formal institutions need to successfully engage with the public. It is then important to develop a better understanding of how stakeholders view public participation. This can elucidate how LAC cities are fostering active stewardship of the urban forest through, for example, co-management arrangements and other decentralized forms of decision-making (Gulrud et al., 2018; Buijs et al., 2019; van der Jagt et al., 2019). To date, most of the empirical literature on stakeholder views is limited to educating the public, mainly by raising public awareness about the benefits of trees to reduce barriers for program implementation, rather than engaging the public in decision-making (Grado et al., 2013; Kirkpatrick et al., 2013; Young, 2013; see Ordóñez et al., 2019).

### 3. Methods

We developed appropriate methodological protocols and procedures to meet the objectives of this study centered on exploring the views of urban forest stakeholders in LAC region regarding (1) their definition of urban forests, (2) how they prioritize issues affecting urban forest management and governance, and (3) the availability of educational and training opportunities. We used an online survey to collect data on stakeholders' views, and delivered this survey in two consecutive rounds. We then used several quantitative (statistical) and qualitative (interpretative) analyses to meet the objectives previously set. We also explored how the geographical and professional characteristics of stakeholders influence the responses obtained.

#### 3.1. Survey design, content, and delivery

An online survey based on an exploratory, tailored, and targeted approach (Dillman et al., 2014) was designed comprising of 20 questions grouped into three main sections, each representing a research objective, namely: (1) urban forest definitions; (2) views on urban forest governance and management issues; (3) availability of educational and training opportunities. The survey also included another three minor sections that asked respondents for information on their: (4) characteristics of job in urban forestry; (5) stakeholder demographics including most recent qualification, gender identity and age range; and (6) experiences in urban forestry. Sections 1–3 correspond directly to the three main objectives of the study, while sections 4 and 5 were used to understand the sample characteristics, and how these characteristics may influence stakeholder views. Section 6 was additional to these objectives and an optional question for all respondents. It was used to collect qualitative data that could complement our study and expand on past and future changes in urban forest management and governance (Table 1).

To better understand how urban forests were defined by stakeholders (study objective 1, survey Section 1), we constructed a list of urban forest components based on the literature review by Ordóñez et al. (2020a).

To understand stakeholder views about urban forest management and governance we developed a close-ended question based on a multi-dimensional scale (study objective 2, Section 2) combining items previously included in the surveys conducted by Hill et al. (2010); Rines et al. (2011); Grado et al. (2013); Kirkpatrick et al. (2013); Young

**Table 2**  
Simplification of variables used in the analyses.

| Variable                                                            | Threshold                                                               | Conversion                     |
|---------------------------------------------------------------------|-------------------------------------------------------------------------|--------------------------------|
| Spanish language                                                    | 78 % of responses                                                       | Binomial                       |
| More than ten years of work experience                              | 45 % of responses                                                       | Binomial                       |
| Professional domain:                                                |                                                                         | Binomial                       |
| government                                                          | 34 % of responses                                                       |                                |
| academic                                                            | 34 % of responses                                                       |                                |
| Scale of implementation of work at the municipal scale <sup>1</sup> | 43 % of responses                                                       | Binomial                       |
| City population:                                                    |                                                                         | Binomial                       |
| more than 1 million                                                 | 44 % of responses                                                       |                                |
| more than 5 million                                                 | 24 % of responses                                                       |                                |
| Gender female                                                       | 45 % of responses                                                       | Binomial                       |
| Age less than 40 years                                              | 78 % of responses                                                       | Binomial                       |
| Education level with university degree                              | 90 % of responses                                                       | Binomial                       |
| Six bioregions                                                      | Collapsing Central America and Caribbean bioregions due to low response | Five single binomial variables |

<sup>1</sup> Categories for this variable overlapped, so all responses that selected municipal were included.

(2013); Driscoll et al. (2015), as well as other items extracted from the literature on urban forest stakeholder views by Ordóñez et al. (2019; see also Table 2). This multi-dimensional scale is ultimately based on people's views, which we define broadly in this study as how people sense and then mentally process information from the outside environment. These views are based on people's experiences of these issues, which ultimately influence people's perceptions, including their values, beliefs, and attitudes, as well as their behavior or conduct.

To understand the availability of educational and training opportunities, we developed a multi-dimensional scale on these issues (study objective 3, Section 3) using a list of four urban forest education and training items.

Finally, to understand stakeholder experiences in urban forestry (Section 6, optional), we asked two open-ended questions about the past and future of urban forests in LAC, including: "What do you think has been the most significant change(s) achieved in urban forestry in your country over the past decade?", and "Based on your experience, what are the key

priorities/goals for urban forestry in your country in the next decade?".

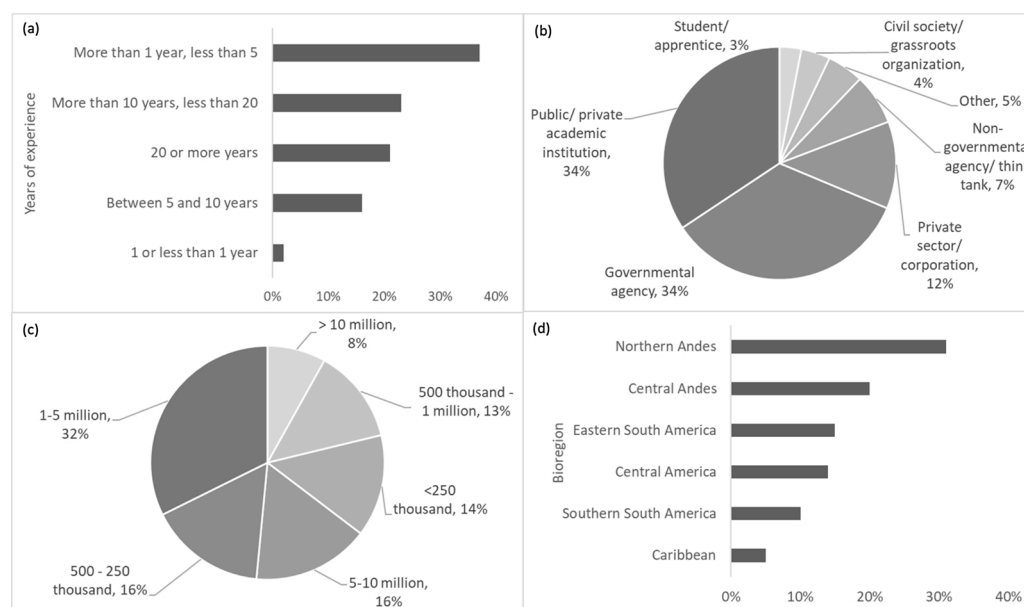
The first version of the online survey was developed in English and was tested by recruiting a sample of 10 researchers as respondents. These researchers came from different geographic locations in the LAC region and included some authors of the study. Their feedback mainly focused on survey length and clarity regarding items included in Section 2. Once revised, the survey was translated into Spanish and Portuguese for final delivery. The survey was uploaded onto Qualtrics and was approved by the independent Behavioural Research Ethics Board of the University of British Columbia, Canada, in line with the British Columbia Freedom of Information and Protection of Privacy Act.

For recruiting respondents, we targeted professionals and non-professionals working in municipal, regional, or national governments; non-governmental organizations, such as community greening groups and knowledge sharing networks; research institutions, including both public and private universities; private sector, such as consultants and contractors; and international or inter-governmental organizations. To target these participants, we delivered the survey between 2017 and 2019 to a list of contacts obtained from the first and second Latin American Fora on Urban and Peri-urban Forests (see details in Appendices, Table A1), coordinated by the Food and Agriculture Organization (FAO) of the United Nations. In sum, the respondent recruitment was done in two rounds: The first targeted attendants of the first forum and the second targeted people registered for the second one (see details in Appendices, Fig. A1). The total number of responses we received was 91 after removing duplicates and incomplete responses. The response rate for the first round was 45 % (out of 184 contacts), and for the second round 26 % (out of 261 contacts). All personal information was removed prior to analysis.

The question about stakeholder experiences in urban forestry (Section 6, optional), was only included in the second round of recruitment. Verbatim responses for this question were collected digitally through Qualtrics. Responses were analyzed in Spanish and Portuguese, and then translated to English (see Data Analysis section).

### 3.2. Data processing

Data were processed to eliminate missing responses, complement geographical information with additional data to facilitate interpretation, and categorize and/or collapse responses.



**Fig. 1.** Characteristics of study sample (n = 91) by (a) work experience, (b) type of sector, and location of respondents categorized (c) by population size and (d) by bioregion.



We complemented geographical information by adding data on city bioregion and city population. City population was obtained from the [World Population Review \(2020\)](#) and was categorized using the [United Nations \(2018\)](#) framework: smaller than 250 thousand people; 250–500 thousand people; 500 thousand to 1 million people; 1–5 million people; 5–10 million; and >10million people (Note that the cut for each category was one person below the threshold, e.g. 250–499 thousand people). To allow region-wide comparisons we categorized the city location of the respondent into bioregions for LAC based on [Dinerstein et al. \(1995\)](#). To determine the bioregion, each city was first matched to their major habitat type, then to the corresponding ecoregion and bioregion ([Dinerstein et al., 1995](#)). Based on the geographical location of our responses, only six bioregions were used in this classification ([Fig. 1](#)).

We also simplified some of our variables to reduce: (1) overprediction of regression models based on a wide range of categorical and ordinal variables ([Rosner, 2011](#); [Hair et al., 2014](#)); (2) skewness in categorical variables where not enough responses exist for certain categories (e.g., some bioregions not having enough responses); and (3) the multi-dimensional nature of the rating scales, specifically the governance and management scale (Section 3; see [Table 1](#)). To address these concerns, we collapsed and/or segmented the professional and demographic variables (Sections 4–5) into single numeric binomial 1/0 scales or fewer categories ([Table 2](#)).

### 3.3. Quantitative data analysis

Descriptive statistics were obtained to understand the sampled population, including their professional and demographic characteristics (Sections 4–5), and their definitions of urban forests (Section 1). We performed and reported significant results from analysis of means (Welch Two Sample t-test) to understand the difference of responses among all the binary geographic and demographic variables.

To achieve the second and third objectives of our study, we implemented different statistical analyses. First, to better understand how stakeholder expressed different views about urban forest management and governance, we used the scale on governance and management while recognizing that this was the first time such scale was used (Section 2). To do this, we extracted the key dimensions (also termed latent variables, components, or factors) of this scale based on principal component analyses (PCA) with a varimax rotation (for full details, see results in [Table 2](#)) using the *princomp* function in R (v. 4.0.2). Exploratory PCA provides a useful way to extract the different dimensions of a scale ([Thurstone, 1947](#); [Kaiser, 1974](#)). A varimax orthogonal rotation is usually employed to improve statistical validity of the PCA model and improve interpretability. Dimensions were then extracted based on their eigenvalue (>1.0) and variance explained (cumulative above 50 %). We also used the Kaiser-Meyer-Olkin test (values 0.6–0.9 accepted) and Bartlett's sphericity test (significant at the 95 % level) to assess the outputs. After extracting dimensions, we generated new scales for each dimension using the average scores of all the items that loaded onto each component (loadings >0.7). We validated these new scales by confirming their construct validity (Cronbach alpha statistic, see Appendices, [Table A2](#)) using the *alpha* function in the *psych* package of R (v. 4.0.2). We also performed a PCA on the availability of educational opportunities scale (Section 3), and confirmed the construct validity of the scale (see Appendices, [Table A3](#)).

To explore how the geographical and professional characteristics of stakeholders influence the responses obtained, we tested the relationship between the geographical and professional characteristics of respondents with their ratings of the governance and management scale and each of its dimensions (Section 2) and availability of educational opportunities (Section 3). We associated respondents' geographical and professional characteristics (Sections 4–5) using standard linear multiple regressions (ordinary least squares) with these two scales (see Appendices, [Tables A4 and A5](#)). We generated models for each dimension of the governance and management scale (i.e., average of items that

loaded to each dimension), as well as for the overall scale average (i.e., average of all items). We only used the overall average of the educational opportunities scale. We included all single numeric binomial variables described in Section 3.2 in these analyses (i.e., language, years of experience professional domain, scale of work implementation, city population, and bioregion). We used a stepwise regression analysis approach with the *lm* and *step* functions in R (v. 4.0.2) in the “backward” mode to generate the models. The technique allowed us to improve the predictability of the scales by discarding variables iteratively and keeping the ones that significantly contributed to the model ([Hair et al., 2014](#)). All models were adjusted for demographic variables, including gender female, age less than 40 years, and education university degree. None of these variables were removed during the stepwise process to keep all the models consistent with each other ([Hair et al., 2014](#)). Only statistically significant results are reported.

### 3.4. Qualitative data analysis

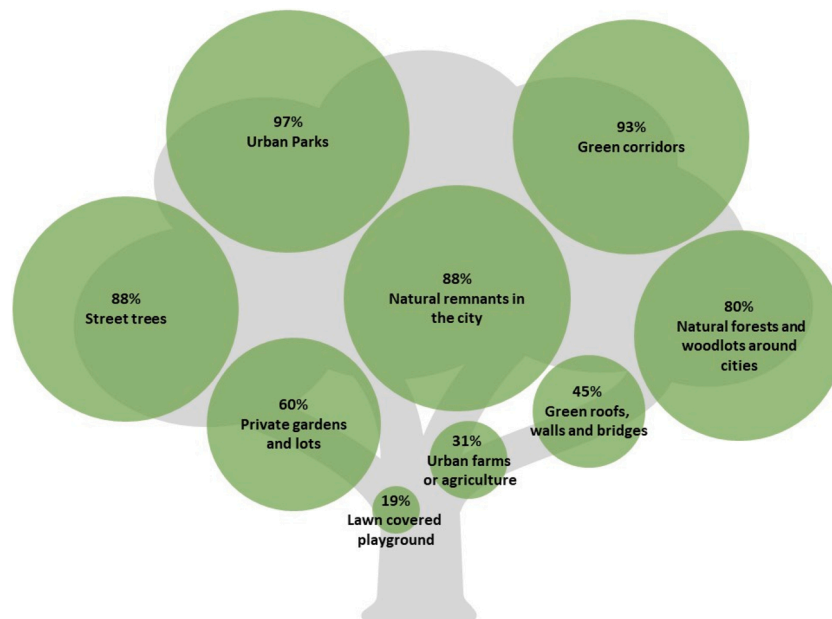
The optional questions included in Section 6 complemented our understanding of stakeholder views on urban forest management and governance. To analyze these open-ended responses, we used a qualitative interpretative approach grounded on the view of respondents ([Creswell, 2017](#)). Verbatim text responses were imported into Excel and analyzed using interpretative, inductive coding techniques established by [Corbin and Strauss \(2015\)](#). This entailed assigning codes to the ideas being conveyed in the answers through interpretation. Coding consistency and accuracy were achieved by applying the principles of densification, constant comparison, and hierarchy as per [Corbin and Strauss \(2015\)](#). This process involved consolidating ideas into one or few codes based on how frequently the idea is mentioned in the context of the answer to a question, as well as of the overall dataset. Codes were then grouped to create new codes at a higher level of abstraction. In doing so, this technique also allowed us to compare and identify patterns across answers. Precision of terms used in the coding is key in these types of analyses, so we provide some examples of these codes based on the original data, as well as the full list of codes used for analysis (see details in Appendices, [Table A6](#)).

## 4. Results

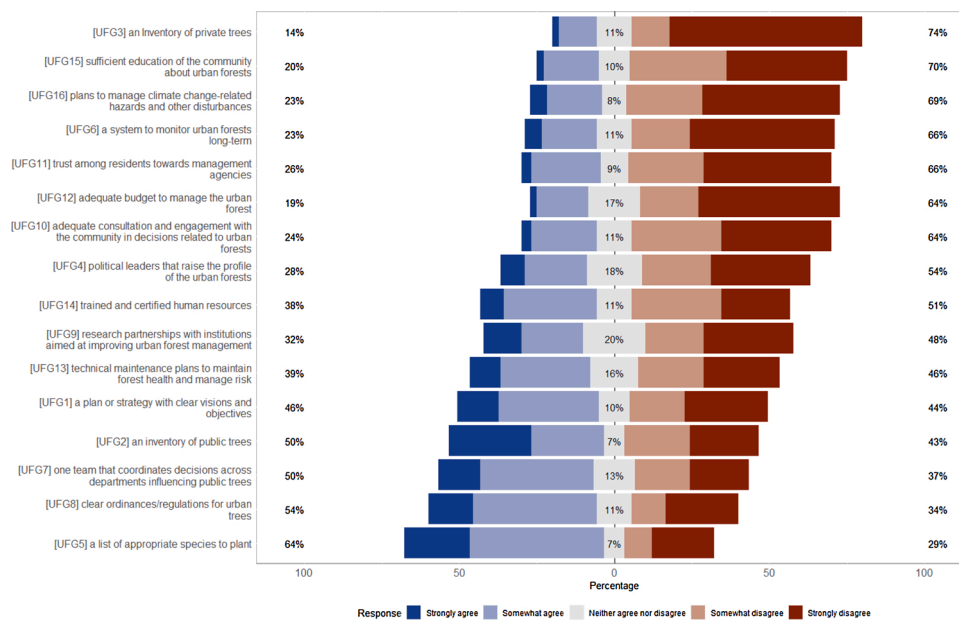
In line with the objectives of this study, this section provides a summary of the views of different urban forest stakeholders working in the LAC in relation to: (1) urban forest definitions, (2) urban forest management and governance issues, and (3) availability of educational and training opportunities. We complement this information with empirical qualitative data on the future outlook of urban forestry in the region as elicited through the open-ended questions in Section 6.

### 4.1. Types of urban forest stakeholders

We collected data from a wide range of stakeholders in government and non-government organizations. Almost half of the respondents (45 %) had more than 10 years of experience in urban forestry, urban greenspace, urban nature, or closely related fields. Respondents were based in 50 different cities of varying population sizes. There were also few international stakeholders ( $n = 4$ ) working in cities outside the region. Some responses (8%) came from cities of more than 10 million inhabitants, and many responses (32 %) came from cities with a population between 1–5 million. LAC bioregions were represented relatively equally, after collapsing the Caribbean and Central American bioregions ([Table 2](#)). The sample of respondents showed a balanced gender distribution (45 % female, 44 % male, 11 % other) and most of the participants had completed a postgraduate degree (58 %). More than half of the respondents (61 %) were above 40 years old ([Fig. 1](#)).



**Fig. 2.** Stylized representation of the components that define the urban forest based on empirical data collected from stakeholders in LAC cities ( $n = 91$ ). Component size relates to the percentage of respondents that considered it as part of the urban forest.



**Fig. 3.** Cumulative ratings for agreement and disagreement with respect to all items of the urban forest management and governance scale (Section 2; Table 1) ( $n = 91$ ). Survey question: How much do you agree/disagree with the following statements? "At present, in the city I work in/with, there is/are...".

#### 4.2. Definitions of urban forests

As components for defining urban forests (section 1), most respondents chose urban parks, planted green corridors, street trees, nature remnants or fragments in the city, and natural forests and woodlots in the peri-urban area (Fig. 2). Fewer respondents chose other components such as private gardens, green roofs and walls, and urban farms as part of the definition. Only one fifth chose lawn-covered playgrounds as an element that makes part of an urban forest.

#### 4.3. Views on management and governance issues

We found that most respondents agreed that operational resources

(e.g., planting, species lists) as well as management tools (e.g., clear regulations) exist in most cities, but they disagreed on the existence of inventories for trees on private lands and issues related to public participation (i.e., public education and trust in government institutions) (Fig. 3).

The PCA of this scale yielded a two-component solution that explained 65.2 % of the total variance. The results suggested that there was a separate view regarding public participation, and another separate view regarding operational issues. For some respondents, issues related to public participation, such as public education and engagement, were more important than other issues. While for other respondents, issues related to management operations, such as having a tree species list and clear regulations were more important (Table 3).

**Table 3**

PCA results for multi-rating scale on considerations in governance and management (section 3) showing separate dimensions (loadings >0.7 highlighted and used for averaging individual component scales; see methods).

| At present, in the city I work in/with, there is/are...                                                                 | Dimensions (components/factors) |                 |
|-------------------------------------------------------------------------------------------------------------------------|---------------------------------|-----------------|
|                                                                                                                         | 1 Public participation          | 2 Operational   |
| 1 a plan or strategy with clear visions and objectives [UFG1]                                                           | 0.542                           | 0.601           |
| 2 an inventory of public trees (ideally georeferenced) [UFG2]                                                           | 0.312                           | 0.508           |
| 3 an inventory of private trees (ideally georeferenced) [UFG3]                                                          | 0.386                           | 0.343           |
| 4 political leaders that raise the profile of the urban forest and trees in the community [UFG4]                        | 0.558                           | 0.413           |
| 5 a list of appropriate species to plant [UFG5]                                                                         | 0.271                           | <b>0.839</b>    |
| 6 a system to monitor urban forests long-term [UFG6]                                                                    | 0.593                           | 0.497           |
| 7 one team that coordinate decisions across departments influencing public trees [UFG7]                                 | 0.480                           | 0.598           |
| 8 clear ordinances/regulations for urban trees [UFG8]                                                                   | 0.324                           | <b>0.765</b>    |
| 9 research partnerships with research institutions aimed at improving management of urban forests [UFG9]                | 0.535                           | 0.474           |
| 10 adequate consultation and engagement with the community in decisions related to urban forests [UFG10]                | <b>0.780</b>                    | 0.417           |
| 11 trust among residents towards management agencies [UFG11]                                                            | <b>0.797</b>                    | 0.373           |
| 12 adequate budget to manage the urban forest [UFG12]                                                                   | <b>0.747</b>                    | 0.275           |
| 13 technical maintenance plans to maintain forest health and manage risk (pruning, watering, fertilizing, etc.) [UFG13] | 0.516                           | 0.600           |
| 14 trained and certified human resources [UFG14]                                                                        | 0.486                           | 0.538           |
| 15 sufficient education of the community about urban forests [UFG15]                                                    | <b>0.744</b>                    | 0.380           |
| 16 plans to manage climate change-related hazards and other disturbances affecting the urban forest [UFG16]             | <b>0.800</b>                    | 0.377           |
| Eigenvalues                                                                                                             | 9.419                           | 1.015           |
| % Variance (Cumulative)                                                                                                 | 58.9 % (58.9 %)                 | 6.34 % (65.2 %) |
| Cronbach alpha                                                                                                          | 0.930                           | 0.842           |

There were some significant differences in how respondents rated the overall scale as well as its separate dimensions. A higher average rating for the public participation dimension was reported by respondents aged less than 40 years ( $M = 2.3$ ,  $SD = 0.16$ ) in comparison to older respondents ( $M = 1.9$ ,  $SD = 0.16$ ) ( $t(89) = 1.77$ ,  $p = 0.02$ ; Welch Two Sample t-test). However, our regression analyses did not reveal any geographical or demographic factor influencing the way respondents viewed the overall scale or the individual dimensions of the scale (see Appendices, Table A4).

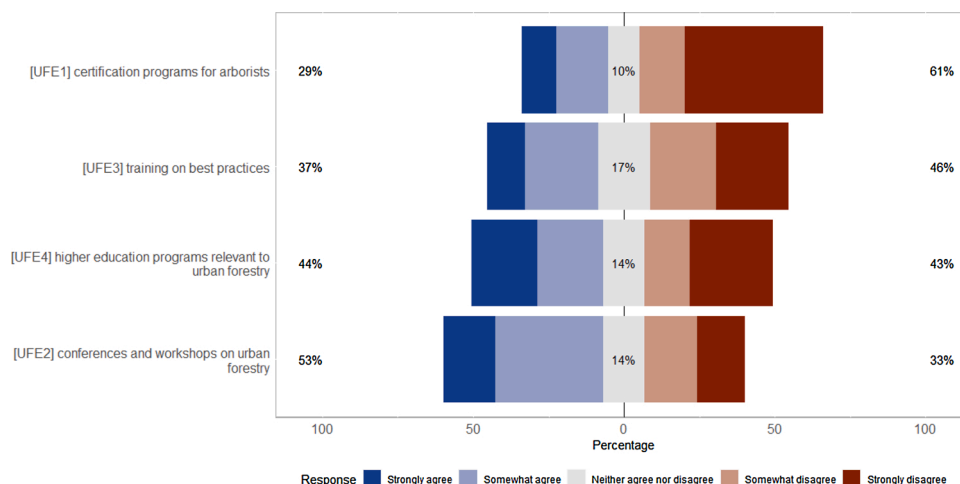
#### 4.4. Views on educational opportunities

In terms of educational and training opportunities (Section 3), we found that conferences or workshop events were the most available educational opportunities, while certification programs for arborists and trainings on best practices were not widely available across cities (Fig. 4). Those reporting the existence of educational activities within their cities were participants closely related to research/teaching institutions such as universities (public and privates), or those who have access to, or are currently engaged in, an urban forestry-related association and have a network of urban foresters/arborists elsewhere. Perhaps because of this reason, a large proportion of the respondents (44 %) recognized the availability of formal higher education opportunities relevant to urban forestry. The educational opportunities scale provided reliable answers across all four items (see details in Appendices, Table A3).

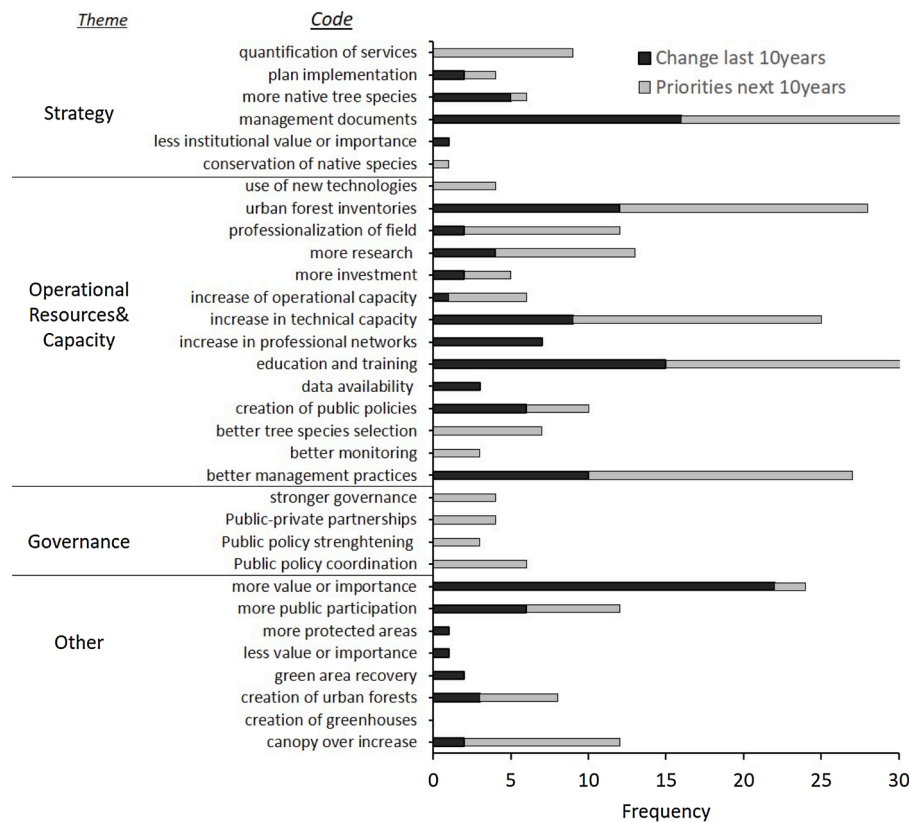
There were some significant differences in how respondents rated the scale. A higher average rating was reported by respondents in the professional government domain ( $M = 3.3$ ,  $SD = 0.21$ ) in comparison to those not in government work ( $M = 2.4$ ,  $SD = 0.16$ ) ( $t(89) = 3.22$ ,  $p = 0.002$ ). A higher average rating of the scale was also reported by female respondents ( $M = 3.0$ ,  $SD = 0.18$ ) in comparison to male or other gender respondents ( $M = 2.4$ ,  $SD = 0.19$ ) ( $t(89) = 2.24$ ,  $p = 0.03$ ) (Welch Two Sample t-test). Our analyses based on regression confirmed this, showing a significant, although small ( $r < 0.5$ ), association between the professional government domain of respondents with a higher perception of educational opportunities, controlling for demographic variables (i.e., gender, age, and education) (see Appendices, Table A5).

#### 4.5. Observations on changes and priorities in LAC urban forestry

The respondents who answered the optional open-ended questions (Section 6) frequently reported that the main observed changes in the past ten years in urban forestry was related to strategic and operational issues (Fig. 5). As most notable changes, the respondents identified the



**Fig. 4.** Ratings for agreement and disagreement with respect to individual items of the educational opportunities scale (Section 3; Table 1) ( $n = 91$ ). Survey question: How much do you agree/disagree with the availability of the following educational activities? "In the city where I work, there are...".



**Fig. 5.** View on changes in the last 10 years, and priorities for the next 10 years, indicating themes and codes emanating from interpretative coding, based on qualitative empirical data collected from stakeholders in LAC cities ( $n = 91$ ).

creation of management documents, urban forest inventories, education and training or personnel, dissemination of best management practices, and the increased value or importance of the urban forest (see examples in Appendices, Table A7). The main priorities identified for the next decade were almost the same as the changes identified in the first question. Surprisingly, governance aspects such as policy coordination and strengthening partnerships were not identified as a priority for the next decade (Fig. 5).

## 5. Discussion

We collected data from a wide range of urban forest stakeholders, including local government and non-governmental professionals and non-professionals. The diversity of stakeholders in our study echoes other studies in North America, Europe, and Australia, where empirical social science research has been conducted on local governments, non-governmental greening groups, private landowners, among others (Lawrence et al., 2013; Molin and Konijnendijk van den Bosch, 2014).

### 5.1. Urban forest definitions from a LAC perspective

The definition of urban forest in LAC is more narrow than international definitions such as the one proposed by FAO (Salbitano et al. 2016), and is more aligned with urban forest definitions of North America (e.g., Wirtz et al., 2021). The definition for most LAC stakeholders in our study includes mainly public areas with trees and forests and areas that are considered as forest fragments located in the peri-urban landscape. These components of the urban forest are probably related to their niche of influence/decision-making.

The definition in LAC did not include components usually related to green infrastructure, such as green roofs and walls. Under the nature-based solutions umbrella, other global regions such as Europe are including green roofs and walls, rainwater gardens, urban agriculture

and playgrounds into policies related to climate change, biodiversity, or even public health (Escobedo et al., 2019).

The inclusion of private trees into the definition of urban forest in LAC could push towards thinking of urban forests as a continuum that is not separated by the ownership of the land. This idea could help understand and promote a more active role of urban residents in conserving and increasing the green in cities, especially within a climate adaptation framework. Cities in the Global North are already highlighting the importance of vegetation in private areas (Dobbs et al., 2013; Phelan et al., 2018; Ordóñez et al., 2021).

### 5.2. Urban forest management and governance from a LAC perspective

In terms of urban forest management themes, we found that while some aspects were considered by stakeholders to be adequately addressed, others were lagging. For example, planting species lists and the clarity of regulations seemed to be adequately addressed. These results differ from previous research that found that urban forest stakeholders, mostly in the US, viewed regulations in their cities as inadequate (e.g., Hill et al., 2010; Rines et al., 2011; Grado et al., 2013; Kirkpatrick et al., 2013; Young, 2013; Driscoll et al., 2015). In contrast, data on trees in private urban land, public participation, and plans to manage climate change-related hazards were viewed as currently inadequate. These results echo the lack of data and research focused on trees in private urban lands (Ordóñez et al., 2021), public participation (Gulsrud et al., 2018; Buijs et al., 2019; van der Jagt et al., 2019; Phelan et al., 2018), and planned responses to climate change adaptation building on urban forestry (Živojinović and Wolfslehner, 2015).

Moreover, our findings highlight the need to strengthen institutional capacity and citizen participation in LAC urban forestry. It is important to note that, based on our survey, we found that LAC stakeholders' views on these issues are not monolithic, but rather distinct and separate for operational capacities and public participation.



First, in our study, stakeholders indicated the need for increased institutional capacity, which includes not only budgets and personnel, but also strategies and policies (Fiedler et al., 2006; Hill et al., 2010; Rines et al., 2011; Grado et al., 2013; Kirkpatrick et al., 2013; Young, 2013; Driscoll et al., 2015; Davies et al., 2017; Locastro et al., 2017; Ordóñez et al., 2019). The importance of improving urban forest strategies has also been mentioned by researchers in other world regions, including in Canadian (Ordóñez and Duinker, 2013), British (Davies et al., 2017), and Australian (Phelan et al., 2018) urban forestry. What we can assume from the survey results is that there seems to be a reactive rather than a preventive or proactive approach to urban forestry in LAC due to a general lack of operational and strategic capacities (Dobbs et al. 2018).

Another aspect of institutional capacity is professional capacity, which among other things depends on professional education (Hill et al., 2010; Rines et al., 2011; Tovar-Corzo, 2013; Driscoll et al., 2015). In our study, we found that urban forest stakeholders perceived educational and training opportunities to be reasonably available in LAC. Even though we did not see any influence of government vs. non-government characteristics on these views, our sample of respondents came mostly from public and research institutions, so it is yet unclear how other types of stakeholders perceive this issue. Either way, education and training are key to building professional capacity in LAC cities (e.g., Tovar-Corzo, 2013). An important aspect of such education and training is moving from tree-focused capacities to system-level capacities, including seeing the urban forest as an ecosystem integrated into almost every aspect of urban planning and governance (Lawrence et al., 2013; Ordóñez and Duinker, 2013; Phelan et al., 2018). This shift can help raise the level of professionalization and forward-thinking in LAC urban forestry, as it has been the case in other world regions (O'Herrin et al., 2020).

Second, public participation is key to urban forestry because urban forest stewardship is not just a technical issue to be solved by professional stakeholders. Broader community issues, such as public perceptions of and support for urban forests, play a key role in urban forest stewardship. Engaging communities then becomes a key aspect of such stewardship and also human behavioural change (Molin and Konijnendijk van den Bosch, 2014; Gulrud et al., 2018; Buijs et al., 2019; van der Jagt et al., 2019). Public participation in urban forestry can also be useful for data collection and posterior monitoring, which are highly valuable for managing collectively-owned natural resources (Folke et al., 2005; Lemos and Agrawal, 2006; Lockwood et al., 2010; Viana et al., 2020). In our study, we found that stakeholders hold separate views about public participation. Some stakeholders view public participation as adequate, which we assume may relate to the fact that public consultation has become mandatory in many urban forestry activities in public urban land (Gulrud et al., 2018). However, for other stakeholders who did not share that view, there may be a lack of awareness about this process, or they may simply not be required to address public participation in their organizational mandates, or not be capable to address them due to lack of capacity (i.e., personnel, budgeting, knowledge, and skills; Janse and Konijnendijk, 2007). Further research is needed to investigate these distinct views, taking into consideration specific contexts. Nevertheless, our results point out that LAC stakeholders recognize the important role of public participation in urban forest management and governance.

### 5.3. Limitations

Our study has some limitations. First, given our convenience recruitment procedure, our data suffered of sampling bias. While non-governmental organizations and private sector can influence why,

where, and how urban trees are planted or removed (Conway et al., 2011; Daniel et al., 2016), our survey did not capture as many professionals in non-governmental organizations and businesses. Rather, most of our sample was represented by academic and local government stakeholders (68 %). These may be because these stakeholders are more likely to engage in the types of regional fora where we collected our data. Overall, the data did not provide enough professional and demographic variability (i.e., government vs. non-government stakeholders; etc.) to associate views about management and governance issues with professional and sociodemographic characteristics. A more comprehensive, stratified, and representative dataset with a wider range of respondents would be required to assess these associations in the future. Nevertheless, we provide an overview of what are the key issues that interest stakeholders and we have established a data collection and analysis approach that could be used in future studies to test the social and geographical pathways that may influence stakeholder views on urban forest governance and management. In that sense, this study enriches the methodological approach to assess stakeholders' views on urban forest management and governance empirically and comparatively.

## 6. Conclusions

This study provides insight into how a diverse range of urban forest stakeholders view issues related to the management and governance of urban forests in different LAC cities. To our knowledge, this is the first region-wide, social science study on urban forest stakeholder views in LAC. This baseline study needs to be complemented with future studies.

Our findings show that most respondents considered operational and management tools for urban forests to exist in most cities, but they disagreed on the existence of inventories for trees on private lands and ways for the public to engage in urban forestry. For some respondents, issues related to public participation were more important than other issues, while for other respondents, issues related to operations, such as having clear regulations, were more important. Our analysis did not reveal any geographical or demographic factor influencing respondents' views, but we speculate this is due to limitations inherent in the data.

We also found that, from the perspective of stakeholders, the main priorities for urban forestry in the next decade are strategic and operational, including the creation of management documents, education and training, and the dissemination of best management practices. While conferences or workshop were the most available educational opportunities in the region, formal certification programs for arborists and trainings were not widely available across cities. Professional capacity building is therefore considered of high demand in the region, and we argue that this could move from tree-focused to more system-level thinking.

Finally, this study has established a scale and analysis approach that could be replicated and used in future studies to test the social and geographical pathways that may influence stakeholder views on urban forest governance and management. We also suggest more empirical research on the role of public participation across different urban forest management activities and contexts in the region, particularly in light of pressing urban environmental and social inequality issues, where there is a need to better understand how to strengthen urban forestry decision-making and governance.

### Author statement

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Project administration; Camilo Ordóñez-Barona: Conceptualization, Methodology, Analysis, Writing – Original Draft, Review & Editing, Visualization, Supervision; Cynnamon Dobbs: Conceptualization, Analysis, Writing – Original Draft, Review & Editing; Mariana Dias Baptista: Methodology, Data Curation, Writing – Original Draft, Review & Editing, Visualization; Nuria Mónica Navarro: Data Curation, Analysis, Writing – Original Draft; Luis Alberto Orozco Aguilar: Methodology, Writing – Original Draft; Jose Felix Cercas Perez: Data Curation, Analysis; Yolanny Rojas Mancebo: Data Curation, Analysis; Francisco Javier Escobedo: Conceptualization, Methodology, Supervision.

### Declaration of Competing Interest

The authors have no conflict of interest to declare.

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### Appendix A

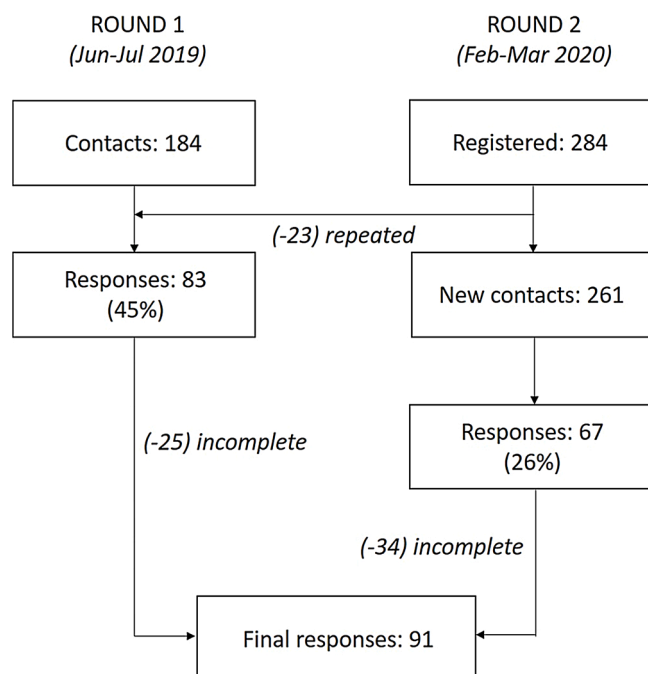


Fig. A1. Responses collected through two rounds of online survey dissemination in 2019 (first round) and 2020 (second round).

Table A1

Events used to generate the contact lists used to recruit survey respondents.

| Round | Event                                                                                                                                                                                                                                                                                                                                                                                                          | Location         | Date              |
|-------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------|-------------------|
| 1     | First Latin American Forum on Urban and Periurban Forests: "Foro latinoamericano y del caribe sobre silvicultura urbana, arboricultura y paisajismo para bosques urbanos y espacios verdes" <a href="http://www.fao.org/p/eru/noticias/detail-events/es/c/892705/">http://www.fao.org/p/eru/noticias/detail-events/es/c/892705/</a>                                                                            | Lima, Perú       | 7–9 June 2017     |
| 2     | Second Latin American Forum on Urban and Periurban Forests: "Segundo foro latinoamericano y del caribe sobre bosque urbanos: silvicultura, arboricultura y áreas verdes" <a href="https://cosmosjaveriana.wixsite.com/cosmos/events/2-foro-latinoamericano-y-del-caribe-sobre-bosques-urbanos">https://cosmosjaveriana.wixsite.com/cosmos/events/2-foro-latinoamericano-y-del-caribe-sobre-bosques-urbanos</a> | Bogotá, Colombia | 5–8 November 2019 |

Table A2

Reliability test for multi-rating scale on governance and management (section 2).

| At present, in the city I work in/with, there is/are...                                                         | Mean  | SD    |
|-----------------------------------------------------------------------------------------------------------------|-------|-------|
| 1 a plan or strategy with clear visions and objectives                                                          | 2.846 | 1.475 |
| 2 an inventory of public trees (ideally georeferenced)                                                          | 3.077 | 1.579 |
| 3 an Inventory of private trees (ideally georeferenced)                                                         | 1.780 | 1.191 |
| 4 political leaders that raise the profile of the urban forest and trees in the community                       | 2.462 | 1.352 |
| 5 a list of appropriate species to plant                                                                        | 3.329 | 1.469 |
| 6 a system to monitor urban forests long-term                                                                   | 2.143 | 1.346 |
| 7 one team that coordinate decisions across departments influencing public trees                                | 3.044 | 1.389 |
| 8 clear ordinances/regulations for urban trees                                                                  | 3.077 | 1.455 |
| 9 research partnerships with research institutions aimed at improving management of urban forests               | 2.648 | 1.417 |
| 10 adequate consultation and engagement with the community in decisions related to urban forests                | 2.253 | 1.261 |
| 11 trust among residents towards management agencies                                                            | 2.198 | 1.302 |
| 12 adequate budget to manage the urban forest                                                                   | 2.088 | 1.235 |
| 13 technical maintenance plans to maintain forest health and manage risk (pruning, watering, fertilizing, etc.) | 2.758 | 1.385 |
| 14 trained and certified human resources                                                                        | 2.692 | 1.339 |
| 15 sufficient education of the community about urban forests                                                    | 2.109 | 1.167 |
| 16 plans to manage climate change-related hazards and other disturbances affecting the urban forest             | 2.132 | 1.327 |
| Average of all items                                                                                            | 2.542 | 1.043 |
| Cronbach alpha                                                                                                  | 0.951 |       |

Table A3

Reliability test for multi-rating scale on availability of educational opportunities (section 3).

| In the city where I work, there are...                  | Mean  | SD    |
|---------------------------------------------------------|-------|-------|
| 1. Certification programs for arborists                 | 2.231 | 1.528 |
| 2. Conferences and workshops on urban forestry          | 3.066 | 1.482 |
| 3. Training on best practices                           | 2.670 | 1.469 |
| 4. Higher education programs relevant to urban forestry | 2.824 | 1.623 |
| Average of all items                                    | 2.698 | 1.374 |
| Cronbach alpha                                          | 0.866 |       |

**Table A4**

Results of analysis of associations between selected survey measures and stakeholder views about management and governance issues using survey data collected in this study.

| Measure                                                                                                                   | Coefficient (Standard Error) | 95 % Confidence Interval of coefficient |
|---------------------------------------------------------------------------------------------------------------------------|------------------------------|-----------------------------------------|
| Multilinear regression model for the association between professional characteristics and management and governance scale |                              |                                         |
| Language_Spanish                                                                                                          | -0.08 (0.28)                 | [-0.63, 0.47]                           |
| >10years work experience                                                                                                  | -0.21 (0.29)                 | [-0.79, 0.36]                           |
| ProfessionalDomain_government <sup>a</sup>                                                                                | 0.25 (0.29)                  | [-0.23, 0.72]                           |
| ScaleofImplementation_municipal <sup>1</sup>                                                                              | 0.24 (0.24)                  | [-0.21, 0.68]                           |
| Multilinear regression model for the association between geographical characteristics and management and governance scale |                              |                                         |
| CityPopulation_>1million <sup>a</sup>                                                                                     | NA                           | NA                                      |
| Bioregion_AndesNorth <sup>a</sup>                                                                                         | 0.29 (0.37)                  | [-0.34, 0.91]                           |

Models adjusted for demographics, including age (>40 years), gender (female), and education (university degree) (see Methods section, main text); only unstandardized comparable regression coefficients included.

\*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$ , NA = not enough data.

<sup>a</sup> Measures with complementary variables but only one variable shown (e.g., for City Population, extra variable of >5million, not shown).

**Table A5**

Results of analysis of associations between selected survey measures and stakeholder views about availability of educational opportunities using survey data collected in this study.

| Measure                                                                                                                   | Coefficient (Standard Error) | 95 % Confidence Interval of coefficient |
|---------------------------------------------------------------------------------------------------------------------------|------------------------------|-----------------------------------------|
| Multilinear regression model for the association between professional characteristics and educational opportunities scale |                              |                                         |
| Language_Spanish                                                                                                          | -0.45 (0.32)                 | [-1.08, 0.19]                           |
| >10years work experience                                                                                                  | 0.28 (0.34)                  | [-0.39, 0.95]                           |
| ProfessionalDomain_government <sup>1</sup>                                                                                | 0.72 (0.28)*                 | [0.17, 1.28]                            |
| ScaleofImplementation_municipal <sup>1</sup>                                                                              | 0.29 (0.26)                  | [-0.21, 0.81]                           |
| Multilinear regression model for the association between geographical characteristics and educational opportunities scale |                              |                                         |
| CityPopulation_>1million <sup>a</sup>                                                                                     | NA                           | NA                                      |
| Bioregion_AndesNorth <sup>a</sup>                                                                                         | 0.82 (0.37)                  | [0.078, 1.57]                           |

Models adjusted for demographics, including age (>40 years), gender (female), and education (university degree) (see Methods section, main text); only unstandardized comparable regression coefficients included.

\*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$ , NA = not enough data.

<sup>a</sup> Measures with complementary variables but only one variable shown (e.g., for City Population, extra variable of >5million, not shown).

**Table A6**

List of all codes used in the qualitative analysis (section 6).

| Question                            | Assigned subcodes                                                                                                                                                                                                                                                           | Code clusters <sup>a</sup>                 |
|-------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------|
| 1 Changes in the last ten years     | Creation of public policies; development of public policies; management documents; loss of value; more value; loss of institutional value; protected areas zoning                                                                                                           | Strategy                                   |
|                                     | Increase operational capacity; training and capacity of personnel; professional associations; professionalization of the field                                                                                                                                              | Operations - personnel capacity & training |
|                                     | More investment                                                                                                                                                                                                                                                             | Operations – budgets                       |
|                                     | Generation of data; management of data; forest inventories                                                                                                                                                                                                                  | Operations - data & monitoring             |
|                                     | More education; more research                                                                                                                                                                                                                                               | Education & Research                       |
|                                     | Monitoring of changes; creation of green areas                                                                                                                                                                                                                              | Implementation of strategy and tools       |
|                                     | Public participation                                                                                                                                                                                                                                                        | Public participation                       |
|                                     | Make decisions together with other stakeholders; governance by many actors                                                                                                                                                                                                  | Coordination of actors                     |
|                                     | No changes; canopy cover increase;                                                                                                                                                                                                                                          | Other                                      |
|                                     | Species conservation; public-private alliances; creation of public policies; development of public policies; management documents; strengthen public policies; more value; better management; better governance; communications plans                                       | Strategy                                   |
| 2. Priorities in the next ten years | Increase operational capacity; training and capacity of personnel; professional associations; professionalization of the field                                                                                                                                              | Operations - personnel capacity & training |
|                                     | More investment                                                                                                                                                                                                                                                             | Operations – budgets                       |
|                                     | Generation of data; management of data; forest inventories; dissemination of data                                                                                                                                                                                           | Operations - data & monitoring             |
|                                     | More education; more research                                                                                                                                                                                                                                               | Education & Research                       |
|                                     | Monitoring of changes; creation of green areas; creation of gardens; planting native species; implementation of green infrastructure plans; assign monetary value; better management implementation; apply best practices; use new technologies; plant the species selected | Implementation of strategy and tools       |
|                                     | Public participation                                                                                                                                                                                                                                                        | Public participation                       |
|                                     | Coordination policies at different levels of government                                                                                                                                                                                                                     | Coordination policies                      |
|                                     | Make decisions together with other stakeholders; governance by many actors                                                                                                                                                                                                  | Coordination of actors                     |

<sup>a</sup> This refers to the ideas in Fig. 5.

**Table A7**

Selected inductive coding examples, indicating assigned code(s).

| Question                            | Verbatim data                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Assigned subcode (s)                                                                   | Code clusters <sup>a</sup>                                                       | Response ID |
|-------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------|----------------------------------------------------------------------------------|-------------|
| 1. Changes in the last ten years    | “En términos de paisajismo se ha comenzado a establecer una mayor conciencia en el sector de la construcción. Se están destinando recursos para sienta de árboles y jardines que permiten ampliar la cobertura verde y la conectividad ecológica a nivel urbano”                                                                                                                                                                                                                                | More value<br>More investment                                                          | Strategy<br>Operations – Budgets                                                 | 50          |
| 1. Changes in the last ten years    | “Desde el ordenamiento territorial, Estructura Ecológica Principal y Complementaria, Inventarios, SIG y otros. Así como, planees de arbolado y planes maestros de silvicultura ha ido mejorando la conceptualización del arbolado y bosques urbanos (zonas de protección) y su importancia en el aporte de los servicios ambientales, pero sobre todo en el tema de cambio climático. Se ha desarrollado normatividad y a la par en algunas ciudades se hacen actividades de arbolado ordenado” | Management documents<br>Forest inventories                                             | Strategy<br>Operations - data & monitoring                                       | 15          |
| 2. Priorities in the next ten years | “1. Promover la conceptualización legal del bosque urbano. 2. Contar con material vegetal Nativo a nivel local que esté a disposición de las municipalidades para construcción de trama verde. 3. Recuperación de terrenos que son áreas de protección invadidos por asentamientos informales consolidados”                                                                                                                                                                                     | More value<br>Species selection                                                        | Strategy<br>Implementation of strategy/tools                                     | 30          |
| 2. Priorities in the next ten years | “1) La declaración de los árboles como patrimonio de la ciudad. 2) El empoderamiento de la ciudadanía en el cuidado del arbolado urbano. 3) La implementación de más áreas verdes que impliquen que como ciudad podamos cumplir con índice verde urbano”                                                                                                                                                                                                                                        | Canopy cover increase<br>Public Participation<br>Create more green areas<br>More value | Strategy<br>Public Participation<br>Implementation of strategy/tools<br>Strategy | 19          |

<sup>a</sup> This refers to the ideas in Fig. 5.

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