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How Urban Forest Managers Evaluate Management and Governance Challenges in Their Decision-Making

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Abstract: Decisions about urban forests are critical to urban liveability and resilience. This study aimed to evaluate the range of positions held by urban forest managers from local governments in the state of Victoria, Australia, regarding the management and governance challenges that affect their decision-making. This study was based on a Q-method approach, a procedure that allows researchers to evaluate the range of positions that exist about a topic in a structured manner based on the experiences of a wide group of people. We created statements on a wide range of urban forest management and governance challenges and asked urban forest managers to rate their level of agreement with these statements via an online survey. Managers generally agreed about the challenges posed by urban development and climate change for implementing local government policies on urban forest protection and expansion. However, there were divergent views about how effective solutions based on increasing operational capacities, such as increasing budgets and personnel, could address these challenges. For some managers, it was more effective to improve critical governance challenges, such as inter-departmental and inter-municipal coordination, community engagement, and addressing the culture of risk aversion in local governments. Urban forest regional strategies aimed at coordinating management and governance issues across cities should build on existing consensus on development and environmental threats and address critical management and governance issues not solely related to local government operational capacity.

Keywords: municipal government; urban planning; urban forest governance; nature-based solutions; ecosystem management; Q-method

1. Introduction

Many cities are actively setting long-term goals to enhance their urban green infrastructure [1], including increasing tree numbers and canopy cover [2,3]. However, urban development policies aimed

at urban densification, consolidation, and expansion are challenging the concurrent implementation of urban forest strategies aimed at retaining and increasing tree numbers and tree canopy. Many cities struggle to maintain tree numbers and canopy cover [4], partly due to urban development challenges [5,6]. These challenges have led some authors to suggest that local governments should not only allocate more resources for urban forests (i.e., more budgets, more personnel), but also facilitate better decision-making with regards to the retention and protection of existing trees and canopy cover [7–10]. However, it remains unclear how those responsible for urban forests in local governments make decisions in the face of new development challenges. This is because most of the literature on decision-making in urban greening is based on a broad understanding that does not differentiate between the various forms of urban nature (e.g., [11–17]), such as the difference between urban trees, gardens, and/or parks, and the specific decisions affecting these. Also, most studies investigating how local governments make decisions about urban trees are focused on resourcing decisions, such as the size of budgets (e.g., [18]), or programming decisions, such as tree-planting campaigns (e.g., [19]) or tree species selection (e.g., [20]). This limits our ability to integrate broader management and governance challenges into a more holistic understanding of urban forest decision-making. These challenges may include development issues, the coordination of non-government actors, and community engagement, among others [10]. Without this understanding, it will be difficult to facilitate better urban forest decision-making within and across local governments.

This study responds to this gap and expands on how municipal urban forest managers working in local governments in the state of Victoria, Australia, evaluate management and governance challenges in their decision-making. To frame our study, we characterize the management and governance challenges in urban forest decision-making.

2. Theoretical Framework

2.1. Management and Governance of Urban Forests

Any understanding of urban forest decision-making must be based on management and governance. Urban forest management is based on ecosystem management, which can be broadly defined as the process of how humans work with nature to achieve management objectives [21,22]. Urban forest management involves strategic decisions, often guided by institutional mandates or top-down policies, such as the canopy-cover or tree diversity goals set by local governments; as well as operational decisions, or those involving day-to-day issues, such as where and how to protect, retain, or plant specific trees [10]. A key concept in urban forest management is multifunctionality, which means that urban forests should be managed to meet various environmental, ecological, and social objectives that can facilitate the transition of urban treed spaces from single-function landscapes to multi-functional landscapes [8,13,14,17]. This also means that people responsible for managing these spaces often attempt to integrate a wide range of priorities into their decision-making, such as urban development, biodiversity, public participation, and human health [22–24].

Urban forest governance can be broadly defined as the rules and processes which urban forest stakeholders use to influence and coordinate their needs in relation to urban trees [25]. How urban forest stakeholders make decisions about, or influence the decision-making related to, urban trees, depends on governance procedures that help stakeholders govern or manage a collectively owned natural resource [26]. These include stakeholder and policy coordination, as well as community engagement, among others [27]. A key concept in urban forest governance is institutional diversity, or the diversity in mandates and discourses among and within institutions that dictate the governing of a natural resource [28]. In urban forests, various institutions, as well as units within these institutions, have diverse mandates and discourses which translate into multiple and, sometimes conflicting, pressures on the decision-making process [7,29].

We can understand the management and governance challenges in urban forest decision-making by studying the views of key urban forest stakeholders. Municipal urban forest managers, a key

stakeholder, are defined as the professionals who work within or for local governments (i.e., city councils, municipalities, depending on context) in an urban forest capacity [10]. Not all urban forest decisions are made by municipal managers. Many decisions related to privately or publicly owned trees are made by other stakeholders, including private landowners [30–32] and community-led greening groups [33,34]. As such, many urban forest decisions cannot easily be traced to a single stakeholder but are made within a network of stakeholders. However, municipal managers play a central role in this network. These managers are responsible for resolving the various demands and strategic and operational decisions concerning, urban trees [10].

To develop a better understanding of how management and governance challenges are integrated in urban forest decision-making, we must look at how municipal urban forest managers make decisions. Building on a recent review on the empirical research of municipal urban forest manager views [10] we discuss below the different types of challenges affecting municipal urban forest managers (Table 1) and identify gaps in how they have been evaluated against each other based on the experience of managers.

Table 1. Management and governance challenges affecting the decision-making of municipal urban forest managers (based on [10]).

Type of Challenge	Specific Examples
Operational and strategic issues	Availability and adequate use of data Existence and implementation of a strategic program/plan Adequate size of budget Adequate size and qualification of personnel
Internal management	Interdepartmental coordination Inter-governmental policy coordination Political leadership Coordination of urban development priorities Strategies to retain existing trees
Conflicts	Increasing budget for tree maintenance Finding space for trees in new developments Risk overestimation
Community issues	Existence of public awareness and education programs Consultation and engagement of the community in urban forest decisions Strategy to improve urban tree stewardship Importance of urban forests to community
Climate change and biodiversity	Balance between biodiversity and environmental benefits Vulnerability of urban trees to climate change Existence of biodiversity strategies

2.2. *Management and Governance Challenges in Urban Forests*

2.2.1. Operational and Strategic Issues

Operational issues refer to the capacity for 'getting the job done'. These include resource availability, such as budgets and personnel [18], and programming, such tree species selection guidelines [20]. It may also include broader strategic programming issues, such as the existence of urban forest guiding documents [35]. While many empirical studies on municipal managers' views have identified some of the most important operational and strategic issues for managers [9,18], many other issues have been omitted from such studies. Operational decisions are not the only decisions managers make, as manager decision-making extends beyond the operational capacity of their workplace [10]. To overcome these limitations, operational decisions must be evaluated against strategic decisions, as well as against broader management and governance challenges, which we discuss below.

2.2.2. Internal Management

The level of local government commitment to urban forests directly affects manager decision-making [7]. This commitment can be reflected, for example, in the way political leaders profile urban forests and trees in their communities, or how local governments coordinate the priorities of developers with their own priorities about urban forests [7,36]. Other issues include the level of coordination among local government departments or and how policies from different levels of government are coordinated [18,29]. However, many of these challenges have not been empirically evaluated against other conflicts and community issues.

2.2.3. Conflicts

An important conflict in urban forests is urban development. This includes urban expansion, densification, renewal, and consolidation that make it difficult to concurrently meet priorities in urban greening, particularly retaining and increasing tree numbers and tree canopy [11,15,16]. Cities may strategically plant a large and increasing number of trees [9,19], but at the same time continue to remove trees to make space for an expanding physical infrastructure [6], or spend more resources maintaining trees in challenging urban conditions [37]. A dynamic equilibrium then emerges where tree numbers and tree canopy often remain stable overall, while increasing in some places and decreasing in others [4,6,38]. These issues translate in a variety of challenges for municipal managers, such as raising costs for urban tree maintenance, difficulty finding space for trees in new developments, or the overestimation of urban tree risk in order to facilitate tree removals (e.g., [29,39,40]).

2.2.4. Community Issues

Community issues are important to manager decision-making because many non-government stakeholders participate in the decisions that affect urban trees, including non-governmental greening groups [33,34] and private landowners [31,32]. However, most of the literature on the views of municipal urban forest managers has focused on the most basic level of community relations, such as public awareness and consultations [10]. These are activities that passively communicate the benefits of trees to the public with the hope of reducing community barriers for tree planting and retention (e.g., [36,41]). More proactive approaches to community engagement include public participation campaigns before and during the development of plans [24] and co-management partnerships [11,25,42]. Community engagement challenges may then include how managers experience the importance urban forests receive in their communities, whether they have a mandate to consult the public in their decisions, and whether their local government has a strategy to improve the stewardship of trees [10]. However, community engagement issues that go beyond public awareness and education campaigns have not been well integrated into previous assessments of the challenges faced by municipal managers [10].

2.2.5. Climate Change and Biodiversity

While environmental and biodiversity issues are at the center of urban forest management [22], many important details have yet to be integrated. For example, native tree species representation within the urban forest, an important ecological criterion for urban forest management in some places, is usually not adequately addressed in urban forest programming [43]. Furthermore, climate change, which represents an important challenge to urban forests [44], is still not commonly integrated into urban forest management [45]. These issues represent major challenges for manager decision-making, such as how well biodiversity issues are prioritized over environmental issues [23], or whether managers identify climate change vulnerability as an important strategic issue [45]. Consequently, while there is much theory about which challenges to address (Table 1), we still do not have an empirical understanding about how they are evaluated against other challenges.

3. This Study

In this study we aimed to empirically examine the range of positions about management and governance challenges in urban forest decision-making. To do this we selected a sample of municipal managers working within regional towns and cities throughout the state of Victoria, Australia, with a focus on local governments in the Melbourne metropolitan area.

Our research was based on a mixed method [46] and multiple case study [47] framework and used a Q-method approach to evaluate the range of positions that exist among urban forest managers regarding management and governance challenges. In the environmental and natural resource literature, Q-method is frequently used to understand shared perspectives and understanding among stakeholders (e.g., [48–50]). In urban forestry research it has only been used to explore how a broad range of stakeholders, including academics and regional and local managers, perceive climate change adaptation [45]. This study builds upon this previous work and focused on understanding how municipal urban forest managers evaluate management and governance challenges to their decision-making. The procedure is overviewed in the methods section.

Our approach was guided by the recognition that every local government faces its own management and governance challenges. These issues are influenced by their physical and social characteristics, including urban development dynamics, community attitudes, population density and growth, and management and governance styles, among many others. The urban-rural gradient lens [51] is useful here to illustrate this variation, and it has been useful before to evaluate urban ecosystem dynamics across metropolitan Melbourne, Australia [52,53].

This research contributes to the existing literature on the views of municipal urban forest managers by expanding our understanding of the range of issues shaping urban forest decision-making. This is important considering that most of the previous literature has focused operational issues without integrating other community and strategic issues [10]. To fill this gap, the objectives of this study were to: (1) evaluate management and governance challenges in municipal urban forest manager decision-making against each other in a structured manner; (2) collect empirical data across several local governments guided by an urban-rural gradient lens. The results from this study can help us increase understanding about how to facilitate better decision-making for tree planting, retention, and protection in rapidly urbanizing cities. It can also contribute to understanding about how key decision-makers can resolve disagreements, and set priorities in relation to, multiple challenges affecting urban forests, within and across local governments.

4. Materials and Methods

4.1. Context

The state of Victoria, Australia has a population of 6.4 million people [54], and a heterogeneous temperate climate ranging from a dry and hot north west, to a cool and wet south east [55]. Victoria comprises 79 local governments, 32 of which are in the Melbourne metropolitan area (henceforth, Greater Melbourne; 37.49° S, 144.58° E; Figure 1). The City of Melbourne is the capital of Victoria and the central local government of Greater Melbourne. Other important local governments in Victoria are regional cities, such as Ballarat, Bendigo, and Geelong. These three cities are the largest regional cities in the state and are becoming residential towns for people who commute to Melbourne to work [56]. The state is projected to experience a rapid increase in population, possibly reaching 7.5 million by 2027, and 10.1 million by 2051 [57]. Most of this population increase is expected in Greater Melbourne (population 4.9 million; 2.7% growth from 2016 to 2017; [54]), as well as regional cities within commuting distance [57].

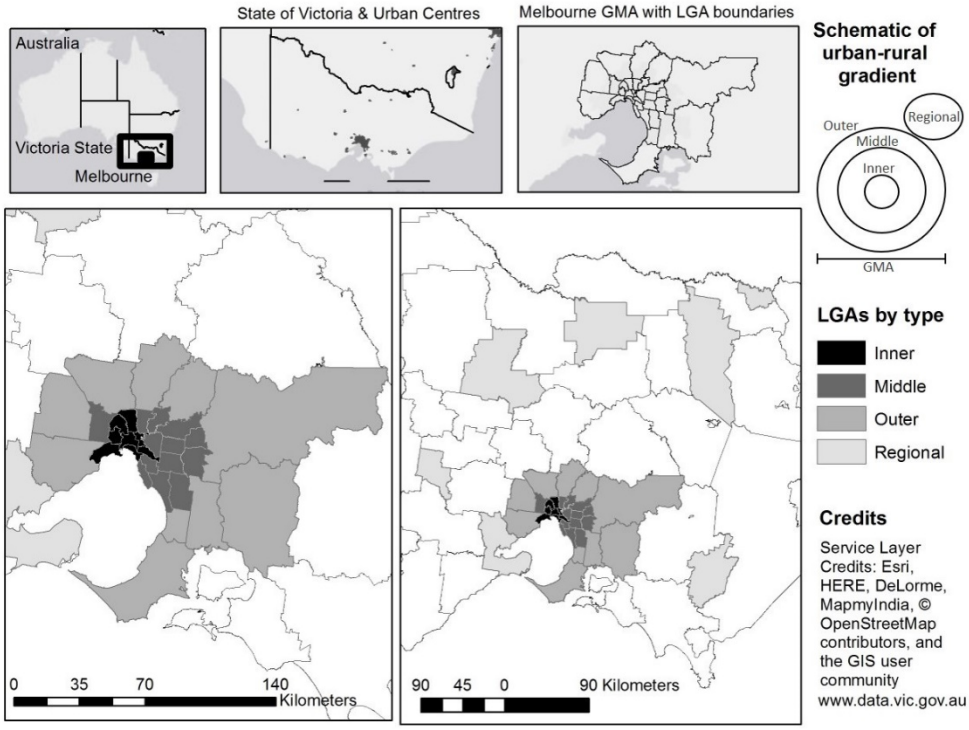


Figure 1. Local governments in the state of Victoria by type (inner, middle, outer, and regional), indicating local governments in and surrounding the Greater Metropolitan Area (GMA) of Melbourne, Australia.

Many Victorian local governments are strategically planning for urban growth and densification, whilst at the same time setting goals to increase urban forest cover [2,8]. Urban planning in Victoria is hierarchical, with the Victorian State government setting the strategic planning direction for local governments with policies aimed at urban densification and avoiding urban sprawl.

Local governments, such as the City of Melbourne [58] and the City of Ballarat [59], have set agendas about urban forests. Urban forest priorities in these local governments include retaining and planting trees in areas facing intensified urban development [6,38], increasing urban tree species diversity [60], reducing the uneven distribution of tree canopy [52], and mitigating the impacts of climate change on urban trees, including drought, heatwaves, and flooding [61].

4.2. Q-Method Overview

The Q-method approach was selected because it provided a structured way to evaluate the range of positions that exist about a topic based on the shared experiences from a wide group of people [62]. The procedure is based on mixed qualitative and quantitative procedures of data collection and data analysis, and it is mostly centred around the creation of a set of statements that describe an issue, ranking these statements by a selected group of people, and statistically analysing how these statements are ranked [62]. As such, the method fitted with our aim of systematically exploring the different perspectives of urban forest managers about management and governance challenges. Q-method was originally developed to evaluate subjectivity and the competing views behind a topic [63]. The approach does not aim to prove or disprove a hypothesis, but instead provide a coherent answer as to how people subjectively evaluate issues related to a topic [64]. We followed the Q-procedure stages as suggested by [62] and combined qualitative and quantitative datasets and procedures that facilitated the evaluation by managers (Figure 2).

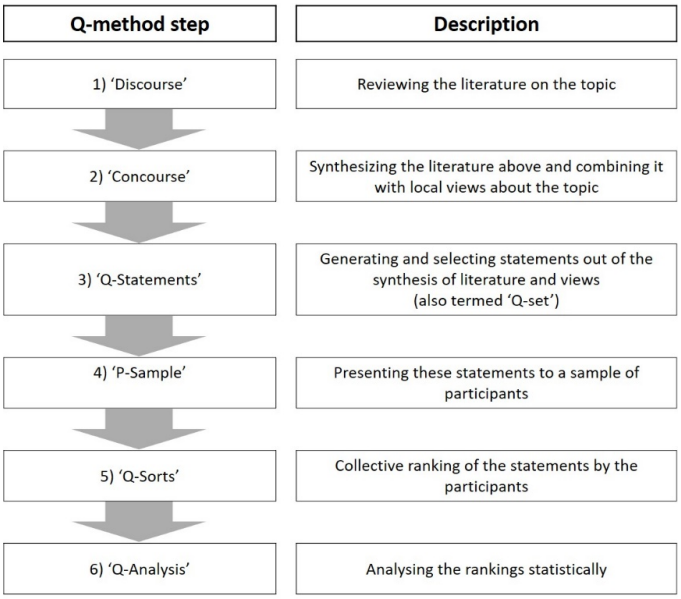


Figure 2. Stages of the Q-method approach used in this study, including steps and procedures (based on [62]; see also [45,48–50]).

4.3. Interviews with Urban Forest Managers

We conducted qualitative, semi-structured interviews with 23 municipal urban forest managers working in 12 local governments across the state of Victoria to gain a qualitative understanding of the decision-making challenges of urban forest managers, and to fulfill the first, qualitative stage of our Q-method procedure (Figure 2). Data from the interviews, comprising a total of 24 h of audio recordings, and more than 100 pages of transcribed text, were analysed and interpreted following inductive coding procedures [65]. Data were analysed using the software NVivo 12 Pro (QSR International, 2018, Melbourne, Victoria, Australia). The data were coded with the goal of extracting insights on management and governance challenges to municipal manager decision-making. To do true justice to the vast amounts of information embodied in these data, and to adequately discuss the insights gained at this stage of the research basing ourselves on qualitative methods, we have published these results in [66]. Following the recommendations by [47,67], we extracted insights that were relevant across multiple local governments in terms of the most frequent management and governance challenges mentioned by the interviewees. This provided us with an empirical basis of management and governance challenges that complemented our literature review (Table 1). We used these two datasets to inform development of the q-statements in the later stages of our research (Figure 2; see also Appendix A), as described in the following section.

4.4. Q-Statements

We created statements that reflected the main management and governance challenges affecting urban forest decision-making by combining our literature review (Table 1) and our qualitative interview data (above). Q-method has no strict guidelines about how many statements to use or how many participants to invite, but it is generally agreed that both parameters influence the validity and reliability of the results [62,64]. We created statements iteratively, guided by the following principles: (1) local and international relevance; (2) statements based on the actions of local governments; (3) a broad and diverse set of challenges; and (4) avoiding cognitive biases. For the full procedure of statement creation, and how these principles were applied to the data, the interested reader can refer to Appendix A. We created 16 thematically diverse statements that represented a wide range of issues related to urban forests (Table 2).

Table 2. Rotated component loadings, including z scores and normalized q scores, by statement.

Statement ID	Statement, Complements the Question: "The Local Government I Work in/with..."	Component 1		Component 2		Component 3		Component 4		Distinguished Components (F) and Consensus Statements [b]
		Z-Scores	Normalized Scores	Z-Scores	Normalized Scores	Z-Scores	Normalized Scores	Z-Scores	Normalized Scores	
1	. . . has one team that coordinate decisions across departments affecting public trees	0.93	2.00	−0.07	0.00	0.23	1.00	1.41	2.00	F1, F4
2	. . . has increased the proportional of the budget spent on maintaining trees over the last 5 years	1.19	2.00	0.12	0.00	1.04	2.00	−0.78	−1.00	F2, F4
3	. . . prioritizes increasing and managing canopy cover to provide shade and cooling in comparison with habitat and biodiversity issues [a]	0.88	1.00	0.42	1.00	−0.23	−1.00	1.55	3.00	All
4	. . . struggles to include space for trees in new housing developments [a]	0.79	1.00	1.73	2.00	0.49	1.00	1.08	2.00	F2
5	. . . has a coordinated response to state policies that relate to the urban forest, such as increasing medium-density housing and fire risk reduction	−0.86	−1.00	0.69	2.00	−0.14	0.00	−1.11	−2.00	F2, F3
6	. . . lacks capacity to collect or make use of existing data on the urban forest [a]	−1.26	−2.00	0.48	1.00	1.87	2.00	0.98	1.00	All
7	. . . has trees that are vulnerable to a changing climate, such as hotter, dryer weather [a]	0.76	1.00	1.95	3.00	0.01	0.00	−1.13	−2.00	All
8	. . . has political leaders that raise the profile of the urban forest and trees in the community	1.21	3.00	−1.26	−2.00	−0.23	0.00	−1.00	−1.00	F1, F3
9	. . . adequately consults and engages the community in decisions related to the urban forest	0.73	0.00	0.32	1.00	−1.96	−3.00	−0.27	0.00	All
10	. . . has an effective strategy to improve the stewardship of privately-owned trees	−1.51	−2.00	−0.29	−1.00	−0.99	−2.00	−0.41	0.00	F1, F3
11	. . . overestimates risks from urban trees, generating unnecessary tree removals in public areas [a]	−0.99	−1.00	−0.07	0.00	1.89	3.00	−1.32	−3.00	F2, F3

Table 2. *Cont.*

Statement ID	Statement, Complements the Question: "The Local Government I Work in/with..."	Component 1		Component 2		Component 3		Component 4		Distinguished Components (F) and Consensus Statements [b]
		Z-Scores	Normalized Scores	Z-Scores	Normalized Scores	Z-Scores	Normalized Scores	Z-Scores	Normalized Scores	
12	... has an adequate budget to manage the urban forest	−0.40	−1.00	−1.76	−3.00	−0.18	0.00	0.57	0.00	F2, F4
13	... has an urban forest that is important to the community	0.64	0.00	0.11	0.00	0.27	1.00	−0.38	0.00	F4
14	... has a strategy to use the urban forest to provide habitat for wildlife	−0.24	0.00	−0.20	−1.00	−0.81	−1.00	0.99	1.00	F3, F4
15	... has enough and adequately qualified people to manage the urban forest	−0.23	0.00	−1.04	−1.00	−0.39	−1.00	0.59	1.00	F2, F4
16	... has a coordinated response that balances the priorities of developers with the needs of the urban forest, such as having space for growing large trees	−1.55	−3.00	−1.13	−2.00	−0.84	−2.00	−0.77	−1.00	Only F1
	% of Variance explained	**19.72%**		**16.98%**		**11.01%**		**10.17%**		

[a] Statements with an inverse logic (agreement means a negative rating) (see Supplementary Material Figure S1; see also Appendix B). [b] Components are labelled as "F" in the "qmethod" package [68]. Accordingly, F1–F4 refers to components 1–4 as explained in the methods section. "All" indicates statements did not distinguish between components; "consensus" indicates statements that all respondents rated equally; "only" indicates statement that only distinguished for that component at 95% level of statistical significance ($p < 0.05$); otherwise indicates distinguishing components at 95% level of statistical significance ($p < 0.05$).

While some Q-method studies use a larger number of statements (between 25 and 50 statements; see [45,49]), they often combine these larger numbers with a smaller number of participants (~20). While studies using a smaller set of statements are not uncommon (e.g., [69]), these smaller sets can be combined with a large selection of participants to yield reliable results [62,70,71].

4.5. Ranking and Sorting Q-Statements

We invited municipal urban forest managers to rank and sort the 16 statements in terms of how they agreed with them in a scale from strongly agree to strongly disagree. Respondents could only agree or disagree with a limited number of statements for each of the ranking levels as based on our sorting model (Figure 3). This is termed a forced sorting technique in Q-method and produces equal means and variances [64]. We avoided the free ranking of statements, not only to obtain results that could be easily interpreted, but, most importantly, to meet our goals of investigating the range of positions that existed among participants in a structured manner. A forced ranking generates more structured subjective views about a topic because respondents are required to choose the statements they most disagree or agree with, and these statements become representative of their subjective views about that topic [62,70,71].

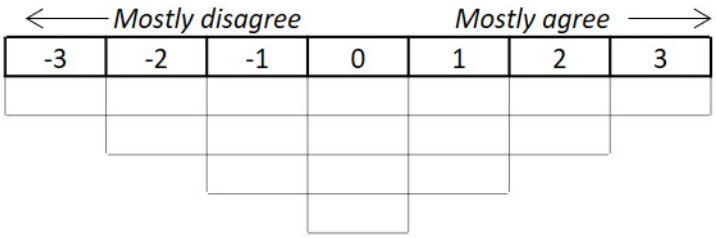


Figure 3. Model of forced rating scheme and number of statements used in this study (note how the model achieves a standard distribution in terms of level of agreement among the number of statements, 16 in this case).

While most Q-method studies use either the initial or a second round of interviews to allow participants to rank statements (e.g., [45,49,50]), this represented a challenge to our multiple case study approach. Our aim was to collect and integrate empirical data from a wide range of Victorian local governments. Coordinating a second round of interviews with a bigger cohort of participants would have been logistically difficult. To get around this issue and to ensure that our multiple case study approach was consistently followed, we collected ranking and sorting data by using an online survey to invite urban forest managers to rank the statements.

To recruit participants, we created a list of 110 managers of urban forests in 35 local governments in Victoria, Australia, including 30 of the 32 local governments in Greater Melbourne, and five other regional local governments. The list had been used to recruit participants for the interviews (above), whereby participants had previously agreed to be contacted for further research.

To collect empirical data on statement ranking and sorting, we developed and delivered an online survey using Qualtrics® (www.qualtrics.com/au, Provo, UT, USA) based on a tailored and exploratory survey design [72]. Using online surveys to collect Q-method data is not rare and can provide reliable results [64]. The online survey was piloted by inviting a group of municipal urban forest managers working with local governments to review the survey in December 2018 (see Supplementary Materials, Table S1, see also Appendix A). The survey was designed to collect some basic employment and demographic data of the respondents (Table 3). We did not specifically ask for the name of the city or municipality where managers worked. This was to ensure participant anonymity, given that the contact information of municipal employees is publicly available. Answers from people not working for local government were filtered out by asking if respondents worked for a local government (yes/no answers; yes accepted). An anonymous email link was sent via email to all the email addresses in

the contact list. The survey was open for responses for 53 days from April to June of 2019. Three reminder emails were sent (i.e., three waves of recruitment; see [72]). The goal of this was not just to increase response rates, but to increase survey coverage and data quality, and to track the number of non-responses [72].

Table 3. Characteristics of the respondents of the online survey (n = 61).

Characteristic	Categories	Number of Cases	% of Total Responses [a]
Local government type where respondent worked [b]	Inner council	28	46
	Middle council	10	16
	Outer council	13	21
	Regional council	8	13
Index of Relative Socio-Economic Disadvantage (IRSD) Quantiles of the local government where the respondent worked [c]	1	0	0
	2	10	16
	3	19	31
	4	16	26
	5	9	15
Professional field [d,e]	Horticulture/Arboriculture/Urban Forestry	68	57
	Other	51	43
Decade born [f,g]	50s	6	10
	60s	15	25
	70s	16	26
	80s	21	34
	90s	1	2
Born in Australia [f,g]	Yes	48	79
	No	13	21
English as a Second Language (ESL) [f,g]	Yes	6	10
	No	55	90
Education [f,g]	No University Degree (Bachelors or Undergraduate)	21	34
	University Degree (Bachelors or Undergraduate)	40	65
Gender [f,g]	Male	42	69
	Female	19	31
	Other	0	0

[a]—N = 61; percentages may not add to 100% due to rounding. [b]—Based on [56] classifications; see Figure 1. [c]—Index of Relative Socio-Economic Disadvantage (IRSD), where 1 = very disadvantaged, and 5 = not disadvantaged, based on Socio-Economic Indexes for Areas (SEIFA) (see http://www.abs.gov.au/websitedbs/censushome.nsf/home/seifa) (link provided to participants to consult the ISRD score of their local government: https://www.abs.gov.au/ausstats/abs@.nsf/Lookup/by%20Subject/2033.0.55.001%7E2016%7EMain%20Features%7EIRSD%20Interactive%20Map%7E15). [d]—Multiple choice, unrestricted answer. [e]—Options "Horticulture/Arboriculture" and "Urban Forestry" were original separate, then aggregated; "Other" includes options Ecology (forest or wildlife ecology, etc.), Urban planning, Architecture (including Landscape Architecture), Community Planning, Open Space/Recreation Planning, Other (open answer). [f]—Single choice, restricted answer. [g]—Also included "prefer not to answer" option, but there were no responses for that option.

4.6. Analysis of Q-Statements

The analysis of Q-method is based on principal component analysis (PCA), a type of exploratory factor analysis that groups the statements into factors, or components, based on how much variance is explained by each assigned component [73]. The goal of the analysis, also termed Q-analysis (Figure 2), is to both arrive at a statistically validated result, and a result that can be easily interpreted through the theoretical framework of the research [62].

There is always a trade off in Q-analysis between variance and interpretability: sometimes, a smaller set of components may explain less variance, but allow for more interpretability, or vice versa [62,64]. Therefore, Q analysis is usually done iteratively until a final solution satisfies both the variance explained and the interpretability. Data analysis was performed using the "qmethod"

package in R (v. 3.6.2; R Development Core Team, December 2019) developed by [68]. Sampling adequacy was determined by inspecting the correlation matrix of each variable [74]. Components were retained based on their eigen value, the Kaiser-Meyer-Olkin (KMO) measure, and Bartlett's test of sphericity [75] (details in Appendix B). The PCAs were undertaken iteratively (between 1–7 components were analyzed) to a final solution that conformed with the statistical and interpretability criteria, chiefly, components that explained, all together, ≥50% of the variance, and allowed for a simple interpretation based on our theoretical framework [64,74]. A Varimax orthogonal rotation was employed to improve interpretability. Normalized component scores and their respective z scores significant at the 95% level ($p < 0.05$) are reported. Bootstrapping was not performed.

We associated both components and statements with respondent characteristics (Table 3) using standard multiple regressions for each component as well as for each individual statement. The component scores were calculated by averaging the statements that significantly contributed to each of the four components (i.e., z-score > 1.0; Table 2). All statements were ranked in a continuous scale of 1–9; inverted logic statements were inverted so all statements had the same scale. We accounted for negative contributions to the components by inverting statement scores. We tested for two models: (1) association between the averaged score of a component or level of agreement of a statement with the type of local government (i.e., inner, middle, outer, regional; Table (3); and (2) association between the averaged score of a component or the level of agreement of a statement with the index of socio-economic disadvantage (i.e., levels 1 to 5; Table 3). We controlled for the effects of individual demographic variables (Table 3; see details in Appendix B). We have reported all results for the component associations, but only statistically significant results for the statement associations.

5. Results

The online questionnaire collected data from 61 respondents, which represented a total response rate of 55.5% from a total of 110 contacts. Only 54 respondents ranked and sorted the statements. The remaining seven respondents identified that they did not work with local government. The average number of years the respondents had been working in the field of urban forestry or urban greening was 13.6 ± 0.8 years, and the average years working with local government was 8.5 ± 0.9 years. Almost half of respondents belonged to inner city councils, and more than half identified with the horticulture, arboriculture, or urban forestry professions. Most respondents were born in Australia, spoke English as a first language, and had a university degree (Table 2). Given that data were collected in 2019, and if we assume that respondents had the median age of the decade they were born in minus one (i.e., born in the 1970s is equivalent to 44 years old as of 2019), then the average age of respondents was 44.7 ± 1.3 years. The average number of people in the local governments where the respondents worked was 152,820 ± 4440 people.

5.1. Components

The PCA of the statement rankings and sortings yielded a four-component solution that explained 57.9% of the total variance, with all four components individually explaining more than 10% of the variance. The correlation matrix showed that all variables had at least one correlation coefficient greater than 0.3. The relatively large number of components in this study suggests that there was some inconsistency in the way respondents ranked items (see Supplementary Materials, Figure S1). Nonetheless, this final solution was both the most easily interpretable and the most statistically valid. Overall, the results show that ideas related to a coordinated local government response to development, risk overestimation by local governments, the vulnerability of urban forests to climate change, and resourcing issues related to budgeting, were the most important to managers, and, consequently, they were the most important in defining the calculated components (Table 2).

The most important result is that there are two competing perspectives on the role of local government resources. For some managers, local governments can be well resourced, but they may still fail to address the challenges related to development and private tree stewardship. For others,

their governments face fundamental challenges resulting from a lack of resources. These insights are revealed in the characteristics of the first two components.

The first component, which we named "public leadership", included (negatively) the statements (ID in brackets; see Table 2) that the local government has a coordinated response to development (16), has a strategy to increase the private stewardship of trees (10), and (positively) that their local governments have political leadership (8), have increased their budgets for tree maintenance (2), and have capacity to collect and use data (6) (Table 2). Problems with development differentiates this perspective, as well as the notion that the structuring and resourcing of the local government, in terms of leadership, data, and budgets may be adequate.

The second component, which we named "under-resourced", included (negatively) the statements (ID in brackets; see Table 2) that the local government they are employed with has an adequate budget to manage urban forests (12), enough and adequately qualified people (15), has political leadership (8), and has a coordinated response to development (16), and (positively) that their local governments have trees that are vulnerable to climate change (7), and that they struggle to find space for trees in new developments (4) (Table 2). Problems with resources, including budget, personnel, and leadership, and the ability to address threats, differentiate this perspective.

The next two components revealed the important role of risk aversion in manager opinions but were not as important—in terms of their statistical (i.e., variance explained) and theoretical (i.e., easily interpretable in terms of the main challenges) significance—as the first two components for explaining the range of views of municipal urban forest managers about these topics (see Table 2). The third component, which we named "risk averse and lacking public engagement", included (negatively) the statements (ID in brackets; see Table 2) that the local government they work with consults and engages the community (9), and (positively) that their local governments overestimate risk associated with trees (11), lack capacity to collect and use data (6), and have increased their budgets for tree maintenance (2) (Table 2). Problems with risk perception and engaging the community, and the ability to collect and use data, differentiate this perspective. Finally, the fourth component, which we named "pragmatic goals", included (negatively) the statements that the local government they work for overestimates risk (11), has trees that are vulnerable to climate change (7), and has a coordinated response to state policies (5), and (positively) that their local governments focus on providing environmental services rather than biodiversity services (3) (Table 2). What differentiates this perspective is the pragmatic approach to management, including not overestimating risks and addressing environmental issues in contrast to biodiversity issues.

5.2. Associations

Our regression analysis did not reveal any significant association with individual components for either of the models we tested (see Supplementary Materials Table S2; see also Appendix B). Our analyses on the individual statements did reveal some associations (Table 4). They revealed that, for example, respondents from inner local governments were more likely to disagree with the statements that the local government they are employed with lacks capacity to collect and use data. Also, respondents from outer local governments were more likely to disagree with the statements that the local government they work with has a strategy to use the urban forest to provide habitat for wildlife. Incomplete data meant that we could not explore associations related to respondents from regional local governments. The level of socio-economic disadvantage of the local government area (Table 3) did not predict the level of agreement of any statements and was therefore not included in the results.

Table 4. Statistically significant regression results associating level of agreement with individual statements with local government type, indicating estimated coefficients and standard errors (in parentheses) (see Table 2).

Variables (Determinant)	Statements (Outcome)				
Model on the Association Between Level of Agreement with Statement (Outcome) and Local Government Type (Determinant) [a]					
Individual statements (outcome)	1	6	8	13	14
Local government type: inner	−2.65 (0.99) *	−3.28 (0.93) **	−2.23 (1.08) *	0.85 (0.78)	−0.55 (0.84)
Local government type: middle	−1.98 (1.21)	−1.46 (1.14)	−1.53 (1.32)	0.41 (0.96)	0.20 (1.02)
Local government type: outer	−1.33 (1.08)	−1.86 (1.02)	−0.48 (1.18)	2.08 (0.86) *	−1.87 (0.92) *
Local government type: regional	NA	NA	NA	NA	NA

[a] All models accounted for demographic variables (see Appendix B) * <0.05, ** <0.01, *** <0.001.

6. Discussion and Conclusions

6.1. Main Findings

We have generated a more structured and quantitative understanding of the management and governance challenges affecting municipal urban forest managers decision-making, issues that were previously and complementarily explored in [66]. We have revealed that to resolve disagreements about urban forest management and governance challenges in rapidly urbanizing cities, stakeholders must recognize that perceptions about the role of local government resources, political leadership, interdepartmental coordination, community engagement, risk aversion, among other important management and governance challenges (see Table 1) are not monolithic. Future studies interested in evaluating the opinions of stakeholders involved in making decisions about urban trees, should recognize that there are separate and distinct perspectives and experiences about these challenges. We must also recognize that the perspectives on urban forest management and governance challenges may be segmented between types of local governments, such as between inner and outer cities in metropolitan areas. Generating urban forest management strategies and policies that strive to coordinate efforts across various local governments, particularly across metropolitan urban areas, should build on existing consensus on development and environmental threats, and address critical governance challenges involving leadership, inter-departmental and inter-municipal coordination, community engagement, and a culture of risk aversion.

An important motivation for our research was that most of the literature on urban greening has not discriminated decisions related to spatially discrete urban green spaces that may or may not have trees, from decisions related to trees (e.g., [11–17]). Considering that urban trees are not confined to discrete green spaces, urban forest decisions are different from those related to, for example, public urban parks. Moreover, most of the insights gained about the governance of urban greening or urban nature-based solutions have been in the context of adding or redesigning discrete, public, and open green spaces, such as parks or gardens (e.g., [12,14]). However, many of the decisions of municipal urban forest managers are related to protecting, retaining, and removing trees in spaces that may not be public, open, or green [7,18,29,40,66]. Considering these gaps, this study has allowed us to empirically elaborate on how managers evaluate the management and governance challenges affecting their decision-making.

6.2. Local Government Resourcing and Strategic Programming

We have found in this study that urban forest managers do not always agree about the role of local government resourcing for solving the management and governance challenges affecting their decision-making. This is echoed by [10] in their recent review on the empirical research on urban forest managers views. Most of the studies the authors reviewed had focused on how the operational and strategic management capacities of local governments, chiefly budgets, personnel, and strategic programming, such as the existence of management plans [9,76], were widely considered

as indicators of urban forest management success [10]. These indicators were then used to evaluate urban forest management success (e.g., [39,77]). Indeed, the literature on municipal managers' views has consistently stressed that lack of resources and strategic programming are the most important challenges facing municipal urban forest manager decision-making (e.g., [9,18,35,39]).

However, our study shows that, at least for some municipal urban forest managers, bigger budgets, more personnel, or the mere existence of a management plan may not necessarily solve the challenges of growing and protecting trees in cities, particularly in the context of urban development and climate change. In fact, our research has shown that there are two competing perspectives on the role of local government resources, which were identified in our results as the "public leadership" and "under-resourced" views of managers. These meant that, for some managers, improving critical governance challenges, such as inter-departmental and inter-municipal coordination, community engagement, and addressing a culture of risk aversion in local governments, are important issues. Yet, for other managers, the lack of resources still represents an important challenge. A more nuanced and less monolithic appreciation of the role of resourcing is needed. We have referred to this as a non-resource perspective.

6.3. A Non-Resource Perspective for Local Governments

A complementary finding of this study is that non-resource issues are also important for solving the management and governance challenges affecting the decision-making of urban forest managers. A non-resource perspective refers to the important role of environmental management and governance processes that facilitate better decision-making and that go beyond simply allocating more financial resources [7,8,11,12,15,16]. This perspective is more focused on strengthening institutions and their coordination, rather than increasing resources or management techniques [78], as has been shown in studies on stakeholder perspectives on natural resource management (e.g., [48,79]), including urban forests (e.g., [66,80]. This echoes what [10] found on their recent review of empirical research on urban forest managers views, where they observed that while many of these studies identified broader management and governance processes as important in urban forest manager decision-making, including, for example, the coordination of stakeholders and interdepartmental coordination, these processes were not widely considered as indicators of urban forest management success. These processes have been previously identified in the empirical literature of manager views (e.g., [19,20,36,41,81]), but in most of these studied they are referred as simply a challenge or obstacle for management (e.g., [18,19,29,36,41,81] without substantiating what they means for manager decision-making, how they could be improved [10], or how they are evaluated for how important they are to municipal manager decision-making among other issues.

Our study sheds some light on the specifics of the non-resource perspective in urban forest decision-making, complementing previous research on the opinion of municipal urban forest managers on governance issues (e.g., [7,10,66]). Basing ourselves on the findings of this study, we define these specifics as a combination of having political leadership, engaging the public, having the capacity to collect and use data, improving the stewardship of privately-owned trees, having one team that coordinates urban tree decisions, and addressing the overestimation of risk associated with urban trees. We believe these are some of the most important aspects behind this non-resource perspective in urban forest decision-making as based on empirical data elicited directly from urban forest managers.

6.4. The Important Role of Development, Community Engagement, Climate Change, and Biodiversity

Adopting a non-resource perspective is even more important considering some of the main conflicts and challenges affecting urban forest manager decision-making, including development, community engagement, climate change, and biodiversity issues.

Our study has corroborated the ideas in the literature that intensified urban development is an obstacle for local governments to implement strategies aimed at greening cities [11,12,15,16], and that improving community stewardship of trees is necessary to address these challenges [11,12,25,42].

We observe that development and community engagement challenges influence the strategic decisions of managers but, in some ways, go beyond the reach or responsibilities of these managers. This is why statements such as "having a coordinated response to development", "responding to state policies on urban development", and "making citizens more responsible for privately-owned trees" were so widely disagreed with by managers in our study (see Results). However, it is also important to note that these conflicts do not exist in isolation from other issues. This is illustrated by the fact that statements such as "increasing the budget spent on maintaining trees" were almost always grouped alongside the above statements, such as in the case of the "under-resourced", "risk averse and lacking public engagement", and "pragmatic goals" components we extracted in this study (see Results). These issues have been previously identified as important in the literature (e.g., [29,39,40]) but had never been explicitly related to existing conflicts. Our research then advances a more interrelated understanding of the conflicts affecting forest manager decision-making and the management and governance processes that are needed to address these conflicts, such as increasing tree maintenance capacity.

The challenge of community engagement in urban forest management and governance has been widely discussed in the academic literature but is seldomly addressed from the perspective of municipal urban forest managers using empirical data [10]. Considering the important role of community engagement in this study, this topic deserves some more attention. It is undeniable that community engagement is important to manager decision-making. This is because urban forest decisions are not solely made my managers but also made by other stakeholders, including non-governmental greening groups [33,34] and private landowners [31,32]. However, and as mentioned before, most of the research on the views of municipal managers has focused on the most basic level of community relations, such as public awareness, education, consultations, or volunteering (e.g., [36,41,82]). More proactive approaches to community engagement include, for example, co-management partnerships, but such examples are only now becoming more frequently mentioned in the literature (e.g., [7,11,25,42,80]. In our study, we integrated the important role of community engagement by introducing statements related to the topic (Tables 1 and 2). We found that municipal managers were mostly concerned in influencing the decisions about privately owned trees as a way for them to successfully engage the community into a collective stewardship of urban forests. This corroborates what we also found in our qualitative work (see [66]). This contrasts with some previous finding in the literature that address co-management partnerships but usually in the context of publicly owned trees (e.g., [7,11,25,42,80]. In this way, our research contributes to the important role of private-tree stewardship for manager decision-making.

Finally, our study has corroborated the importance of climate change and biodiversity issues in the decision-making of municipal urban forest managers. These issues have been identified as important in some of the literature on urban forest manager views (e.g., [43–45], but have not been evaluated in terms of their importance in contrast to other issues. These issues were salient in almost every component in our Q-analysis (see Results) and were also profiled prominently in our qualitative work [66].

6.5. The Multiple Objectives of Urban Forest Management

It is common for urban greening authors to advocate for the view that those in charge of making decisions about urban nature should consider multiple objectives [8,13,14,17,22–24]. While these theoretical contributions are insightful, the underlying message of this literature is how municipal managers should think rather than how they actually think. In this study, we have given structure on how these multiple objectives are evaluated by municipal managers. This builds on previous work on the multiple objectives of urban forest management plans (e.g., [76]). Specifically, we have shown that development, climate change, community engagement, and biodiversity issues are all actively considered by managers in their decision-making, despite these issues not being addressed in many management plans (e.g., [76]). Future studies interested in expanding the range of objectives that should be included in urban forest management should review the empirical literature on what managers

think to corroborate or complement intended theoretical advances. This will allow these studies to recognize that managers actually deal with a wide range of considerations in their decision-making.

6.6. Strengths and Limitations

This study is not without its limitations. For instance, the forced ranking approach we used may have generated artificially polarized views about certain issues. Nonetheless, by engaging participants directly in the process of reducing the number of statements through workshops and survey pilots (see Appendix A), we may have generated a more relevant set of statements than those that might otherwise have been selected. In addition, we retained a similar number of components as the average number of components retained in other similar studies (i.e., 3 to 4 components; e.g., [45,48,49]) and we achieved an explained variance similar to that of other studies (i.e., 60%; [64]). A bigger representation from different types of local governments, especially disadvantaged areas, would be needed to explore a fuller range of opinions about how urban forest issues are evaluated.

Supplementary Materials: The following are available online at http://www.mdpi.com/1999-4907/11/9/963/s1, Figure S1: Individual ranking of the 16 statements in this study by type of challenge, based on empirical data collected from municipal urban forest managers working within Victorian local governments, Australia (for statement ID, refer to Table 2 or Appendix A). Table S1: Online survey questions and measures, Table S2: Regression results associating averaged component scores with local government type and index of socio-economic disadvantage, indicating estimated coefficients and standard errors (in parentheses).

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Conflicts of Interest: The authors declare no conflict of interest.

Ethics Statement: Ethics approval for research with human subjects was obtained from The University of Melbourne (Ethics ID Number: 1750430.1). Informed consent was obtained from all participants by sharing a consent forms and plain language statement of the research before interviews took place, and also by including these documents on the first page of the online survey. No personal information, such as IP address, name, or affiliation, is explicitly disclosed in this research to ensure confidentiality and anonymity of the research participants.

Appendix A

Details of Q-Statement Creation

To create the Q-statements, we combined our literature review (Table 1, main text), and our empirical qualitative data on manager views [66]. We created the statements iteratively and workshopped them and piloted them before the final assessment. We were guided by the following principles in our statement creation:

(1) Grounding our statements on local concerns, but stating these concerns in broad terms, so the idea could be relevant to a broader international audience. Any Q-method study faces a predicament regarding the validity of the statements, specifically regarding how the statements are connected to international and local realities. To achieve this balance, and guided by our multiple case study approach, we ensured that the statements we created captured ideas that were applicable across various Victorian local governments, and that could potentially be applicable to a wider set of international cities. While this can be misconstrued as vague, constructing statements in this way also avoids being prescriptive and priming the respondents in charge of ranking them with a predetermined answer.

(2) Grounding our statements on the actions of the institution rather than the individual and subjective actions of the managers themselves. Statements had to be grounded from the perspective of the local government managers worked with (i.e., "the local government I work with … "). In this way, the ranking of these statements could reflect the subjective experiences of managers working with their local governments. This responded to a key principle in the Q-method approach, the main goal of which is to evaluate subjectivity.

(3) Balancing the number of statements per type of management and governance challenge, including operational issues, internal management, conflicts, community issues, and environmental & biodiversity issues. We did not aim for an equal balance of numbers in statistical terms, but rather to be as representative as possible in the number of ideas per type of challenge, so we could expose participants in charge of ranking to a wide range of ideas.

(4) Avoiding cognitive bias in the ranking of statements by combining both positive and negative statements. We did this by stating some ideas with inverse logic.

(5) Avoiding cognitive bias in the ranking of statements by creating statements that could polarize opinions. This avoids statements that are too vague or too positive to disagree with.

Taking Table 1 as our starting point, and combining insights from the qualitative interview data, we first generated as many statements as possible, resulting in the following initial set of statements.

Table A1. Initial set of statements.

Type of Challenge	Statement, Answering to the Question "the Local Government Area I Work with … "
Operational and strategic issues	… has a lack of capacity to collect or make use of existing data related to the distribution and condition of urban trees
	… has an adequate budget to manage all aspects of urban forests and trees
	… has enough and adequately qualified people to manage all aspects of urban forests and trees
Internal management	… coordinates decisions about public urban trees through one team, and people from other departments consult this team for every decision they make about urban trees
	… coordinates the policies of the State of Victoria that relate to urban forests and trees, such as increasing medium-density housing and fire risk reduction
	… raises the profile of urban forests and trees through its political leaders
	… coordinates the priorities of developers that relate to urban forests and trees, such as having enough space for growing big trees
	… considers areas for active use (i.e., sport facilities) more important than areas for passive use (i.e., neighbourhood parks)
	… has a strategy to make use of the available public space to grow trees and to retain existing trees
Conflicts	… has increased the costs for maintaining trees, and maintenance has taken a larger portion of the budget over the last 5 years
	… struggles to find space for trees in new housing developments, mostly because there is no space for them
	… overestimates risks related to urban trees, generating unnecessary tree removals in public areas
	… should use their amenity tree calculations to make it expensive for development to remove a tree
	… is losing a lot of large canopy trees across private and public areas
	… has a lot of old, ageing urban trees
Community issues	… consults and engages the community in decisions related to urban forests and trees
	… has a clear strategy to improve the stewardship of privately-owned trees by the community
	… considers urban forests and trees important for the community
	… promotes urban forests and trees to the community by educating about their benefits
Climate change and biodiversity	… prioritizes increasing and managing existing canopy cover to provide shade and cooling
	… has urban trees that are vulnerable to changing harsh weather conditions, such as hotter, dryer weather
	… prioritizes urban forest decisions to provide habitat for wildlife
	… should manage the urban forest rather than individual trees
	… holds perceptions about eucalyptus trees, such as sudden limb fall, that make it difficult to plant native trees
	… should plant tree species better suited to hotter, dryer weather to avert the impacts of climate change on the urban forest and trees

While these statements were solidly based on our literature review (Table 1, main text) and qualitative interview data (see [66]), we wanted to make sure that the statements really reflected the most important management and governance challenges facing municipal urban forest managers across Victorian regional towns and cities. More practically, we also wanted to ensure that respondents could easily rank these statements. So, we workshopped the statements with a reference group of municipal urban forest managers and piloted their ranking with an initial set of respondents as described below.

We workshopped these statements with a group of five municipal urban forest managers from three different local governments, including one regional city and two inner-city local governments, in August 2018. The researchers benefited from having access to a reference group of municipal manager partners that were part of a larger research study focused on investigating the effects of urban forest management on people and wildlife (see Funding Information). All of the municipal managers in this reference group and in the pool of pilot respondents (see below) were interviewed in the qualitative stage of this research. The workshop took 1 h to complete, and the participants were asked to review statements based on the principles stated above: (1) relevance to Victorian local governments as well as broad regional or international relevance; (2) reflection of the actions of local governments rather than individual actors; (3) balance in the number of statements per type of challenge; (4) cognitive biases emanating from too many positive or too many negative statements; and (5) cognitive biases emanating from statements that were difficult to disagree with.

We also piloted the ranking of statements online with a larger group of municipal managers who participated in the interview stage of this research (i.e., 23 participants; see [66] for details). We conducted this pilot ranking after the workshop above in December 2018, opening the survey for 2 weeks, and obtaining 9 responses. Pilot respondents received the same instructions as the final online survey (see Methods section). We asked these respondents to provide comments about the ease of the ranking of statements. We did not conduct any statistical analyses of these data. We focused on the comments of the respondents to understand the easiness of ranking and created simple frequency graphs with the ranked data to reveal ranking overlaps.

Based on the workshops and the survey pilot, we concluded that anything above 20 statements was too demanding for participants to rank. These processes also allowed us to discard statements that were either not relevant to local governments, not focused on the actions of local governments, too representative of one type of challenge, or that generated biases in the positive or negative ways they were stated, or that were too difficult to disagree with. These resulted in the final list of 16 statements used for this study (also in Table 2, main text):

Table A2. The final list of 16 statements used for this study.

Type of Challenge	Statement, Answering to the Question "the Local Government Area I Work with … "
Operational and strategic issues	… lacks capacity to collect or make use of existing data on the urban forest
	… has an adequate budget to manage the urban forest
	… has enough and adequately qualified people to manage the urban forest
Internal management	… has one team that coordinate decisions across departments affecting public trees
	… has a coordinated response to state policies that relate to the urban forest, such as increasing medium-density housing and fire risk reduction
	… has political leaders that raise the profile of the urban forest and trees in the community
	… has a coordinated response that balances the priorities of developers with the needs of the urban forest, such as having space for growing large trees
Conflicts	… has increased the proportional of the budget spent on maintaining trees over the last 5 years
	… struggles to include space for trees in new housing developments [a]
	… overestimates risks from urban trees, generating unnecessary tree removals in public areas [a]
Community issues	… adequately consults and engages the community in decisions related to the urban forest
	… has an effective strategy to improve the stewardship of privately-owned trees
	… has an urban forest that is important to the community

Table A2. *Cont.*

Type of Challenge	Statement, Answering to the Question "the Local Government Area I Work with … "
Climate change and biodiversity	… prioritizes increasing and managing canopy cover to provide shade and cooling in comparison with habitat and biodiversity issues [a]
	… has trees that are vulnerable to a changing climate, such as hotter, dryer weather [a]
	… has a strategy to use the urban forest to provide habitat for wildlife

[a] Statements with an inverse logic (agreement means a negative rating).

Appendix B

Appendix B.1. Generating Components from Q-Sorts

Principal component analysis (PCA) is the main procedure to analyses the q-sorts of the q-statements. PCA groups the statements into factors, or components, based on the q-sorts provided by the respondents. This allows researchers to understand the range of positions regarding a topic, in this case, how management and governance challenges are evaluated by municipal urban forest managers in their decision-making. The results reflect how much variance is explained by each assigned component [73]. This reduces statement redundancy and collinearity between explanatory components. A Varimax orthogonal rotation then rotates the original components to a more precise solution. The goal of this analysis is both t arrives at a statistically validated result, but also a result that can be easily interpreted through the theoretical framework of the research [62].

We performed PCAs of the data iteratively, as explained in the main Methods section (subsection Analysis of Statements, see main text). Everything between one and seven components was analyzed. Sampling adequacy was determined by inspecting the correlation matrix of each variable, where adequacy was determined by each variable having at least one correlation coefficient higher than 0.3 [74]. Components were retained based on their eigen value (>1.0) and variance explained (between 5% and 10%; [75]). We also used the Kaiser-Meyer-Olkin (KMO) measure, with values between 0.6 and 0.9 accepted [75], as well as Bartlett's test of sphericity significant at the 95% level ($p < 0.05$).

Appendix B.2. Modelling the Relationship of Components and Q-Statements

We associated the characteristics of the respondents with the way they ranked the q-statements. To achieve this, we modelled the relationships between the respondent characteristics and each of the individual statements as well as each of the components in which the statements were grouped according to the results of the PCA (see above). This means we tested for both: a) groups of statements (i.e., the components obtained through the PCA analysis, 1-4; see Table 2, main text); and b) for each individual statement (1–16; see Table 2, main text; see also Appendix A). To do this, we conducted two main models:

(1) How well the averaged score of a component or level of agreement of a statement could be predicted by the type of local government (i.e., inner, middle, outer, regional; Table 3, main text) where the respondent came from; and
(2) How well the averaged score of a component or the level of agreement of a statement could be predicted by the index of socio-economic disadvantage (i.e., levels 1 to 5; Table 3, main text) that classified the local government where the respondent came from.

We controlled for the effects of individual demographic variables in all these models. The relevant demographic variables included in each of the regression analyses ran included (see Table 3, main text):

- years in field
- years in government
- field (horticulture, arboriculture, and urban forestry)
- decade born
- born in Australia

- English-as-second-language (ESL)
- education (university degree)
- gender (female)

All multinominal and categorical variables were converted into single binomial scales 1/0 for analysis to avoid under or overestimation of the regression models [74]. For example, local government type (i.e., inner, middle, outer, regional; Table 3, main text) became 4 separate variables, each with 1/0 scale. Another example is education level (i.e., university degree or no university degree; Table 3, main text) became a 1/0 scale with university degree as 1 and no university degree as 0.

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