

PROTECTING THE EXCEPTIONAL: CHALLENGES AND OPPORTUNITIES TO
ENHANCE HAWAI'I'S EXCEPTIONAL TREE PROGRAM WITH IMPLICATIONS FOR
GLOBAL STANDARDS

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DEDICATION

For my grandparents Ralph G. Spurrell and Margaret Rose Spurrell. Your guidance, support, wisdom, and kindness are the reasons why this dissertation was possible and I can truly never thank you enough.

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ABSTRACT

“Exceptional trees” have long been recognized for the unique characteristics that set them apart from other trees. While the terms used to identify exceptional trees can vary based on geographic location (e.g., “significant,” “heritage,” “champion,” “monumental,” etc.), these trees embody similar traits that represent important attributes valued by humans. However, anthropogenic activities often conflict with exceptional trees, threatening their existence and the benefits they provide to society and the local environment. Exceptional trees are recognized in various locations worldwide through urban forestry conservation programs, which are designed to identify and sometimes offer legal protections to these valued specimens. For example, Hawai‘i’s “Exceptional Tree Program” began in 1975 with the enactment of Act 105 by the Hawai‘i State Legislature, conferring legal protections to exceptional trees. However, in the intervening five decades, the program has become stagnant and remains relatively unknown by the public and practitioners due to ineffective programmatic components, which have also seen few improvements since the program’s inception.

This three-paper dissertation examines the current state of Hawai‘i’s Exceptional Tree Program to identify its known weaknesses and provide suggested improvements to enhance this urban forestry conservation program. The first paper explores current challenges associated with Hawai‘i’s Exceptional Tree Program based on the lived experiences of exceptional tree practitioners through the use of the Reflexive Thematic Analysis methodology. The second paper is based upon an analysis of exceptional tree case studies in Hawai‘i and South Australia in order to provide suggested improvements to the widely-used Delphi methodology, while also providing methodological context for the third paper. The third paper uses the Delphi method to achieve expert consensus on the ideal program components that should be include in Hawai‘i’s Exceptional Tree Program. Together, these three papers provide a template on how an exceptional tree program in Hawai‘i and elsewhere can be improved, in addition to urban forestry conservation programs more broadly. The collective findings of these papers also help to better understand the knowledge exchange preferences of urban forestry practitioners and experts. Finally, the study’s recommended Delphi methodological improvements could be used

to aid future research utilizing this method, particularly studies focusing on exceptional tree and urban forestry topics.

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CHAPTER 1: INTRODUCTION

Trees representing unusual and historical significance have long been recognized for the unique traits they possess (Lekan, 2004). These trees are often identified by many names (Jim, 2017), such as “exceptional,” “heritage,” “significant,” “champion,” “monumental,” “notable,” etc. (Ritchie, 2019). As the primary case study location for this dissertation research focuses on Hawai‘i, USA, the term “exceptional tree” will be used to refer to these trees throughout the dissertation, including when referring to literature and programs that may use different titles. Furthermore, this research will also use the term “Exceptional Tree Program” to collectively refer to the four exceptional tree programs for each of Hawai‘i’s counties which are mandated by the same state law.

Exceptional trees are essential components of an urban forest (Jim, 2018), have irreplaceable value (Lau et al., 2017), provide a sense of importance that “*traverse geographical, temporal and cultural divides*” (Jim, 2017, p. 289), and act as environmental, social, and historical symbols (Ali et al., 2016). Exceptional trees have been identified by at least 40 unique criteria which set them apart from other trees (see Ritchie, 2019). These criteria can comprise traits such as botanical and ecological values (Britton et al., 2015; Lau et al., 2017), aesthetics, size, historical importance, and cultural values (Clark et al., 2020). Exceptional trees can be found in countries around the world (Ritchie, 2019), ranging from local (Village of Glenview, 2013) to national scales (National Parks Board Singapore, 2017). The programs that manage exceptional trees vary in their intended goals, with some having an educational focus (Nebraska Forest Service, 2018), while others also include protection mechanisms (City of Portland, 2016; Hawai‘i State Legislature, 1975). These legal protections can vary in terms of the level at which they are administered, with some exceptional tree programs implementing protections at a municipal (City of Melbourne, 2012), state/provincial (Forests Ontario, 2017; Hawai‘i State Legislature, 1975), or national scale (Jim, 2004). However, even when exceptional tree programs have legal protections in place to conserve these trees of importance, high mortality rates have been seen (Jim, 2005; Chen, 2015), particularly from anthropogenic sources such as roadwork and

construction (Jim, 2004; Jim, 2005; Chen, 2015). Two examples depicting these losses were seen in Hong Kong and Guangzhou, China, when 14% and 21.5% of their exceptional trees were lost over the span of a decade respectively (see Jim 2004; Jim, 2005). The loss of iconic trees has prompted some locations to initially begin (City and County of Honolulu, 2021), or restart (McNamara & Carter, 2006), an exceptional tree program to conserve these unique specimens (Britton et al., 2015) which can act as keystone structures in an urban forest (Stagoll et al., 2012).

The field of urban forestry utilizes knowledge from different disciplines, such as natural resource management, planning, social sciences, and economics (Konijnendijk & Gauthier, 2006). The practitioners and experts who represent these fields to address tree-related issues can be thought of as “urban forest managers” (Jim, 2018). These “managers” are responsible for protecting trees in urban and peri-urban areas (Jim, 2018), while also engaging in stakeholder management (Moskell et al., 2011). There have been recent calls for new research to focus on exceptional tree issues at local scales, while at the same time, developing more effective knowledge transfer methods to see this information utilized in practice (see Jim 2018, p. 73). To date, there are no known studies that have examined exceptional tree knowledge exchange practices in Hawai‘i.

Based on the aforementioned needs identified from the literature, it is clear that improvements need to be made to exceptional tree programs (see Jim, 2018; Ritchie, 2019; Ritchie et al., 2021), with Hawai‘i being an ideal case study based on its relative longevity, virtually no changes since its inception in 1975, and a lack of standardized program components throughout the state. This dissertation research seeks to address the above issues by examining the current weaknesses and desired improvements of Hawai‘i’s Exceptional Tree Program derived from the lived experiences of the practitioners who frequently interact with this program. Additionally, the preferences and opinions of exceptional tree experts throughout Hawai‘i were obtained in order to identify ideal program components that should be included in Hawai‘i’s Exceptional Tree Program to improve its overall effectiveness. These components include nomination

selection criteria, protection mechanisms, public education and outreach, fundraising, climate change mitigation, etc. Together, these provide a framework that should be considered by the Arborist Advisory Committees, as well as other audiences such as government agencies, nonprofits, industry professionals, etc., who contribute to the management of exceptional trees throughout the state. For the purposes of this research a practitioner was defined as “*an individual who spends a significant amount of time interacting with Hawai‘i’s exceptional tree program, either directly by working with these trees, or indirectly through implementing program components,*” while an expert was deemed to be “*an individual who has extensive knowledge about an exceptional tree program and its collective components. Examples of these experts may include exceptional tree committee members (Arborist Advisory Committee), academics, urban forestry department managers, directors of nonprofits and professional associations, etc.*”

This dissertation primarily focuses on the results from a case study conducted in Hawai‘i from May 2022 until May 2023 utilizing the Reflexive Thematic Analysis and Delphi methodologies. In addition, the study was also replicated in South Australia during the same timeframe. However, while the majority of the South Australia case study content is beyond the scope of this three-paper dissertation, the second paper (chapter 3) presents a brief overview of the Delphi results from this location in order to provide recommended Delphi methodological improvements using Hawai‘i and South Australia as comparative case studies.

Hawai‘i’s Exceptional Tree Program

Hawai‘i’s Exceptional Tree Program began in 1975 when there was a noticeable loss of iconic trees due to development, prompting the Hawai‘i State Legislature to enact a law to protect these trees (City and County of Honolulu, 2021). This legislation states that each of Hawai‘i’s four counties are mandated to have a standing Arborist Advisory Committee selected by the local Mayor and comprised of experts tasked with a) reviewing exceptional tree nominations, b) providing arboricultural advice to owners who have one or more of these trees on their property, c) recommending appropriate exceptional tree protective measures to their

City/County Council, and d) reviewing actions that endanger an exceptional tree (Hawai'i State Legislature, 1975). The initial seven criteria enacted in 1975 remain the same to this day and allow a tree to be deemed exceptional if it represents one or more of the following criteria: historical/cultural value, age, rarity, location, size, aesthetic quality, or endemic status (Hawai'i State Legislature, 1975).

Program components can vary between counties, particularly legal protections. For example, the City and County of Honolulu only permits the removal of an exceptional tree if approval is first obtained from the City Council, or in emergency situations where there is a threat to life and/or property (American Legal Publishing, 2023). In Maui County, a property owner can ask the Arborist Advisory Committee and Director of Parks and Recreation to de-list an exceptional tree, although this seldomly occurs and instead, these trees are generally only removed if they are *“dead, diseased, irretrievably damaged, or is a hazard to the public”* (Maui County Arborist Advisory Committee, 2016, p. 88). Kaua'i County states that the County Council must approve the removal of an exceptional tree (Kaua'i County, n.d.), whereas in Hawai'i County, *“it shall be unlawful for any person, corporation, public agency or other entity to substantially damage, remove or destroy an exceptional tree in the County”* (Hawai'i County, 2017, p. 14-27).

South Australia's Exceptional Tree Program

The State of South Australia has three types of exceptional tree programs, referred to locally as “significant trees.” The first is managed by the state government and allows trees with a circumference of three meters or greater to receive the exceptional designation as long as they are located in the Council regions of Adelaide, Adelaide Hills, and Mount Barker (exemptions may apply in certain instances) (Government of South Australia, 2021b). These trees cannot be removed unless a permit is approved, the tree dies (Legal Services Commission of South Australia, 2021), or is a threat to public safety (Government of South Australia, 2021a). The second is a variation of the aforementioned state government program which uses the same three-meter circumference metric as the sole selection criterion and permit process for removals (City of Marion, 2019), but each program is managed by an individual Council

(municipal government) rather than the state government, and some of these Councils offer maintenance incentives (see City of Burnside, 2024; City of Marion, n.d.). The third program began in 1981, is managed by the National Trust of Australia (McNamara & Carter, 2006), and uses 21 selection criteria grouped within four categories (scientific, social, historical, and aesthetic) (National Trust of Australia 2021a). However, this National Trust program lacks legal protections for the trees it recognizes, rendering it solely as an educational program (National Trust of Australia, 2021b).

The clear lack of standardization for exceptional trees in South Australia has been further exemplified by Ballantyne et al. (2021) who stated that *“significant tree regulations are not working to protect our large trees or prevent unnecessary removals”* (p. 2). The authors additionally state that *“a coordinated capture of data of significant trees across councils is needed. Included in this should be culturally significant trees, regardless of their size to ensure they are afforded protection”* (p. 19). These issues suggest that a re-examination of South Australia’s exceptional tree programs should be conducted to ensure that the selection criteria and other program components used are based off of expert recommendations.

The dated, weak, and confusing state of exceptional tree programs in Hawai‘i and South Australia collectively highlights a need to better identify how these trees are recognized, as well as the program components that should be used to protect and promote exceptional trees.

Research Questions

Paper 1 - Challenges and Opportunities for Hawai‘i’s Exceptional Tree Program Based on the Lived Experiences of Urban Forestry Practitioners

1) What fundamental deficiencies currently exist within Hawai‘i’s Exceptional Tree Program based on the lived experiences of exceptional tree practitioners?

- 2) What exceptional tree program improvements are *desired* by Hawai'i's exceptional tree practitioners?
- 3) How and in what format is exceptional tree knowledge *currently transferred* to practitioners in Hawai'i?
- 4) How and in what format *should* exceptional tree knowledge be transferred to practitioners in Hawai'i?
- 5) What content is desired by exceptional tree practitioners in Hawai'i to improve this urban forestry conservation program?

Paper 2 - Discussing Known Delphi Method Deficiencies Through an Examination of Exceptional Tree Studies in South Australia and Hawai'i

- 1) What are the strengths and rationale in using the Delphi method?
- 2) How should the known Delphi methodological concerns of consensus value, attrition rates, study duration, and validity be improved?

Paper 3 - Identifying Essential Selection Criteria and Program Components to Improve Hawai'i's Exceptional Tree Program Based on Expert Consensus

- 1) What are the essential components of Hawai'i's Exceptional Tree Program based on the insights, preferences, and consensus of exceptional tree experts?
- 2) How should the knowledge exchange gap between Hawai'i's exceptional tree practitioners and experts be improved?

Contributions to the Fields of Exceptional Trees, Urban Forestry, and Biophilic Urbanism

This dissertation research is the first known empirical study to examine exceptional tree programs in Hawai'i and South Australia, as well as the knowledge exchange preferences of exceptional tree practitioners and experts throughout Hawai'i. The results add to the growing body of literature seeking to identify, recognize, and protect exceptional trees (see Jim, 2004; Jim, 2005; Jim & Zhang, 2013; Britton et al., 2015; Chen, 2015; Jim, 2017; Lau et al., 2017; Ritchie, 2019, Ritchie et al., 2021). Many of the findings may also be applicable to other urban forestry programs, primarily the identification of best practices for program components such as protection mechanisms, public education and outreach, funding sources, climate change mitigation, etc. The study's results could also be used to enhance the field of biophilic urbanism by providing an updated exceptional tree program framework, helping to ensure that this important green infrastructure component is successfully incorporated into the designs of a biophilic city. Furthermore, the knowledge exchange findings may be able to remedy the exceptional tree knowledge transfer gap identified by Jim (2018). If successful, this could help to ensure that new information is obtained from preferred sources, in the most digestible format possible, allowing Hawai'i's exceptional tree education and outreach to be improved. Finally, a set of exceptional tree selection criteria are presented which could be the foundation for a global standardized list of traits that should be used to recognize trees of importance through exceptional tree programs.

All of the aforementioned contributions transcend exceptional trees by having applicability in the fields of urban forestry and arboriculture more broadly. Using the solutions provided, it could be possible to assist other tree-related conservation programs facing many of the same problems addressed throughout this dissertation.

Overview of Dissertation Chapters

This dissertation is divided into five chapters. The first chapter is an introduction to the dissertation and provides a brief overview of exceptional tree programs from around the world. This is followed by a closer examination of exceptional tree programs in the case study locations

of Hawai'i and South Australia, the philosophical underpinnings for the Reflexive Thematic Analysis and Delphi methods used, the study's research questions, and contributions to the fields of urban forestry and arboriculture.

The second, third, and fourth chapters are based on three academic papers. Chapter two presents the content from the first paper examining the weaknesses and desired improvements associated with Hawai'i's Exceptional Tree Program based on the lived experiences of statewide exceptional tree practitioners. The third chapter presents a Delphi methodological paper which identifies current deficiencies with the method and presents potential solutions based on an analysis of Delphi exceptional tree case studies conducted in Hawai'i and South Australia. The fourth chapter showcases the content from the third paper which sought to identify the ideal selection criteria and program components that should be included in Hawai'i's Exceptional Tree Program based on expert consensus. The final chapter is the dissertation's conclusion, which summarizes the main findings from the three academic papers and their collective importance towards improving a) exceptional tree and urban forestry programs, b) knowledge exchange between exceptional tree/urban forestry practitioners and experts, and c) providing solutions to current Delphi methodological weaknesses identified in the literature. This concluding chapter also suggests future research that should be conducted to further the fields of urban forestry, arboriculture, biophilic design, and the Delphi method.

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CHAPTER 2: CHALLENGES AND OPPORTUNITIES FOR HAWAII'S EXCEPTIONAL TREE PROGRAM BASED ON THE LIVED EXPERIENCES OF URBAN FORESTRY PRACTITIONERS

Abstract

Exceptional trees have been recognized and valued for centuries based on the unique traits they represent. Programs exist worldwide to protect these keystone specimens, with many facing challenges that reduce their efficacy as a conservation strategy. This study examines the weaknesses and desired improvements of Hawai'i's exceptional tree program based on the lived experiences of exceptional tree practitioners throughout the state. A reflexive thematic analysis method was used to produce five themes which highlight current issues associated with Hawai'i's exceptional tree program and lays the foundation for future research to examine solutions to these problems to better recognize, manage, and protect these majestic trees of urban and peri-urban forests.

Introduction

Overview of Exceptional Trees

Trees of importance have been recognized due to their unusual and historical significance for centuries (Lekan, 2004). These trees have many terms used to describe them (Jim, 2017) including "exceptional," "heritage," "significant," "champion," "monumental," "notable," etc., with geographic location generally dictating the title used (Ritchie, 2019). As this study focuses on Hawai'i, the term "exceptional tree" will be used throughout this paper to denote these trees of importance, including when referring to literature that may use other epithets.

Exceptional trees have irreplaceable value (Lau et al., 2017), act as environmental, social, and historical symbols of past landscapes (Ali et al., 2016) and have an "*importance attached to them that traverse geographical, temporal and cultural divides*" (Jim, 2017, p. 289). Identifying an exceptional tree requires a blend of art, science, objectivity, and subjectivity and can be influenced by politics and public perception (Jim, 2004). Exceptional trees are essential components of an urban forest (Jim, 2018). Urban forestry is comprised of experts and

practitioners from different disciplines such as natural resources, planning, social sciences, economics, etc. (Konijnendijk, & Gauthier, 2006). These urban forest managers are tasked with conserving these trees in both urban and peri-urban areas (Jim, 2018) and act as facilitators of stakeholder engagement (Moskell et al., 2010). Recently there have been calls for exceptional tree research to focus on issues impacting these trees at local scales, and to improve the means through which new knowledge is transferred into practice (Jim, 2018, p. 73). This research seeks to identify the weaknesses and desired improvements of Hawai'i's exceptional tree program based on the experiences, perspectives and opinions of the practitioners that interact with this conservation program. The findings represent a baseline analysis for this program which has remained relatively unchanged for nearly half a century and have the potential to improve exceptional tree programs in Hawai'i and other locations.

Hawai'i's Exceptional Tree Program

The State of Hawai'i began its recognition of exceptional trees in 1975 due to the loss of iconic trees resulting from increased developmental pressures (City and County of Honolulu, 2021). These trees must represent one or more of seven selection criteria (historic/cultural value, age, rarity, location, size, aesthetic quality, and endemic status) and can be either an individual specimen or grove (Hawai'i State Legislature, 1975). These trees are protected by state law and are managed by each of Hawai'i's four counties (Honolulu, Maui, Big Island and Kaua'i) through a mayor-appointed Arborist Advisory Committee (AAC) (Hawai'i State Legislature, 1975). Exceptional trees can only be removed if they pose a threat to public safety, die, or are delisted by a county council (Kaua'i County n.d; Maui County Arborist Advisory Committee, 2016; Hawai'i County, 2017; American Legal Publishing, 2023; City and County of Honolulu, 2021). However, aside from the introduction of a modest tax deduction in 2004, there have been minimal updates to Hawai'i's exceptional tree program since it was enacted over 48 years ago, prompting the need to identify ideal program components that reflect current conservation goals in order to improve this urban forestry conservation program.

Materials and Methods

Reflexive Thematic Analysis

Our study utilized the reflexive thematic analysis (RTA) method produced by Braun and Clarke (2022) to identify the weaknesses and desired improvements of Hawai'i's exceptional tree program through the lived experiences Hawai'i's exceptional tree practitioners. RTA is a method used to *"identify patterns within and across data in relation to participants' lived experience, views and perspectives... to understand what participants' think, feel and do"* (Clarke & Braun, 2017, p.297). RTA has become one of the most commonly used qualitative analytic techniques in many disciplines (Braun & Clarke, 2022). Its popularity of use could be attributed to the theoretical flexibility it provides, allowing both inductive and deductive analytic lenses to be applied (Clarke & Braun, 2017). RTA also utilizes methodological guidelines that are easy to learn, can be used on different datasets and with different participant group sizes, is ideal when an experiential focus is sought, and is effective even if a single researcher is working on the study (Braun & Clarke, 2006).

RTA themes share an overarching concept produced from codes derived from the dataset (Braun & Clarke, 2022). According to Braun and Clarke (2022), the six phases of RTA are 1) data familiarization, 2) data coding, 3) initial theme generation, 4) theme development and review, 5) theme refining, defining, and naming, and 6) writing up the findings. The authors also state that these six steps represent a guideline, allowing the researcher to go back and forth between various steps as needed.

Qualitative interviews were selected for this study as *"the organized and systematic manner that this research approach demands, provides a much higher likelihood of generating reliable data, compared to informal stakeholder interaction"* (Harper et al., 2020, p. 73), while also being able to convey complex policy processes (Klenk & Hickey, 2011).

Theoretical Lens

This study is founded upon a critical-realist ontology with a contextual epistemological focus that utilizes an inductive analytic approach through a semantic lens. A critical-realist ontology states that a researcher cannot be removed from the reality they are researching (Braun & Clarke, 2022), while a contextual epistemology proposes that a researcher's values influence the content they produce (Clarke & Braun, 2017). An inductive approach was selected because it is useful when analyzing novel topics (Clarke & Braun, 2017) and a semantic lens derives themes based on explicitly stated data, which is useful when working with experiential data that focuses on meaning and experience (Braun & Clarke, 2022).

Practitioner Selection and Data Collection

Seven exceptional tree practitioners were identified by the researcher using a non-probability sampling technique and defined as: "an individual who spends a significant amount of time interacting with Hawai'i's exceptional tree program, either directly by working with these trees, or indirectly through implementing program components." These practitioners represented public, private, and/or nonprofit sectors and included arborists, landscape architects, urban forestry managers, community activists, and former arborist advisory committee members, professions that have been identified as urban forest practitioners by others (see Moskell et al., 2010; Britton et al., 2015; Sax et al., 2020).

The study's co-investigator reviewed and confirmed each participant's qualifications as an exceptional tree practitioner, after which each was assigned a unique identification code to ensure anonymity. Each participant was interviewed once using Zoom, with meetings lasting 37 to 82 minutes and averaging one hour in duration. The interviews were transcribed using Otter.ai and were checked for accuracy by listening to each interview multiple times. The transcripts were produced verbatim, with the only exceptions being that duplicate words, misspoken words, and phrases such as "um" were removed for an easier and more coherent understanding of the content. Once the verbatim transcripts were produced, redactions were applied to content that could identify the participant, (i.e., names, places, organizations, job

title, etc.). Any redacted content was replaced with a placeholder such as [Place Name 1], [Nonprofit Name 1], etc., and if any significant amount of personal correspondence took place during the interview that did not relate to the topic being studied, it was also omitted.

Coding Process

MAXQDA was the software used to organize and analyze the redacted transcripts. Transcripts were not coded in the same order that they were transcribed to avoid giving extra focus towards later transcripts than earlier ones (i.e., 7, 3, 4, 2, 6, 5, 1 when coding compared to 1, 2, 3, 4, 5, 6, 7 when transcribing) (Braun & Clark, 2022). Initial codes (i.e., qualitative statements related to important concepts found in the data) were generated by reading and listening to each transcript. When a transcript was coded, any duplicate codes were removed and similar/overlapping codes were merged to ensure each was unique prior to coding a new transcript.

Initial Theme Generation

Prior to the initial theme generation stage, all codes were reviewed and any that required modifications were re-named and/or reorganized (merged or sub-divided) for greater clarity. Coded segments were compared to each of their respective transcript data to ensure that they represented the original content accurately. Coded segments were clustered into initial themes that identified the weaknesses and desired improvements of Hawai'i's exceptional tree program based on the lived experiences, opinions and preferences of practitioners who interact with this program. These initial themes were then compared to each of the codes that comprised them to make sure that these coded units still represented the theme's unifying concept. After this stage, each theme was then compared to the original data segments that comprised it to ensure compatibility and accuracy. This process saw the initial themes become "refined themes."

Theme Development and Review

Each refined theme was compared to the full dataset. This was accomplished by listening to all transcripts in full and noting key components from each interview. As the transcripts were being

reviewed, the refined themes were tested to see if they were prominent components depicted by the practitioners based on the research question looking to identify the known weaknesses and desired improvements for Hawai'i's exceptional tree program based on the lived experiences of these practitioners. The most important themes were confirmed and any changes to their titles were made at this stage to best reflect the data.

Theme Defining, Refining and Review

Once the accuracy of the refined themes was confirmed, a definition was made for each to depict their central concept. This was done to verify that each theme was distinctly unique from one another, while also telling an overarching story (Braun & Clarke, 2022). Any final modifications to a theme's title and/or codes that comprised it were made during the definition stage and resulted in the final iteration of the study's themes. The aforementioned processes of iterative coding and refinement helped to ensure validity in the study's findings.

Results

Five themes were produced from 16 codes (Table 2.1) based on the accounts of Hawai'i's exceptional tree practitioners, which collectively highlight the key weaknesses and desired improvements that should be considered to improve this conservation program (Figure 2.1). Collectively these themes shed light on the deficiencies that currently exist within Hawai'i's exceptional tree program. This was first exhibited by a lack of program clarity due to minimal education and outreach efforts undertaken by the Arborist Advisory Committees that manage Hawai'i's exceptional tree program. This lack of education and outreach has led to insufficient exceptional tree protection mechanisms and a non-existent master plan to cultivate Hawai'i's next generation of exceptional trees. Furthermore, until the identified knowledge exchange deficiency between exceptional tree experts and practitioners is addressed, many of the program's stated weaknesses will be difficult to resolve. Exceptional tree experts for the purposes of this study refer to decision makers (i.e., current Arborist Advisory Committee members) and academic researchers. There was general consensus among the participants that this urban forestry conservation program could and should be improved to protect Hawai'i's

most important tree specimens. Each of the five themes are discussed in detail below. The practitioners who referenced the corresponding theme in their dataset were also identified.

Table 2.1. Sixteen Codes Used to Produce the Study’s Five Themes.

1) Lack of Knowledge Exchange Between Exceptional Tree Experts and Practitioners	2) Hawai’i’s Exceptional Tree Program Lacks Clarity	3) Next Generation of Exceptional Trees Require a Master Plan to Address Known Obstacles	4) Inadequate Exceptional Tree Education and Outreach	5) Exceptional Tree Protection Mechanisms are Insufficient
<p>1.1) Need to Forge New Collaborative Efforts Between Exceptional Tree Experts and Practitioners</p> <p>1.2) Exceptional Tree Practitioners Often Do Not Receive New Program Information</p>	<p>2.1) Hawai’i’s Exceptional Tree Program Lacks Clarity</p>	<p>3.1) Next Generation of Exceptional Trees are Essential</p> <p>3.2) Threats to Potential Future Exceptional Trees</p> <p>3.3) Development/Infrastructure Impact Exceptional Trees</p> <p>3.4) Implementing a Long-Term Exceptional Tree Management Plan</p>	<p>4.1) Inadequate Exceptional Tree Education and Outreach</p> <p>4.2) Improve Exceptional Tree Education and Outreach</p> <p>4.3) Exceptional Tree Knowledge Needs to be Accessible/Available</p> <p>4.4) Provide Statistics on Exceptional Tree Program</p>	<p>5.1) Review Exceptional Tree Penalties</p> <p>5.2) Inadequate Incentives</p> <p>5.3) Insufficient Legal Protections and Enforcement</p>

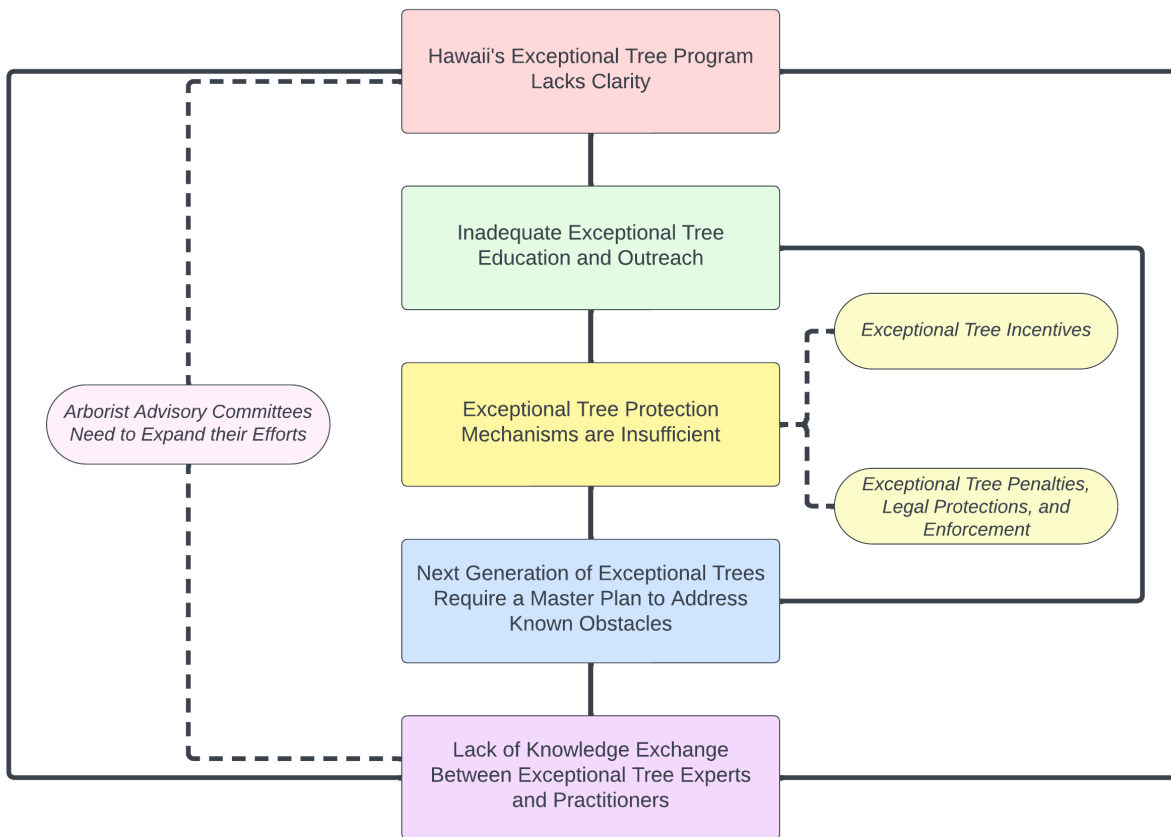


Figure 2. 1. Thematic Map Examining Challenges and Opportunities for Hawai'i's Exceptional Tree Program.

Note: solid lines indicate connections between themes, while dashed lines show connections between sub-themes and themes.

Theme 1: Lack of Knowledge Exchange Between Exceptional Tree Experts and Practitioners

(6/7 Practitioners – HP 1, 2, 3, 4, 5, 7)

There is a clear lack of two-way communication between exceptional tree experts and practitioners. This is based on inadequate and/or non-existent knowledge transfer to practitioners unless they are a member of an Arborist Advisory Committee (AAC), even though practitioners in our study clearly indicated that they want to receive new exceptional tree knowledge from experts:

"I've been on the committee, so I've been able to share information with experts there. If I wasn't on the committee, it would be very hard for a practitioner to share information and be involved. I mean, it's not impossible, but it's pretty hard.... We need to figure out ways to make those interactions happen." (HP1).

"I don't receive information. The only way I have received information about exceptional trees is when I was on the AAC." (HP3)

"Well, when I served on the committee, you know, we had minutes and reports and all that. And I don't currently get updates. I would like to, I would like to see what new trees are put on the list, or any that are removed." (HP7)

One practitioner suggested that the “inadequate” (HP4) communication between experts and practitioners is complex due to the disconnect that transcends not only these two groups, but also internally amongst exceptional tree practitioners, so much so that there should be two practitioner subgroups, determined by professional status:

“Many of the practitioners are disconnected...they're not professionals, they're doing a job. They're doing the job, and they're doing the best they can based on what they think is good...they're not interested in being connected.... And then many of the other ones [practitioners] who are very much connected don't have the time. They're trying to run their business or trying to do what they're doing and then on the other side, and it's interesting because I think I straddle both groups, is many of the experts are also a little out of touch.” (HP4)

Theme 2: Hawai‘i’s Exceptional Tree Program Lacks Clarity

(7/7 Practitioners – HP 1, 2, 3, 4, 5, 6, 7)

There was uniform consensus from the study’s practitioners that Hawai‘i’s exceptional tree program lacks clarity. They stated that the program is too complex and needs to be simplified,

as many non-experts most likely do not even know the exceptional tree program exists, highlighting a need to improve their understanding of these trees:

"I think the entire process to get a tree exceptionalized is too complicated. Because... you can't find out about the program unless you already know about the program and if you know about the program, then the only way to get the ball rolling is to go find the proper application online through the county's websites, which if our county has any clue, they're all a frickin nightmare and you get dispirited and nothing happens." (HP2)

This was exemplified by a clear lack of understanding by non-exceptional tree experts regarding exceptional tree selection criteria, their meanings, and implementation of other program components. One practitioner stated that the program's selection criteria should be clearer and better defined, as they are currently subjective and lack any definitions, allowing discrepancies to arise when trying to apply exceptional tree criteria (i.e., *Historical/Cultural Value*). This difficulty defining an exceptional tree, as well as the confusion as to what qualifies as damaging one of these trees, were stated program component weaknesses:

"Some people may think that a tree is very exceptional, but in fact because of its condition or its location, it's exceptional for all the wrong reasons." (HP4)

"I'm not sure how well it is codified... say you just cut a branch off indiscriminately, does that cause a fine? Or is it only if you cut it down? Or what does 'damaged the tree' mean? I don't know that that's necessarily clear." (HP5)

Documents such as an exceptional tree "cheat sheet" were noted as desired additions that should be produced to show examples of qualified exceptional trees. A template such as this could be a useful resource for those wishing to nominate an exceptional tree to ensure their candidate has a chance at receiving this designation. These documents also have the potential to address the transparency issues identified with this program, particularly when it comes to

why an exceptional tree nominee was rejected, as a nominator would have an opportunity to see if they agree with the AAC's decision making based on a standardized template and list of current exceptional trees:

"...what would really help is when they do the assessment of trees, would be to know why a tree didn't make it? What was the overriding criteria that allowed a tree to fall through the cracks or being rejected? Because that would certainly help in, frankly, the nominating process. If you can see (some trees) and go 'oh yeah, that one's not going to make it. Let's not bother doing that one.'" (HP6)

Furthermore, it was suggested that, if possible, exceptional tree program components should be made more uniform throughout the state to improve clarity through collaborations and knowledge sharing between the four AACs:

"...one other thing that we haven't tapped into yet is working with our neighbor island committees and learning from them. I don't think that we all have to be the same, but I think that we could definitely build off each other's strengths and make sure that there isn't any, you know, glaring inconsistencies. There should be some degree of, you know, parallels in there, it all comes from the same Act 105." (HP1)

Finally, improving access to exceptional tree knowledge was a focal point for many of the practitioners, although the medium through which new information is presented needs to be considered, as the same format will not be ideal for all stakeholders.

Theme 3: Next Generation of Exceptional Trees Require a Master Plan to Address Known Obstacles

(4/7 Practitioners – HP 1, 2, 4, 6)

A strong emphasis was placed on the need to develop an exceptional tree next generation master plan to future proof Hawai'i's program and address challenges facing these trees. This

management plan would focus on identifying where exceptional trees are currently found, highlighting areas devoid of any approved exceptional trees so nominees can be sought, officially nominating new candidates, and determining ideal locations where exceptional trees should one day be found. AAC members would need to interact with the community and other stakeholders to identify areas where these future exceptional tree plantings are desired. This master plan would allow incremental progress to be made as redevelopment opportunities arise, which would otherwise be lost if a plan was not ready to implement:

"I guess that might be the one thing we haven't said directly, which almost goes without saying, is a management plan. For the long-term, the vision. Take the vision and put that into a management plan.... develop a mechanism that effectuates that, in other words saying 'alright, so here's where our exceptional trees are, here's the mapping, this is what we got, what do we want to see in 100 years?'....and that'll give us a goal, if you will, a focus to look for opportunities as they arise because it isn't going to happen overnight by a longshot.... But in 10, 20 years, someone might redevelop that lot.... are they going to redo the roads? Now we have an opportunity. So we have that set up in advance, it's on the radar if you will. There's nothing on the radar right now." (HP4)

Some practitioners stated that threats to exceptional trees must be addressed for this program to thrive. These include a lack of space due to developmental and infrastructure pressures, which can create “challenging experiences...where [I’ve] had to weigh the program and the intent of the program and the tree against development” (HP1), as well as the planting of inadequate species:

"We're running out of spaces in which to either plant or even find locations to enjoy a 300-foot diameter tree, or 100-foot diameter tree, we're finding it hard to find a 10-foot diameter tree in the density of communities right now. We're lucky to get street trees in a two-foot-wide planter strip along the roadway and that's a very difficult place to plant an exceptional tree." (HP6)

"In the new communities that are being built... unfortunately, big canopy trees have gotten the connotation that 'oh, the roots are too bad. The leaf droppage is too bad. How about we just plant a Silver Buttonwood tree or a Dwarf White Tecoma?' Well, unfortunately, those will never achieve the exceptional criteria associated with trees of that magnitude. So it's very important that, you know, through this program we're able to either plant species of trees that will achieve that magnitude of size and condition and uniqueness that are the qualities associated with the criteria for exceptionalization... also in locations that allow them to achieve their natural form and size." (HP6)

The master plan would need to rely on a long-term vision that sees developers incorporate future exceptional tree candidates into their design plans. This would require incentives to "make it worth their while" (HP4) and offset lost income, while also changing the current "roadblock" (HP2) mentality developers have when confronted with an exceptional tree.

Theme 4: Inadequate Exceptional Tree Education and Outreach

(7/7 Practitioners – HP 1, 2, 3, 4, 5, 6, 7)

Practitioners in our study indicated that there is a substantial lack of exceptional tree education and outreach, which should be a primary focus for Hawai'i's AACs. A better online presence is required to improve this, comprised of easily digestible exceptional tree information conveyed in a variety of formats that appeal to different demographics. Content should include an updated exceptional tree registry, list of current AAC members, and more data/statistical information:

"We don't have any outreach; we haven't really done any outreach functions on any of the committees that I've been on.... we haven't been proactive as much as I think we need to be and I think that would help the program a lot, if we could have some capacity to be a little bit more proactive at the front end of it, I think that that would be really important and make it more robust." (HP1)

"...signage helps, the maps have been super helpful, the book that Outdoor Circle puts out, that's a really good tool, because it highlights those trees. The maps that Outdoor Circle has done on exceptional trees, so you can like go and tour exceptional trees, I think that's really cool. And I think the two in combination would be even a stronger tool, once you have all these great maps, and highlighted with incredible signage that not only tells about the tree, but sells the program as well, I think that's kind of a missed opportunity." (HP3)

Outreach materials should be presented via websites, pamphlets, and a pocket handbook and should combine different formats, such as signage and maps, to be as successful as possible. Signage is particularly problematic for Hawai'i's exceptional tree program because *"the signs right now are really small and they don't tell you enough...about the exceptional tree program, I think that's a missed opportunity" (HP3)*. Furthermore, conveying exceptional information through a diverse set of non-technological platforms is important, as some end-users may not be able to utilize online and digital content. This was clearly depicted by one practitioner who stated that *"I see online presence as both a strength and a weakness because the vast majority of [our members] could not find an exceptional tree if they only had online to be able to do it. So I think that that is a downside." (HP2)*

Hawai'i's exceptional tree program is not well known, particularly by the general public, so much so that one practitioner stated *"if you just went out and polled 100 people, I would be surprised if even 1% knew that we had an exceptional tree program" (HP2)*. Some practitioners went into further detail, suggesting there are significant program flaws that stem from an uninformed public:

"John Q Public does not know.... so there's something wrong with that process because I think if more people knew about it, they would do it because it gives them the opportunity to have the state support them in taking care of a tree that they might

*otherwise just figure 'oh, well, I'll just cut it down.' Which is the worst possible outcome."
(HP2)*

"So, I will call you or I will call somebody at DUF or I will call somebody at The Outdoor Circle, somebody on the AAC, only because I know these people, right. But if I was just an average person on the street, I don't know how you would find that information." (HP3)

"...the average public, and I know this from my interaction, most of the people I talked to that aren't tree people have no idea about exceptional trees." (HP4)

This lack of awareness by Hawai'i's general public extends to other demographics including politicians who do not understand the intent of the exceptional tree program due to lack of exposure to it, as well as practitioners who do not receive updates about these trees.

"The times I felt when I've had to explain it to politicians or city council, a lot of them don't really quite get it yet, or they just haven't worked with it." (HP1)

The inability of these groups to understand Hawai'i's exceptional tree program stems from the significant lack of education and outreach conducted on behalf of the program. The AAC has not traditionally been a conveyor of the exceptional tree program and generally focuses on its core task of vetting nominations. This highlights a program flaw, specifically that education and outreach efforts to practitioners and the general public is not a stated task for these committees, which limits opportunities for those outside of the AAC to learn about or participate in Hawai'i's exceptional tree program:

"I think trying to develop some sort of outreach through the committee as well, some sort of outreach function, which we've never really done at all. It's been pretty internal, you know...it needs to go more external." (HP1)

The result is a population that is uneducated about the existence of Hawai'i's exceptional tree program, unaware that anyone can nominate these trees, and how the program's components function, such as the tax incentives provided to private property owners who have these trees on their land:

"They don't know.... we try to let people know in our own community that this program exists, but it isn't well publicized. So people don't necessarily know that, you know, say they have a spectacular tree on their property, they don't know that there is this thing called the exceptional tree registry that would allow them, they get a tax incentive to have it maintained. And maybe they would put it on the registry, you know, just publicizing the fact that the program exists would be something really cool because I think people would recognize, 'oh, I've got a cool tree and I'm paying a lot of money to have it maintained, maybe I could put it on.'" (HP5)

This suggests that a large education and outreach campaign that improves current knowledge sources, and provides new exceptional tree knowledge desired by relevant stakeholders in an accessible and digestible format, should be a focus going forward:

"Let's try to get the word out about it so that people know about it.... I think the biggest issue with why trees don't get put on the registry is because nobody knows that they can do that." (HP5)

Practitioners in our study agreed that it is difficult for an average person to know how to find exceptional tree information. An uneducated public that does not know about these trees is detrimental for the program. Based on our findings, exceptional tree content needs to have a greater online presence that is easier to access, particularly on county websites. Our study also noted that exceptional tree information behind paywalls can be problematic to users who have found useful content, but cannot utilize it due to lack of free access. This suggests that exceptional tree knowledge should be made freely available from accessible sources, presented

in a variety of formats that can be utilized by different stakeholders, in order to improve exceptional tree education and outreach efforts.

Theme 5: Exceptional Tree Protection Mechanisms are Insufficient

(5/7 Practitioners – HP 2, 4, 5, 6, 7)

The “Exceptional Tree Protection Mechanisms are Insufficient” theme was generated based on the two subthemes of a) incentives, and b) penalties, legal protections and enforcement.

Incentives:

There were several instances where practitioners in our study stated that Hawai'i's exceptional tree program lacks adequate incentives to entice private property owners nominate an exceptional tree. One practitioner suggested that *“the program is not so strong because it's mostly downsides when you really look at it. I don't think the tax incentive is strong enough”* (HP4). While others question the efficacy of an incentive value that hasn't changed since it was enacted in 2004, even though costs to maintain a tree have increase dramatically since this time:

“Well, the thing is, I'm wondering, how does the \$1,000 a year hold up against actual cost of maintaining the tree? Because the whole point of the program in 2004, was to be able to help you maintain the tree. And in this day and age, you know, 1000 bucks doesn't go as far as it once did.” (HP2)

Many of our practitioners supported reviewing the current incentives associated with Hawai'i's exceptional tree program including increasing the tax deduction offered, providing periodic pro-bono maintenance services, and even the formation of an *“Adopt an exceptional tree”* program to assist with maintenance costs:

“I think if the rewards aspect could be improved upon, whether it's the existing reward program, or modifications and updating the rewards program, I think that'd be worth

looking at. I think it's always worth reassessing, especially when you said it was established in 2004, and hasn't been looked at since then, I think it's time to reassess this. No one is working for the same amount of money that they were working for in 2004. But I think there are certain things that can be added to the program to add some vigor and attractiveness to it. It doesn't have to be cash; it can be other things. But I think that's critical to how the program is perceived by the public. I think that's worth if nothing else, at least investigating it and see whether the people or the person are willing to address that. No harm in asking." (HP6)

"So, again, getting back to the strength of the program, I don't think it's that strong... because of the lack of benefits to the folks that would otherwise put it out there.... I'm sure if we go up to folks that had some of these big trees in their yard and said, 'look, if we can make this an exceptional tree, this fits the criteria, would you be willing to accept that by losing some of the control of that tree, but at the same token, a lot of the maintenance that you want to do and need to do, that could be taken care of for you?'...that would strengthen the program, I think, big time." (HP4)

It was noted that incentives are critical to how the program is perceived by the public and should be focused on to improve Hawai'i's exceptional tree program. However, this would require going beyond the incentives offered to private property owners to establish others that appeal to local and state governments, and nonprofits, all of which are unable to claim the current tax deduction.

The practitioners in our study also suggested that developers should receive incentives to preserve existing exceptional tree candidates during construction projects and/or incorporate species of trees into design plans with the intent that they will one day become the next generation of these trees. Offering positive recognition and/or tax breaks for developers that support Hawai'i's exceptional tree program were suggested as two potential incentive improvements which could also lead to better care for these trees:

"And when the opportunity comes up, they're tearing the roads or the sidewalk, or they're doing a development, they're rehashing it, we can then develop the site and finding a mechanism, a financial mechanism again through either donations or giving developers tax breaks or helping them financially and then having that tree come under the program and it will be maintained for folks.... So they will have a truly exceptional tree, because this is a tree that's special within the purview of our definition, that is also special because it's being taken care of by professionals." (HP4)

Penalties, Legal Protections, and Enforcement:

Hawai'i's exceptional tree program lacks the required "teeth" to fulfill the purpose of the program:

"There's probably more disappointments of trees that should be exceptional trees that aren't being saved because the program doesn't have the strength that we need, it doesn't have that support I guess." (HP4)

"You know, when you really deal with it, it's rather weak truthfully, because people can choose not to have their tree exceptionalized." (HP7)

This stems from inadequate regulatory and enforcement perspectives that impose minor fines of \$1,000 for damaging or removing an exceptional tree. This fine has not been modified since the program's inception which is problematic as the penalty would likely fail to deter a large developer building a multi-million-dollar project, as they could choose to pay this nominal fine. However, even issuing a fine for damaging an exceptional tree is seldomly done by the managing entity (i.e., the Department of Parks and Recreation) and punishment is generally seen in the form of a warning or "hand slap." One suggestion was to increase this penalty and go beyond a monetary fine to include legal ramifications which would provide more "teeth" for the program:

"When you're talking about a developer that's putting in a multi-million-dollar project, a thousand dollars is not going to bother that person, that development company, you know, they'll say, "well, I'll just cut it down." But they can't, you know, I think there should be something more than a fine, there should be some legal action taken if they do, something to give it more impetus.... so the point is that we have had cases where.... someone actually chopped down a bunch of trees on the property. There were multiple trees, and they were on the registry.... I don't know that they were ever fined. I think they had their hand slapped, because it was after the fact, what can you do anyway? So... this is a hard question because making it illegal to alter, cut down, damage is one thing, but then what should the penalty be? I'm not sure." (HP5)

Furthermore, Hawai'i's exceptional tree statutes need to increase the protections afforded to these iconic trees:

"I think the more clout that goes behind the ongoing protection of these trees would certainly assist in making the program more attractive to the property owner so that there would be more of a beneficial reward associated with the nomination of a tree to the exceptional tree category. I don't know whether you know, punishment is the correct word for it, but I think because of the nature of these trees, these are living entities, you know, they have a certain life expectancy, but during that period of time when frankly they've reached this majestic state of their lives to become exceptionalized, I think that is the time when their true beauty, embrace and stature is most appreciated by the community. And I think that's when both the benefits to the community and the potential hazard to the tree becomes most prominent and I think it's a reciprocal need to have more protection afforded for these specimens." (HP6)

Discussion

Theme 1: Lack of Knowledge Exchange Between Exceptional Tree Experts and Practitioners

The lack of effective knowledge exchange and communication between practitioners and experts is a common problem. Also known as the “science-practice gap” (Cabin et al., 2010), “knowing-doing gap” (Habel et al., 2013), and “research-implementation gap” (Arlettaz et al., 2010; Anderson, 2014), Hawai‘i’s exceptional tree knowledge exchange gap could be bridged by knowing the sources where conservation professionals receive their information (Fabian et al., 2019), and if this scientific knowledge is currently presented in an appropriate format (Walsh et al., 2015). Our study showed that Hawai‘i’s exceptional tree practitioners are eager and willing to interact and collaborate with current exceptional tree experts, which comports with other studies looking at practitioner and expert interactions (Seavy & Howell, 2010; Fabian et al., 2019). Face-to-face presentations and practical activities have been identified as common knowledge transfer methods between urban forestry practitioners, academics, and public administrators (Ugolini et al., 2015) and should be considered to improve Hawai‘i’s exceptional tree knowledge exchange gap. Our study also noted that a two-way dialogue needs to be established between exceptional tree experts and practitioners so each can convey their needs and ensure that the production of new knowledge focuses on pressing and applicable needs, similar to what has been noted by others elsewhere (see Roux et al., 2006; McNie, 2007; Arlettaz et al., 2010; Busbridge et al., 2021). The use of online content as the preferred knowledge source for our urban forestry practitioner interviewees is in basic alignment with with others such as Ugolini et al. (2015), prompting the need for increased digital exceptional tree information that’s easily accessible.

Hawai‘i’s arborist advisory committees (AACs) also need to ensure that exceptional tree information is shared with practitioners, rather than the current practice of experts retaining this knowledge solely amongst the committee. It has been suggested that interactions with colleagues can be a key knowledge source for conservation practitioners (Busbridge et al., 2021). In Hawai‘i, Laursen et al., (2018) found that information acquired from professional colleagues (i.e., scientists and local experts), learning from direct observation or practice, and

increased networking between professionals were identified as important themes for natural resource managers on Hawai'i Island, Hawai'i. All three of these components were highlighted by one or more practitioners in our study, suggesting that these themes may be ideal knowledge exchange practices for conservation professionals throughout Hawai'i. The importance of ensuring that exceptional tree information is relevant and provided in an understandable way cannot be overstated, as the *“generation of relevant scientific knowledge and their translation into general knowledge, professional practices and enabling policies could augur well for the welfare of our beloved living companions”* (Jim, 2017, p. 302).

Theme 2: Hawai'i's Exceptional Tree Program Lacks Clarity

Our study found that Hawai'i's exceptional tree practitioners perceived this statewide conservation program as being too complex and lacking clarity. Confusion regarding exceptional trees has been observed when comparing these programs at various geographic scales (Ritchie, 2019), prompting a need to identify the selection criteria that should be used to identify these trees of importance based on expert opinion (Lau et al., 2017; Ritchie et al., 2021). Others have also noted a need to improve exceptional tree program clarity and information dissemination (Britton et al., 2015), which our practitioners stated could be presented in the form of a *“cheat sheet”* or an evaluation template that is easily digestible. Regardless of the specifics, it has been recommended that templates (Busbridge et al., 2021), synthetic reviews (Seavy & Howell, 2010), and concise publications or summary reviews could all assist conservation practitioners who have limited time (Fabian et al., 2019), as long as clear implications from the research are presented in non-technical terms with examples of how to use the findings (Klenk & Hickey, 2011). Implementing these suggestions could foster greater transparency as to why an exceptional tree was accepted or denied, as well as improve the overall clarity of Hawai'i's exceptional tree program.

Theme 3: Next Generation of Exceptional Trees Require a Master Plan to Address Known Obstacles

It was determined that an exceptional tree next generation master plan is a necessary program component that's currently non-existent in Hawai'i. This plan would help identify new exceptional tree candidates, while also planting desirable species of trees in adequate locations that have the potential to achieve exceptional status in the future. This issue of planting small and non-ideal species of trees in urban areas can limit the potential number of future exceptional trees, prompting a focus on identifying optimal locations where the next generation of exceptional trees can grow (Jim 2004), comprised of ideal species that could attain exceptional status in the future. However, conflicts between exceptional trees and development needs to be mitigated for this master plan to be initiated as roadwork and construction lead to substantial exceptional tree mortality rates (Jim, 2004, Jim, 2005b).

Four things should be considered to address this conflict. First, soil protection zones should be applied when construction is taking place in the vicinity of an exceptional tree and should have a minimum diameter to the tree's dripline and a depth of at least 1 meter (Jim, 2017). Second, degraded sites could be improved through rehabilitation efforts and should be considered (Jim, 2017). Third, tree health and adequate space for the tree's crown and root system should be considered when a development site is being designed (Jim, 2018). Fourth, incentives need to be provided to developers to ensure current trees are retained and future exceptional trees are planted in developing areas, a prominent finding in our study.

The master plan proposed by our practitioners would have the potential to address the exceptional tree generational gap that has been identified by Jim (2017), which results due to an aging exceptional tree population with minimal successors in the pipeline. This process will require an intergenerational arboricultural view (Jim, 2005b), but is essential in Hawai'i as few trees have been awarded exceptional status over the past several years, particularly on the islands of Oahu, Kaua'i and Hawai'i.

Theme 4: Inadequate Exceptional Tree Education and Outreach

There was unanimous consensus from the practitioners in our study that Hawai'i's exceptional tree program lacks adequate education and outreach efforts. This has led to a lack of program awareness by key stakeholder groups including practitioners, policy makers and the general public. Our study noted the minimal awareness that statewide politicians have regarding how Hawai'i's exceptional tree program functions. This is problematic because politicians have the potential to positively impact urban forest decision-making (Ordonez et al., 2019). The willingness of policymakers to provide support and resources for an exceptional tree program can be improved if the public supports these trees (Jim, 2018), unfortunately, the practitioners in our study highlighted that the general public has little to no idea that Hawai'i's exceptional program exists. This is a major weakness as educating the public has been identified as an essential component of an exceptional tree program (Ali et al., 2016) and public participation in urban forestry projects can lead to better decision-making by providing alternative sources of information and management strategies, building trust, and minimizing delays (Beckley et al., 2006). The public also plays a role in legitimizing urban forestry decisions, by having their values and preferences taken into consideration (Janse & Konijnendijk, 2007).

Exceptional trees in publicly accessible areas can improve the public's perception of these trees through increased interactions and promotion of the many benefits exceptional trees provide (Chen, 2015). Others such as Jim (2017) have stated that the social and cultural benefits provided by exceptional trees are another way to improve community perceptions, so much so that exceptional tree content should be included in school curriculums for children. Our participants indicated that the Arborist Advisory Committee for each county should take the lead on exceptional tree education and outreach initiatives regardless of the stakeholder group being targeted. This has been echoed by Britton et al. (2015) who identified that tree advisory boards play an important role in improving exceptional tree planning. Others have stated that urban forest managers, practitioners (Moskell et al., 2010; Seamans, 2013), and community groups (Ordonez et al., 2020) all have the potential to impact the management of urban forests, while nonprofits (LeRoux, 2007; Seamans, 2013) and private entities (Seamans, 2013) can play a

significant role as exceptional tree outreach and education partners. As the public becomes better informed about these trees and their cultural and recreational values, support for an exceptional tree willingness-to-pay (WTP) program should also increase (Chen, 2015). This notion of a public's WTP to support urban forestry programs has been noted in the USA, specifically in the states of Louisiana (Lorenzo et al., 2000) and Alabama (Zhang et al., 2007), and provides an alternative funding mechanism to maintain Hawai'i's exceptional trees.

The language used to convey urban forestry scientific knowledge needs to be made more end-user friendly and should also focus on public engagement, synthesis of content to assist with decision making, distilling results, and science translation and dissemination (Ugolini et al., 2015). These recommendations were echoed by our study's participants, in addition to a need for an informative website (Michalak et al., 2016), exceptional tree plaques and/or QR codes to educate in a direct way (Jim, 2018), and an online tree register that could easily disseminate exceptional tree knowledge and awareness (Jim, 2017). When all of this educational content is being created to suit a given stakeholder's ideal format, special attention should be given to residents, as improved awareness of exceptional trees from this demographic could potentially lead to increased protections for these trees (Lin et al., 2020) due to their status as "*effective tree guardians*" (Jim, 2018, p. 72).

An important theme that arose was the inability of our practitioners to access exceptional tree knowledge due to scientific journal paywalls, even though this was coveted information. This contrasts the findings from Fabian et al. (2019) who found that scientific journals were the least important source of information for conservation professionals. The seldom use of scientific publications by Hawai'i's exceptional tree practitioners due to cost barriers has been seen with urban forestry practitioners (Ugolini et al., 2015) and conservation practitioners more broadly (Fabian et al., 2019), prompting the need to ensure that scientific knowledge is freely available to practitioners (Jim, 2018; Fabian et al., 2019). However, the costs to publish in an open access journal may prevent some academic researchers from doing so (Ugolini et al., 2015). An alternative to this is to publish in urban forestry open access journals that do not charge fees to

authors, such as the International Society of Arboriculture's (ISA) *Arboriculture and Urban Forestry* journal (International Society of Arboriculture, 2023), allowing content such as exceptional tree knowledge to be freely disseminated to the practitioners who need it.

Theme 5: Exceptional Tree Protection Mechanisms are Insufficient

The anthropogenic threats that face exceptional trees (see Jim, 2004; Jim, 2005a; Chen, 2015), prompts the need for effective exceptional tree protection mechanisms to prevent the destruction of these trees (Jim, 2018). For tree protection mechanisms to be effective, public support is required (Zhang et al., 2009. Koeser et al. (2023) found that residents in Florida supported tree protections, including 82% of homeowners indicating that they would plant a tree if a tax incentive was offered, in addition to 86% stating they would retain a tree if a tax incentive was provided. Britton et al. (2015) found that exceptional tree practitioners were supportive of incentives, including tax incentives. We found that Hawai'i's exceptional tree practitioners support a range of incentives, regulations, and penalties to protect these trees. However, the current tax deduction incentive of \$3,000 (USD) per exceptional tree every three years for maintenance support was identified as being dated and ineffective due to the monetary amount provided. Justification for this can be seen as only 23 tax deduction claims were made statewide between 2011-2021 amounting to only \$64,952 (USD) (Gary Suganuma, Director, Hawai'i State Department of Taxation, personal communication, July 11, 2023). This supports the claims made by our practitioners that Hawai'i's exceptional tree incentives need to be improved if protections are to be more effective. By looking at exceptional tree programs elsewhere, incentive solutions can be obtained. In the state of South Australia, the City of Port Adelaide Enfield provides \$1,000 (AUD) for maintenance on their exceptional trees (City of Port Adelaide Enfield, 2023), while the City of Burnside covers 75% of exceptional tree maintenance up to \$2,000 (AUD) per tree (City of Burnside, 2023), amounts that greatly exceed the incentive offered in Hawai'i as these are refunds not tax deductions.

Regulations, penalties, and enforcement were also lacking exceptional tree program components identified in our study. As development poses the greatest threat to exceptional

trees in urban areas, it has been suggested that tying property values to trees could increase protections (Jim, 2017). The desire to identify incentives for developers indicated by our participants could take the form of a non-monetary incentive where the public's view of a project can be improved if an exceptional tree is incorporated into a project's design (Jim, 2017). Increasing the current \$1,000 (USD) fine for illegally damaging or removing an exceptional tree should also be considered. Alternative exceptional tree penalty evaluation methods in use elsewhere include a fine of up to \$5,000 (USD) (Menlo Park, 2023), \$120,000 (AUD) (Government of South Australia, n.d.), and \$300 (USD) per inch of circumference the illegally removed exceptional tree possessed (Casey Trees, 2023). Any of these penalty values could be considered for use in Hawai'i to increase the current fine which has remained the same since the program's inception in 1975.

Conclusion

This study represents the first systematic, peer-reviewed investigation of Hawai'i's exceptional tree program utilizing the lived experiences of exceptional tree practitioners. Five themes were generated that identified current weaknesses associated with this conservation program based on the perspectives and opinions of these practitioners. These themes serve as the foundation upon which Hawai'i's exceptional tree program can be improved to better identify, manage and conserve these majestic trees for generations to come. The findings also have the potential to enhance exceptional tree programs located elsewhere, in addition to urban forestry programs more broadly.

Three aspects should be the focus of future research. First, this study should be replicated in other locations around the world at local, state/provincial, national, and international scales. This would increase the generalizability of our study's findings, while also further examining if the exceptional tree program weaknesses identified in our study (i.e., protection mechanisms, education and outreach, program clarity, next generation exceptional tree master plan, knowledge exchange between experts and practitioners, etc.) are prominent elsewhere. Second, Hawai'i's exceptional tree experts should be consulted to develop solutions that

address the weaknesses identified by our practitioners. Finally, any derived solutions to Hawai'i's exceptional tree program should be implemented to determine their effectiveness, which will require the combined efforts of exceptional tree practitioners and experts throughout the state. This process would allow an exceptional tree program best practice framework to be produced which could be utilized in other locations to address common issues and ultimately help identify and improve protections for these iconic keystone specimens of urban and peri-urban forests.

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CHAPTER 3: DISCUSSING KNOWN DELPHI METHOD DEFICIENCIES THROUGH AN EXAMINATION OF EXCEPTIONAL TREE STUDIES IN SOUTH AUSTRALIA AND HAWAI'I

Abstract

The Delphi method is a flexible research design that utilizes expert experiences and opinions to generate new knowledge, particularly on novel topics. However, there is a lack of agreement as to how many of the essential methodological components should be implemented, including consensus, expert selection, attrition, and study duration. We discuss these known discrepancies and present potential solutions based on “exceptional tree” Delphi case studies conducted in the states of South Australia, AU and Hawai'i, USA. A three-iteration modified Delphi study was used for each case study, utilizing the opinions of 10 and 13 “exceptional tree” experts from South Australia and Hawai'i respectively, to better identify the most important selection criteria and program components that should be included in these conservation programs. The findings from this study adds to the Delphi methodological literature by presenting recommendations that could assist researchers using this method.

Introduction

The Delphi method *“has been used in research to develop, identify, forecast and validate”* (Skulmoski et al., 2007, p. 5) and arguably its main goal is to use the experiences and opinions of experts to generate tacit knowledge about a topic through evaluation and consensus (Lilja et al., 2011). The Delphi method was originally created in the 1950s by the RAND corporation to *“obtain the most reliable consensus of opinion of a group of experts”* (Dalkey & Helmer, 1963, p. 458) by *“eliciting and refining group judgements”* (Dalkey, 1969, p. v). It has since become a scientifically-and practically-verified research technique (von der Gracht, 2012) with the ability to derive consensus through multiple iterations using controlled feedback (Dalkey & Helmer, 1963; Dalkey, 1969). It is particularly useful when a novel topic is being examined that may not have substantial content in the literature (McPherson et al., 2018), can assist in identifying new priorities related to the topic being studied (Keeney et al., 2011), and allows complex

phenomena to be studied that involve multiple stakeholders (Kezar & Maxey, 2016), all of which provide a firm foundation for future research (McPherson et al., 2018; Hirschhorn, 2019).

When researching the Delphi process, *“one quickly concludes that there is no ‘typical’ Delphi; rather, that the method is modified to suit the circumstances and research question”* (Skulmoski et al., 2007, p. 5). One of the Delphi method’s greatest strengths is found in its flexible design that can allow the researcher to uniquely tailor the study design to fit their identified objectives (Skulmoski et al., 2007; Hirschhorn, 2019). Modifications can be seen in the type of questions used, methods of analysis, selection of participants, and desired outcomes (e.g. consensus) (Hirschhorn, 2019). However, according to Rowe and Wright (2001), the four components that must be present for a study to be classified as a Delphi are anonymity, iterations, controlled feedback and statistical analysis to interpret data. There are few agreed upon Delphi methodological considerations aside from these four components, which warrants an examination of key Delphi components and their current use to better understand how to best-utilize this method.

Expert Selection

Non-probability sampling techniques are used to select Delphi participants (Keeney et al., 2006) based on criteria established at the beginning of the study (McPherson et al., 2018). Expert validity can be increased through the use of a well-defined term (see Lilja et al., 2011, p. 4), which should be produced prior to the study’s onset (Franklin & Hart, 2007). Experts should be selected based on their prominence in the field (Hirschhorn, 2019) and/or professional and organizational ties (Donohoe et al., 2012), and should be confirmed by someone other than the researcher conducting the study (e.g. colleague) (Lilja et al., 2011).

There is no agreed upon number of experts that should be included in a Delphi study (Hsu & Sandford, 2007; Lilja et al., 2011), as the study’s aims play a major role in determining the panel size (Keeney et al., 2011; Belton et al., 2021). Expert selection is also based on the amount of feedback that will be provided for each survey, as too many experts can make summaries *“unmanageable”* (Belton et al., 2019, p. 74). The number of participants in a Delphi vary, with

some studies using approximately 12 (Davis et al., 2014), 5-20 (Rowe & Wright, 2001; Rowe & Wright, 2011), 15-20 (Ludwig, 1997), less than 50 (Toma & Piciooreanu, 2016), or up to 1,000 experts (Nasa et al., 2021). This wide variation in the number of experts included in a Delphi study has also been highlighted by Skulmoski et al. (2007) who found that this value could range from 3-171 (see Table 1, Skulmoski et al., 2007). Further complicating the issue, some have argued for larger Delphi panels (Linstone & Turoff, 1975), while others have stated fewer experts may suffice (i.e., ≤ 19) (Belton et al., 2021). This recommendation of smaller Delphi panels is supported by Boje and Murningham (1982) who found that larger panels do not improve accuracy or confidence. It is important to note that there exists a point where the benefits of a larger sample size diminish and are no longer worth the extra data analysis that takes place as a result (Skulmoski et al., 2007), inferring that a relatively large sample size may not be the best methodological choice. Conversely, Garrod and Fyall (2005) have suggested that the size of the panel is not critical to a Delphi study, and instead, the focus should be a balanced panel of experts who have different backgrounds and skills (Wheeller et al., 1990).

Number of Survey Iterations

A Delphi study may only require one or two survey iterations (Skulmoski et al., 2007), although three are commonly used (Skulmoski et al., 2007; Trevelyan & Robinson, 2015) as consensus or dissensus (aka lack of consensus) is typically achieved by this iteration (Rowe & Wright, 2001; Boulkedid et al., 2011). Components that reach the stated consensus threshold are no longer included in subsequent Delphi rounds (English & Kerman, 1975; Rayens & Hahn, 2000; Stewart et al., 2017; Ritchie et al., 2021). The study concludes when a stopping metric such as consensus (McPherson et al., 2018), stability of rounds (Dajani et al., 1979; Chaffin & Talley, 1980; Linstone & Turoff, 2011), or a predetermined number of iterations has been achieved (Nasa et al., 2021). The number of survey iterations is often dependent on the time and budget allocations for the study (von der Gracht, 2012). Stating if a pre-determined round limit will be used to terminate the study is especially important in the event that consensus has not been achieved by that point (Diamond et al., 2014).

Consensus

Expert consensus is a focal point of a Delphi study (Sourani & Sohali, 2015). It has also been referred to as “*collective agreement*” (Keeney et al., 2011, p. 14) as group unanimity is often not the focus due to the difficulty in achieving 100% agreement from the expert panel (Keeney et al., 2006). Interestingly, there is no agreed upon definition as to what constitutes consensus (Keeney et al., 2006; Keeney et al., 2011; Diamond et al., 2014), or how it should be measured when using a Delphi study (von der Gracht, 2012), resulting in a lack of stringent consensus standards (Mitchell, 1991) and a plethora of methods used to determine consensus and convergence (von der Gracht, 2012). These include descriptive statistics (i.e., level of agreement, coefficient of variation, interquartile range, subjective analysis, stipulated number of rounds, etc.) and inferential statistic techniques (i.e., McNemar change test, Wilcoxon matched-pairs signed-ranks test, Kendall’s *W* coefficient, t-statistics and F-tests) (see von der Gracht, 2012). That said, level of agreement, interquartile range, and coefficient of variance are three of the most common ways to evaluate consensus in a Delphi study. Level of agreement measures the percentage of participants that agree on a statement (e.g., 82% felt that a topic was “very important”) (Keeney et al., 2011). A review of 100 Delphi studies by Diamond et al. (2014) found that level of agreement (aka percent agreement) was the most common method to determine consensus. The interquartile range (IQR) is “*an objective and rigorous way of determining consensus*” (von der Gracht, 2012, p. 1531), measures the middle 50% of observations based on the dispersion of the median (Sekaran & Bougie, 2016), and is the preferred metric compared to the data’s range in order to account for extreme values (Argyrous, 2005). IQR is viewed as a robust statistical measure that has been recommended by Beiderbeck et al. (2021) “*despite the fact that there are various quantitative measures for consensus and stability*” (p. 13), and is used as an evaluation metric for the quality of group judgement (Garrod & Fyall, 2005). Coefficient of variation (CV) measures dispersion by dividing the standard deviation by the mean (English & Kernan, 1975) to identify consensus. CV can also be used to determine the stability of responses between Delphi survey iterations, a metric that some have argued should be measured during Delphi studies (Dajani et al., 1979; von der Gracht, 2012; Belton et al., 2019), although this rarely happens (von der Gracht, 2012). Furthermore, Diamond

et al. (2014) found that using stability of responses to end a Delphi only occurred in 3.1% of the studies they reviewed.

Among these different consensus methods there exists a wide disparity as to what constitutes consensus. For example, when level of agreement between experts is used to determine consensus, some researchers have used values such as 51%, (Loughlin & Moore, 1979), 67% (Alexandrov & Pullicino, 1996), 75% (McKenna et al., 2001; Mcleod, 2012; Belton et al., 2019; Ritchie, 2021), 80% (Toma & Piciooreanu, 2016), or >80% (Putnam et al., 1995; Green et al., 1999). IQR values such as ≤ 1.25 (Beiderbeck et al., 2021) and ≤ 1 (Raskin, 1994; Jeffery et al., 2000; Rayens & Hahn, 2000; De Vet et al., 2005) are commonly used to signify consensus has been reached if the value is below the predetermined threshold (von der Gracht, 2012), while a value of ≤ 0.5 has been used for CV measurements (English & Kernan, 1975; Zinn et al., 2001).

Combinations of these three consensus methods have also been utilized. Rayens and Hahn (2000) used IQR and level of agreement to determine consensus in order to account for the considerable variability that could be seen if responses are bimodal (i.e., the level of agreement threshold has been met, but the IQR value is over 1 indicating variability among responses). Von der Gracht (2012) recommended that IQR and CV could be used together in a Delphi study to address consensus and stability. It is interesting to note that Rayens and Hahn (2000) also evaluated questions between survey rounds for stability, albeit only those that failed to achieve consensus in the prior iteration, as questions that met the stated consensus threshold were not included in the subsequent Delphi round. This process of removing questions that attained consensus has been used in several Delphi studies (see Dean et al., 2000; Flores et al., 2014; Boceta et al., 2016; Stewart et al., 2017; Boel et al., 2021; Ritchie et al., 2021) and can allow dissensus criteria and open-ended questions to be focused on. Deciding upon a consensus level to be used in a Delphi study should ultimately be based on the importance of the research topic (i.e., 51% consensus when deciding on new uniforms compared to 100% consensus regarding when to remove someone from life support) (Keeney et al., 2006). It should also be noted that while higher consensus values give increased validity to a study's findings, these values could be

difficult to achieve in practice (Belton et al., 2019). Regardless of what consensus value is used, this metric should be decided prior to the onset of the study (Belton et al., 2019), as well as any other criteria that could determine the study's conclusion (e.g., number of survey rounds) (Nasa et al., 2021). This is an important methodological step that is often omitted by researchers conducting a Delphi (Williams & Webb, 1994).

Finally, in some Delphi studies dissensus may be observed instead of group consensus and can occur if differing, yet stable, responses are provided by the panel (see Belton et al., 2019). However, such instances of dissensus can still be beneficial as they can provide a more thorough understanding of the topic being considered (Rowe & Wright, 2011; von der Gracht, 2012; Beiderbeck et al., 2021).

Data Collection and Analysis

Likert scales are commonly used for Delphi studies (Jeffery et al., 2000; Keeney et al., 2011), particularly 5-point scales (Belton et al., 2019). It has been recommended that labels should be used for all Likert selection choices to improve the psychometric quality of the scales (Krosnick et al., 2010; Belton et al., 2019). Open-ended questions can also be incorporated into the study to identify any content that may have initially been omitted (Keeney et al., 2006), and can help produce focused questions for subsequent iterations (see McKenna, 1989; Keeney et al., 2006; Frewer et al., 2011). These questions also provide the expert panel with an opportunity to justify their responses, which can improve the quality of feedback (Rowe & Wright, 2001; Meijering & Tobi, 2016).

Delphi data analysis can comprise various approaches as there lacks a single agreed upon standard to use (Keeney et al., 2011). Measures of central tendency are often used to describe quantitative data (McPherson et al., 2018), with mean, median, and mode being common metrics evaluated (von der Gracht, 2012), along with percentages and frequency counts (McPherson et al., 2018). Measures of central tendency are useful in Delphi summaries as they allow experts to compare their answers to the rest of the panel (Hasson et al., 2000). Open-

ended responses can be evaluated using content analysis (McKenna & Hasson, 2002; Beiderbeck et al., 2021) or qualitative data analysis (von der Gracht, 2012; McPherson et al., 2018). Some Delphi process steps can be conducted concurrently with others, such as topic generation, software testing, expert selection (Belton et al., 2019), or data collection and analysis (Munhall, 2012).

Many Delphi studies are currently conducted using digital data collection methods (de Loe et al., 2016; Foth et al., 2016), such as Qualtrics (McPherson et al., 2018; Belton et al., 2019; Ritchie et al., 2021) and SurveyMonkey (Belton et al., 2019). Digital methods can expedite the analysis phase for each round, decreasing the amount of time between iterations (McPherson et al., 2018). Finally, it is recommended that a pilot test of the initial Delphi survey be conducted (Belton et al., 2019) to determine if the answers being produced address the fundamental research question(s) (Lilja et al., 2011).

Evaluating Trustworthiness

Lincoln and Guba (1985) recommended that trustworthiness in a qualitative study relies on credibility, dependability, transferability, and confirmability. Credibility is based on the researcher's actions, decisions and biases, dependability examines an audit trail to determine if the methodology was followed correctly, transferability can be verified if an expert not associated with the study can see the findings as an accurate representation of their own experiences, and confirmability is based on others reproducing the same findings from the study's dataset. A well-done qualitative study would comprise all four of these trustworthiness components (Lincoln & Guba, 1985; Melnyk & Fineout-Overholt, 2014). These aspects are particularly important for the open-ended components contained within the Delphi's mixed method approach.

Delphi Advantages

Anonymity

Anonymity is a focal point of the Delphi method (McPherson et al., 2018) as it reduces the influence of more vocal participants (Dalkey, 1969), while also ensuring individuals do not have to fear repercussions from peers based on their responses (von der Gracht, 2012). Anonymity has also been shown to improve response rates (von der Gracht, 2012), which is important given the high attrition typically associated with Delphi studies (Garrod & Fyall, 2005).

Geographically Diverse Experts

A benefit of the Delphi method is that the location of the participants doesn't have a negative impact on the study (Toronto, 2017), allowing experts from different geographic locations to participate (Boulkedid et al., 2011; McPherson et al., 2018), generally through the use of electronic methods (McPherson et al., 2018).

Delphi Concerns

Attrition

High participant attrition rates can be a significant problem for Delphi studies (Garrod & Fyall, 2005; Trevelyan & Robinson, 2015). The corresponding low response rates can lead to weaker study results (McPherson et al., 2018), negatively impact the validity of the data, can produce a response bias (Keeney et al., 2006), and pose a major threat to the entire Delphi process (e.g., reduced accuracy) (Franklin & Hart, 2007; Hirschhorn, 2019). Attrition could be reduced by keeping participants engaged (Franklin & Hart, 2007), selecting experts that are interested in the topic and research process, maintaining contact with experts throughout the entire Delphi process (Franklin & Hart, 2007; Donohoe et al., 2012), and having shorter questionnaires (Keeney et al., 2011).

Slow Process Due to Multiple Survey Iterations

The significant time needed to complete a Delphi study has been noted (see Keeney et al., 2006; Ritchie, 2019) and is a component often overlooked by researchers (Keeney et al., 2006). The

duration of a Delphi study can vary significantly, as some have seen the entire process last approximately 4 months (Grant et al., 2018) to 5.8 months (Mcleod, 2012), while others saw the process take 7.5 months (Ritchie, 2019) to 12 months (see Keeney et al., 2006). While one of the Delphi's greatest potential limitations is the amount of time required to complete this process from start to finish, by sending reminders to participants, presenting concrete deadlines during the recruitment phase, and avoiding scheduling surveys during busy times of the year such as holidays (Donohoe et al., 2012), the time it takes to complete a Delphi study could be reduced and the overall timeline made more predictable.

This paper seeks to add to the Delphi literature by examining the aforementioned issues pertaining to consensus values, study duration, attrition rates, and the inclusion of a confirmation of findings verification phase through an analysis of exceptional tree case studies in South Australia and Hawai'i.

Case Studies

“Exceptional Tree” Programs

Exceptional (aka “significant,” “heritage,” “champion,” “monumental,” etc.) trees have been recognized around the world based on at least 40 unique traits that set them apart from other trees (Ritchie, 2019). Examples of exceptional tree selection criteria have included botanical value, ecological value (Britton et al., 2015; Lau et al., 2017), historical value, cultural value, aesthetics, and size (Clark et al., 2020), and can be applied to trees on public and private land (City of San Diego, 2005; Britton et al., 2015; City of Milpitas, 2016), and found at local (Village of Glenview, 2013) to national (National Parks Board Singapore, 2017) scales. Some exceptional tree programs focus solely on recognition and education (Nebraska Forest Service, 2018), while others comprise these aspects in addition to legal protections (Hawai'i State Legislature, 1975; Jim, 2004; City of Melbourne, 2012; Forests Ontario, 2017). However, anthropogenic factors are constant threats to these trees (Jim, 2004, Jim, 2005) and have led to the loss of a significant number of exceptional trees (see Jim, 2005, Chen, 2015). The implementation of an exceptional tree program has the ability to protect these iconic tree specimens (Britton et al., 2015) which

can act as keystone structures of urban forests (Stagoll et al., 2012). However, with the confusing amount of selection criteria and program components used in these programs, it is important that expert consensus serves as the foundation for current and planned exceptional tree initiatives to ensure that the most optimal selection criteria and program mechanisms are utilized to protect these trees for current and future generations.

South Australia's "Significant Tree" Program

The state of South Australia has three types of "significant tree" programs. The first is managed by the National Trust of Australia and began in 1981, with the first trees nominated in 1983 (McNamara & Carter, 2006). The program was created through a collaborative process between the National Trusts throughout Australia to produce a National Register of Significant Trees (National Trust of Australia, 2021a). Each Australian state or territory has a committee that manages their respective programs and consists of experts from the fields of arboriculture, botany, heritage conservation, and environmental management (National Trust of Australia, 2021a). Significant tree selection criteria for this program are grouped into four main categories (scientific, social, historical, and aesthetic) with a total of 21 criteria used (National Trust of Australia, 2021b). These trees can be comprised of an individual specimen, grove, or avenue (McNamara & Carter, 2006), and while the program itself serves only as an educational tool, the National Trust still advocates for significant tree legal protections (National Trust of Australia, 2021a).

The South Australia state government program is the second of these significant tree programs and includes any trees with a circumference of three meters or greater located in the Adelaide, Adelaide Hills, and Mount Barker Council regions (Government of South Australia, 2021b). These trees cannot be removed unless a permit is applied for and granted, the tree dies (Legal Services Commission of South Australia, 2021), or is a threat to public safety (Government of South Australia, 2021a).

The third type of significant tree program in South Australia is a modified version of the state government program as it uses the same three-meter circumference criteria and permitting process for removals (City of Marion, 2019), but is managed by individual councils/municipalities.

As evident from the different components used to identify and manage significant trees in South Australia, there is a clear lack of standardization between these programs. The efficacy of these programs has also been called into question by Ballantyne et al. (2021) when they stated *“significant tree regulations are not working to protect our large trees or prevent unnecessary removals”* (p. 2). Furthermore, the authors go on to say that the current criteria for the state government and council programs do not account for non-physical metrics and that *“a coordinated capture of data of significant trees across councils is needed. Included in this should be culturally significant trees, regardless of their size to ensure they are afforded protection”* (p. 19). These issues highlight a need to improve South Australia’s significant tree programs by re-examining the selection criteria and protection mechanisms that comprise them.

Hawai’i’s “Exceptional Tree” Program

The State of Hawai’i began its recognition of “exceptional trees” in 1975 due to the loss of iconic trees resulting from increased development pressures (City and County of Honolulu, 2021). These trees must meet one or more of the seven stated criteria (historic/cultural value, age, rarity, location, size, aesthetic quality, and endemic status) and can be either an individual specimen or grove (Hawai’i State Legislature, 1975). These trees are legally protected and can only be removed if there is a threat to public safety (City and County of Honolulu, 2021). These trees are protected by state law and are managed by each of the four counties (Honolulu County, Maui County, Hawai’i County, and Kaua’i County) through a mayor-appointed Arborist Advisory Committee (AAC) (Hawai’i State Legislature, 1975). However, aside from the introduction of a tax deduction to assist with tree maintenance, the selection criteria and program components (i.e., fines for illegal removal) have not been updated since the program

was enacted 46 years ago, raising the question if these aspects adequately represent current program values and needs.

It is clear that South Australia and Hawai'i need to better identify how these trees of importance are recognized, as well as the program components used to promote and protect them, if these conservation programs are to have improved success. The remainder of this paper will collectively refer to South Australia's "significant trees" and Hawai'i's "exceptional trees" as "exceptional trees" (including when referring to other studies which may use different terms) to ensure uniformity when describing the results of these two Delphi studies.

Methodology

Survey Design

Both of our case studies used the three-iteration modified Delphi produced by Ritchie et al. (2021) (Figure 3.1). Our first survey was comprised of 45 closed-ended questions derived from an exhaustive list of 45 potential exceptional tree criteria produced by Ritchie et al. (2021) to determine which selection criteria should be used to identify "exceptional trees," in South Australia and Hawai'i. Fifty-five open-ended questions were also included to better understand why these criteria were selected and what other program components should be included to improve the success of the exceptional tree program (e.g., legal protections, incentives and penalties, educational outreach/education, funding, management best practices, climate change mitigation, etc.). The initial survey for each case study contained identical content, except the local term to denote a tree of importance was maintained (i.e., "significant tree" for South Australia and "exceptional tree" for Hawai'i).

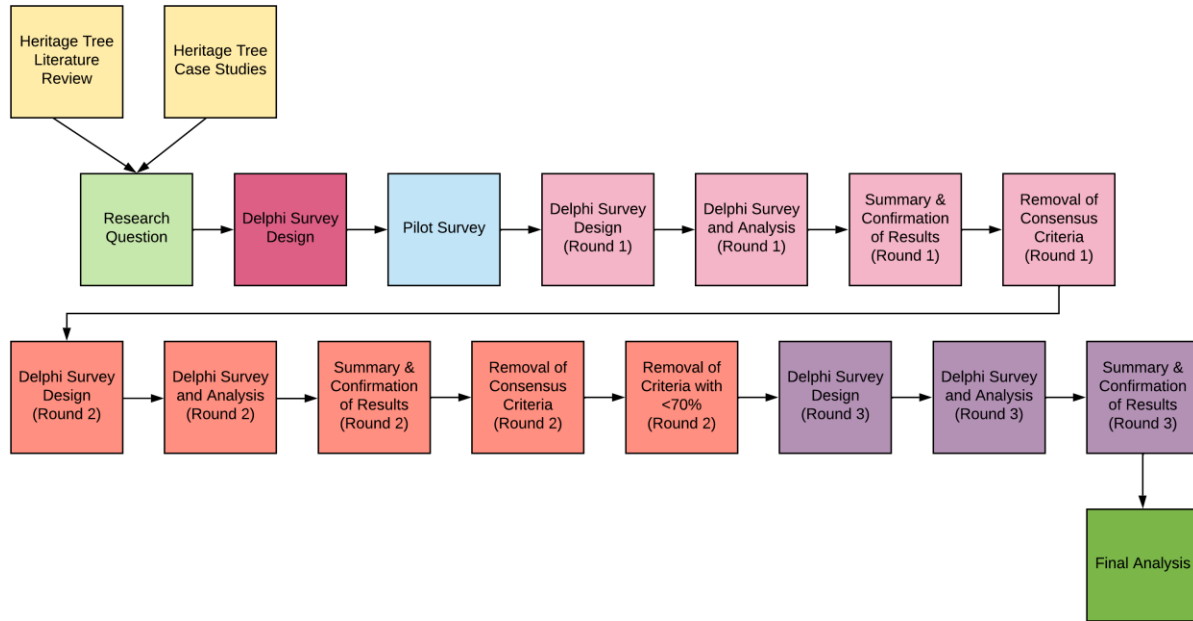


Figure 3. 1. South Australia and Hawai'i Exceptional Tree Delphi Methodological Phases.

A 5-point Likert scale based on criteria importance (1 = not at all important, 2 = slightly important, 3 = moderately important, 4 = significantly important, 5 = critically important) was used to assess all closed-ended questions. Open-ended questions allowed experts to expand upon their quantitative responses, provide feedback on all presented content (selection criteria and program components), suggest new content to be included in subsequent survey rounds, and elaborate their reasoning for any criteria that received a “not at all important” value. Content analysis was used to analyze the qualitative questions, as had been recommended by von der Gracht (2012) and Beiderbeck et al. (2021). The closed and open-ended question responses were provided to the entire panel between survey rounds so the opinions of their peers could be considered before the next survey iteration. All responses had personal identifiers redacted to ensure anonymity.

Expert Selection

A non-probability snowball sampling technique was used to form our Delphi panels, as expert opinion was the focus of our study rather than the general population (Keeney et al., 2006). Experts in our study were defined as “an individual who has extensive knowledge about an

exceptional tree program and its collective components. Examples of these experts may include exceptional tree committee members (e.g., National Trust Committee/Arborist Advisory Committee), academics, urban forestry department managers, directors of nonprofits and professional associations, etc.” They also had to meet the following four Delphi components produced by Adler and Ziglio (1996):

- 1) Knowledge and practical engagement with the issues under investigation.
- 2) The capacity and willingness to contribute to the exploration of a particular problem.
- 3) Assurance from the experts that they will be able to dedicate sufficient time to the Delphi exercise.
- 4) Skills in written communication and in expressing priorities through voting procedures.

The qualifications and expertise of each participant were verified by the study’s co-researcher, leading to a 10- and 13-member expert panel for South Australia and Hawai’i respectively based on the 10-15 expert panel size suggested by Adler and Ziglio (1996) and Skulmoski et al. (2007).

Level of Agreement and Percentage of Importance Values

For each survey round, expert level of agreement values were assigned to each criterion based on the cumulative value from the significantly important (Likert category 4) and critically important (Likert category 5) categories (e.g., if a criterion received 40% for the significantly important category and 20% for the critically important category, the level of agreement value would be 60%). The calculated level of agreement values were then grouped into one of four “percentage of importance” categories, high importance ($\geq 75\%$), medium importance (50-75%), low importance (25-50%), and very low importance ($< 25\%$) (see Mcleod, 2012; Ritchie et al., 2021 for similar Delphi ranking systems) (see Figure 3.2). For example, if a criterion obtained a 35% level of agreement value (“significantly” or “critically” important), this means that 65% of the expert panel felt that the criterion was “not at all,” “slightly,” or “moderately” important, which signifies low importance for an exceptional tree program. Conversely, if a criterion obtained an 80% level of agreement value (“significantly” or “critically” important), this means

that only 20% of the expert panel felt that the criterion was “not at all,” “slightly,” or “moderately” important, indicating the criterion had high importance for an exceptional tree program.

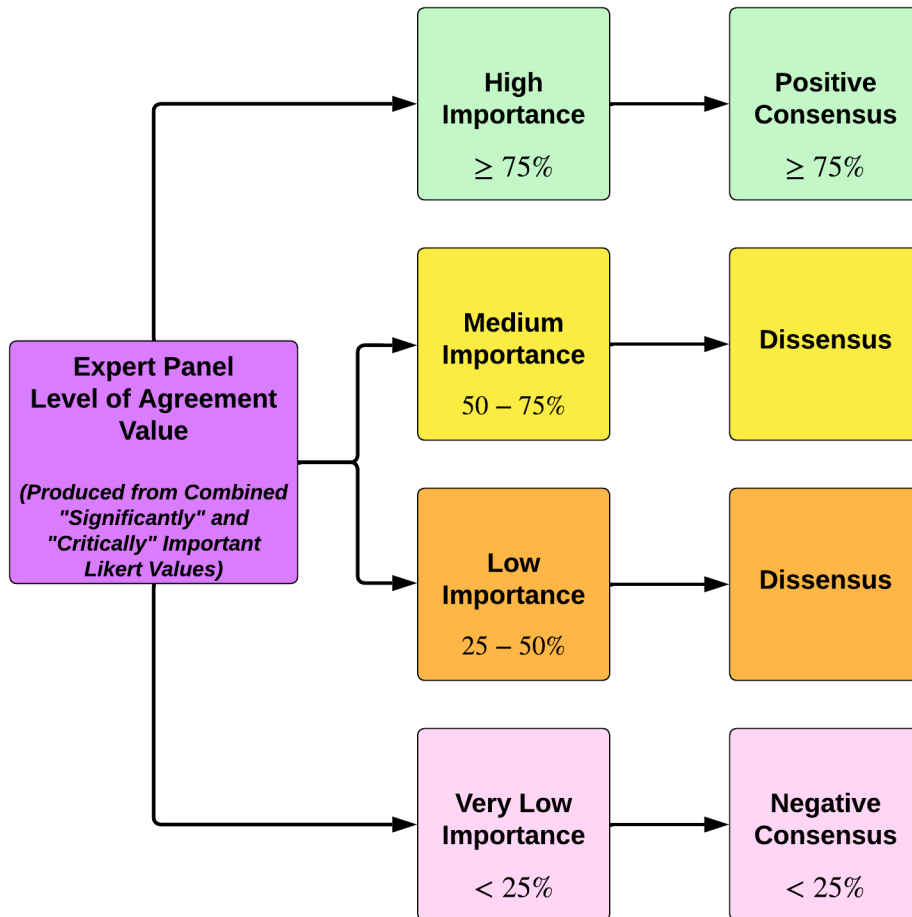


Figure 3. 2. Determination of Consensus and Dissensus Based on Percentage of Importance Categories Derived from Expert Level of Agreement.

Consensus Value

The consensus threshold was set at $\geq 75\%$ to ensure that the significant majority of the panel was in agreement regarding the importance of a criterion. Consensus for this study was divided into two types, positive and negative. Positive consensus was achieved if a criterion had a high importance value ($\geq 75\%$), while negative consensus occurred if a criterion had a very low importance value ($< 25\%$). Criteria that reached the positive consensus threshold were classified as recommended exceptional tree selection criteria and were removed from further discussion

in the study. Negative consensus criteria were also removed from the study, but were not recommended for inclusion in an exceptional tree program due to very low importance values. The large number of questions presented in the first iteration of the Delphi survey (100) was a key reason why consensus criteria were removed each round. This was done to allow dissensus criteria (those with medium and low importance values which failed to reach consensus) and open-ended questions to be focused on in rounds two and three. Dissensus criteria were re-evaluated by the panel in the subsequent survey, only after reviewing the responses and feedback produced by their peers during the prior round.

Expert Feedback

Feedback for each survey was provided in the form of a 1) full summary (graphs and tables, Likert-scale responses, level of agreement values, participant comments, and synthesized summaries), 2) shortened summary (level of agreement values and synthesized summaries), and 3) confirmation of findings document (listing positive and negative consensus criteria, including their level of agreement values and definitions, and also any recommended definition modifications). This last document initiated the confirmation of findings verification phase between survey rounds.

Confirmation of Findings Verification Phase

The confirmation of findings verification phase was conducted to confirm that one or more experts did not have significant opposition to any of the criteria that reached consensus (including their stated definitions) after reviewing feedback from their peers. If one or more experts disagreed with the consensus criteria outcomes and/or their stated definitions from the previous round, the criterion in question would be re-evaluated in the subsequent round based on the stated reasons for this decision. It is also important to note that an expert was not removed from the subsequent Delphi round if they failed to complete the confirmation of findings phase. However, if they did not respond to one of the three main Delphi rounds, they could no longer participate in the study (i.e., if they did not respond to round two, they would be omitted from the third round). The confirmation of findings phase was introduced for three

reasons. First, to instill greater confidence in the consensus findings produced throughout the study as the consensus criteria would have to reach the consensus threshold and not be explicitly problematic for one or more of the expert panel members. Second, to assist in preventing a bimodal occurrence where the expert panel could be divided on a criterion, but the overall level of agreement value could still potentially achieve consensus. The verification phase could mitigate this issue as an expert was able to ask for the consensus criterion to be re-introduced for further discussion and reanalysis if they were in opposition to the findings. Finally, to help ensure that the expert panel read the Delphi feedback summaries provided between survey rounds, as participants needed to review this content in order to respond to questions stated in the confirmation document.

Survey Rounds

A pilot test of the survey with four individuals not affiliated with the research was conducted prior to the onset of the first round. Modifications were suggested and used to produce the initial survey, which was emailed to the South Australia and Hawai'i expert panels in May 2022. The survey software "Qualtrics" was selected for the study's data collection and quantitative analysis.

Two weeks were allotted to each expert to complete the first round of the study, although extra time was provided to those who explicitly asked for it. Reminder emails were sent out approximately one week prior to the stated submission deadline for the survey round, with additional emails sent weekly to the panel members who had not responded by the deadline. Once all responses had been obtained, the quantitative and qualitative data were analyzed to produce three feedback summary documents (full summary, shortened summary, and confirmation of findings document). Responses from the first survey and the confirmation of findings verification phase were used to produce the content examined during the second round. The second survey included all criteria that had failed to reach consensus in the previous round, in addition to newly recommended selection criteria, criteria definition modifications, and open-ended questions focused on essential program components that should be included

in an exceptional tree program. Once the second round was released, it followed the same format as the first round. The third iteration of the study followed the same processes as the first two surveys, albeit with one modification. As this was the final round, in order to focus on criteria that were close to achieving positive consensus, as well as any remaining open-ended questions, any criterion with a level of agreement value <70% was omitted from the survey. However, if an expert wanted to see one or more criteria with a value of <70% re-introduced in the final round for additional discussion and voting, they could state which ones during the round two confirmation of findings phase.

Delphi studies have removed questions from the final survey iteration if the prior round saw consensus (Cheung et al., 2017), a significant lack of consensus (Mcleod, 2012), or minimal movement towards the consensus threshold (Ritchie 2021) transpire. The removal of stagnant dissensus criteria is to account for potentially increased attrition rates that could result from differing opinions that remain unresolved (see Belton et al., 2019, p. 78). The <70% criteria removal step in our study was implemented to maintain low attrition rates as experts had consistently indicated responses below the 75% consensus threshold for these criteria through the first two rounds.

Results

The following content compares and contrasts important Delphi methodological findings from our exceptional tree research conducted in South Australia and Hawai'i from May 2022-May 2023. These two studies used the same methodology and began with identical content, with the goal of identifying Delphi weaknesses to present solutions that could be used by others implementing this methodology. The results also highlight interesting findings pertaining to exceptional tree programs in each location.

Duration of Study

The entire duration of each Delphi study was 372 days for South Australia and 387 for Hawai'i (Appendix 1). South Australia's average expert response time for each round (not including the

verification phases) was 10.6, 12.8, and 16.3 days for rounds one, two, and three respectively for a cumulative average of 13.2 days throughout the study, while Hawai'i saw average response times of 17.9, 21.6 and 17.1 days per round and a cumulative average of 18.9 days. It is important to note that the significantly elevated duration for South Australia's round three confirmation of findings phase occurred to accommodate panel members in South Australia who explicitly stated they wanted to participate but needed more time, seeing 71 days allocated for this phase of the study. A benefit from this increased time allotment was a 100% response rate for this phase. Hawai'i's duration for this same phase was only 23 days due to a lack of response from experts despite multiple reminder emails, which resulted in the study's conclusion after being unable to contact these experts and seeing a response rate of 83% for the final verification phase.

The average amount of time for each survey to be returned by the panel (not including verification phases) increased for South Australia throughout the study (21, 37, and 52 days), while the opposite was seen for Hawai'i (73, 60, and 51 days).

The duration between survey rounds for South Australia was 33 days (Aug 10-Sept 11) and 28 days (Nov 17-Dec 14) for rounds 1-2 and 2-3 respectively, while Hawai'i saw values of 18 days (Sept 12-Sept 29) and 14 days (Feb 28-Mar 13).

The three verification phases at the end of each survey round added 108 days and 92 days to the overall Delphi study duration for South Australia and Hawai'i respectively (23, 14, and 71 days for South Australia and 15, 54, and 23 days for Hawai'i).

Attrition

Only one expert was lost from each panel throughout the duration of our study. South Australia saw this attrition during the second round, while Hawai'i saw this occur in the third round, leading to overall retention rates of 90% for South Australia and 92% for Hawai'i at the conclusion of our study. However, the verification phases for our Hawai'i case study did see

lower response rates (77%, 92%, and 83%) compared to the three main survey rounds (100%, 100%, and 92%). This trend was not seen with the South Australia expert panel, as response rates were 100% for all three verification phases.

Number of Questions per Survey Round

Both of our case studies saw decreases in the number of overall questions presented to each expert panel as the study progressed, mainly due to the removal of criteria that had achieved consensus in the prior round (Table 3.1). The increased number of open-ended questions seen in subsequent survey iterations allowed dissensus criteria and their definitions to be focused on, particularly addressing why a lack of agreement was taking place amongst the panel. The open-ended questions also allowed other exceptional tree program components to be discussed (i.e., protection mechanisms, public education and outreach, funding, climate change mitigation, etc.).

Table 3. 1. Number and Type of Questions Asked Per Delphi Survey Round Based on Case Study Location.

<u>Survey Iteration</u>	<u>Closed-Ended Questions</u>	<u>Open-Ended Questions</u>	<u>Total Number of Questions</u>
South Australia Round 1	45	55	100 (45% Closed, 55% Open)
Hawai'i Round 1	45	55	100 (45% Closed, 55% Open)
South Australia Round 2	34	54	88 (39% Closed, 61% Open)
Hawai'i Round 2	18	47	65 (27% Closed, 72% Open)
South Australia Round 3	15	27	42 (36% Closed, 64% Open)
Hawai'i Round 3	9	33	42 (21% Closed, 79% Open)

Consensus Criteria

The identical 45 exceptional tree selection criteria presented to both the South Australia and Hawai'i expert panels at the onset of the study ultimately became 59 and 47 criteria by the end of the study for each location respectively. South Australia's expert panel produced 14 criteria throughout the study, two of which were sub-criteria for the "*Indigenous Cultural Associations*" criterion. 12 of these were produced during the first round of the study, while the remaining two were identified during the second round (Table 3.2). Hawai'i's expert panel produced two

new criteria throughout the study (“*Socio-Cultural Benefits*”, and “*Survivor Tree*”), both in the second round.

Only one criterion from the initial 45 had a name change throughout the study. This was seen with the Hawai’i case study when the “*Legends, Mythical, Folklore*” criterion was changed to “*Legends and Oral Histories*”.

Table 3. 2. Criteria Produced by South Australia’s Expert Panel Throughout the Delphi Study.

Criterion	Round Produced
Veteran Age	Round Two
Era-Specific Age	Round Two
Human Modifications	Round Two
Natural Modifications	Round Two
Program-Specific Height	Round Two
Species-Specific Height	Round Two
Program-Specific Crown Spread	Round Two
Species-Specific Crown Spread	Round Two
Program-Specific Volume	Round Two
Species-Specific Volume	Round Two
Indigenous Culturally Significant Associations*	Round Two
Indigenous Culturally Modified Associations*	Round Two
Program-Specific Diameter	Round Three
Species-Specific Diameter	Round Three

* = Sub-criteria of “*Indigenous Cultural Associations.*” Not stand-alone criteria.

The number of criteria in each level of agreement category were similar for both case studies (Table 3.3). South Australia and Hawai’i both saw numerous criteria achieve consensus during the first survey. The reduced number of criteria examined each round was due to the removal of consensus criteria from the previous round so that dissensus criteria could be focused on.

Table 3. 3. South Australia and Hawai'i Selection Criteria Level of Agreement Values Per Category for Each Survey Round.

<u>South Australia</u>	<u>Percentage of Importance Category</u>	<u>Hawai'i</u>
<u>Survey Round One</u>		<u>Survey Round One</u>
15	High Importance	21
16	Medium Importance	14
6	Low Importance	4
8	Very Low Importance	6
45	Total	45
<u>Survey Round Two</u>		<u>Survey Round Two</u>
7*	High Importance	9
11	Medium Importance	6
13	Low Importance	3
3	Very Low Importance	0
34	Total	18
<u>Survey Round Three</u>		<u>Survey Round Three</u>
6	High Importance	3
4	Medium Importance	5
2	Low Importance	1
3	Very Low Importance	0
15	Total	9

* Two high importance criteria evaluated in this round are sub-criteria of the “*Indigenous Cultural Associations*” criterion. They are not stand-alone criteria on their own. This was decided by a majority of the expert panel during the second iteration of the survey.

Both case studies saw several exceptional tree selection criteria achieve positive and negative consensus based on high and very low level of agreement values respectively (Table 3.4).

Table 3. 4. Final Percentage of Importance Category Ratings for All Exceptional Tree Selection Criteria Presented in Each Case Study.

<u>South Australia Total</u>	<u>Percentage of Importance Category</u>	<u>Hawai'i Total</u>
26	High Importance	33
7	Medium Importance	6
10	Low Importance	2
14	Very Low Importance	6
57	Total	47

The large number of consensus criteria (high and very low importance) in both case study locations highlights that many different traits are used to identify these trees of importance at a statewide level regardless of country. For South Australia, if the consensus threshold was increased to 80%, 90% and 100%, 14, 11, and 2 criteria would have achieved consensus respectively, while Hawai'i would have seen 12, 9 and, 6 criteria for these same thresholds.

Significant agreement on exceptional tree selection criteria was also seen between our expert panels, as consensus thresholds of 75%, 80%, and 90% saw 21, 13, and 5 shared consensus criteria respectively for South Australia and Hawai'i (Table 3.5).

Criteria/Definition Changes Produced During Confirmation of Findings Verification Phases

South Australia saw 0 disagreements with the consensus criteria determined at the end of each survey round. However, five criteria definitions were contested by one or more experts ("Landmark/Location/Landscape," "Aesthetics," "Legends/Mythical/Folklore Value," "Botanical/Horticulture/Arboriculture/Biological Value," "Outstanding Example of Species," (the "Landmark/Location/Landscape", and "Legends/Mythical/Folklore Value" criteria each had definition modifications occur twice throughout the study based on expert feedback) and two criteria were introduced based on feedback from this confirmation of findings phase ("Program-Specific Circumference/Diameter," and "Species-Specific Circumference/Diameter"), the latter of which reached consensus during the final round of the study.

Hawai'i also saw no opposition to the derived consensus criteria determined at the end of each survey round, although, four criteria definitions were initially contested by some experts ("Ecological/Habitat Value," "Significant Environmental Value," "Legends and Oral Histories," and "Socio-Cultural Benefits"). All criteria definition modifications were resolved by each expert panel prior the conclusion of each case study.

Table 3. 5. Consensus Criteria Found in Both South Australia and Hawai'i Based on the Minimum Level of Agreement Shared by Both Case Studies.

South Australia	Criterion	Hawai'i
100.0	Endangered (•)	100.0
90.0	Rarity (§)	100.0
90.0	Indigenous Cultural Associations (§)	100.0
90.0	Cultural Value (§)	92.3
90.0	Social/Community Value (§)	92.3
100.0	Ecological/Habitat Value (‡)	84.6
100.0	National Interest (‡)	84.6
90.0	Historical Value (place, events, dates, etc.) (‡)	84.6
88.9	Botanical/Horticulture/Arboriculture/Biological (including genetic) Value (‡)	100.0
90.0	Remnant (‡)	84.6
80.0	Landmark/Location/Landscape (‡)	100.0
80.0	Local Significance (‡)	100.0
80.0	Relic Specimen (‡)	84.6
90.0	Historic Person/Memorial Planting (†)	76.9
90.0	Historical Witness (†)	76.9
90.0	Represented in Historical Documents (sketches, journals, photos, etc.) (†)	76.9
88.9	Collection/Grove/Avenue (†)	76.9
77.8	Specific Species/Species Significance (†)	92.3
77.8	Legends/Mythical/Folklore Value* (†)	84.6
77.8	Significant Environmental Value (†)	84.6
77.8	Aesthetics (†)	84.6

Note: The following icons/colors represent the minimum consensus threshold value shared by South Australia and Hawai'i for each criterion - "•"/red = 100%, "§"/purple = ≥90%, "‡"/blue = ≥80%, and "†"/green = ≥ 75%

*Originally titled "Legends/Mythical/Folklore Value." Modified to "Legends and Oral Histories" in the Hawai'i case study to reflect expert consensus at the conclusion of the study

Discussion

Number of Questions Throughout Study

Frontloading our first round with the greatest number of total questions allowed consensus content to be identified and removed, leaving more time in subsequent survey rounds to focus on dissensus content and in-depth open-ended responses that built on the foundation

produced from the initial survey's content. This process also followed the advice of McPherson et al. (2018) who stated that the goal of a Delphi's first round is to identify a substantial amount of content on the phenomenon. We found that having a large number of questions in the first round also had the added benefit of filtering out any experts that may be lost to attrition early on in the study, while also acting as a positive motivator, as the experts were made aware that subsequent iterations would contain fewer questions.

Defining, Recruiting, and Retaining the Expert Panel

The recommendation of 10-15 experts in a Delphi study by Adler and Ziglio (1996) and Skulmoski et al. (2007) worked well in both of our studies, although we recommend that 15 well-qualified and committed participants should be included to account for any attrition. The 10 and 13 experts in our South Australia and Hawai'i case studies respectively were able to come to consensus on numerous exceptional tree criteria, while also ensuring that the amount of feedback was manageable for both the researcher to process and the expert panel to absorb (see Belton et al., 2019). Furthermore, our findings suggest that attempting to reduce expert attrition will generally lengthen the study's duration and also require expert retention techniques to be implemented concurrently, such as those proposed by Franklin and Hart (2007), Keeney et al., (2011), and Donohoe et al. (2012).

Study Duration

Our study duration of 372 days for South Australia and 387 for Hawai'i is longer than many Delphi studies published, although this is not surprising given the three confirmation of findings verification phases that we included, and the ample amount of time provided to experts to respond to each survey iteration. The average expert response time per round (not including the confirmation of findings phase) of 13.2 and 18.9 days for South Australia and Hawai'i respectively, is in line with what others have recommended should be allotted to participants (Delbecq et al., 1975; Duffield, 1993). The average duration for each round (33.7 days for South Australia and 61.3 days for Hawai'i) is also in agreement with other Delphi studies (English & Kernan, 1975; Duffield, 1993; Ritchie, 2021). Finally, our average duration between survey

rounds (30.5 days for South Australia and 16 days for Hawai'i) is in line with what others have recommended (Hohmann & Brand, 2018), showing a relatively quick turnaround between Delphi iterations by the researchers, especially with both studies being run concurrently. This was accomplished by simultaneously conducting the data collection and analysis phases. These findings show that the duration of our Delphi phases was optimal, albeit for the additional time produced by the confirmation of findings phase for each round.

Confirmation of Findings Verification Phases

The 108 and 92 days added to the overall Delphi study duration for our South Australia and Hawai'i case studies respectively due to the confirmation of findings verification phase was significant. However, we recommend this step should be included as part of a Delphi study as long as there is sufficient time to do so. The benefits of this extra phase, such as greater confidence in consensus criteria, outlier responses easily accounted for, re-introduction of consensus criteria if requested, definition modifications, and creation of newly suggested criteria are invaluable to the overall validity of the Delphi process and can help ensure that consensus and stability have been achieved. This extra verification is especially important when removing consensus criteria at the end of each survey, rather than at the end of the study, as the panel is still able to review all feedback from the previous survey round and experts can request the re-introduction of consensus criteria in the subsequent iteration based on this feedback.

Attrition

The total attrition rates of 10% and 8% for South Australia and Hawai'i respectively are low compared to what others have seen, such as 27-48% (McKenna & Hasson, 2002), 38% (Sourani & Sohail, 2015), 54% (Boel et al., 2021), 91% (Duffield, 1993), and 92% (Cooney et al., 1995), and is particularly important considering our study's relatively-long duration

Low attrition rates were also seen by Toronto (2017), McKenna et al. (2001), and McKenna (1989) with 87%, 97%, and 100% respectively due to expert retention techniques, such as

building relationships with the participants, ensuring interest in the study topic, follow-up communication, and gaining buy-in and ownership of the research.

The low attrition values for both of our expert panels could be attributed to six key aspects. First, personalized correspondence took place throughout the study, specifically reminder emails to encourage participation (generally one to three times per Delphi round) (McKenna & Hasson, 2002). Second, a substantial amount of time was provided to accommodate the busy schedules of experts who sometimes required longer to respond than initially anticipated. Third, three summary documents (full summary, shortened summary, and confirmation of findings verification document) were provided to the expert panel after each Delphi round to improve the absorption of panel feedback. This was done to avoid overwhelming our expert volunteers with a single large summary for each survey. Fourth, the removal of criteria that had achieved consensus each round, in addition to those that represented dissensus <70% after the second round, may have also improved attrition rates by removing the need to repeatedly assign level of agreement values to criteria that had clearly achieved consensus, or had been evaluated and not changed in any meaningful way between survey rounds. Fifth, topic interest and/or other rewards (e.g., exceptional tree program improvements derived from the study's findings which could be valuable and useful for the participants) may have reduced attrition rates (Keeney et al., 2001). Finally, the extra time provided between and within survey rounds may have reduced participant response fatigue and allowed a longer duration to consider the feedback of other experts, while the three detailed summaries for each round provided an opportunity for all content to be reviewed and retained even after this extensive duration.

These findings suggest that a longer Delphi study and low attrition rates can be complementary factors, rather than competing ones, as providing more time and flexibility for experts to respond can lead to higher response rates, as long as expert retention tactics are implemented concurrently (see Franklin & Hart, 2007; Keeney et al., 2011; Donohoe et al., 2012).

Determining a Consensus Threshold

Common Consensus Criteria Across Case Studies

When comparing the 16 consensus criteria found by Ritchie et al. (2021) to our own from South Australia and Hawai'i, it was discovered that South Australia shared 14 of these criteria, while Hawai'i comprised all 16 (Table 6).

Table 3. 6. Comparing the 16 Exceptional Tree Consensus Criteria Identified by Ritchie et al. (2021) to those Found in our Study Based on Level of Agreement.

<u>South Australia</u>	<u>Level of Agreement</u>	<u>Hawai'i</u>
14/16 (88%)	≥75%	16/16 (100%)
14/16 (88%)	≥80%	12/16 (75%)
11/16 (69%)	≥90%	9/16 (56%)
2/16 (13%)	≥100%	6/16 (38%)

The 14 common exceptional tree consensus criteria across these studies can be found in Table 3.7, which also highlights those that were used by <20% of the 46 case studies examined by Ritchie (2019). This amounts to 8/14 (57%) of these criteria seldomly being used, potentially indicating a disconnect between the criteria currently being used to identify exceptional trees and those that experts recommend.

Level of Agreement

Comparing our findings to those from Ritchie (2021), it is clear that the 75% level of agreement consensus threshold works well for both of our case studies. We advocate that this level of agreement threshold should continue to be used going forward for exceptional tree and urban forestry related topics. However, a modification to the consensus analysis could be the introduction of unique terms to differentiate levels of consensus, such as “unanimous consensus” (100%), “significant consensus” (≥90%), “moderate consensus” (≥80%), and “minor consensus” (≥75%).

Table 3. 7. Fourteen Shared Exceptional Tree Consensus Criteria Found Between South Australia, Hawai‘i, and International Case Studies* Based on their Level of Agreement ($\geq 75\%$ Threshold).

<u>Common Criteria Across All Case Studies</u>	<u>International Case Studies*</u>	<u>South Australia</u>	<u>Hawai‘i</u>
Botanical/Horticulture/Arboriculture/Biological Value	93.3%	88.9%	100%
Cultural Value	80.0%	90.0%	92.3%
Endangered ‡	86.7%	100%	100%
Historic Person/Memorial Planting	80.0%	90.0%	76.9%
Historical Value ‡	100%	90.0%	84.6%
Historical Witness	78.6%	90.0%	76.9%
Indigenous Cultural Associations ‡	80.0%	90.0%	100%
Landmark/Location/Landscape	93.3%	80.0%	100%
Local Significance ‡	93.3%	80.0%	100%
National Interest ‡	93.3%	100%	84.6%
Rarity	86.7%	90.0%	100%
Remnant ‡	92.9%	90.0%	84.6%
Represented in Historical Documents ‡	86.7%	90.0%	76.9%
Social/Community Value ‡	80.0%	90.0%	92.3%

* = 16 selection criteria produced by Ritchie (2021).

‡ = 8 selection criteria that are not significantly utilized ($< 20\%$) by the 46 programs evaluated by Ritchie (2019).

§ = Identified as “Aboriginal Association” by Ritchie (2019).

Combining Level of Agreement, Interquartile Range, and Coefficient of Variation to Measure Consensus and Stability

The 75% level of agreement to determine consensus worked well for our study. While the interquartile range (IQR) and coefficient of variation (CV) were not used during our study, for the purpose of this paper we quantified their values to evaluate their potential effectiveness as Delphi consensus and stability metrics. Appendices 2-5 compare these three-consensus metrics [level of agreement ($\geq 75\%$), IQR (≤ 1), and CV (≤ 0.5)] for our South Australia and Hawai‘i case studies, while also examining the concept of stability [CV (≤ 0.5)].

The tables highlight significant agreement between these three-consensus metrics, as well as the minimal dispersion of expert responses for each criterion within and between survey rounds

to identify stability. These findings suggest that all three of these metrics could be used in combination with one another to determine if consensus and stability have been reached in a Delphi study, particularly one that removes consensus criteria between successive iterations (Figure 3.3).

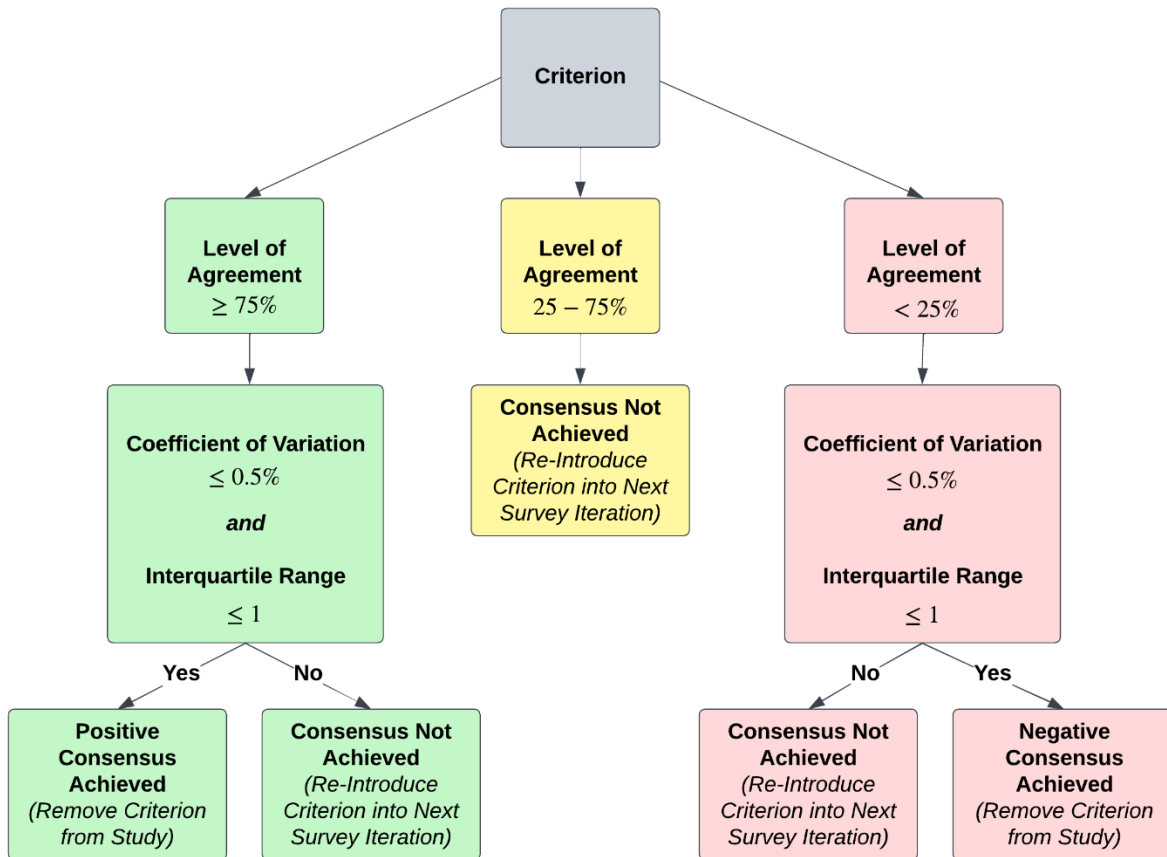


Figure 3. 3. Decision Tree to Determine Delphi Consensus Through the Collective Use of Level of Agreement, Interquartile Range, and Coefficient of Variation.

While not mandatory, using all three metrics to determine consensus could strengthen the confidence that expert consensus has been reached, while also monitoring for stability between rounds for criteria that failed to reach the consensus threshold during the previous survey iteration. If time is available, including a confirmation of findings verification phase between survey rounds could further help to improve validity and confidence in the study’s results. If using the aforementioned method is not possible, we suggest the following two alternatives to accommodate for potential time or attrition concerns. First, if the amount of time to complete

the study is a concern (but not attrition rates), a 75% level of agreement, ≤ 1 interquartile range, and ≤ 0.5 coefficient of variation should collectively be used to determine consensus. Second, if attrition rates are a concern (but not the amount of time to complete the study), a 75% level of agreement value should be used in combination with a confirmation of findings verification phase between survey rounds to determine consensus. However, future studies will need to replicate this process to see if the stability and tri-consensus measurements presented here are applicable to other Delphi studies.

Conclusion

The Delphi method used in our studies identified 27 and 33 consensus criteria for South Australia and Hawai'i respectively, in addition to numerous program components (protection mechanisms, public education and outreach, funding, climate change mitigation, etc.,) that should be utilized by these conservation program to improve their effectiveness. The use of a 75% consensus threshold based on expert level of agreement worked well for both studies and is in agreement with what others have recommended for a Delphi study. We recommend that a 75% level of agreement value should be the minimum threshold for consensus in a Delphi study that examines "exceptional trees," as well as urban forestry and conservation topics more broadly. Furthermore, our findings show that future Delphi studies could consider combining a 75% level of agreement, ≤ 1 interquartile range, and ≤ 0.5 coefficient of variance to further improve confidence when identifying if positive consensus and stability among responses have occurred. We also recommend providing ample time for experts to respond to each round. Our study has shown that catering to the temporal needs of the expert panel, in conjunction with the implementation of expert retention techniques, can significantly reduce attrition, suggesting that these two aspects should be Delphi priorities over a study's total duration.

Future research should consider the following four components. First, this study should be replicated in South Australia and Hawai'i with a different group of experts to further verify what our findings have shown. Second, this study should be replicated in different locations that have exceptional tree programs to see if the 14 exceptional tree consensus criteria shared between

our two case studies and those from Ritchie et al. (2021) are found elsewhere, potentially identifying a universal set of exceptional tree selection criteria. Third, locations that have, or are planning to design an exceptional tree program should implement this Delphi method to ensure that selection criteria and program components are based upon the opinions of local exceptional tree experts. Finally, future studies that use the Delphi method should consider combining CV (≤ 0.5), IQR (≤ 1), and level of agreement ($\geq 75\%$) when deciding which metrics will be used to determine consensus and stability.

The Delphi method may have its known limitations but the benefits it provides outweigh the costs. Its ability to rely upon anonymity to derive knowledge on a novel topic through the use of expert consensus sets it apart from other methods, while also providing the foundation for future research opportunities. Potential concerns associated with this method, particularly consensus values, attrition rates, and study duration, could be improved based on the suggestions provided in this paper, allowing the Delphi method to accomplish its intended purpose of producing new knowledge that can address important needs identified in the academic literature and throughout society.

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CHAPTER 4: IDENTIFYING ESSENTIAL SELECTION CRITERIA AND PROGRAM COMPONENTS TO IMPROVE HAWAI'I'S EXCEPTIONAL TREE PROGRAM BASED ON EXPERT CONSENSUS

Abstract

Hawai'i's exceptional trees are currently identified based on 7 selection criteria established in 1975. These criteria and their corresponding program components (i.e., protection mechanisms, public education and outreach, funding sources, climate change mitigation plans, etc.) have remained stagnant with minimal improvements since the program's inception. This study builds upon previous exceptional (aka "heritage," "significant," "champion," "monumental," "notable," etc.) tree research conducted in other geographic locations, in an attempt to discover if consensus exists regarding how these trees of importance should be identified, managed, and protected. Forty-five exceptional tree selection criteria and several program components (i.e., protection mechanisms, public education and outreach, program management best practices, etc.) were presented to a panel of 13 experts from around the state using a three iteration Delphi method to determine if consensus exists on which criteria and program components should be used by an exceptional tree program in Hawai'i. The result saw 33 exceptional tree selection criteria and 8 program mechanisms recommended by the expert panel, as well as examples of how each should be implemented to improve the efficacy of this conservation program. These findings add to a growing body of exceptional tree research designed to identify, recognize and protect a region's most valued trees.

Introduction

There has been a plethora of names used to denote trees of importance, including 60 identified by Jim (2017). While these terms include "exceptional," "heritage," "significant," "champion," and "monumental" trees (Ritchie, 2019, p.17), the specific name used is often based on where the respective program is located even, even though different terms may represent similar selection criteria (Ritchie et al., 2021). As the State of Hawai'i was the geographic focus of this

study, the term “exceptional tree” will be used exclusively to describe these specimens (including when referring to other studies which may use similar terms).

Exceptional trees around the world have been identified by at least 40 unique criteria (see Ritchie, 2019, p. 18-19) such as historical value, cultural value, aesthetics, size (Clark et al., 2020), botanical value, and ecological value (Britton et al., 2015; Lau et al., 2017). Exceptional tree programs can be found from local (Village of Glenview, 2013) to national (National Parks Board Singapore, 2017) scales and on public and private land (City of San Diego, 2005; Britton et al., 2015; City of Milpitas, 2016). These programs often have an educational focus (Nebraska Forest Service, 2018), with some also including legal protections (City of Portland, 2016; Hawai‘i State Legislature, 1975). Legal protections can exist at various levels including municipal (City of Melbourne, 2012), state/provincial (Forests Ontario, 2017; Hawai‘i State Legislature, 1975), and national (Jim, 2004) scales, although even with these protections high mortality rates can still occur (Jim, 2005; Chen, 2015). For example, one notable loss of exceptional trees took place between 1986-1995 in Guangzhou, China when 21.5% of their exceptional trees died (Jim, 2004). Instances such as these are largely the result of anthropogenic factors such as roadwork and construction (Jim, 2004; Jim, 2005). The loss of these iconic and irreplaceable trees (Lau et al., 2017) is often one of the motivating factors in beginning (City and County of Honolulu, 2021) or restarting (McNamara & Carter, 2006) an exceptional tree program, as these programs are designed to conserve these unique tree specimens (Britton et al., 2015), the largest of which act as keystone structures (Stagoll et al., 2012) in urban forests which have been valued at \$2.4 trillion in the United States alone (Nowak et al., 2002).

Hawai‘i’s Exceptional Tree Program

Hawai‘i’s exceptional tree program began in 1975 when the state legislature passed S.B. NO. 106 Act 105, becoming Hawai‘i Revised Statutes Chapter 58 which was designed to “*safeguard exceptional trees from destruction due to improper land development*” (Hawai‘i State Legislature, 1975, p. 186; Department of Land and Natural Resources, Division of Forestry and Wildlife, 2019). This legislation mandates each of the state’s four counties to enact legal

protections for trees and/or groves of trees that comprise one or more of the seven following selection criteria: “historic or cultural value,” “age,” “rarity,” “location,” “size,” “esthetic quality,” or “endemic status” (Hawai‘i State Legislature, 1975, p. 187). Trees of exceptional status in each county are evaluated by their respective Arborist Advisory Committee (AAC), and nominees deemed worthy are submitted to the City/County Council for approval through an ordinance process (Kaua‘i County n.d.; Maui County Arborist Advisory Committee, 2016; Hawai‘i County, 2017; American Legal Publishing, 2022).

Hawai‘i’s exceptional tree protection mechanisms focus on regulations and incentives. State regulations administered by each county prohibit the removal of designated exceptional trees (Hawai‘i State Legislature 1975), although each county implements slight variations on the strict process to remove exceptional trees. For the City and County of Honolulu, these trees can only be removed if approval is first obtained from the City Council, or in emergency situations where “*there is imminent danger to life or property*” (American Legal Publishing, 2022, p. 1). In Maui County, a property owner can request the Director of Parks and Recreation and Arborist Advisory Committee to examine an exceptional tree, although approval to remove one of these trees rarely occurs and is generally due to the tree being “*dead, diseased, irretrievably damaged, or is a hazard to the public or welfare*” (Maui County Arborist Advisory Committee, 2016, p. 88). Kaua‘i County requires that the county council approve any removal of exceptional trees (Kaua‘i County, n.d.), while Hawai‘i County has the most substantial protections as “*it shall be unlawful for any person, corporation, public agency or other entity to substantially damage, remove or destroy an exceptional tree in the County*” (Hawai‘i County, 2017, p. 14-27).

The intent of this research is to utilize the opinions and preferences of exceptional tree experts in Hawai‘i to define which traits should be used to characterize Hawai‘i’s most iconic trees. These results add to a growing body of exceptional tree research designed to identify, recognize, and protect a region’s most valued trees (see Jim, 2004; Jim, 2005; Jim & Zhang, 2013; Britton et al., 2015; Chen, 2015; Jim, 2017; Lau et al., 2017; Ritchie, 2019, Ritchie et al., 2021). Furthermore, many of the solutions identified in our study could be applicable to other urban

forestry conservation programs that experience similar issues, specifically program components such as protection mechanisms, public education and outreach, funding sources, climate change mitigation plans, etc.

Methods and Materials

The Delphi Method

The 50 “heritage tree” selection criteria identified by Ritchie et al. (2021), in addition to several open-ended questions, were used as the foundation for this modified Delphi study. The Delphi method is ideal for instances where there is inadequate and/or incomplete knowledge about a topic (Skulmoski et al., 2007) and relies upon the use of expert opinions (Okoli & Pawlowski, 2004). The process is dependent on anonymity, survey iterations and controlled feedback (Rowe & Wright, 1999) to allow opinions to converge towards consensus through multiple iterations (Dalkey & Helmer, 1963, p. 458). Three survey iterations are commonly used by the Delphi method (Jones et al., 1992; Skulmoski et al., 2007), there are no minimum or maximum number of experts attributed to this method (Evans, 1997), although 10-15 participants are generally considered to be ideal (Adler & Ziglio, 1996; Skulmoski et al., 2007), and the selection of the expert panel uses a non-probability snowball sampling technique (Keeney et al., 2006). Likert scales are used to obtain quantitative responses (Shah & Kalaian, 2009; von der Gracht, 2012) and percentage of agreement in the two upper Likert categories (Mcleod, 2012; von der Gracht, 2012; Stewart et al., 2017) and measures of central tendency (von der Gracht, 2012) are used to quantify the data. Once a criterion reaches consensus, it should be removed from further discussion in the study (Stewart et al., 2017; Ritchie et al., 2021) and verification of the previous survey’s findings takes place with the expert panel between survey rounds (Mcleod, 2012; Ritchie et al., 2021). There is no set value for consensus in the literature (Keeney et al., 2006). This value is topic-dependent with medical decisions sometimes requiring 100% agreement (Keeney et al., 2006), while studies pertaining to environmental topics such as vulnerability and adaptation assessments might require only 70% (Mcleod, 2012).

Exceptional Tree Delphi Research Method

This research follows the three-iteration Delphi methodology used by Ritchie et al. (2021). The initial survey was comprised of 45 exceptional tree selection criteria and eight program components that were evaluated through the use of closed and open-ended questions. A five-point Likert scale (1 = not at all important, 2 = slightly important, 3 = moderately important, 4 = significantly important, 5 = critically important) was used to evaluate the presented criteria. The combined Likert scale ratings for categories 4 & 5 were used to produce “percentage of importance” values for each criterion, with $\geq 75\%$ representing high importance, 50-75% medium importance, 25-50% low importance, and $< 25\%$ very low importance (e.g., if a criterion received 50% for the significantly important category and 30% for the critically important category, its percentage of importance value would be 80%). Positive expert consensus was defined as any criterion achieving a percentage of importance value of $\geq 75\%$, while negative consensus was any criterion with a percentage of importance value of $< 25\%$. Criteria that achieved consensus (positive or negative) were omitted from future survey iterations, with positive consensus criteria being recommended for use in Hawai‘i’s exceptional tree program, while negative consensus criteria should not. A *confirmation of findings* verification phase preceded each subsequent survey round to ensure the panel didn’t have any objections with the findings from the previous survey round and to provide an opportunity to suggest additional criteria, definition modifications, and content that should be included in the upcoming survey round.

Each survey iteration was designed to take approximately 45-60 minutes to complete. 13 exceptional tree experts were selected to participate in the study and were identified using a snowball sampling method to ensure that participants represented government agencies, nonprofits, private corporations and community experts, all of which are important contributors to exceptional tree programs (Ritchie, 2019).

The criteria used to select each expert was based on the following four components produced by Adler & Ziglio (1996):

- 1) Knowledge and practical engagement with the issues under investigation
- 2) The capacity and willingness to contribute to the exploration of a particular problem
- 3) Assurance from the experts that sufficient time will be dedicated to the Delphi exercise
- 4) Skills in written communication and in expressing priorities through voting procedures

The study defined exceptional tree experts as “an individual who has extensive knowledge about an exceptional tree program and its collective components. Examples of these experts may include exceptional tree committee members (Arborist Advisory Committee), academics, urban forestry department managers, directors of nonprofits and professional associations, etc.” Hawai‘i’s premier exceptional tree professionals were selected as experts for this study. These individuals collectively provided a comprehensive analysis of the state of Hawai‘i’s Exceptional Tree Program based on the different sectors they represented (i.e., government, private, and nonprofit). The study’s co-researcher verified that each expert possessed the required qualifications to participate in the study.

Results

Selection Criteria

The first survey saw a response rate of 100% with an average submission time of 17.9 days. 96 closed and 24 open-ended questions were presented to the panel. Of the 45 criteria examined, there were 21 high, 14 medium, 4 low and 6 very low percentage of importance values (Table 1), amounting to 27 criteria reaching consensus, with 21 being positive consensus and six representing negative consensus. There were no objections to these results by the expert panel during the *confirmation of findings* stage.

The second survey once again had a 100% response rate with an average submission time of 21.6 days. 55 closed and 21 open-ended questions were presented to the panel. The 18 remaining criteria examined saw 9 high, 6 medium, 3 low and 0 very low importance values, indicating 9 additional criteria achieving positive consensus. There were no objections to these results by the expert panel during the confirmation of findings stage. Additionally, in accordance with the study's methodology, the remaining 9 criteria with medium (6) and low (3) percentage of importance values were scheduled to be removed from the third round due to having values <70%. However, during the *confirmation of findings* verification phase that took place between the second and third survey rounds, members of the expert panel indicated that seven of these nine selection criteria should still be included for discussion and re-evaluation in the final round due to their perceived importance ("Growth Conditions," "Biological Heritage," "Form/Structure/Morphology," "Oldest Specimen in Region," "Species-Specific Age," "Resistant to Disease/Climate Conditions," and "Other Unique Qualities").

The final round of the survey had a 92% response rate with an average time of 17.1 days. 41 closed and 10 open-ended questions were presented to the panel. The 9 criteria examined (7 recommended by the expert panel from the previous round and 2 additional criteria produced during the second round), saw 3 high, 5 medium, 3 low and 0 very low percentage of importance values, indicating 3 positive consensus criteria. There were no objections to these results by the expert panel during the *confirmation of findings* stage.

Of the 47 selection criteria considered by the expert panel throughout this study (Table 2), 39 reached consensus. 33 achieved positive consensus and are recommended for inclusion in Hawai'i's exceptional tree program (see Table 3 for criteria definitions), whereas the 6 negative consensus criteria should not. Furthermore, the most significant findings identified during the study can be found below and are divided based on selection criteria and program mechanism topic.

Unexpected Selection Criteria Findings

Age

No *Age* criteria achieved a high percentage of importance throughout the study. The lack of support for including these criteria in Hawai'i's exceptional tree program stems from the issues associated with identifying tree age and determining species-specific age thresholds, along with the notion that even though a tree is old, it may not represent exceptional characteristics. It was noted by one of the experts that the "Species-Specific Age" criterion would require a significant amount of time and research to produce the required threshold values, which the current Arborist Advisory Committees are unable to do at this time. Assigning species-specific thresholds can become even more complex when the local environment is taken in to consideration, as the lifespan of a given species in Hawai'i may be different than ages found in the species' native range and environmental conditions. Opposition was seen from the expert panel towards using the "Program-Specific Age" criterion due to the single threshold it utilizes, which fails to take into consideration the different lifespans species can have (i.e., what is considered old for one species may be young for another). Furthermore, several experts agreed that age is only moderately important when determining exceptional status in Hawai'i and that health and location (i.e., enough space to grow) considerations take precedence over age.

6 out of 11 experts also noted that thresholds for the "Species-Specific Age" criterion should be based on what is considered old for the species in a program's geographic region, rather than where the tree species originated. These thresholds take into consideration the impacts that local environmental and climatic conditions can have on tree age. For example, an *Albizia saman* (Monkeypod) tree in Hawai'i may be considered old at 70 years of age, whereas in its native environment in Central America, 100 may be considered old. However, it was noted by some on the panel that while a "Species-Specific Age" criterion would be interesting to use in Hawai'i's exceptional tree program, extensive research would need to be conducted before its implementation, something that the current AACs in charge of exceptional tree programs throughout Hawai'i may not be able to do on their own. Of the remaining five experts, one felt

that the known natural lifespan of a species (non-location specific age) should determine the age threshold, two thought both local environment and natural lifespan age thresholds were important, and the remaining two experts thought neither should be used due to the aforementioned difficulties in determining tree age, and that age criteria should not be examined independently of health, structure and location considerations.

Size

The single biggest concern for criteria in the *Size* category related to thresholds used to denote exceptional status. Several experts opposed the use of the “Program-Specific/Non-Champion Size” criterion as it could omit trees that are large for their species, but are below the stated threshold for the program. The “Species-Specific Size” criterion was viewed as important, but similar to the “Species-Specific Age” criterion, requires substantial time and effort to derive the size metrics that will be used for each species. To help remedy this, three research based suggestions were provided by the expert panel regarding how to determine thresholds for the “Species-Specific Size” and “Species-Specific Age” criteria. First, botany texts and credible websites should be reviewed. Second, known size and age values based on historical and current observations for a given species should be analyzed. Finally, collaborative research should be conducted with college classes (as a project), community volunteers, and exceptional tree committee members to produce some of these species-specific thresholds.

Historical Value

Collective feedback for criteria in this category highlighted the importance of requiring proven and factual information so these criteria could be implemented correctly, evaluating candidates on a case-by-case basis, and giving greater weight to a tree that played a part in a historical event, rather than merely being around during a certain point in time that is classified as being historical (e.g., a certain era).

Key Findings and Discrepancies for Hawai'i's Exceptional Tree Program Components

Key findings from the panel pertaining to exceptional tree program mechanisms in Hawai'i can be found below in Table 1. As some experts did not respond to all questions, the number of experts that provided feedback were identified when necessary.

Protection Mechanisms

The panel unanimously agreed (13/13 experts) that legal policies, regulations and protections should be imposed to assist exceptional trees in Hawai'i. Many on the panel stated that the current format of the program (i.e., each exceptional tree is protected unless it poses a hazard risk to humans or property and/or no longer possesses the exceptional trait it was nominated for, requires a permit for pruning, retains its exceptional status even when a property changes ownership, etc.) works well, although, enforcement of such laws and regulations need to be effectively implemented. One expert suggested that Arborist Advisory Committee (AAC) members could act as "enforcers" for the program, however, as the AAC relies upon volunteers and has minimal resources, this would be unlikely to transpire. Regardless of who acts as the enforcers of an exceptional tree program, it was made clear that one or more entities need to take the lead on promoting and protecting Hawai'i's exceptional tree program to ensure its success.

Enforcement of Legal Policies/Regulations

Many on the panel agreed that enforcement capabilities should be provided to an Arborist Advisory Committee to improve the effectiveness of current protections. It was also noted that other county departments would need to be involved in this enforcement process (i.e., Parks and Recreation/Division of Urban Forestry, Planning and Permitting, etc.) to improve the monitoring of known threats to exceptional trees. Specifically, whenever an exceptional tree is in an area scheduled for development/construction, the Department of Planning and Permitting should inform both the Department of Parks and Recreation/Division of Urban Forestry and the county's Arborist Advisory Committee. It was also advised that neighborhood watch and citizen forester programs should be approached to take on a supporting role to assist enforcement

Table 4. 1. Exceptional Tree Selection Criteria Percentage of Importance Values Throughout Three Rounds.

Criterion	Percentage of Importance R1	Percentage of Importance R2	Percentage of Importance R3	Final Percentage of Importance
Endangered	100.0	N/A	N/A	100.0
Rarity	100.0	N/A	N/A	100.0
Botanical/Horticulture/Arboriculture/Biological Value	100.0	N/A	N/A	100.0
Indigenous Cultural Associations	100.0	N/A	N/A	100.0
Local Significance	100.0	N/A	N/A	100.0
Landmark/Location/Landscape	100.0	N/A	N/A	100.0
Champion Size - Cumulative Points	61.5	100.0	N/A	100.0
Specific Species/Species Significance	92.3	N/A	N/A	92.3
Cultural Value	92.3	N/A	N/A	92.3
Species-Specific Size	69.2	92.3	N/A	92.3
Social/Community Value	92.3	N/A	N/A	92.3
Ecological/Habitat Value	84.6	N/A	N/A	84.6
Significant Environmental Value	84.6	N/A	N/A	84.6
Remnant	69.2	84.6	N/A	84.6
Relic Specimen	84.6	N/A	N/A	84.6
Aesthetics	84.6	N/A	N/A	84.6
Seed Source/Propagation Stock	69.2	84.6	N/A	84.6
National Interest	84.6	N/A	N/A	84.6
Religious/Spiritual Value	84.6	N/A	N/A	84.6
Legends and Oral Histories*	61.5	84.6	N/A	84.6
Historical Value (place, events, dates, etc.)	84.6	N/A	N/A	84.6
Socio-Cultural Benefits	Introduced in R3	Introduced in R3	83.3	83.3
Resistant to Disease/Climate Conditions	53.9	69.2	83.3	83.3
Economic Benefits	53.9	76.9	N/A	76.9
Productive Trees	38.5	76.9	N/A	76.9
Outstanding Example of Species	76.9	N/A	N/A	76.9
Historic Person/Memorial Planting	69.2	76.9	N/A	76.9
Represented in Historical Documents (sketches, journals, photos, etc.)	76.9	N/A	N/A	76.9
Historical Witness	69.2	76.9	N/A	76.9
Collection/Grove/Avenue	76.9	N/A	N/A	76.9
Champion Size - Category	76.9	N/A	N/A	76.9
Non-Specific Size	76.9	N/A	N/A	76.9
Form/Structure/Morphology	53.9	46.2	75.0	75.0
Endemic	69.2	69.2	N/A	69.2
Biological Heritage	69.2	61.5	66.7	66.7
Survivor Tree	Introduced in R3	Introduced in R3	66.7	66.7
Other Unique Qualities	46.2	61.5	66.0	66.0
Oldest Specimen of Species in Region	46.2	61.5	50.0	50.0
Species-Specific Age	53.9	46.2	50.0	50.0
Growth Conditions	38.5	69.2	41.7	41.7
Non-Specific Age	61.5	38.5	N/A	38.5
Unusual/Curious Growth Form	23.1	N/A	N/A	23.1
Unusual Species for Area/Outside Natural Range	23.1	N/A	N/A	23.1
Edge of Natural Range/Localized Distribution	23.1	N/A	N/A	23.1
Unique Location/Context	23.1	N/A	N/A	23.1
Program-Specific Age	15.4	N/A	N/A	15.4
Program Specific/Non-Champion Size	7.7	N/A	N/A	7.7

Note: Green = High Importance, Yellow = Medium Importance, Orange = Low Importance, Pink = Very Low Importance

*Originally titled "Legends/Mythical/Folklore Value." Modified to reflect expert consensus at the conclusion of the study.

Table 4. 2. Exceptional Tree Selection Criteria Percentage of Importance Values Throughout the Study Based on Criteria Category.

Criterion	Percentage of Importance R1	Percentage of Importance R2	Percentage of Importance R3	Final Percentage of Importance	Category
Aesthetics	84.6	N/A	N/A	84.6	Aesthetics
Oldest Specimen of Species in Region	46.2	61.5	50.0	50.0	Age
Species-Specific Age	53.9	46.2	50.0	50.0	Age
Non-Specific Age	61.5	38.5	N/A	38.5	Age
Program-Specific Age	15.4	N/A	N/A	15.4	Age
Ecological/Habitat Value	84.6	N/A	N/A	84.6	Benefits
Significant Environmental Value	84.6	N/A	N/A	84.6	Benefits
Socio-Cultural Benefits	Introduced in R3	Introduced in R3	83.3	83.3	Benefits
Economic Benefits	53.9	76.9	N/A	76.9	Benefits
Endangered	100.0	N/A	N/A	100.0	Botanical/Horticulture/Arboriculture/Biological Value
Rarity	100.0	N/A	N/A	100.0	Botanical/Horticulture/Arboriculture/Biological Value
Botanical/Horticulture/Arboriculture/Biological Value	100.0	N/A	N/A	100.0	Botanical/Horticulture/Arboriculture/Biological Value
Specific Species/Species Significance	92.3	N/A	N/A	92.3	Botanical/Horticulture/Arboriculture/Biological Value
Seed Source/Propagation Stock	69.2	84.6	N/A	84.6	Botanical/Horticulture/Arboriculture/Biological Value
Resistant to Disease/Climate Conditions	53.9	69.2	83.3	83.3	Botanical/Horticulture/Arboriculture/Biological Value
Endemic	69.2	69.2	N/A	69.2	Botanical/Horticulture/Arboriculture/Biological Value
Biological Heritage	69.2	61.5	66.7	66.7	Botanical/Horticulture/Arboriculture/Biological Value
Indigenous Cultural Associations	100.0	N/A	N/A	100.0	Cultural Value
Local Significance	100.0	N/A	N/A	100.0	Cultural Value
Cultural Value	92.3	N/A	N/A	92.3	Cultural Value
Social/Community Value	92.3	N/A	N/A	92.3	Cultural Value
National Interest	84.6	N/A	N/A	84.6	Cultural Value
Religious/Spiritual Value	84.6	N/A	N/A	84.6	Cultural Value
Legends and Oral Histories*	61.5	84.6	N/A	84.6	Cultural Value
Productive Trees	38.5	76.9	N/A	76.9	Cultural Value
Outstanding Example of Species	76.9	N/A	N/A	76.9	Form/Structure/Morphology
Form/Structure/Morphology	53.9	46.2	75.0	75.0	Form/Structure/Morphology
Unusual/Curious Growth Form	23.1	N/A	N/A	23.1	Form/Structure/Morphology
Remnant	69.2	84.6	N/A	84.6	Historical Value
Historical Value (place, events, dates, etc.)	84.6	N/A	N/A	84.6	Historical Value
Historic Person/Memorial Planting	69.2	76.9	N/A	76.9	Historical Value
Represented in Historical Documents (sketches, journals, photos, etc.)	76.9	N/A	N/A	76.9	Historical Value
Historical Witness	69.2	76.9	N/A	76.9	Historical Value
Landmark/Location/Landscape	100.0	N/A	N/A	100.0	Landmark/Location/Landscape
Relic Specimen	84.6	N/A	N/A	84.6	Landmark/Location/Landscape
Collection/Grove/Avenue	76.9	N/A	N/A	76.9	Landmark/Location/Landscape
Survivor Tree	Introduced in R3	Introduced in R3	66.7	66.7	Landmark/Location/Landscape
Unusual Species for Area/Outside Natural Range	23.1	N/A	N/A	23.1	Landmark/Location/Landscape
Edge of Natural Range/Localized Distribution	23.1	N/A	N/A	23.1	Landmark/Location/Landscape
Unique Location/Context	23.1	N/A	N/A	23.1	Landmark/Location/Landscape
Other Unique Qualities	46.2	61.5	66.0	66.0	Other Unique Qualities
Champion Size - Cumulative Points	61.5	100.0	N/A	100.0	Size
Species-Specific Size	69.2	92.3	N/A	92.3	Size
Champion Size - Category	76.9	N/A	N/A	76.9	Size
Non-Specific Size	76.9	N/A	N/A	76.9	Size
Growth Conditions	38.5	69.2	41.7	41.7	Size
Program Specific/Non-Champion Size	7.7	N/A	N/A	7.7	Size

Note: Green = High Importance, Yellow = Medium Importance, Orange = Low Importance, Pink = Very Low Importance

*Originally titled "Legends/Mythical/Folklore Value." Modified to reflect expert consensus at the conclusion of the study.

Table 4. 3. Definitions for Hawai'i's 33 Recommended Exceptional Tree Selection Criteria.

Category	Criterion	Definition
Aesthetics	Aesthetics	A visually-impressive tree that stands out from others in the area. Exceptional trees with this characteristic often add an awe-inspiring component to the landscape. For example, this could be due to its representation of special size, age and form features, in addition to others such as captivating flowers, seeds, leaves and/or other aspects.
Benefits	Ecological/Habitat Value	A tree that provides significant benefits to organisms in the surrounding environment. An example would be a specimen that has large and/or old characteristics which can facilitate or support a large amount of life forms such as birds, bats, mammals and even aquatic organisms should water collect in a crevasse.
Benefits	Significant Environmental Value	A tree that provides significant environmental benefits, usually in the form of ecosystem services such as carbon sequestration, stormwater runoff avoidance, reduced erosion, shading, reduction in the urban heat island effect and pollutant removal.
Benefits	Socio-Cultural Benefits	A tree that provides significant socio-cultural benefits, generally in the form of cultural ecosystem services (CES). These benefits can be represented through aspects such as place-based knowledge/education and promotion of physical and/or mental wellbeing provided intrinsically by the tree. For example, the grove of fifty banyan trees along Bayan Drive in Hilo, Hawai'i
Benefits	Economic Benefits	A tree that provides significant economic benefits to a given geographic region, usually through ecotourism. An example could be an iconic tree that attracts visitors due to its historical, cultural, size, age, aesthetic or other impressive traits.
Botanical/Horticulture/Arboriculture/Biological Value	Endangered	A tree that is valued based on its endangered status worldwide. The IUCN's "Red List of Threatened Species" could be one resource for determining this.
Botanical/Horticulture/Arboriculture/Biological Value	Rarity	A tree that is rare due to its infrequent occurrence worldwide.
Botanical/Horticulture/Arboriculture/Biological Value	Botanical/Horticulture/Arboriculture/Biological Value	A tree that has unique or exceptional botanical, horticultural, arboricultural or biological value. These trees are often a valuable source for future propagation efforts based on their genetic components.

Table 4. 3. (Continued) Definitions for Hawai'i's 33 Recommended Exceptional Tree Selection Criteria.

Botanical/Horticulture/ Arboriculture/Biological Value	Specific Species/Species Significance	A specific species of tree that is deemed to be of importance for a given program's area (e.g., 'Ōhi'a lehua in Hawai'i.)
Botanical/Horticulture/ Arboriculture/Biological Value	Seed Source/ Propagation Stock	A tree that is an important source of seed or propagation stock.
Botanical/Horticulture/ Arboriculture/Biological Value	Resistant to Disease/Climate Conditions	A tree that is valued due to its ability to resist disease and/or exposure to climatic conditions over time. This could be applicable to specimens that are better adapted to a changing climate, particularly from a tree that provides significant socio-cultural benefits, generally in the form of cultural ecosystem services (CES). These benefits can be represented through aspects such as place-based knowledge/education and promotion of physical and/or mental wellbeing provided intrinsically by the tree.
Cultural Value	Indigenous Cultural Associations	A tree of importance to indigenous cultures and/or associated with various indigenous events.
Cultural Value	Local Significance	A tree that is locally known as a key fixture within the community. The removal of such a tree can negatively impact the community through a change in aesthetics and/or loss of an iconic natural structure.
Cultural Value	Cultural Value	A tree that represents a wide range of cultural aspects and values which benefit a community or specific culture. This can include an association with past and current groups, such as a plant that was and remains a part of a specific group's culture. This tree can provide a sense of place for those in the local community, act as a fundamental component of a community's identity, etc.
Cultural Value	Social/Community Value	A well-known tree that is prominent in the community and provides a connection for those who interact with it (e.g., memories associated with a tree or those that occurred in its vicinity.)
Cultural Value	National Interest	A tree with a characteristic(s) so important that it is considered a vital component of a country's stated cultural/conservation goals. These trees can also be recognized and included in exceptional tree programs at lower geographic scales such as states/provinces, counties and municipalities.
Cultural Value	Religious/Spiritual Value	A tree that is associated with religious and spiritual practices.
Cultural Value	Legends and Oral Histories	A tree that is specifically mentioned as being associated with legends and oral histories, as depicted through stories, songs, dances, etc.
Cultural Value	Productive Trees	A tree that was planted and/or preserved due to its use as a culturally important resource (e.g., food source, medicinal purposes, useful materials, etc.)

Table 4. 3. (Continued) Definitions for Hawai'i's 33 Recommended Exceptional Tree Selection Criteria.

Form/Structure/ Morphology	Outstanding Example of Species	An exemplary tree that represents a species optimal form/structure.
Form/Structure/ Morphology	Form/Structure/ Morphology	A tree that displays an iconic physical appearance, unusual physical growths and/or other characteristics that set it apart from other trees (both of the same and alternative species.) For example, the <i>Hitachi</i> Monkeypod tree on Oahu
Historical Value	Remnant	A tree that represents the characteristics of a previously significant era (e.g., one that predates colonization), the work of a master artist and/or possesses high artistic values. This includes, but is not limited to, tree lined avenues and areas where historically unique landscaping designs/styles are still visible.
Historical Value	Historical Value (place, events, dates, etc.)	A tree that is associated with a historical place, event and/or date that had a lasting and important contribution to a given area (e.g., place, events, dates, etc.)
Historical Value	Historic Person/Memorial Planting	A tree that was planted for, by or in association with a historically significant person. A tree can also receive this distinction if it was planted to commemorate an event, group or institution of importance.
Historical Value	Represented in Historical Documents (sketches, journals, photos, etc.)	A tree that is mentioned or visually depicted in historical documents (e.g., sketches, journals, photos, etc.).
Historical Value	Historical Witness	A tree that has "witnessed" an important historical and/or cultural event. This can occur if a tree is located at the site of a notable event and/or was somehow a part of the acts that transpired.
Landmark/Location/ Landscape	Landmark/Location/ Landscape	A tree that is a visually dominant in the landscape and often contributes aesthetically to the local area. This type of tree can also be associated with various historical events that it continues to represent. The removal of such a tree would drastically alter the local area in a negative way.
Landmark/Location/ Landscape	Relic Specimen	A tree that is a relic of a former ecosystem. For example, a species of tree that may have once been common in an area, but now only a few individuals remain.
Landmark/Location/ Landscape	Collection/Grove/ Avenue	A grove or avenue (including an allee) of trees that are grouped together in close proximity to provide an exceptional example of the species.

Table 4. 3. (Continued) Definitions for Hawai'i's 33 Recommended Exceptional Tree Selection Criteria.

Size	Champion Size - Cumulative Points	A tree that has the greatest point total for its species in a program's geographic region based on girth (diameter/circumference), height and crown spread. This criterion is used to determine "champion" status by adding various metrics to achieve a cumulative point score for a specific species. For example, one common method used by the nonprofit American Forests is: "Trunk Circumference [inches] + Height [feet] + ¼ Average Crown Spread [feet] = Total Points," but this method can vary based on geographic region. If two or more trees of the same species have totals within 10 points of each other, "co-champion" status will be awarded.
Size	Species-Specific Size	Size is used to compare physical metrics (height, diameter, canopy spread etc.) only amongst trees of the same species to determine what is large. This helps to contrast the different physical metrics that various species can exhibit to more accurately show what is considered to be large. For example, a height of 100 feet or a diameter of 10 meters may be considered small for one species, while vary large for another.
Size	Champion Size - Category	A tree that represents the largest physical metric(s) for a species in a program's geographic region. This criterion is based solely on physical measurements such as height, diameter/circumference and canopy spread. The "champion" title is awarded to the largest tree of each species in each of these three categories. A single tree can be the "champion" of multiple categories.
Size	Non-Specific Size	Size is used for the designation of an exceptional tree without listing a specific minimum threshold value.

officers (i.e., police officers) who many not know the current laws afforded to exceptional trees in each Hawai'i county.

All of these recommendations have the ability to improve the enforcement of exceptional tree legal protections in Hawai'i. However, it is noted that catching someone in the act of damaging one of these trees can be difficult to do, so greater monitoring is necessary so that any violations can be reviewed by legal authorities, such as Hawai'i's Environmental Court.

Incentives vs Penalties

Ninety-two percent of the panel (11/12 experts) felt that both incentives and penalties should be used to encourage protective measures for Hawai'i's exceptional trees, although incentives should be the primary focus. Experts stated that a tax credit based on the average annual maintenance cost for an exceptional tree, produced from quotes provided by three different arborists, could be a useful incentive, which may also promote better periodic maintenance of these specimens which provide benefits to the community. Penalties should be based on tree value assessments/appraisals, with a specific focus on the factors that made the tree exceptional in the first place (e.g., if a tree had half of its canopy illegally removed, but it received exceptional status based on the aesthetics criterion, the fine would be higher due to this lost characteristic).

Enacting incentives and penalties for both property owners and developers were common themes, although many experts felt that incentives would be more impactful for property owners, while penalties would be more effective for developers. Ten experts supported incentives for property owners, five were in favor of developer incentives, five supported penalties for property owners and seven were in favor of penalties for developers. Incentives could include maintenance assistance, tax incentives, rebates, and/or direct subsidies, while penalties may be seen in the form of fines, with one expert suggesting a monetary penalty amounting to three times the value of the exceptional tree that was removed. A different

expert suggested that such an evaluation could be determined using “industry standard plant appraisal guidelines,” although no specific methods were proposed.

It was noted that while incentives “*are grand and exciting for those who are truly interested in preserving exceptional trees,*” they need to be modernized, which could lead to the increased promotion of Hawai‘i’s exceptional tree program if enticing enough. Conversely, penalties for developers “*need to be higher and strictly enforced,*” although it was noted that it “*would be extremely hard to match the profits that the developer is going to make from the development of the land.*” Furthermore, the implementation of penalties for damaging or removing an exceptional tree could see fewer exceptional tree nominees as a result of such a policy.

Incentives were suggested as a means counter this, by generating public interest in the program through the provision of tree maintenance support and/or financial assistance. Alternative suggestions to improve protections afforded to Hawai‘i’s exceptional trees include increased education for developers on the value of trees (i.e., shade and other amenities) rather than of receiving penalties, in addition to focusing on research that further investigates incentives and penalties associated with exceptional tree programs.

Expert Suggested Improvements

A unique method to monitor and ensure the continued health of existing exceptional trees was provided by one expert who suggested that when a known parcel of land (public and/or private) is sold, a certified plant inventory survey could be conducted. “*If an existing Exceptional Tree is on the property, then the committee will be notified and action taken to verify that the tree will stay alive and healthy on the property. If a notable tree is on the property but not an Exceptional Tree, the new owner can decide to petition for the tree to be on the Exceptional Tree list but it is an optional decision for the landowner to make.*” Suggested improvements for exceptional tree protections range from fines and incentives, to best construction practices for crews working around an exceptional tree. Fines were highlighted by one expert who provided the following example “*fines will be given to the property owner for the inappropriate treatments to the Exceptional tree. e.g., 1) careless chop down elimination of entire tree- fine is*

\$6,000 2) inappropriate pruning of tree from a non-certified arborist- fine is \$2,500 3) examples above and so forth if fines are unpaid payment can be garnished from their income (tax or paychecks)." Another expert took this notion even further by stating that fines should be considered for those who intentionally neglect their exceptional tree(s). They also suggested that updates should be made to the current exceptional tree tax deductions to ensure that the incentive amount can adequately offset some or all of an exceptional tree's maintenance costs, helping to mitigate any negative views produced fines. Special protections afforded to exceptional trees during construction projects was also highlighted as needed improvement. These protections would go above and beyond currently established tree protection protocols to ensure that any exceptional trees in the area would be minimally impacted during construction activities.

Private Property Exceptional Tree Maintenance Costs

77% of the panel (10/13 experts) felt maintenance costs for exceptional trees on private property should be covered by both the homeowner and government. Their reasons included that *"the owner should have some investment in the tree,"* to keep them aware and engaged in the upkeep of their exceptional tree. Governmental assistance covering a percentage of an exceptional tree's associated maintenance costs, awarding grants for property owners under a certain income threshold, and/or providing a tax credit, (adjusted every five years to account for increased maintenance costs and/or inflation) were some suggested methods to provide exceptional tree maintenance support. Conversely, two other experts felt that the entire cost of maintaining an exceptional tree on private property should be incurred by the homeowner, while another felt that a partnership between the government and a *"watchdog organization"* should be used.

Program Funding

83% of the panel (10/12 experts) agreed that Hawai'i's exceptional tree program should receive funding. Many supported a multi-funding public/private approach led by the government (county, state, and federal), followed by the private sector, non-profits, philanthropists,

fundraisers, and funds collected from fines generated due to illegal activities affecting exceptional trees. This public/private funding model could also have the added benefit of introducing more stakeholders to Hawai'i's exceptional tree program, which could increase participant involvement. The remaining two experts were not opposed to program funding, but were concerned about what the funding would support (e.g., maintenance, resources for an Arborist Advisory Committee, etc.), how tree benefits would be quantified (i.e., potentially using the software *I-Tree* to determine ecosystem services), and if public tax dollars should be used for exceptional trees on private land.

Public Outreach/Education

There was general consensus that social media, websites and community presentations should be the focus for exceptional tree public outreach and education programs. Community groups/non-profits and the government (county and state) should collaborate on these initiatives which could be highlighted on social media platforms such as Facebook, Instagram and YouTube. Websites that contain a one-page exceptional tree fun facts document and exceptional tree maps could be used in combination with a social media presence to initiate outreach presentations. These presentations would be provided to community members, policy makers, and developers on a consistent basis to promote *“everyday awareness of the exceptional trees program and the importance of trees in the urban and rural areas.”*

Campaigns, such as an “Exceptional Tree of the Week or Month” and monthly exceptional tree walking tours, could also further inform the public about the existence of these trees. Finally, different demographics could be appealed to if radio (i.e., Hawai'i Public Radio) and/or TV programs (i.e., news stations) also promoted Hawai'i's exceptional tree program. It was also suggested that a county's Department of Parks and Recreation/Division of Urban Forestry and Arborist Advisory Committee be tasked with educating property owners, developers, policy makers/politicians, and the general public about Hawai'i's exceptional trees to improve program awareness throughout the state.

Program Management/Best Practices

The expert panel stated nine program management best practices that should be utilized by an exceptional tree program in Hawai'i, all of which rely on an Arborist Advisory Committee (AAC) being comprised of members that represent a "diverse group of backgrounds and knowledge." The first focuses on establishing a clear and concise set of criteria and nomination procedures to be used when selecting potential exceptional tree candidates. Second, several experts stated that there needs to be a current list of all exceptional trees in a county database. Third, laws and policies should focus on incentives, penalties, and a tree replacement program for removed or dead exceptional trees. Fourth, exceptional trees need to be monitored. This could be accomplished via annual inspections of each exceptional tree by a certified arborist to ensure they are alive, as well as identify any maintenance needs. However, deciding who should pay for this maintenance is a contentious issue. Fifth, only a certified arborist approved by the AAC and/or Division of Urban Forestry using best management practices, such as those promoted by the International Society of Arboriculture (ISA), should be able to prune/maintain an exceptional tree. Sixth, outreach and education are essential components of an exceptional tree program. Seventh, increased collaborative efforts between stakeholders (i.e., arborists, developers, architects, etc.) and improved communication with developers and government agencies (i.e., Department of Planning and Permitting) need to take place. Eighth, having an effective means of responding to community concerns and questions pertaining to exceptional trees was also stressed. This could also be improved through increased publicity efforts, accomplished by having a social media presence, informative maps, concise brochures, and facts sheets.

Finally, a long-term management plan should be produced for Hawai'i's exceptional trees. It was suggested that *"people need to be 'visionaries' to expedite this long-term plan beyond their own lifespan"* and components of such a plan could include: pruning, scanning for disease/pests, annual tree appreciation days/tree celebrations, education and outreach methods (i.e., an interactive map) increased recruitment of new exceptional trees, maintenance and removal of trees when necessary, and funding opportunities. There should

also be procedures in place to prevent newly elected policy/decision-makers from being able to easily change the long-term management plan.

Climate Change Impacts/Management

Two proactive measures were suggested to help mitigate the predicted threats of climate change on Hawai'i's exceptional trees. The first focused on researching important risks such as temperature, precipitation, drought/wildfire events, and new pests, as well as examining solutions such as *“what tree species will be able to endure the changes best and plant them today.”* Second, the health of exceptional trees needs to be a focal point to increase their resiliency along with implementing structural pruning, irrigation systems and fire breaks. One expert felt that not much could be done aside from supporting climate change initiatives, while another felt that it would be *“very hard, and very expensive, to try and protect old mature trees from climate change”* and instead, research should focus on which species will thrive in future climate scenarios.

Portfolio of Examples for Each Exceptional Tree Criterion

There was unanimous consensus (10/10 experts) that a portfolio of exceptional tree criteria examples should be produced to assist interested individuals navigate the specifics of Hawai'i's exceptional tree program. It was noted that such a portfolio should be updated annually, include a clear definition of what constitutes an exceptional tree, as well as explicitly stating that the intent of such a document is to provide context that is not limited to only the trees presented. However, the question of who would produce and maintain such a document was raised, something which the Arborist Advisory Committee would most likely need decide.

Health as a Disqualifier

70% of the panel (7/10 experts) supported using health status as a mandatory requirement when nominating exceptional trees, while 10% opposed this and 20% stated that a decision should be made on a case-by-case basis. For those in support of making health a prerequisite requirement, it was stated that there is little value in nominating a tree that is dying or a hazard

to the public and would have to be removed eventually. However, one supporter cautioned that while the health of an exceptional tree nominee is important, any decision should take into consideration the difference between a specimen that is dying compared to in natural decline. The lone expert opposing the health requirement stated that trees are often resilient and a specimen with damage or surrounding growth restrictions can survive for extended periods of time in poor health. Finally, the two remaining experts that suggested a case-by-case evaluation stated that many variables come into play and that a mature tree in natural decline should not be disqualified, unless it is actively dying and/or in a continual state of substantial decline.

Discussion

Selection Criteria

This study produced a list of 33 criteria that should be included in an exceptional tree program in Hawai'i. While this appears to be a substantial number of criteria, even if the consensus threshold was increased from $\geq 75\%$ to 80%, 90% and 100%, the number of high importance criteria for each would be 23, 11, 7 respectively. This indicates a significant amount of agreement between the expert panel as to how exceptional trees in Hawai'i should be identified. It's not surprising that many of the recommended exceptional tree criteria from our study are included within the four categories of *Historical Value*, *Cultural Value*, *Botanical Value* and *Size*, as these four traits are highly valued by exceptional tree programs elsewhere (Ritchie, 2019; Ritchie et al., 2021). However, there were some interesting and somewhat contradictory aspects found that warrant further discussion.

Age

The lack of any *Age* criteria achieving a high percentage of importance was surprising given that Hawai'i's current exceptional tree program uses age as one of its criteria. This inability by the panel to agree upon specific thresholds, concerns raised about time and resources required to implement certain age criteria, and the known difficulties associated with accurately determining a tree's age have been found by others (see Ritchie et al., 2021). This leaves the usage of exceptional tree *Age* criteria in a grey zone where experts have noted their importance

in an exceptional tree program (Ritchie, 2019), but have to omit the inclusion of specific thresholds, shifting the onus of determining exceptional age onto the respective Arborist Advisory Committee or other review board. This appears to be a common problem for these programs worldwide, as the majority of case studies examined by Ritchie (2019) did not utilize specific age thresholds when *Age* criteria were part of an exceptional tree program.

Size

Four *Size* criteria were recommended for inclusion in Hawai'i's exceptional tree program. Organized based on higher to lower percentage of importance values, these criteria were "Champion Size-Cumulative Points," "Species-Specific Size," "Champion-Size-Category," and "Non-Specific Size" and initially appear to contradict each other. However, exceptional tree programs that have multiple *Size* criteria do exist (see Jim & Zhang, 2013; City of Milpitas, 2016; City of West Hollywood, 2018; County of San Diego, Parks and Recreation, 2018; Minneapolis Park and Recreation Board, 2018, Ritchie, 2019, p. 18), suggesting that the use of the four *Size* criteria should be considered on a case-by-case basis, based on the knowledge of each species under review (i.e., if species-specific size thresholds are known for the species).

Endemic Status

The failure of the "Endemic" criterion to achieve a high percentage of importance was also noteworthy as this criterion is also currently used to identify exceptional trees in Hawai'i. However, as this criterion was recommended during the program's inception in 1975, this shift away from any endemic tree potentially receiving exceptional status could highlight a different direction the program is taking. For example, an endemic tree may have substantial value, but this status may act as supporting justification for a nominee to be awarded exceptional status, rather than the sole cause of it. Such a change could help to ensure that the stringent standards of Hawai'i's exceptional tree selection process are upheld by only recognizing truly exceptional trees. Furthermore, out of the 46 case studies examined by Ritchie (2019), Hawai'i was the only exceptional tree program that explicitly stated "Endemic Status" as a selection criterion, showing that the use of this criterion is an exception to the norm.

Comparing Criteria Findings with Other Exceptional Tree Research

It is interesting to note that all 16 of the exceptional tree selection criteria recommended by Ritchie et al. (2021) reached consensus in this current study. This highlights the potential universal appeal that these 16 exceptional tree criteria may have regardless of geographic location or scale. Furthermore, it appears as if there may be a disconnect between the current exceptional tree selection criteria used by many programs around the world and those recommended by the expert panels in our study, as well as that of Ritchie et al. (2021). This disconnect can be seen when comparing these 16 consensus criteria identified in both studies to the criteria currently being used by many exceptional tree programs around the world (see Ritchie, 2019, p.58), which shows that 10 of these 16 recommended exceptional tree selection criteria were seldomly or never used by the 46 exceptional tree programs examined by Ritchie (2019).

This trend also applies to Hawai'i's seven current exceptional tree selection criteria, as only four of these are included as part of the 16 criteria found by Ritchie (2019). When comparing these seven criteria to the 33 produced from this study, five of these are currently used by Hawai'i's exceptional tree program, highlighting a potential need to re-evaluate the characteristics that comprise these trees. Future research replicating this study will be required to determine if this trend is conveyed elsewhere, including the greater number of consensus criteria observed at lower scales compared to higher ones (i.e., state/provincial vs international). It is important to note that this study can be directly compared to that of Ritchie et al. (2021) as both studies used identical Delphi procedures, evaluated the same exceptional tree selection criteria, and did not share any of the same experts on their panels.

Program Components

Regulations and Enforcement

Our study found that exceptional tree experts in Hawai'i see the value in a two-pronged approach consisting of regulations and incentives to implement protection mechanisms that conserve exceptional trees. Both regulatory components and incentives have been shown to

address tree loss (Ordonez et al., 2021). Regulations are an important conservation mechanism (Stern, 2006), particularly through strong ordinances which can lead to the preservation of nearly 75% of trees in areas where construction is taking place (Pike et al., 2021). However, the enforcement concerns raised in our study are not unique and have the potential to reduce the effectiveness of regulatory approaches (Clark et al., 2020) due to enforcement costs (Busbridge et al., 2021) and impracticality of implementation (Stern, 2006). These issues could also be further exacerbated when government enforcement officers are unable to, or unwilling to, implement tree protection laws on private land (Ordonez et al., 2021).

The inadequate resources allocated to urban forestry programs and conservation programs more broadly has been widely reported (see Moskell et al., 2011; Driscoll et al., 2015; Busbridge et al., 2021), but could be mitigated through collaborative efforts between urban forestry stakeholders which could lead to funding opportunities (Ugolini et al., 2015). Furthermore, enacting tree bond policies, as suggested by our expert panel, could assist in providing funds to protect trees and/or planting and maintenance efforts (Ordonez et al., 2021), as tens of thousands of dollars could be provided to a local government if a tree isn't protected during construction projects (Hurley et al., 2018). The preemptive collection of financial collateral for tree bonds could also assist with enforcement efficacy, as all tree bond deposits are required in advance (Ordonez et al., 2021).

Incentives

While stricter regulation, enforcement and fines can assist with the retention of trees (Clark et al., 2020), incentives have also been noted as an important tree protection and retention mechanism (Maddison & Denniss, 2013), that are preferred over penalties (Stern, 2006), particularly by local governments due to reduced resource requirements, reductions in bureaucracy, less resistance from stakeholders, and an image of a less intrusive government (Ordonez et al., 2021). This view applies to exceptional trees, as Britton et al. (2015) found that political support for heritage trees on public land was 93.5%, whereas this value was only 39.3% for heritage trees on private property (Britton et al., 2015), suggesting that incentives should be

prioritized over regulations and their corresponding penalties to facilitate public participation and support.

Many different types of incentives can be used to retain trees in urban forestry and conservation programs more broadly. Free arboricultural maintenance and tax rebates have been proposed (Ordonez et al., 2021), while others suggest a combination of monetary and social incentives (i.e., certificates, awards, etc.,) could be used together to improve behaviors around conservation needs (Stern, 2006). Providing free arboricultural maintenance and tax incentives were identified in our study as ideal methods that should be used to protect Hawai'i's exceptional trees, although social incentives may also need to play a complementary role, as surprisingly few exceptional tree tax deduction claims have been made, with only 23 between 2011-2021 totaling \$64,952.00 (Gary Suganuma, Director, Hawai'i State Department of Taxation, personal communication, July 11, 2023). These low redemption rates could be an indication that the tax deduction amount is insufficient to incentivize filing a claim, that the notarized documentation required is overly tedious, and/or exceptional tree owners are unaware that there is a tax deduction for maintaining trees on private property.

To help remedy this potential lack of awareness, advertising exceptional tree incentives should be a priority, as the outcomes could be more beneficial than increasing the monetary value of the incentive itself (Stern, 2006). Hawai'i's exceptional tree program has been highlighted as one of the world's most innovative tree retention mechanisms primarily due to the state tax deduction offered (Ordonez et al., 2021), however with only 23 claims made over a decade there is a clear need to further refine and improve the incentives offered by this program. Finally, similar to the private property tree retention methods identified by Clark et al. (2020), this research suggests a holistic view needs to be considered for Hawai'i's exceptional tree program that would see tree protection mechanisms combined with increased education/outreach activities to foster public support with the aim of addressing the aforementioned regulatory and incentive deficiencies that currently reduce the efficacy of this urban forestry conservation program.

Public Outreach/Education

Urban forestry professionals have called for increased public participation (Baur et al., 2016) to foster awareness which could lead to positive views towards urban forest initiatives (Zhang et al., 2007). Our study found that social media, websites and community presentations should be the focus of exceptional tree public outreach and education in Hawai'i. There should be two distinct sets of documents when producing exceptional tree outreach content, with one designed for a homeowner, and the other focusing on technical aspects that could be more applicable to professionals (Pokorney, 1998). Our expert panel also suggested that a one-page exceptional tree fun fact document be produced to improve education and outreach activities, which is similar to what other urban forestry practitioners have recommended, the two most common being fact sheets and "how to" informational brochures (Pokorney, 1998). Pamphlets, brochures, websites, videos and workshops have also been recommended as useful urban forestry outreach methods (Driscoll et al., 2015), as well as activities designed to promote the benefits of urban forests, tree maintenance education, and hands-on involvement opportunities (Moskell et al., 2011), all of which should be considered by exceptional tree programs in Hawai'i. Facilitating direct experiences has been shown to produce a strong connection that can impact one's view towards a given topic (Fazio & Zanna, 1981), and could include events such as tours (Baur et al., 2016). Providing these opportunities to urban forestry stakeholders could improve their long-term engagement in urban forestry projects (Clark et al., 1997).

The experts in our study also felt that nonprofits and government entities should collaborate on public outreach and education initiatives. Nonprofits can act as a catalyst that brings together research, policy, and urban forestry concepts, which is then disseminated through their education and outreach efforts (Konijnendijk & Gauthier, 2006), while government agencies could interact with communities to foster behavioral changes and increased stewardship of urban forests (Ordonez et al., 2021). Ideal knowledge brokers for exceptional tree programs are arborists/foresters and tree boards (i.e., Hawai'i's Arborist Advisory Committees), both of which can act as effective resources for new tree policies (Britton et al., 2015).

The benefits produced by an exceptional tree program must be effectively communicated and understood by relevant stakeholders (Britton et al., 2015). Using the public education and outreach recommendations found in our study, in combination with those suggested by others, the effectiveness of this vital exceptional tree program component could be significantly improved.

Conclusion

This research represents the first systematic, peer-reviewed investigation of Hawai'i's exceptional tree program, contributing new knowledge to a growing body of exceptional tree research, while also being applicable to urban forestry programs more broadly. The Delphi method was able to utilize the opinions and recommendations of 13 statewide exceptional tree experts to produce a list of 33 selection criteria that should be used to identify exceptional trees in Hawai'i. Many of these criteria are the same as those suggested by others, prompting the possibility that a universal set of exceptional tree selection criteria may exist, although this study needs to be replicated in different geographic locations and at varying scales (i.e., municipal, state, national, and international) to confirm this. This study also identified several program components that are essential for a successful exceptional tree program in Hawai'i including effective protection mechanisms, increased public education and outreach efforts, program funding from a variety of sources, assisting with exceptional tree maintenance on private property, producing management plans to mitigate the predicted impacts of climate change on these trees, and producing a portfolio of exceptional trees that clearly depicts ideal candidates for each criterion.

Future research should replicate this study in different areas to see if universally agreed upon exceptional tree selection criteria exist. These studies should also further investigate the exceptional tree program components identified in this study to unravel the interwoven complexities they share. These components should be viewed as a complex problem that requires a holistic view to solve, as many program components impact each other, particularly public education and outreach, incentives and penalties, and funding opportunities. Hawai'i's

exceptional tree program has been identified as an ideal urban forestry conservation program, however, as indicated by the expert panel in this study, there are significant improvements that need to be made to better protect Hawai'i's most majestic trees, which will require collaborative efforts from all relevant stakeholders if these trees are to be protected for generations to come.

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CHAPTER 5: CONCLUSION

An examination of exceptional tree literature and existing exceptional tree programs indicate that there are substantial issues with these urban forestry conservation programs that require improvements to program components such as exceptional tree selection criteria, legal protections, education and outreach, funding, best management practices, etc., to realize the full potential of these programs (see Jim, 2017; Jim, 2018; Ritchie, 2019). The high mortality rates of exceptional trees, primarily due to anthropogenic threats from development (Jim, 2004, Jim, 2005), inadequate protection mechanisms, and a lack of awareness for exceptional tree conservation practices (Chen, 2015), demands that greater attention be focused on exceptional tree program components to improve their overall efficacy. Hawai'i's Exceptional Tree Program is an ideal example of one of these programs requiring a reexamination of its foundational structure to determine if the program is fulfilling its goals as envisioned when enacted in 1975. Specifically, examining this program could help to determine if the selection criteria and other program components originally utilized are still accurate, relevant, and comprehensive enough to identify and protect Hawaii's exceptional tree specimens.

The purpose of this dissertation was to ascertain the current state of Hawai'i's Exceptional Tree Program and suggest solutions to identified deficiencies. This was accomplished through the combined use of the Reflexive Thematic Analysis (RTA) and Delphi methodologies, with the former applying to exceptional tree practitioners and the latter focusing on statewide exceptional tree experts. This research was presented in the form of three papers, with the first paper examining the current weaknesses and suggested desired improvements of Hawai'i's exceptional tree program based on the practitioners who interact with it on a frequent basis. The second paper conducted a methodological review of the Delphi process through the lens of exceptional tree case studies in Hawai'i and South Australia. The findings from this paper provide recommended improvements to this widely-used method that hitherto lacks agreement on how certain methodological components should be implemented (i.e., consensus value, attrition rates, study duration, etc.). The third paper relied on the lived experiences, opinions,

and preferences of statewide exceptional tree experts to identify the essential characteristics of this urban forestry conservation program in order to address the program weaknesses stated by the practitioners in the first paper.

Collectively, these three papers weave a narrative that identifies five key deficiencies with Hawai'i's Exceptional Tree Program, from which a plethora of solutions to address each of these issues was produced based on the recommendations from our study's exceptional tree experts. The result is a framework that should be considered to improve Hawai'i's Exceptional Tree Program. These collective findings also have the capability to improve the fields of urban forestry and biophilic urbanism more broadly through theoretical and practical implications and recommendations. These implications and recommendations will be presented following an analysis of the key Delphi and Reflexive Thematic Analysis methodological conclusions and contributions identified in this study.

Methodological Implications and Recommendations

The study's findings contribute to the Delphi methodological literature by comparing and contrasting methodological components that currently lack agreement on their use, as well as providing recommended improvements to address these known issues. Furthermore, a review and of the combined use of the Reflexive Thematic Analysis and Delphi methods is provided, along with a recommendation to improve their collective use in a single study.

Delphi Implications

The Delphi method used in our study was able to successfully identify many program components that should be included in an exceptional tree program in Hawai'i and South Australia based on the experiences, opinions, and preferences of statewide experts. The 75% consensus threshold selected was optimal for both case studies and is in agreement with other exceptional tree studies (see Ritchie, 2019; Ritchie et al., 2021) and Delphi studies broadly (McKenna et al., 2001; Mcleod, 2012; Belton et al., 2019). The known issue of attrition in Delphi studies was examined, with rates in both of our case studies remaining low (8% and 10% for

Hawai'i and South Australia respectively), even with a long study duration for each location. This was accomplished by accommodating the scheduling needs of the study's experts, as well as implementing participant retention techniques, such as those recommended by Franklin and Hart (2007), Keeney et al. (2011), and Donohoe et al. (2012). This suggests that a longer Delphi study and low attrition rates can be complementary to one another as long as the study's experts are provided ample time to respond to each Delphi survey round and participant retention techniques are used. Finally, the inclusion of a confirmation of findings verification phase after each Delphi round was beneficial and increased the overall validity of the study's findings by providing a) an opportunity for experts with outlier opinions the chance to have any consensus criteria re-evaluated, b) an additional discussion forum to refine selection criteria definitions and thresholds, and c) an additional opportunity to recommend new exceptional tree selection criteria that should be included in the subsequent Delphi survey round. This verification phase was particularly important for our Delphi studies, as consensus criteria were removed from further discussion once the 75% threshold was reached, rather than at the end of the study. Including the verification phase allowed feedback from the prior round to still be reviewed and considered by each expert before to deciding whether they agreed or disagreed with the selection criteria that had obtained consensus.

Delphi Recommendations

We recommend five Delphi modifications that should be considered and tested by those using the methodology from our study to examine topics pertaining to exceptional trees, urban forestry, biophilic urbanism, and conservation more broadly. First, positive consensus could refer to any value $\geq 75\%$ (as used in our study), or be sub-divided into six categories based on the identified level of agreement value in order to provide greater clarity on the specific amount of consensus achieved. For example, "unanimous consensus" (100%), "overwhelming consensus" (95-100%), "major consensus" (90-95%), "significant consensus" (85-90%), "strong consensus" (80-85%), and "moderate consensus" (75-80%). Second, a determination of consensus could be based on a 75% level of agreement concurrently used with an interquartile range of ≤ 1 and a coefficient of variation value of ≤ 0.5 . The use of a ≤ 0.5 coefficient of variation

value also allows stability to be examined between survey rounds for dissensus criteria that are re-evaluated in subsequent survey iterations. All three of these metrics complemented each other in our Hawai'i and South Australia Delphi case studies and appear promising for future use, although additional Delphi studies will need to test this applicability further. Third, Delphi studies should provide ample time for experts to respond to each survey iteration. However, this should only apply if the expert has explicitly stated they need this accommodation. Fourth, it is imperative that effective retention techniques are used with experts throughout a Delphi study to reduce attrition rates. Finally, a confirmation of findings verification phase should be included after each Delphi round, as long as sufficient time has been allocated to the entirety of the study, in order to increase the confidence and validity attributed to the study's findings.

Reflexive Thematic Analysis and Delphi Combined Implications

The combined use of the Reflexive Thematic Analysis (RTA) and Delphi methodologies worked well to derive new exceptional tree knowledge concerning this novel topic. RTA was able to generate five themes centered around current weaknesses associated with Hawai'i's exceptional tree program derived from exceptional tree practitioners, in addition to numerous desired improvements. The Delphi study was able to use the experiences, opinions, and preferences of exceptional tree experts to provide a template of the optimal program components that should be used by an exceptional tree program in Hawai'i. Together, the results from these case studies identified the problems and corresponding solutions that need to be implemented to improve Hawai'i's exceptional tree program. Thus, both methodologies were able to successfully complement one another to produce a more holistic and complete understanding of the topic being examined.

Reflexive Thematic Analysis and Delphi Combined Recommendations

While our study implemented the RTA and Delphi methods concurrently for both Hawai'i and South Australia, it is recommended that if time is available, the RTA process should be completed prior to the onset of the Delphi portion of the study. This is to ensure that all essential findings from the RTA case study is explored by the Delphi study. However, doing so

could lead to a study duration of nearly 1.5 years, which may not be an option for some researchers.

Research Implications and Recommendations

Modernizing Hawai'i's Exceptional Tree Selection Criteria

The 33 positive consensus criteria produced by the study's Delphi expert panel represents the first time that Hawai'i's exceptional tree selection criteria have been reexamined since their initial inception in 1975 and provides recommended changes that should be considered by Hawai'i's Arborist Advisory Committees. The substantial agreement by our panel of statewide exceptional tree experts on the merits that should be used to identify these trees of importance is noteworthy and becomes even more apparent when increasing the consensus threshold from the initial 75% to 80%, 90%, and 100%, resulting in 23, 11, and 7 recommended exceptional tree selection criteria for these three increased values respectively.

Interestingly, responses pertaining to the exceptional tree selection criteria of *Age*, *Size*, and *Endemic Status* were curious. For example, even though age is currently one of Hawai'i's seven exceptional tree selection criteria, no age criteria achieved positive consensus in this study even though the panel indicated the importance of age when identifying an exceptional tree. The lack of any *Age* criteria to achieve positive consensus was primarily due to an inability by the panel to agree on specific age thresholds that should be used, in addition to the known difficulties associated with accurately determining a tree's age. Conversely, the recommended inclusion of four size criteria by the panel highlights the importance that this category has for Hawai'i's exceptional tree program and allows a case-by-case approach to be implemented. For example, if size information is known for a species, the "Species-Specific Size" criterion should be used. However, if no reference information is available for the species, then the "Non-Specific Size" criterion can still suffice, while the "Champion" criteria are able to highlight the largest specimen of each species if comparison data is available. The exclusion of the "Endemic Status" criterion was the most peculiar of these three findings, as this criterion is also one of the seven selection criteria currently used by Hawai'i's exceptional tree program, while at the same time,

it is not a component of any of the other 46 programs examined by Ritchie (2019). As such, our findings seem to indicate a shift away from this criterion due to the potential dilution of exceptional tree quality that could transpire if all endemic trees automatically qualify for this status. Instead, the panel recommended that endemic status should be considered as supporting documentation due to the significance it still has throughout Hawai'i.

Fourteen Potential Universally Applicable Exceptional Tree Selection Criteria

The findings from our study are in agreement with those from Ritchie et al. (2021) who sought a 75% consensus threshold from their panel of exceptional tree experts from 11 different countries. This agreement was seen when all 16 of the exceptional tree consensus criteria recommended from their study were also included as part of the 33 criteria recommended by our Hawai'i expert panel. Interestingly, only six of these shared 16 criteria are commonly used by the 46 exceptional tree programs examined by Ritchie (2019) during their comprehensive exceptional tree literature review, potentially indicating a disconnect between the selection criteria currently used by many exceptional tree programs around the world and those identified from our research. This trend is also seen in Hawai'i, as only four of the seven criteria currently used by its exceptional tree program are part of the 16 consensus criteria identified by Ritchie (2021). When comparing these same seven criteria to the 33 produced in our study, only five are currently used by Hawai'i's exceptional tree program (Size, Aesthetics, Location, Rarity, and Historic/Cultural Value).

Furthermore, these results have potential applicability beyond Hawai'i's exceptional tree program. For example, as previously noted, all 16 of the criteria recommended by Ritchie et al. (2021) were found in our Hawai'i case study. In addition, 14 of these same 16 criteria were also found in the South Australia case study examined in our third paper. This suggests that these 14 exceptional tree selection criteria could represent the foundation for a universal set of traits that should be used to identify trees of importance around the world. These findings show that significant re-evaluations of exceptional tree selection criteria should take place for many programs around the world, since only 6 of the 14 shared criteria between Ritchie et al. (2021)

and our Hawai'i and South Australia case studies are commonly used by the 46 "exceptional tree" programs analyzed by Ritchie (2019). This potentially indicates a disconnect between the criteria that are often used to identify exceptional trees and those currently recommended by experts.

Contributions to the Fields of Urban Forestry and Biophilic Urbanism

This is the first-known empirical study examining Hawai'i's exceptional tree program. Its findings improve our knowledge about exceptional tree programs, as well as the fields of urban forestry, and biophilic urbanism broadly. Specifically, it is now known which selection criteria and program components should collectively be used by exceptional tree programs in Hawai'i and South Australia to improve their efficacy. The 14 identified consensus criteria shared between our Hawai'i and South Australia case study locations, as well as that from Ritchie et al. (2021), may also finally provide a set of universally applicable exceptional tree selection criteria.

These findings directly address the need stated by Jim (2018) to identify issues impacting exceptional trees at local scales, thus adding to the growing body of literature on exceptional trees. The results also provide a foundation for future urban forestry research that conduct in-depth analyses comparing exceptional tree consensus criteria and program components from different locations around the world.

Urban forestry has been defined as "*an integrative approach, combining street and garden trees with urban woodland, and extending from policy-making to establishment, maintenance, and management activities*" (Nilsson et al., 2013, p. 703). It includes urban, suburban, and peri-urban areas (Nilsson et al., 2013) "*at scales ranging from single trees to landscapes*" (FAO, 2016, p. 2). The goal of urban forestry management is to maximize the physiological, sociological, and economic benefits provided by an urban forest, through "*integrated, interdisciplinary, participatory, and strategic*" approaches (FAO, 2016, p. 2).

The findings from our study have theoretical implications for the field of urban forestry through the notion of urban forest governance, which is derived from actor-network theory and links human and non-human (i.e., plants, animals, materials, and technology) components to understand the actors involved in urban forestry (see Konijnendijk, 2016). Our study's results contribute to urban forestry governance by providing new perspectives of human (i.e., exceptional tree practitioners and experts) and non-human (i.e., exceptional trees) actors. For example, the study identified connections between exceptional tree experts, practitioners, politicians, and the general public. Additionally, the exceptional tree historical and cultural values identified by our experts depicts these trees as urban forest governance actors through the concept of "tree agency," a notion produced by Jones and Cloke (2008, p. 80-81). "*Trees have agency in terms of non-reflexive action, as they have the capacity of engendering affective and emotional responses from the humans who dwell amongst them*" (Konijnendijk, 2016, p. 180), which is a key factor in place-making and urban forestry (Jones & Cloke, 2008; Konijnendijk, 2016). Furthermore, tree agency was specifically demonstrated for "exceptional trees" by Konijnendijk (2016) through an analysis of European examples (i.e., the Anne Frank tree in Amsterdam and TV Oak in Stockholm).

Furthermore, our findings can now be applied to the urban forest governance framework produced by Lawrence et al. (2013) in an attempt to better understand the complex interactions that take place in an exceptional tree program to improve governance strategies. Using this framework could also assist policy making by highlighting cultural ecosystem services provided by exceptional trees (i.e., recreation, aesthetics, spirituality, education, etc.), in addition to regulatory ecosystem services (i.e., carbon sequestration, stormwater runoff avoidance, pollutant removal, etc.) (Konijnendijk, 2016). A focus on cultural ecosystem services could allow the notion of "biocultural diversity" [i.e., an "*outcome of a process in which cultural values and practices interact with biodiversity*" (Konijnendijk, 2016, p. 185)] to be emphasized, allowing the significant number of historical and cultural selection criteria identified in our study to show "*deeper*" connections between humans and trees (see Konijnendijk, 2016, p. 181).

Exceptional trees (Barau et al., 2020) and urban forestry (Beatley, 2009; Beatley & Newman, 2013) are also important elements of biophilic urbanism which is *“a creative mix of green urban design, a commitment to outdoor life, protection and restoration of green infrastructure from neighborhood to bioregional levels, and much more”* (Beatley, 2009, p. 227). Biophilic urbanism is based on the notion of biophilia which *“claims that human affinity with nature is inherent in the way our nervous systems develop,”* which can be used as a framework to study how people relate to trees (Delavari-Edalat & Abdi, 2010, p. 162).

Exceptional trees have been noted as biophilic urbanism components that should be protected (Newman, 2013) and researched further to better understand the cultural focus they provide (Barau et al., 2020). As biophilic designs can improve urban sustainability and resilience (Beatley & Newman, 2013), the use of exceptional tree programs as part of a comprehensive biophilic design could promote adaptive capacity and resilient outcomes. As such, the findings from this study can now be used to facilitate the incorporation of exceptional trees into biophilic urbanism designs in Hawaii, providing an opportunity for their increased recognition and protection, while also promoting the many regulatory and cultural ecosystem services they provide.

Finally, the study’s findings produced the first-known knowledge exchange and utilization preferences for Hawai’i’s exceptional tree practitioners and experts. These preferences can now be used to potentially improve how exceptional tree knowledge is transferred into practice, addressing a significant concern raised by Jim (2018). These knowledge exchange and utilization preferences have applicability beyond exceptional trees, as all of our participants are also involved in the field of urban forestry more broadly, thus allowing the findings to be extended to that field as well.

Practical Implications and Recommendations

Improving Hawai'i's Exceptional Tree Program by Addressing Identified Deficiencies

The practitioners from our Hawai'i RTA case study identified five themes pertaining to current weaknesses associated with Hawai'i's exceptional tree program:

- 1) A lack of knowledge exchange between exceptional tree experts and practitioners.
- 2) Hawai'i's exceptional tree program lacks clarity.
- 3) The next generation of exceptional trees require a master plan to address known obstacles.
- 4) There is inadequate exceptional tree education and outreach.
- 5) Exceptional tree protection mechanisms are insufficient.

These five themes build upon one another to highlight Hawai'i's exceptional tree program as dated and lacking efficient implementation of program components, even though its foundation encompasses basic urban forestry conservation principles.

The most pressing challenge for Hawaii's Exceptional Tree Program identified by our practitioners was the near non-existent education and outreach efforts. These practitioners felt that the Arborist Advisory Committees should have the most responsibility in improving this deficiency. This dearth of exceptional tree education and outreach has prevented a long-term master plan from being produced, along with modifications to protection mechanisms for these trees, such as updated values for currently enacted incentives and penalties. Even if these weaknesses were resolved, the inability of exceptional tree experts and practitioners to effectively exchange knowledge exacerbates all of the aforementioned issues. However, even with these known weaknesses, there was general consensus among the practitioners in our study that Hawai'i's exceptional tree program could and should be improved to protect these majestic tree specimens.

Practical Recommendations

Having identified these five deficiencies and the corresponding desired program improvements stated by our practitioners (Table 1), the recommendations provided by our expert panel during

the Delphi portion of our study can now be used to address these programmatic weaknesses (Table 2). These proposed solutions center around the need to significantly improve statewide exceptional tree education and outreach efforts for the practitioners who interact with these trees on a frequent basis, politicians who can impact exceptional tree legal protections and funding, and the general public which can arguably have the greatest impact on improving an exceptional tree program through increased public engagement and support.

For example, regarding a lack of public awareness of exceptional trees, if widespread public knowledge and involvement were to be gained, public support should naturally follow for Hawai'i's Exceptional Tree Program, increasing the likelihood that political support would also follow, thus making it easier to pass legislation and ordinances to improve current protection mechanisms. Increased public support could also allow important feedback from this group to be combined with that of other stakeholders, which could then be used to produce a holistic master plan for current and future exceptional trees. This co-production of knowledge could result in a beneficial feedback loop where the incorporation of stakeholder input leads to greater buy-in and in turn, increased stakeholder input, thus improving the overall amount of support for Hawai'i's Exceptional Tree Program.

The study's collective findings highlight that the single most important thing that should be used to improve Hawai'i's exceptional tree program is a focus on education and outreach for all stakeholders (i.e., practitioners, experts, politicians, and the general public) (Table 5.1). However, the knowledge exchange preferences for each of these four stakeholder groups must be known to ensure that new exceptional tree information is obtained from trusted sources and presented in an ideal format. This study was able to identify the preferred knowledge formats and sources that should be used when presenting new information to Hawai'i's exceptional tree practitioners and experts. These findings should now be used to improve knowledge exchange practices between these two groups in the most effective manner possible, with the simultaneously goal of fostering collaborations between these two groups to improve this conservation program.

Practically, the study's results provide a ready-to-use template that can be adopted by each Arborist Advisory Committee and/or the Hawai'i State Legislature to address the five identified exceptional tree program weaknesses. Using the provided solutions, Hawai'i's exceptional tree program now has the knowledge required to update its core components for the first time in almost 50 years. The result should see improved education and outreach efforts, leading to greater program clarity, increased public support, stronger protection mechanisms, and a long-term management plan, all of which should improve the overall efficacy of Hawai'i's exceptional tree program and lead to the protection of these majestic trees for generations to come.

Table 5. 1. Desired Program Improvements for each of the Five Weaknesses Identified by Hawai'i's Exceptional Tree Practitioners.

<u>Program Weaknesses Identified by Hawai'i's Exceptional Tree Practitioners (Paper 1)</u>	<u>Program Improvements Desired by Hawai'i's Exceptional Tree Practitioners (Paper 1)</u>
1) Lack of Knowledge Exchange Between Exceptional Tree Experts and Practitioners	<ul style="list-style-type: none"> a) Practitioners want to receive new exceptional tree information from experts. b) Establish a two-way dialogue and increased interactions between Hawai'i's exceptional tree practitioners and experts. c) Practitioners should provide experts with explicit program research needs to make sure the most critical exceptional tree/urban forestry questions are being focused on. d) Arborist Advisory Committee members need to interact with practitioners to identify where future exceptional trees should be planted. e) Information should be provided to practitioners in an online/digital format.
2) Hawai'i's Exceptional Tree Program Lacks Clarity	<ul style="list-style-type: none"> a) Improve access to exceptional tree knowledge to promote clarity on program components. b) Ensure exceptional tree program components are standardized throughout the state to avoid confusion if different counties have different rules and policies. c) Produce an exceptional tree "cheat sheet" and/or evaluation template to show examples of qualified specimens. This would help to provide clarity to those who are nominating an exceptional tree to see if their candidate is worthy of this designation, as well as improve transparency during the nomination review process.
3) Next Generation of Exceptional Trees Require a Master Plan to Address Known Obstacles	<ul style="list-style-type: none"> a) Future proof Hawai'i's exceptional tree program from challenges (i.e., developmental and infrastructure conflicts). This will require a next generation master plan that focuses on identifying where exceptional trees are found, areas where they are lacking, suggest new candidates, and determine ideal locations where these trees should be found. b) Developers need to incorporate future exceptional tree candidates into their designs. Incentives should be provided to facilitate this and change the current mentality that these trees are "roadblocks" during development projects. c) Plant ideal species of trees in suitable locations that should be able to achieve exceptional status.

Table 5. 1. (Continued) Desired Program Improvements for each of the Five Weaknesses Identified by Hawai'i's Exceptional Tree Practitioners.

<p>4) Inadequate Exceptional Tree Education and Outreach</p>	<p>a) Improve exceptional tree education and outreach efforts. The Arborist Advisory Committee should take a lead role on this.</p> <p>b) Websites, pamphlets, brochures, brief cheat sheets, signage, and maps should be used for education and outreach efforts.</p> <p>c) Combine exceptional tree maps with improved signage to produce a “<i>stronger tool</i>” that provides information on the exceptional tree, as well as promotes the exceptional tree program.</p> <p>d) Improve the online presence of Hawai'i's exceptional tree program. Content should consist of easy to digest information in a variety of formats that will appeal to different demographics. Content should include an updated exceptional tree registry, list of current arborist advisory committee members, and statistical information regarding these trees (i.e., number of species included in the exceptional tree program, number of exceptional trees per county, etc.).</p> <p>e) Exceptional tree information needs to be freely available from accessible sources, not located behind paywalls.</p> <p>f) Include non-technical methods to convey exceptional tree information so that end-users without access to online or digital content can still receive this knowledge.</p>
<p>5) Exceptional Tree Protection Mechanisms are Insufficient</p>	<p>Management</p> <p>a) Enact a combination of regulations, penalties, and incentives.</p> <p>Incentives</p> <p>b) Reassess and improve exceptional tree incentives, particularly the current tax deduction offered to assist with exceptional tree maintenance.</p> <p>c) Provide reduced/free exceptional tree maintenance.</p> <p>d) Devise incentives that do not have a monetary focus.</p> <p>e) Incentives need to be produced that are appealing and apply to governments, nonprofits, and developers. Incentives for developers could be seen in the form of tax breaks and/or positive recognition to improve their image.</p> <p>Penalties</p> <p>f) Legal action against those who violate Hawai'i's exceptional tree laws should be considered in order to improve the efficacy of this program.</p>

Table 5. 2. Providing Expert Recommended Solutions from Paper 2 to the Five Program Deficiencies Identified by Hawai'i's Exceptional Tree Practitioners in Paper 1.

<p><u>Program Weaknesses Identified by Hawai'i's Exceptional Tree Practitioners (Paper 1)</u></p>	<p><u>Program Improvements Recommended by Hawai'i's Exceptional Tree Experts (Paper 2)</u></p>
<p>1) Lack of Knowledge Exchange Between Exceptional Tree Experts and Practitioners</p>	<p>a) Increase collaborative efforts between stakeholders.</p> <p>b) Facilitate interactions and dialogue between exceptional tree experts and practitioners by:</p> <ul style="list-style-type: none"> - Identifying all relevant expert and practitioner stakeholders. These two groups should maintain regular communication, provide each other with updates, and collaborate when necessary. - Provide continuing education credits to those who attend exceptional tree workshops/seminars/webinars. - Send a current list of exceptional trees to industry professionals. - Provide information on how to fill out an exceptional tree permit. - Utilize social media. - Prioritize support for nonprofits that advocate for exceptional trees so they can foster interactions between exceptional tree experts and practitioners. <p>c) Conferences, webinars, monthly Arborist Advisory Committee meetings, meeting of local organizations, outreach events, arboretums, job sites, and locations where exceptional trees are located are ideal locations for exceptional tree experts and practitioners to interact.</p> <p>d) The co-creation of exceptional tree knowledge between experts and practitioners can be facilitated by creating a panel with members from each group who attend general discussions/public meetings, and participate in research projects.</p> <p>e) Improve knowledge transfer to Hawai'i's exceptional tree experts by considering their stated preferences and identified barriers (<i>responses for each item below are listed based on their stated order of importance</i>):</p> <ul style="list-style-type: none"> - Experts mainly convey new information to statewide practitioners via presentations, email, and informal conversations.

Table 5. 2. (Continued) Providing Expert Recommended Solutions from Paper 2 to the Five Program Deficiencies Identified by Hawai'i's Exceptional Tree Practitioners in Paper 1.

	<ul style="list-style-type: none"> - Experts stated that a lack of time, inadequate outreach, and a lack of effort/motivation were the main barriers preventing them from receiving new information, as well as sharing it with practitioners. - Conferences, trade magazines, colleagues, emails, and professional associations were the preferred knowledge sources of experts. - Colleagues, other experts, Arborist Advisory Committee members, and government administrators were the preferred information sources for experts. <p>Visual (i.e., maps), anecdotal, digital, text (i.e., reports and articles), and numerical (i.e., data tables) data were the preferred knowledge formats for experts.</p>
<p>2) Hawai'i's Exceptional Tree Program Lacks Clarity</p>	<p>a) Increase and improve communication about exceptional tree program components through education and outreach efforts.</p> <p>b) Establish a clear and concise set of exceptional tree selection criteria and nomination procedures.</p> <p>c) Produce a portfolio of exceptional trees that highlights the program's selection criteria through past and current exceptional tree examples. This should be updated periodically and needs to include a clear definition of what constitutes an exceptional tree.</p> <p>d) Maintain an updated registry of exceptional trees in a county database.</p> <p>e) Have an effective means of responding to community concerns and questions pertaining to exceptional trees.</p>
<p>3) Next Generation of Exceptional Trees Require a Master Plan to Address Known Obstacles</p>	<p>a) Produce a long-term management plan that focuses on the maintenance of exceptional trees (i.e., pruning, monitoring for pests and pathogens), annual tree appreciation days/celebrations, education and outreach efforts, and identifying funding opportunities.</p> <p>b) Include climate change mitigation components, such as researching risks pertaining to changing temperatures, precipitation rates, drought/wildfire events, and the introduction of new pests.</p> <p>c) Research which trees will thrive under various climate change scenarios to produce a palette of trees that should be planted now (i.e., species distribution models).</p>

Table 5. 2. (Continued) Providing Expert Recommended Solutions from Paper 2 to the Five Program Deficiencies Identified by Hawai'i's Exceptional Tree Practitioners in Paper 1.

	<p>d) Provide increased maintenance on existing exceptional trees to improve their resiliency and longevity.</p> <p>e) Legislative processes should be enacted to prevent the agreed upon long-term management plan from being easily modified by policy/decision-makers</p>
<p>4) Inadequate Exceptional Tree Education and Outreach</p>	<p>a) Nonprofits and government entities (county and state) should more closely collaborate on education and outreach efforts.</p> <p>b) Arborist Advisory Committees and government Urban Forestry Departments should be information messengers.</p> <p>c) Produce a one-page exceptional tree fun fact document, concise brochure, and an interactive map that is frequently updated.</p> <p>d) Social media, websites, and community presentations should be a priority.</p> <p>e) Use traditional media (Radio and TV) to reach different demographics.</p> <p>f) Presentations should be provided to community members, policy makers, and developers on a frequent basis.</p> <p>g) Educate developers on the value and importance of trees.</p> <p>h) Provide exceptional tree walking tours.</p> <p>i) Initiate an exceptional tree of the week or month program.</p>
<p>5) Exceptional Tree Protection Mechanisms are Insufficient</p>	<p>Management</p> <p>a) One or more entities must take the lead in promoting and managing Hawai'i's exceptional tree program (i.e., City and County of Honolulu Division of Urban Forestry, Division of Planning and Permitting, Arborist Advisory Committee, etc.)</p> <p>b) Only certified arborists who use best management practices, such as those recommended by the International Society of Arboriculture, should be able to prune/maintain an exceptional tree. All certified arborists who want to work on an exceptional tree would need to be approved by the Division of Urban Forestry and/or the Arborist Advisory Committee</p> <p>c) Require industry standard best management practices when construction is taking place in the vicinity of an exceptional tree.</p>

Table 5. 2. (Continued) Providing Expert Recommended Solutions from Paper 2 to the Five Program Deficiencies Identified by Hawai'i's Exceptional Tree Practitioners in Paper 1.

	<p>d) Ensure an exceptional tree replacement program exists.</p> <p>Monitoring</p> <p>e) The Division of Urban Forestry and the Arborist Advisory Committee should be informed by the Department of Planning and Permitting when development/construction will take place in the vicinity of an exceptional tree.</p> <p>f) A health evaluation of an exceptional tree must take place when a parcel of land is sold that contains one or more of these trees. New exceptional tree candidates can also be identified and noted during this visit.</p> <p>g) Annual inspections of exceptional trees by a certified arborist should be conducted to verify the tree is alive and determine if any maintenance needs are required.</p> <p>h) Citizen forester and/or neighborhood watch programs should take on a supporting role in assisting enforcement officers by educating those unfamiliar with the exceptional tree program's legal protections.</p> <p>Incentives</p> <p>i) Modernize Hawai'i's exceptional tree incentives, including the current tax deduction of \$3,000 every three years per exceptional tree. This amount should be updated periodically to account for increased costs and inflation to ensure that the incentive amount can offset some or all of an exceptional tree's maintenance costs.</p> <p>j) Add new direct subsidies such as government rebates and/or tax incentives, (i.e., a tax credit based on the average annual maintenance cost for an exceptional tree produced from quotes provided by three different arborists).</p> <p>k) Incentives should be provided to exceptional tree property owners under a certain income threshold.</p> <p>l) Offer indirect government-funded maintenance assistance.</p> <p>m) Incentives should be applied to homeowners more often than developers.</p> <p>Penalties</p> <p>n) Increase current exceptional tree penalties for developers.</p> <p>o) Tree bonds should be implemented to ensure that industry standard tree protection measures are applied when exceptional trees are in the vicinity of construction sites.</p>
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Table 5. 2. (Continued) Providing Expert Recommended Solutions from Paper 2 to the Five Program Deficiencies Identified by Hawai'i's Exceptional Tree Practitioners in Paper 1.

	<p>p) Fines should be considered for those who intentionally neglect their exceptional trees.</p> <p>q) Fines should be based on the exceptional tree's appraisal value and should scale based on the amount and type of damage done. For example, higher penalties should be issued if an iconic characteristic is lost (i.e., if a tree was deemed exceptional due to the aesthetics of its canopy and half of it was illegally removed, the fine would be higher).</p> <p>r) Penalties should be applied to developers more often than homeowners.</p> <p>Enforcement</p> <p>s) Improve enforcement of exceptional tree laws.</p> <p>t) Arborist Advisory Committee members should be given enforcement capabilities for illegal acts committed against exceptional trees.</p> <p>u) Violators of Hawai'i's exceptional tree laws should have their case reviewed by proper legal authorities, such as Hawai'i's Environmental Court.</p>
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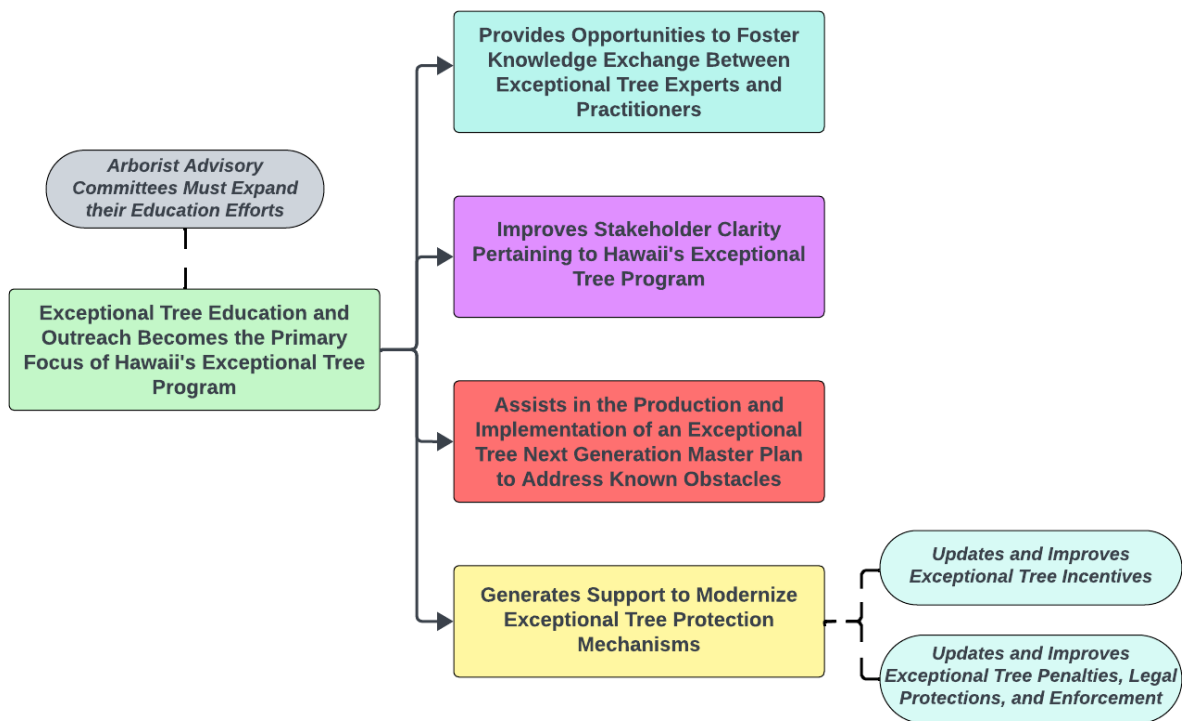


Figure 5. 1. Ability for Education and Outreach Efforts to Improve all Five of the Stated Weaknesses of Hawai‘i’s Exceptional Tree Program.

Opportunities for Future Research

Future research should examine nine exceptional tree and two Delphi methodological components.

Exceptional Tree Programs

First, this study should be replicated both in Hawai‘i and South Australia using different practitioners and experts to further verify our findings. Second, exceptional tree Reflexive Thematic Analysis (RTA) studies conducted in Hawai‘i and South Australia should include politicians and members of the general public as stakeholders of interest to better understand the weaknesses and desired improvements of exceptional tree programs based on the experiences these stakeholders have had. This would provide an optimal opportunity to inquire about the extent of their knowledge pertaining to exceptional tree programs, as well as the

program components they would like to see incorporated into the program's framework. Third, the RTA and Delphi methodologies we used should be replicated elsewhere where exceptional tree programs exist to provide a better understanding of how these programs operate in other locations, as well as any similarities and differences attributed to exceptional tree program weaknesses and preferred selection criteria and program components. It is important that municipal to national scales are examined within and between countries, and a collective RTA and Delphi study should include all four influential exceptional tree stakeholder groups (i.e., practitioners, experts, politicians, and the general public). Having the views of these four stakeholder groups could significantly expand our current understanding of exceptional tree programs and should lead to improvements that could be used to better conserve these trees of importance. The collective findings from these four stakeholder groups could also provide greater insights on how urban forestry programs could be improved, as these individuals are frequently involved with this field.

Next, a Delphi study and/or an in-person focus group should bring together Hawai'i's four Arborist Advisory Committees to examine the results from our study and decide on any components they would like to incorporate into Hawai'i's exceptional tree program based on these empirical findings. Fifth, additional research should be conducted to identify the knowledge exchange preferences and barriers of exceptional tree practitioners, experts, politicians, and the general public in locations where exceptional tree programs exist. This should assist with the dissemination of any newly produced knowledge from the aforementioned RTA and Delphi studies to all four stakeholder groups. Sixth, a study should be conducted using adoption-diffusion theory to examine the real-world effectiveness of the knowledge exchange recommendations produced from our research pertaining to exceptional tree practitioners and experts. Seventh, the findings from our study should be combined with the urban forestry governance framework produced by Lawrence et al. (2013) to provide a greater understanding of the actors and connections that comprise Hawaii's exceptional tree program. Eighth, study examining the Biophilic preferences towards trees conducted by Delavari-Edalat and Abdi (2010) should be replicated with a focus on exceptional trees. This

could strengthen the connection between exceptional trees and biophilic urbanism. Finally, our recommended exceptional tree program components should be tested as part of a larger biophilic urbanism framework to see how they interact with non-exceptional tree necessities.

Delphi Methodology

Future Delphi studies should further test the compatibility of using level of agreement (75%), interquartile range (≤ 1), and co-efficient of variation (≤ 0.5) to determine consensus that has been reached. Additionally, these same studies should include the confirmation of findings verification phase after each survey iteration to provide increased validity and confidence in the study's results, especially if consensus criteria were removed between survey rounds.

Conclusion

This dissertation research sought to examine the fundamental deficiencies that currently exist within Hawai'i's exceptional tree program based on the experiences of exceptional tree practitioners, as well as the essential components that should be included in this program as recommended from the insights and preferences of exceptional tree experts. Through the use of the Reflexive Thematic Analysis method, practitioners throughout Hawai'i were able to identify five exceptional tree program weaknesses. The Delphi method produced solutions to these five deficiencies based on expert knowledge in order to improve this invaluable urban forestry conservation program. The research also examined knowledge exchange and utilization current practices, preferences, and barriers for Hawai'i's exceptional tree practitioners and experts to ensure that existing and newly produced knowledge on this novel topic is conveyed in the most effective format and from the most desirable information source. Collectively, the study's findings provide a template that should be considered by each of the four Arborist Advisory Committees in Hawai'i to improve a statewide exceptional tree program that has seen few modifications since its inception in 1975. Paramount to these recommended changes are the 33 exceptional tree selection criteria derived by our expert panel, in addition to numerous program modifications that address the five program deficiencies identified by our practitioner group. Furthermore, this research transcends Hawai'i and South Australia as 14 of the

recommended consensus criteria shared by these two case studies are also valued in other locations around the world (see Ritchie et al., 2021). This suggests that these criteria may comprise a set of universal exceptional tree criteria, although, our research needs to be replicated in different countries and at varying scales (i.e., municipal to national) to verify this.

The practitioners and experts from our study both felt that Hawai'i's exceptional tree program has strong foundational components. However, these need to be updated and improved to account for new scientific knowledge produced since 1975, as well as incorporate current preferences held by practitioners, experts, politicians, and the general public throughout the state. Future research exploring the preferences of these and other essential exceptional tree stakeholder groups would provide additional knowledge that could enhance exceptional tree programs in Hawaii and beyond.

The study's collective findings also have the potential to serve as the foundation to improve the fields of urban forestry and biophilic urbanism more broadly. This could be realized by placing a greater emphasis on exceptional tree programs in order to increase access to nature in urban areas, while also providing a vital biocultural resource.

As the fundamental nature of exceptional tree programs become increasingly better understood, their incorporation into a holistic biophilic design may be improved, building upon an idea mentioned in 1989:

“Perhaps it is time to recognize this resource officially for what it is, time for governments and mental health professionals and economists to acknowledge what many others have already figured out. It is rare to find an opportunity for such diverse and substantial benefits available at so modest a cost. Perhaps this resource for enhancing health, happiness and wholeness has been neglected long enough” (Kaplan & Kaplan, 1989, p. 198).

This notion of utilizing the immense benefits that nature provides in order to solve many of the dominant environmental and human health concerns in urban areas should continue to be a primary focus of urban forestry research going forward. In doing so, natural and anthropogenic designs could be combined to address the aforementioned environmental and human health issues, with exceptional trees acting as the catalyst to raise awareness, generate support, and spur meaningful environmental change in urban areas often currently devoid of significant natural landscapes.

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APPENDICES

Appendix 1. Duration and Response Rates for Hawai'i and South Australia Exceptional Tree Delphi Case Studies.

Duration for Each Delphi Phase	Hawaii	South Australia
Round One	Round One	Round One
Time from Document Release to Received Responses	73 days (May 9 - July 20)	21 days (May 9 - May 29)
Ranged Response Time (First to Last Submission)	71 days (May 11 - July 20)	21 days (May 9 - May 29)
Average Response Time (Document Release Until Received Response)	17.9 days	10.6 days
Median Response Time (Document Release Until Received Response)	10 days	11.5 days
Number of Surveys Administered (n) and Response Rate (%)	n = 13 (100%)	n = 10 (100%)
Round One Verification Phase	Round One Verification Phase	Round One Verification Phase
Time from Document Release to Received Responses	15 days (August 29 - September 12)	23 days (July 19 - August 10)
Ranged Response Time (First to Last Submission)	14 days (August 30 - September 12)	23 days (July 19 - August 10)
Average Response Time (Document Release Until Received Response)	8.4 days	10.5 days
Median Response Time (Document Release Until Received Response)	7.5 days	11.5 days
Number of Surveys Administered (n) and Response Rate (%)	n = 13 (77%)	n = 10 (100%)
Total Duration - Round One	127 days	94 days
Round Two	Round Two	Round Two
Time from Document Release to Received Responses	60 days (September 29 - November 27)	37 days (September 11 - October 17)
Ranged Response Time (First to Last Submission)	59 days (September 30 - November 27)	36 days (September 12 - October 17)
Average Response Time (Document Release Until Received Response)	21.6 days	12.8 days
Median Response Time (Document Release Until Received Response)	16 days	13 days
Number of Surveys Administered (n) and Response Rate (%)	n = 13 (100%)	n = 10 (90%)
Round Two Verification Phase	Round Two Verification Phase	Round Two Verification Phase
Time from Document Release to Received Responses	54 days (January 6 - February 28)	14 days (November 4 - November 17)
Ranged Response Time (First to Last Submission)	51 days (January 9 - February 28)	13 days (November 5 - November 17)
Average Response Time (Document Release Until Received Response)	15.9 days	9.4 days
Median Response Time (Document Release Until Received Response)	13 days	12 days
Number of Surveys Administered (n) and Response Rate (%)	n = 13 (92%)	n = 9 (100%)
Total Duration - Round Two	153 days	68 days
Round Three	Round Three	Round Three
Time from Document Release to Received Responses	51 days (March 13 - May 2)	52 days (December 14 - February 3)
Ranged Response Time (First to Last Submission)	50 days (March 14 - May 2)	52 days (December 14 - February 3)
Average Response Time (Document Release Until Received Response)	17.1 days	16.3 days
Median Response Time (Document Release Until Received Response)	12.5 days	12 days
Number of Surveys Administered (n) and Response Rate (%)	n = 13 (92%)	n = 9 (100%)
Round Three Verification Phase	Round Three Verification Phase	Round Three Verification Phase
Time from Document Release to Received Responses	23 days (May 8 - May 30)	71 days (March 6 - May 15)
Ranged Response Time (First to Last Submission)	22 days (May 9 - May 30)	71 days (March 6 - May 15)
Average Response Time (Document Release Until Received Response)	8.4	25.3 days
Median Response Time (Document Release Until Received Response)	10	21 days
Number of Surveys Administered (n) and Response Rate (%)	n = 12 (83%)	n = 9 (100%)
Total Duration - Round Three	79 days	71 days
Total Study Duration	387 days (May 9, 2022 - May 30, 2023)	372 days (May 9, 2022 - May 15, 2023)

Appendix 2. South Australia Case Study (part 1) - Comparing Coefficient of Variation, Interquartile Range, and Level of Agreement to Determine Delphi Consensus and Stability.

Criterion	CV R1	IQR R1	Level of Agreement R1	CV R2	IQR R2	Level of Agreement R2	CV R3	IQR R3	Level of Agreement R3	Final CV Values	Final IQR Values	Final Level of Agreement
Veteran Age	Introduced R2	Introduced R2	Introduced R2	0.11	1	100.0	Removed R2	Removed R2	Removed R2	0.11	1	100.0
Ecological/Habitat Value	0.11	1	100.0	Removed R1	Removed R1	Removed R1	Removed R1	Removed R1	Removed R1	0.11	1	100.0
Endangered	0.08	0	100.0	Removed R1	Removed R1	Removed R1	Removed R1	Removed R1	Removed R1	0.08	0	100.0
Indigenous Culturally Modified Associations†	Introduced R2	Introduced R2	Introduced R2	0.06	0	100.0	Removed R2	Removed R2	Removed R2	0.06	0	100.0
Indigenous Culturally Significant Associations†	Introduced R2	Introduced R2	Introduced R2	0.06	0	100.0	Removed R2	Removed R2	Removed R2	0.06	0	100.0
National Interest	0.11	1	100.0	Removed R1	Removed R1	Removed R1	Removed R1	Removed R1	Removed R1	0.11	1	100.0
Cultural Value	0.15	1	90.0	Removed R1	Removed R1	Removed R1	Removed R1	Removed R1	Removed R1	0.15	1	90.0
Historic Person/Memorial Planting	0.15	1	90.0	Removed R1	Removed R1	Removed R1	Removed R1	Removed R1	Removed R1	0.15	1	90.0
Historical Value	0.15	1	90.0	Removed R1	Removed R1	Removed R1	Removed R1	Removed R1	Removed R1	0.15	1	90.0
Historical Witness	0.2	0.75	90.0	Removed R1	Removed R1	Removed R1	Removed R1	Removed R1	Removed R1	0.2	0.75	90.0
Indigenous Cultural Associations	0.14	0.75	90.0	Removed R1	Removed R1	Removed R1	Removed R1	Removed R1	Removed R1	0.14	0.75	90.0
Rarity	0.21	1	90.0	Removed R1	Removed R1	Removed R1	Removed R1	Removed R1	Removed R1	0.21	1	90.0
Remnant	0.14	0.75	90.0	Removed R1	Removed R1	Removed R1	Removed R1	Removed R1	Removed R1	0.14	0.75	90.0
Represented in Historical Documents	0.15	1	90.0	Removed R1	Removed R1	Removed R1	Removed R1	Removed R1	Removed R1	0.15	1	90.0
Social/Community Value	0.13	0	90.0	Removed R1	Removed R1	Removed R1	Removed R1	Removed R1	Removed R1	0.13	0	90.0
Botanical/Horticulture/Arboriculture/Biological Value	0.24	1.5	70.0	0.15	1	88.9	Removed R2	Removed R2	Removed R2	0.15	1	88.9
Collection/Grove/Avenue*	0.27	1	50.0	0.31	1	44.4	0.12	0	88.9	0.12	0	88.9
Landmark/Location/Landscape	0.22	0.75	80.0	Removed R1	Removed R1	Removed R1	Removed R1	Removed R1	Removed R1	0.22	0.75	80.0
Local Significance	0.18	1	80.0	Removed R1	Removed R1	Removed R1	Removed R1	Removed R1	Removed R1	0.18	1	80.0
Relic Specimen	0.28	1	80.0	Removed R1	Removed R1	Removed R1	Removed R1	Removed R1	Removed R1	0.28	1	80.0
Aesthetics	0.4	2.5	50.0	0.31	2	66.7	0.17	0	77.8	0.17	0	77.8
Era-Specific Age*	Introduced R2	Introduced R2	Introduced R2	0.3	2	66.7	0.26	0	77.8	0.26	0	77.8
Human Modifications*	Introduced R2	Introduced R2	Introduced R2	0.28	1	33.3	0.22	0	77.8	0.22	0	77.8
Legends/Mythical/Folklore Value	0.37	1.75	50.0	0.2	2	66.7	0.24	1	77.8	0.24	1	77.8
Significant Environmental Value	0.4	1.75	70.0	0.22	0	77.8	Removed R2	Removed R2	Removed R2	0.22	0	77.8
Species-Specific Circumference/Diameter	Introduced R3	Introduced R3	Introduced R3	Introduced R3	Introduced R3	Introduced R3	0.17	0	77.8	0.17	0	77.8
Endemic	0.32	2.25	70.0	0.19	1	77.8	Removed R2	Removed R2	Removed R2	0.19	1	77.8
Specific Species/Species Significance	0.23	1.75	50.0	0.18	1	77.8	Removed R2	Removed R2	Removed R2	0.18	1	77.8

‡ Recommended and approved for removal from the final round of the study

* Recommended criteria to be re-introduced in the final round

† Sub-criteria of "Indigenous Cultural Associations" criterion

Appendix 3. South Australia Case Study (part 2) - Comparing Coefficient of Variation, Interquartile Range, and Level of Agreement to Determine Delphi Consensus and Stability.

Criterion	CV R1	IQR R1	Level of Agreement R1	CV R2	IQR R2	Level of Agreement R2	CV R3	IQR R3	Level of Agreement R3	Final CV Values	Final IQR Values	Final Level of Agreement
Oldest Specimen of Species in Region‡	0.39	2	40.0	0.37	2	66.7	Removed R2	Removed R2	Removed R2	0.37	2	66.7
Outstanding Example of Species	0.19	1.5	70.0	0.36	3	55.6	0.26	2	66.7	0.26	2	66.7
Program-Specific Circumference/Diameter	Introduced R3	Introduced R3	Introduced R3	Introduced R3	Introduced R3	Introduced R3	0.26	2	66.7	0.26	2	66.7
Seed Source/Propagation Stock*	0.36	1.75	50.0	0.23	1	55.6	0.28	2	55.6	0.28	2	55.6
Religious/Spiritual Value‡	0.27	1.75	50.0	0.27	2	55.6	Removed R2	Removed R2	Removed R2	0.27	2	55.6
Resistant to Disease/Climate Conditions*	0.37	1.75	50.0	0.32	2	55.6	0.3	1	55.6	0.3	1	55.6
Species-Specific Size‡	0.39	1.75	40.0	0.26	1	55.6	Removed R2	Removed R2	Removed R2	0.26	1	55.6
Biological Heritage*	0.33	1.75	50.0	0.26	1	55.6	0.24	1	44.4	0.24	1	44.4
Champion Size - Category*	0.4	1	55.0	0.24	1	66.7	0.32	2	44.4	0.32	2	44.4
Economic Benefits‡	0.4	2.5	50.0	0.31	1	44.4	Removed R2	Removed R2	Removed R2	0.31	1	44.4
Non-Specific Size‡	0.34	1	40.0	0.19	1	44.4	Removed R2	Removed R2	Removed R2	0.19	1	44.4
Productive Trees‡	0.36	2	40.0	0.43	3	44.4	Removed R2	Removed R2	Removed R2	0.43	3	44.4
Program-Specific Crown Spread‡	Introduced R2	Introduced R2	Introduced R2	0.44	3	44.4	Removed R2	Removed R2	Removed R2	0.44	3	44.4
Program-Specific Height‡	Introduced R2	Introduced R2	Introduced R2	0.42	3	44.4	Removed R2	Removed R2	Removed R2	0.42	3	44.4
Edge of Natural Range/Localized Distribution‡	0.44	1.75	40.0	0.53	3	33.3	Removed R2	Removed R2	Removed R2	0.53	3	33.3
Program-Specific/Non-Champion Size‡	0.43	2.75	50.0	0.28	1	33.3	Removed R2	Removed R2	Removed R2	0.28	1	33.3
Species-Specific Height‡	Introduced R2	Introduced R2	Introduced R2	0.41	2	33.3	Removed R2	Removed R2	Removed R2	0.41	2	33.3
Species-Specific Crown Spread	Introduced R2	Introduced R2	Introduced R2	0.35	1	22.2	Removed R2	Removed R2	Removed R2	0.35	1	22.2
Species-Specific Volume	Introduced R2	Introduced R2	Introduced R2	0.34	1	22.2	Removed R2	Removed R2	Removed R2	0.34	1	22.2
Natural Modifications*	Introduced R2	Introduced R2	Introduced R2	0.32	2	44.4	0.31	1	22.2	0.31	1	22.2
Unique Location/Context*	0.42	2	40.0	0.35	1	33.3	0.28	0	22.2	0.28	0	22.2
Unusual Species for Area/Outside Natural Range*	0.45	2	50.0	0.41	2	44.4	0.43	1	22.2	0.43	1	22.2
Form/Structure/Morphology	0.29	0	20.0	Removed R1	Removed R1	Removed R1	Removed R1	Removed R1	Removed R1	0.29	0	20.0
Other Unique Qualities	0.36	0.75	20.0	Removed R1	Removed R1	Removed R1	Removed R1	Removed R1	Removed R1	0.36	0.75	20.0
Species-Specific Age	0.35	1	20.0	Removed R1	Removed R1	Removed R1	Removed R1	Removed R1	Removed R1	0.35	1	20.0
Unusual/Curious Growth Form	0.39	1	20.0	Removed R1	Removed R1	Removed R1	Removed R1	Removed R1	Removed R1	0.39	1	20.0
Growth Conditions	0.27	1	13.0	Removed R1	Removed R1	Removed R1	Removed R1	Removed R1	Removed R1	0.27	1	13.0
Program-Specific Volume	Introduced R2	Introduced R2	Introduced R2	0.35	1	11.1	Removed R2	Removed R2	Removed R2	0.35	1	11.1
Champion Size - Cumulative Points	0.33	2	11.0	Removed R1	Removed R1	Removed R1	Removed R1	Removed R1	Removed R1	0.33	2	11.0
Non-Specific Age	0.21	0.75	10.0	Removed R1	Removed R1	Removed R1	Removed R1	Removed R1	Removed R1	0.21	0.75	10.0
Program-Specific Age	0.45	1.75	10.0	Removed R1	Removed R1	Removed R1	Removed R1	Removed R1	Removed R1	0.45	1.75	10.0

‡ Recommended and approved for removal from the final round of the study

* Recommended criteria to be re-introduced in the final round

Appendix 4. Hawai'i Case Study (part 1) - Comparing Coefficient of Variation, Interquartile Range, and Level of Agreement to Determine Delphi Consensus and Stability.

Criterion	CV R1	IQR R1	Level of Agreement R1	CV R2	IQR R2	Level of Agreement R2	CV R3	IQR R3	Level of Agreement R3	Final CV Values	Final IQR Values	Final Level of Agreement
Botanical/Horticulture/Arboriculture/Biological Value	0.1	0	100.0	Removed R1	Removed R1	Removed R1	Removed R1	Removed R1	Removed R1	0.10	0	100.0
Champion Size - Cumulative Points	0.185	1	61.5	0.142	1	100.0	Removed R2	Removed R2	Removed R2	0.14	1	100.0
Endangered	0.105	1	100.0	Removed R1	Removed R1	Removed R1	Removed R1	Removed R1	Removed R1	0.11	1	100.0
Indigenous Cultural Associations	0.111	1	100.0	Removed R1	Removed R1	Removed R1	Removed R1	Removed R1	Removed R1	0.11	1	100.0
Landmark/Location/Landscape	0.107	1	100.0	Removed R1	Removed R1	Removed R1	Removed R1	Removed R1	Removed R1	0.11	1	100.0
Local Significance	0.098	1	100.0	Removed R1	Removed R1	Removed R1	Removed R1	Removed R1	Removed R1	0.10	1	100.0
Rarity	0.112	1	100.0	Removed R1	Removed R1	Removed R1	Removed R1	Removed R1	Removed R1	0.11	1	100.0
Cultural Value	0.136	1	92.3	Removed R1	Removed R1	Removed R1	Removed R1	Removed R1	Removed R1	0.14	1	92.3
Species-Specific Size	0.273	2	69.2	0.142	1	92.3	Removed R2	Removed R2	Removed R2	0.14	1	92.3
Specific Species/Species Significance	0.141	1	92.3	Removed R1	Removed R1	Removed R1	Removed R1	Removed R1	Removed R1	0.14	1	92.3
Social/Community Value	0.191	1	92.3	Removed R1	Removed R1	Removed R1	Removed R1	Removed R1	Removed R1	0.19	1	92.3
Ecological/Habitat Value	0.203	1	84.6	Removed R1	Removed R1	Removed R1	Removed R1	Removed R1	Removed R1	0.20	1	84.6
Relic Specimen	0.211	1	84.6	Removed R1	Removed R1	Removed R1	Removed R1	Removed R1	Removed R1	0.21	1	84.6
Remnant	0.196	2	69.2	0.151	0	84.6	Removed R2	Removed R2	Removed R2	0.15	0	84.6
Significant Environmental Value	0.234	0	84.6	Removed R1	Removed R1	Removed R1	Removed R1	Removed R1	Removed R1	0.23	0	84.6
Aesthetics	0.168	1	84.6	Removed R1	Removed R1	Removed R1	Removed R1	Removed R1	Removed R1	0.17	1	84.6
Historical Value	0.165	1	84.6	Removed R1	Removed R1	Removed R1	Removed R1	Removed R1	Removed R1	0.17	1	84.6
Legends and Oral Histories†	0.204	1	61.5	0.172	0	84.6	Removed R2	Removed R2	Removed R2	0.17	0	84.6
National Interest	0.165	1	84.6	Removed R1	Removed R1	Removed R1	Removed R1	Removed R1	Removed R1	0.17	1	84.6
Religious/Spiritual Value	0.172	0	84.6	Removed R1	Removed R1	Removed R1	Removed R1	Removed R1	Removed R1	0.17	0	84.6
Seed Source/Propagation Stock	0.315	2	69.2	0.21	1	84.6	Removed R2	Removed R2	Removed R2	0.21	1	84.6
Resistant to Disease/Climate Conditions*	0.258	2	53.9	0.224	1	69.2	0.194	0	83.3	0.19	0	83.3
Socio-Cultural Benefits	Introduced R3	Introduced R3	Introduced R3	Introduced R3	Introduced R3	Introduced R3	0.204	0.25	83.3	0.20	0.25	83.3
Champion Size - Category	0.219	1	76.9	Removed R1	Removed R1	Removed R1	Removed R1	Removed R1	Removed R1	0.22	1	76.9
Collection/Grove/Avenue	0.258	0	76.9	Removed R1	Removed R1	Removed R1	Removed R1	Removed R1	Removed R1	0.26	0	76.9
Economic Benefits	0.277	1	53.9	0.157	0	76.9	Removed R2	Removed R2	Removed R2	0.16	0	76.9
Historic Person/Memorial Planting	0.172	1	69.2	0.139	0	76.9	Removed R2	Removed R2	Removed R2	0.14	0	76.9
Historical Witness	0.24	2	69.2	0.157	0	76.9	Removed R2	Removed R2	Removed R2	0.16	0	76.9
Non-Specific Size	0.289	0	76.9	Removed R1	Removed R1	Removed R1	Removed R1	Removed R1	Removed R1	0.29	0	76.9
Outstanding Example of Species	0.185	1	76.9	Removed R1	Removed R1	Removed R1	Removed R1	Removed R1	Removed R1	0.19	1	76.9
Productive Trees	0.275	1	38.5	0.157	0	76.9	Removed R2	Removed R2	Removed R2	0.16	0	76.9
Represented in Historical Documents	0.179	1	76.9	Removed R1	Removed R1	Removed R1	Removed R1	Removed R1	Removed R1	0.18	1	76.9
Form/Structure/Morphology*	0.247	1	53.9	0.269	1	46.2	0.177	0.5	75.0	0.18	0.5	75.0

‡ Recommended and approved for removal from the final round of the study

* Recommended criteria to be re-introduced in the final round

Appendix 5. Hawai'i Case Study (part 2) - Comparing Coefficient of Variation, Interquartile Range, and Level of Agreement to Determine Delphi Consensus and Stability.

<u>Criterion</u>	<u>CV R1</u>	<u>IQR R1</u>	<u>Level of Agreement R1</u>	<u>CV R2</u>	<u>IQR R2</u>	<u>Level of Agreement R2</u>	<u>CV R3</u>	<u>IQR R3</u>	<u>Level of Agreement R3</u>	<u>Final CV Values</u>	<u>Final IQR Values</u>	<u>Final Level of Agreement</u>
Endemic‡	0.196	2	69.2	0.203	2	69.2	Removed R2	Removed R2	Removed R2	0.20	2	69.2
Biological Heritage*	0.297	2	69.2	0.185	1	61.5	0.221	1	66.7	0.22	1	66.7
Survivor Tree	Introduced R3	Introduced R3	Introduced R3	Introduced R3	Introduced R3	Introduced R3	0.194	1.25	66.7	0.19	1.25	66.7
Other Unique Qualities*	0.275	1	46.2	0.263	1	61.5	0.244	2	66.0	0.24	2	66.0
Oldest Specimen of Species in Region*	0.37	1	46.2	0.317	1	61.5	0.221	1.25	50.0	0.22	1.25	50.0
Species-Specific Age*	0.426	3	53.9	0.333	1	46.2	0.308	1	50.0	0.31	1	50.0
Growth Conditions*	0.428	2	38.5	0.308	1	69.2	0.311	1	41.7	0.31	1	41.7
Non-Specific Age‡	0.285	1	61.5	0.348	2	38.5	Removed R2	Removed R2	Removed R2	0.35	2	38.5
Unusual/Curious Growth Form	0.37	1	23.1	Removed R1	Removed R1	Removed R1	Removed R1	Removed R1	Removed R1	0.37	1	23.1
Edge of Natural Range/Localized Distribution	0.429	1	23.1	Removed R1	Removed R1	Removed R1	Removed R1	Removed R1	Removed R1	0.43	1	23.1
Unique Location/Context	0.341	1	23.1	Removed R1	Removed R1	Removed R1	Removed R1	Removed R1	Removed R1	0.34	1	23.1
Unusual Species for Area/Outside Natural Range	0.386	1	23.1	Removed R1	Removed R1	Removed R1	Removed R1	Removed R1	Removed R1	0.39	1	23.1
Program-Specific Age	0.549	2	15.4	Removed R1	Removed R1	Removed R1	Removed R1	Removed R1	Removed R1	0.55	2	15.4
Program Specific/Non-Champion Size	0.48	1	7.7	Removed R1	Removed R1	Removed R1	Removed R1	Removed R1	Removed R1	0.48	1	7.7

‡ Recommended and approved for removal from the final round of the study

* Recommended criteria to be re-introduced in the final round

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