A 2018 Assessment of TREE Fund Research Grant Program: Research Outputs, Outcomes, & Impacts

A Review of Research Grant Programs from 2003 to 2018

Acknowledgments

There many hands who made this project possible. The authors of this report are indebted to Barbara Duke for her help in providing the original Tree Research and Education Endowment Fund (TREE Fund) applications and final grant reports submissions. The authors also thank the past grant recipients who helped identify additional products and impacts associated with their research efforts. Finally, we thank the participants of our key informant interviews. These industry leaders, researchers, and educators provided a wealth of insights as the end users of TREE Fund-supported information and innovation from supported research.

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Executive Summary

This report for Tree Research and Education Endowment Fund (TREE Fund) includes findings from 190 research grants funded through the Hyland R. Johns, Jack Kimmel International, John Z. Duling, Safe Arborist Techniques Fund, and the Utility Arborist Research Fund. In addition, TREE Fund-supported three research fellowships since 2009. TREE Fund's mission is to *support scientific discovery and dissemination of new knowledge in the fields of arboriculture and urban forestry*. TREE Fund is a 501(c)3 nonprofit organization established in 2002 and resulted from the merger of the International Society of Arboriculture Research Trust and the National Arborist Foundation of the National Arborist Association (now the Tree Care Industry Association). The impact of research awarded before the establishment of TREE Fund was not a part of this study. Additionally, we did not address the impacts of the various educational grants and scholarships administered by TREE Fund. The findings in this report quantify the knowledge gained through TREE Fund research grants and the outcomes that ideally enhance the practice of arboriculture and urban forestry and people in communities throughout the world impacted by trees every day.

In documenting the impact of past TREE Fund grants, a comprehensive review of past funded projects was conducted to gauge direct and indirect research outcomes, outputs, and impacts. Research outcomes and outputs were assessed both quantitatively and qualitatively through our review of proposals and reporting documents submitted to TREE Fund and an intensive search of academic journals and academic databases. This systematic assessment of archival and published records was used to quantify the number of peer-reviewed and popular press articles, creative media works, training opportunities, new professionals, and leveraged research funds that can be traced back to TREE Fund-supported research grants. We determined research impacts through an analysis of industry standards/BMPs and responses from a panel of key informants (including educators, NGO representatives, government coordinators, and industry representatives). Additionally, we quantified research impacts as possible given the data available.

The impact phase was a challenging aspect of the project given information currently available. As such, the professional expertise of the research team supplemented by the key informant analysis was used to develop a summary of impacts (e.g., economic, environmental, health, social) from TREE Fund granted projects.

Highlights from the study:

- TREE Fund has distributed over $3.9 million in grants over the past 15 years. In comparison, the ISA Research Trust distributed $460,000 (CPI adjusted to 2018) in the 15 years before TREE Fund's establishment.
- A total of five research grant programs are currently in place, and two more (i.e., Barborinas Family Fund and Bob Skiera Memorial Fund) are slated to be implemented in 2019.
- The number of awards dispersed by TREE Fund peaked between 2003 and 2007. As award funding levels increase, the number of awards has steadily decreased.
- A total 175 TREE Fund sponsored peer-reviewed articles were located, with an average of 20.8 citations per paper in other peer-reviewed papers.
- Over 56% of the research published is readily accessible to practitioners through open-source publication. Technology transfer remains another viable conduit of knowledge gained with 46 articles located in industry publications.

- On average, $2.63 in additional funds were leveraged for each grand dollar awarded by TREE Fund.
- TREE Fund has supported over eight Ph.D. students and over 28 M.S. students.
- The majority (68%) of invited key informants participated and provided insight into the outcomes and impact of TREE Fund grant program which revealed:
  - Seventeen themes of practice (e.g., application to culture and maintain trees) with urban forestry (ten responses), planting (eight responses), safety (seven responses), utility (five responses), soils (three responses), and tree risk (three responses) were most often reported.
  - Themes of the impact (e.g., outcome of sponsored research) found TREE Fund-supported research influenced the practice of arboriculture and urban forestay through revised tree care standards, local planting standards, benchmarking, and assessment protocols.
  - The majority of key informants indicated that TREE Fund grants were *very important* as a funding source for research on urban tree care (6.4 index score, one to seven scale with one = *very unimportant* and seven = *very important.*
  - More importantly, informants rated the research funded by TREE Fund was *very important* (6.5 index score, one to seven scale with one = *very unimportant* and seven = *very important*).
  - Additionally, the outcomes of TREE Fund-supported projects were rated as being *very important* (6.3 index score, one to seven scale with one = *very unimportant* and seven = *very important*).
  - Traditional areas of arboriculture and urban forestry practice (e.g., pest control, tree planting, pruning, soil & root management) ranked well (5.7 to 6.2 index scores, one to seven scale with one = very little and seven = very much) with regard to perceived importance.
- TREE Fund co-sponsored webinar series has resulted in approximately 4,800 people attending since its inception. On average, approximately 400 professionals are attending the live broadcasts of each presentation.
- TREE Fund sponsored research has been instrumental in the review and updating of industry tree care standards.
  - By example, the recent pruning standard (ANSI A300 Part 1) was updated significantly based on pruning research sponsored by TREE Fund.
  - The ANSI A300 tree planting standard and the root management standard (both currently in revision) have also benefited from TREE Fund sponsored research.

The results that follow describe the outputs, outcomes, and impacts of TREE Fund research grant programs. In conducting this review, we used multiple methods to identify the new knowledge gained from funded projects – tracing this, as possible, to tangible industry impacts. The key informant interviews provide further evidence of the impact of TREE Fund as industry leaders share their views on the importance of research, research funded by TREE Fund, and what they consider to be the most meaningful impacts linked to the past 15 years of funding. Overall, the results paint a positive picture of TREE Fund grant program. Several recommendations are offered about the submission of final reports, the acknowledgment of funding, and technology transfer. Ultimately we hope the presented results serve as a strong foundation of information as TREE Fund plans its next 15 years of operation.

Introduction

TREE Research and Education Endowment Fund (TREE Fund) is an organization that supports the creation and dissemination of knowledge needed to safely and effectively maintain the health of trees in communities throughout the world. The 501(c)3 nonprofit organization was established in 2002 and is dedicated to supporting scientific discovery and dissemination of new knowledge in the fields of arboriculture and urban forestry. Specifically, their efforts include:

- The funding of scientific research on urban tree care issues.
- The support of education programs related to trees.
- The selection of scholarship recipients for students aspiring to be tree care professionals.

The roots of TREE Fund began with the 2002 merger of the International Society of Arboriculture Research Trust and the National Arborist Association (now the Tree Care Industry of America) National Arborist Foundation. To date, the organization's endowment has distributed over $3.9 million through more than 260 research, education, and scholarship awards. Five thematic research areas are currently supported through the various research programs managed by TREE Fund (Figure 1). In addition to these awards, over $4.5 million has been endowed by TREE Fund, and the endowed funds continue to grow (Figure 2).

TREE Fund actively pursues its mission to *support scientific discovery and dissemination of new knowledge in the fields of arboriculture and urban forestry* through a multitude of partners, volunteers, and staff. Partnerships include many organizations and industry professionals that provide guidance and financial support. Volunteers involve dedicated people such as *Tour des Trees* riders and the organization's board of trustees currently chaired by Steven Geist. Five TREE Fund staff provide the organizational structure to raise funds, support partnership development, implement educational outreach, conduct community engagement, and support grant operation and management. The staff in 2018 include:

- Barbara Duke, Grants and Operations Manager
- Maggie Harthoorn, Community Engagement Associate
- Karen Lindell, Communications Coordinator
- Monika Otting, Development Manager
- J. Eric Smith, President and CEO

The focus of this report is the assessment of TREE Fund research grant programs. The project was envisioned by TREE Fund Board of Trustees to support the assessment of past projects for their impacts and outcomes (Appendix A). To accomplish this, a multiple methods approach was used to determine outputs through scientific and popular publications, graduate students trained/mentored, presentations through conferences, and webinars. Although the scientific worth of these outputs can be tricky to determine, impact as measured through citations, journal impact factors, and international reach serve, in part, as a means of assessing program outcomes. Qualitatively, a key informant investigation was used to further describe the impact of TREE Fund grant programs (Appendix B). The methods and results of this work follow in greater detail below.

Root and Soil Management: Many urban tree problems originate below ground. Promoting root development, protecting roots from injury, and conflicts with infrastructure are issues that arborists encounter regularly. Managing roots includes soil management.

Planting and Establishment: Tree survival and vigorous growth after planting are of concern to arborists and the entire green industry. Arborists are increasingly dealing with problems that originate in, or could be avoided by, the planting process.

Plant Health Care: Healthy plants have more effective defense systems and are better able to resist pests. Complete understanding of plant health may lead to new pest control strategies.

Risk Assessment and Worker Safety: Safety is a major concern. It can be a life-or-death issue to tree workers and the public. Detection of defects and knowing how they develop are important. Improved equipment and work practices are needed.

Urban Forestry: Urban forestry is the care and management of urban forests (i.e., tree populations in urban settings) for the purpose of improving the urban environment.

Figure 1. Research priority areas of Tree Research and Education Endowment Fund (TREE Fund). Source: TREE Fund Research web page https://treefund.org/research

COMPARATIVE STATEMENT OF FINANCIAL POSITION

	FY 2017	FY 2016
ASSETS		
Cash and Cash Equivalents	$121,732	$233,946
Pledges Receivable	$137,646	$10,550
Endowment (Held by Chicago Community Trust)	$4,543,784	$3,771,410
Other (Prepaid Expenses, Equipment, Etc.)	$10,009	$4,947
TOTAL ASSETS	**$4,813,171**	**$4,020,853**
LIABILITIES		
Accounts Payable	$11,046	$21,142
Accrued Expenses	$15,956	$18,707
Monetary Grants Payable	$351,100	$332,992
TOTAL LIABILITIES	**$378,102**	**$372,841**
NET ASSETS		
Unrestricted/Temporarily Restricted	($72,068)	$98,403
Permanently Restricted	$4,507,137	$3,549,609
TOTAL NET ASSETS	**$4,435,069**	**$3,648,012**
TOTAL LIABILITIES AND NET ASSETS	**$4,813,171**	**$4,020,853**

Figure 2. Financial statement of Tree Research and Education Endowment Fund (TREE Fund). Source: 2017 TREE Fund Annual Report.

Methodology

A multiple methods approach was used to conduct this program review. Specifically, we looked at archival materials provided by TREE Fund, conducted systematic searches of peer-reviewed and trade publications, performed a content analysis of the published abstracts, and conducted a key informant study of research end-users (i.e., industry leaders, educators, and other researchers). Each of these methods is described in greater detail below.

Review of Past Submissions and Final Reports

TREE Fund served as the initial source for records in developing a database of all the research grants administered since 2003. Records were compiled from TREE Fund's online archive, all available final reports (n = 115), and all available grant proposals (from successful applicants; n = 111). The six funded programs included in this report are: 1) Hyland R. Johns Grant, 2) John Z. Duling Grant, 3) Jack Kimmel International Grant, 4) the Research Fellowship, 5) the Utility Arborist Research Fund, and 6) the Safe Arborist Techniques Grant. The TREE Fund's newer funding initiatives (e.g., the Barborinas Family Fund Grant and Bob Skiera Building Bridges Grant) nor its directed grants were included in our assessment.

The information contained in these internal sources served as the foundation for our program review and database. Specifically, the following data were captured in our project database:

- Year of award
- Grant program
- Project title
- Principal investigator (PI) and co-principal investigator (Co-PI)
- PI/Co-PI institution, institution country, and contact information
- Named students in proposal
- Associated funding priority area (as archived on TREE Fund website)
- Funds requested
- Total project budget
- Number of International Society of Arboriculture (ISA) Annual Conference presentations
- Number of ISA Chapter presentations delivered
- Number of other academic or professional conference presentations delivered
- Number of academic journal articles published
- Journals chosen for publication (with associated publications counts)
- Future academic journal articles anticipated
- Number of trade/professional articles published
- Trade magazines chosen for publication (with associated publication counts)
- Number of other reports, fact sheets, etc. produced
- Number of undergraduate student researchers supported
- Number of graduate (masters-level) student researchers supported
- Number of graduate (doctoral-level) student researchers supported
- Number of patents filed
- Number of awards/honors associated with the project
- Other creative works/deliverables associated with the project

Citation Search of Past TREE Fund Awardees

Building on the archive data compiled above, we completed a systematic search of citations for the 109 unique PIs funded by TREE Fund over the past 15 years. The publication record for each PI was accessed using Google Scholar profiles, ResearchGate profiles, and other online citations listings (e.g., personal websites, posted *curriculum vitae*, etc.). These results were cross-referenced against targeted Google Scholar searchers – limiting the search results to articles written by the PI in the years following their first TREE Fund grant (including the year of their first award). Google Scholar was selected as the primary research database as it finds journals and reports in non-Institute for Scientific Information- (non-ISI-) indexed journals. Other research tools commonly employed in literature reviews (e.g., Web of Science) do not currently include articles in *Arboriculture & Urban Forestry*, *Arboricultural Journal*, *Cities and the Environment*, the *Journal of Environmental Horticulture,* and other peer-reviewed outlets favored by TREE Fund recipients as they limit their scope to ISI-indexed titles (e.g., *Urban Forestry & Urban Greening, Tree Physiology*). As a final check, an author search was conducted on the *Arboriculture & Urban Forestry* (the most popular non-ISI title) website to assure the completeness of the Google Scholar results.

Once a complete list of peer-reviewed publications was generated for each PI, any published works not listed in the final project reports were accessed and read to assess whether TREE Fund was acknowledged as a source of research funding. All articles officially acknowledging TREE Fund were added to the citation list featured in Appendix C. A Mendeley-generated BibTeX file containing these papers is available for download here.

Noting the importance of technology transfer, we generated a second citation list of trade publications (Appendix D). This citation list was initially created based on the citations noted in the final reports. Additionally, a complete search of *Arborist News* and *Tree Care Industry Magazine* was conducted for issues published within the 2003 to 2018 assessment period. These two trade magazines were among the most commonly cited in final reports and feature online, open-access archives. As with the peer-reviewed literature search, any articles that officially acknowledged TREE Fund as a source of financial support (but were not included in the final reports) were added to our final citation list (Appendix D).

Content Analysis of Published Research Titles, Abstracts, and Keywords

Titles, abstracts, and keywords were assessed to identify key findings and common themes. This resulting text was assessed qualitatively using the RQDA package (Huang, 2014) in R (R Core Team, 2018). The content was initially coded using topics related to the ISA Certified Arborists test domains and current ISA Best Management Practices titles. After an initial assessment, additional codes were added as needed (e.g., deep planting) to capture themes not categorized with our original coding list.

Our final list of 18 research topic areas was:

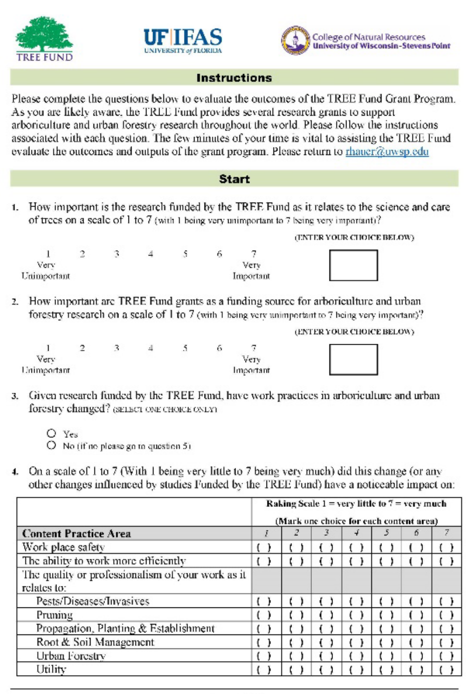
- Amendments/Mulching
- Biomechanics
- Deep Planting
- Diversity/Plant Selection

- Fertilization
- Nursery Production
- Plant Health Care - Disease Management
- Plant Health Care - Pest Management
- Plant Health Care - Other
- Planting and Establishment
- Pruning
- Risk Assessment
- Root Management
- Tree Biology
- Tree Worker Safety
- Urban Forestry
- Urban Soils
- Utility Arboriculture/Forestry

Key Informant Assessment of Outcomes

Key informant interviews are qualitative, in-depth discussions with people who best know a subject matter. A representative set of participants from academia (both researchers and educators), nongovernmental organizations, and industry (commercial, municipal, and utility) was asked to participate in our key informant assessment (Appendix E). Both phone calls and an e-mailed informant survey were used to communicate with participants. To make valid inferences, we had a target minimum of 12 informants. A total of 25 potential informants were initially contacted in the process. Of those contacted, 17 were able to participate in our interview process.

Key informants were asked to rank the importance of research funded by TREE Fund and the importance of the funding in allowing industry researchers to carry out their research. A seven-point Likert scale using a ranking of one (*very unimportant*) to seven (*very important*) was used to rank perceived importance, with an index score of four serving as *neutral*. We also attempted to ascertain whether work practices in arboriculture and urban forestry had changed as a result of research funded by TREE Fund. If informants said "yes" they next were asked to describe the impact of research funding on practices using the scale mentioned above. Areas of possible change included workplace safety and the ability to work more efficiently. Additionally, informants were asked if TREE Fund-supported research had improved the quality of professional work practice in six themed areas which align with current TREE Fund priority areas (i.e., 1. pests/disease/invasives; 2. pruning; 3. propagation, planting, and establishment; 4. root and soil management; 5. urban forestry; and 6. utility). Finally, key informants were asked to provide a specific example (or examples) of a notable outcome(s) that has influenced the practice of arboriculture and urban forestry.


TREE FUND — UF|IFAS UNIVERSITY of FLORIDA — College of Natural Resources, University of Wisconsin-Stevens Point

Instructions

Please complete the questions below to evaluate the outcomes of the TREE Fund Grant Program. As you are likely aware, the TREE Fund provides several research grants to support arboriculture and urban forestry research throughout the world. Please follow the instructions associated with each question. The few minutes of your time is vital to assisting the TREE Fund evaluate the outcomes and outputs of the grant program. Please return to rhauer@uwsp.edu

Start

1. How important is the research funded by the TREE Fund as it relates to the science and care of trees on a scale of 1 to 7 (with 1 being very unimportant to 7 being very important)?

(ENTER YOUR CHOICE BELOW)

1 Very Unimportant 2 3 4 5 6 7 Very Important

2. How important are TREE Fund grants as a funding source for arboriculture and urban forestry research on a scale of 1 to 7 (with 1 being very unimportant to 7 being very important)?

(ENTER YOUR CHOICE BELOW)

1 Very Unimportant 2 3 4 5 6 7 Very Important

3. Given research funded by the TREE Fund, have work practices in arboriculture and urban forestry changed? (SELECT ONE CHOICE ONLY)

○ Yes
○ No (if no please go to question 5)

4. On a scale of 1 to 7 (With 1 being very little to 7 being very much) did this change (or any other changes influenced by studies Funded by the TREE Fund) have a noticeable impact on:

	Raking Scale 1 = very little to 7 = very much (Mark one choice for each content area)						
Content Practice Area	1	2	3	4	5	6	7
Work place safety	( )	( )	( )	( )	( )	( )	( )
The ability to work more efficiently	( )	( )	( )	( )	( )	( )	( )
The quality or professionalism of your work as it relates to:							
Pests/Diseases/Invasives	( )	( )	( )	( )	( )	( )	( )
Pruning	( )	( )	( )	( )	( )	( )	( )
Propagation, Planting & Establishment	( )	( )	( )	( )	( )	( )	( )
Root & Soil Management	( )	( )	( )	( )	( )	( )	( )
Urban Forestry	( )	( )	( )	( )	( )	( )	( )
Utility	( )	( )	( )	( )	( )	( )	( )

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Project Findings

TREE Fund traces its historical roots to the 1970s and the proposed tax-exempt Memorial Research Trust Fund promoted by O.J. Anderson and John Duling (TREE Fund undated). In 1976 the International Society of Arboriculture created the ISA Research Trust. A total of five research grants each totaling $500 ($2500 total) were awarded in this first year. For context, a $500 award in 1976 would be approximately $2,200 in 2018 (Consumer Price Index, CPI inflation adjusted). Over the initial 15 years, the ISA Research Trust awarded 162 grants totaling $250,000. The average award per grant was $1500 during this period. Adjusted for inflation (CPI), the nominal $250,000 amount is worth a real $460,000 in 2018. In 1995 the Hyland R. Johns Grant Program was created to expand the size of a research grant to $5,000 ($8,240 CPI adjusted for 2018) or more as needed for special situations. The John Z. Duling Grant program was also formalized at this time. The historical legacy has grown to the present research funding levels at $50,000 for the Hyland R. Johns and $25,000 John Z. Duling grants (Table 1). When adjusted for inflation the funding capacity of a grant is six times larger today for a $50,000 Hyland R. Johns grant.

Table 1. TREE Fund grant programs and associated funding level as of November 2018.

Grant Program	Funding Level Range
Barborinas Family Fund[1]	$5,000 to $10,000
Bob Skiera Memorial Fund[1]	$10,000 to $25,000
Directed Grant Programs	Varies[2]
Hyland R. Johns	$10,000 to $50,000
Jack Kimmel International	$5,000 to $10,000
John Z. Duling	$10,000 to $25,000
Utility Arborist Research Fund	$10,000 to $50,000
Safe Arborist Techniques Fund	$5,000 to $10,000
Sponsored Grant Program	Varies[3]

[1] Currently not implemented, target 2019 inaugural granting
[2] Not specified, past grants were each $100,000
[3] Varies based on the directed research activity and sponsor funding level

Several research needs assessments for arboriculture and urban forestry have been written in the past three decades. The first seminal work, *A National Research Agenda for Urban Forestry in the 1990s'* was created using a multiple mode assessment approach that included an advisory committee, the Delphi process, white papers generation, and a formal summit (Dwyer et al. 2002, Makra and Watson 2003). A 2002 update of this needs assessment was funded by TREE Fund resulting in 32 identified technical disciplines (Table 2). The National Urban & Community Forestry Advisory Council and ISA have also been instrumental in developing and shaping an arboriculture and urban forestry research agenda (National Urban and Community Forestry Advisory Council 2005, Clark et al. 2006, Wolf 2010, Avenue M Group 2015, University of Virginia Institute for Environmental Negotiation 2015). Each of these research priority reports was used to develop research agendas. A common thread through all of these efforts was a proposed set of research priorities. However, none of these needs assessments looked specifically at past research outcomes. Similarly, none of these reports were revisited to evaluate research efforts within the stated research priorities. This report marks the first known attempt to determine the outcomes and impact of past TREE Fund sponsored research. Findings from this effort follow and are broken down broadly by research priority area (and more specifically in the themes noted in the content analysis).

Table 2. A Revised National Research and Technology Transfer Agenda for Urban and Community Forestry June 2003 (Makra and Watson 2003). (Note: The Advisory Committee identified 32 technical disciplines and grouped them into two major categories.)

Urban Forest Management and Resulting Benefits
Land-Use Planning and Public Policy
Tree and Forest Inventories and Analysis
Trees and Infrastructure
Rights-of-Way Management
Urban Ecosystem Restoration and Sustainability
Urban-Wildland Interface
Urban Tree Waste Utilization
Watershed Protection
Urban Forest Health
Municipal Forestry Program Status and Scope
Economic Benefits and Value of Urban Forests
Environmental Benefits of the Urban Forest
Benefit-Cost Analysis and Modeling
Social Benefits (Impacts on Neighborhood and Community Quality of Life)
Human Health Benefits
Tree-Care Practices and Supporting Tree Biology
Tree Dynamics and Worker Safety
Pruning Trees in Urban and Suburban Landscapes
Plant Health Care
Tree Structure and Risk Assessment
Damage to Mature Trees from Construction and Development
Cable and Bracing, Lightning Protection
Nursery Production and Site Selection
Root Growth on Urban Sites
Tree Water Management
Soil Management
Genetics and Breeding: Tree Evaluation and Improvement
Tree Growth Regulators
Plant Pathology
Entomology
Decay Development and Wound Closure
Environmental Stress
Phytoremediation

Review of Past Submissions and Final Reports

Of the six grant programs assessed for this report, John Z. Duling awards were the most numerous over the past 15 years (Figure 3). With regard to the number of awards distributed annually, the John Z. Duling grant program peaked in 2005 with 16 funded proposals (Figure 3). However, since 2011 this program has typically funded two submissions per year. The Hyland R. Johns grant follows a similar pattern, with the number of funded proposals diminishing beginning in 2009 (Figured 3). When regressed over time, there is a notable decline in the number of awards distributed across all TREE Fund programs since the beginning of this study period (Figure 4). Though the Utility Arborist Research program, the research fellowship, and the Safe Arborist Techniques Fund have begun dispersing research awards in more recent years (Figure 3), their impact was not enough to reverse this trend of total number of funded grants.

The reduction in the number of John Z. Duling grants awarded in a given year does coincide with incremental increases in the maximum allowable funding request. In 2009, the maximum allowable budget increased from $7,000 to $10,000. This was later increased to a maximum requested budget of $25,000 in 2016. Throughout much of our assessment period, maximum award levels for Hyland R. Johns grants remained largely unchanged. In 2017, the maximum award of this funding program increased from $25,000 to $50,000. Additionally, three research fellowships (with $100,000 request limits), were funded during this time frame, as well as the initiation of the three newest grant programs assessed in this report (i.e., Jack Kimmel International grant, Utility Arborist Research grant, and the Safe Arborist Technique grant).

This decrease in the number awards does not reflect a diminished applicant pool. As an example, the fall 2018 John Z. Duling call for submissions drew a total of 57 applications for its single award (Figure 3). With this success rate of less than 2%, an applicant is over 10x more likely to receive funding through the National Science Foundation's Biological Science program (National Science Foundation 2018). Rather, this trend reflects a push to both increase the endowments behind TREE Fund's granting programs and an effort to provide researchers with the larger awards needed to ensure their continued employment and promotion. The latter objective stems from conversations and appeals made to TREE Fund in 2013 by several TREE Fund recipients and the ISA Science and Research committee.

The majority of research funded by TREE Fund was directed towards researchers from the United States (n= 152, Figure 5). With 17 funded proposals, researchers in the United Kingdom were the next most successful. Italy (n=5), Canada (n=4), New Zealand (n=3), Australia (n=2), and Germany (n=2) all had multiple awards (Figure 5). The remaining five countries (China, Columbia, Ethiopia, Sweden, Ukraine) represented in the pool of funded proposals each had a single award funded (Figure 5).

With regard to TREE Fund's expressed research priorities, research proposals focused on *soil and root management* were the most successful over the assessment period (27%; Figure 6). The next two most successful categories were *propagation, planting, and establishment* and *risk assessment and worker safety* (both 18% of funded proposals; Figure 6). *Pests, diseases, and invasives* was the next most funded research priority (17%; Figure 6). *Urban forestry* (12%), *pruning* (5%), and *utility* (3%) themed projects made up a smaller proportion of TREE Fund-supported research (Figure 6).

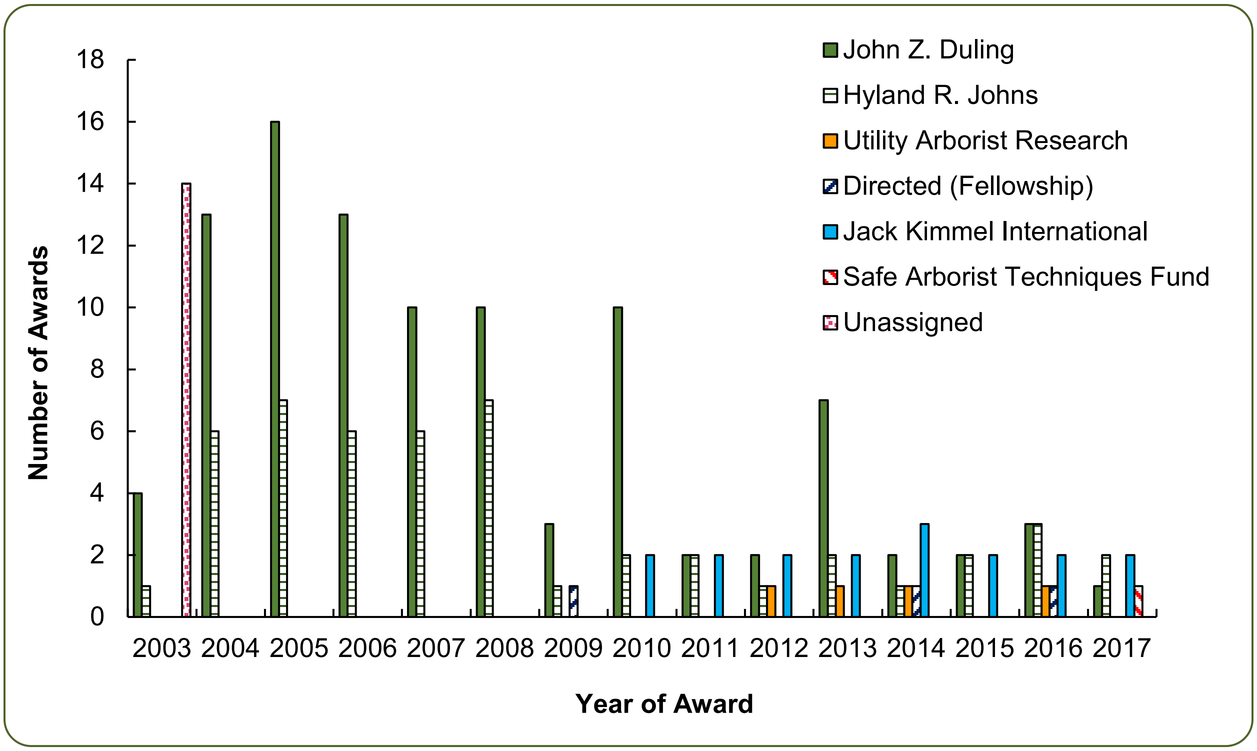

Figure 3. Grants awarded by TREE Fund by granting program from 2003 – 2008.

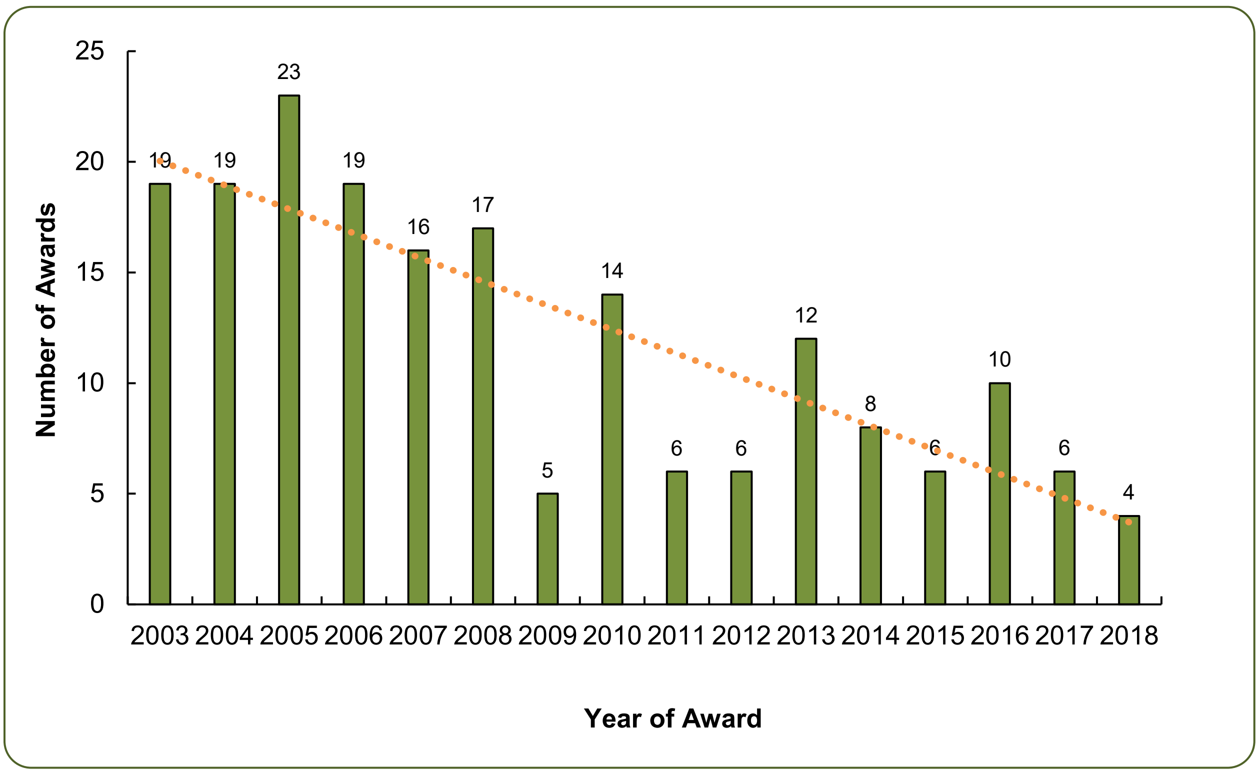

Figure 4. Trends in total research grants awarded by TREE Fund from 2003 - 2018.

Figure 5. International scope and reach of TREE Fund research grants.

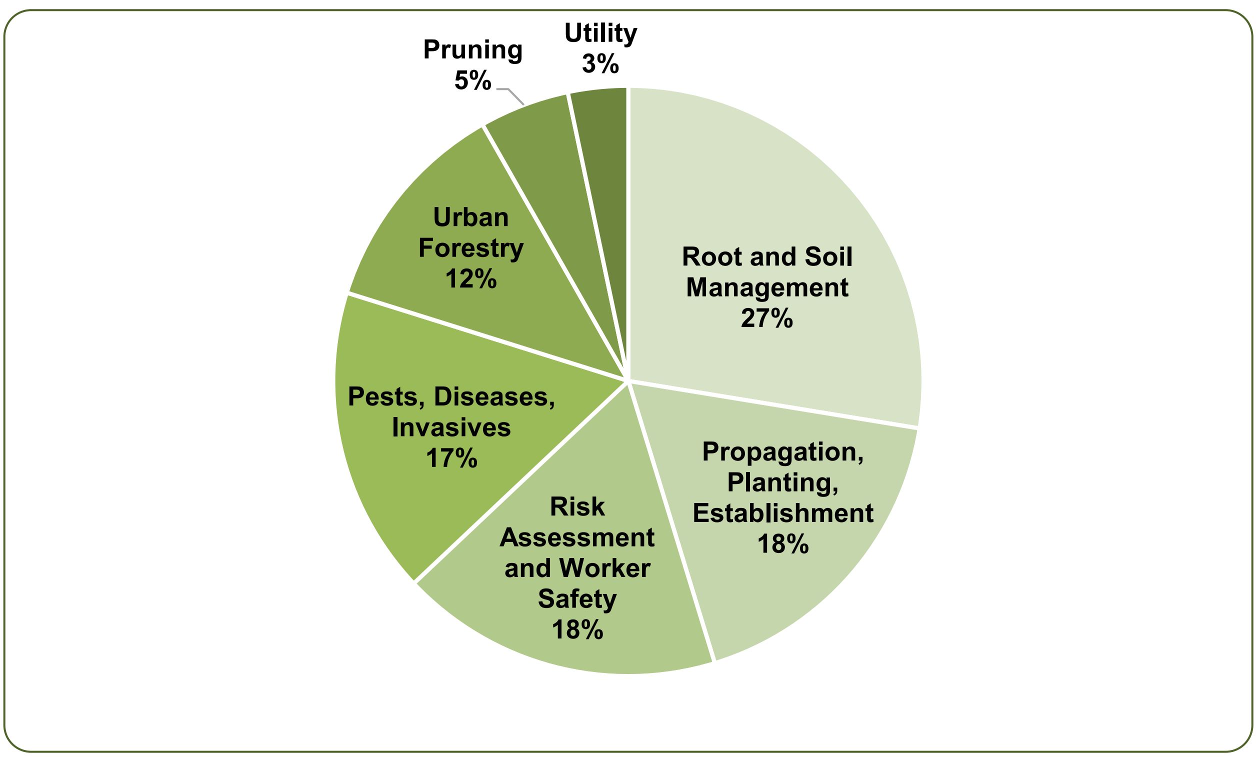

Figure 6. Relative proportions of TREE Fund grant awards by research priority area.

A total of 174 TREE Fund-supported research articles were published in 52 different peer-reviewed academic journals (Figure 7). The most common journal among TREE Fund recipients was *Arboriculture & Urban Forestry* (46%). The next most common publication destination was the journal *Urban Forestry & Urban Greening* (12%). Other notable, but less common publication venues included *HortScience* (4%) and *Journal of Chemical Ecology* (3%). The remaining 35% of published works were divided among the 49 different journals (Figure 7).

As mentioned in the methods, *Arboriculture & Urban Forestry* is a non-ISI indexed journal. As such, it does not have a calculated impact factor (a metric derived by dividing a journal's citations for a given period over the number of papers published by the journal). This value placed on journal significance is becoming a more common means of assessing the academic merit of researchers attempting to maintain employment or obtain a promotion. The highest impact journal in our citation list (Appendix C) was *Fungal Diversity* (IF = 14.07). The average impact factor for the 38 journals with ISI indexing in our citations list was 3.15. This noted, measured impact of a journal is not the same as the impact of individual articles. TREE Fund sponsored articles identified in Appendix C average 20.9 citations each per paper in other peer-reviewed papers.

As one of the highest rated journals in forestry, *Urban Forestry & Urban Greening* (IF = 2.78) continues to attract more and more research articles from TREE Fund recipients. Currently, *Arboriculture & Urban Forestry* and the *Journal of Environmental Horticulture* include the logo of TREE Fund in the acknowledgments for papers that specify the endowment as a source of support. While these two publications are edited by the professional societies that support them (a for-profit publisher produces *Urban Forestry & Urban Greening*), TREE Fund may wish to consider reaching out to the editorial board of *Urban Forestry and Urban Greening* to see if a similar arrangement could be agreed upon.

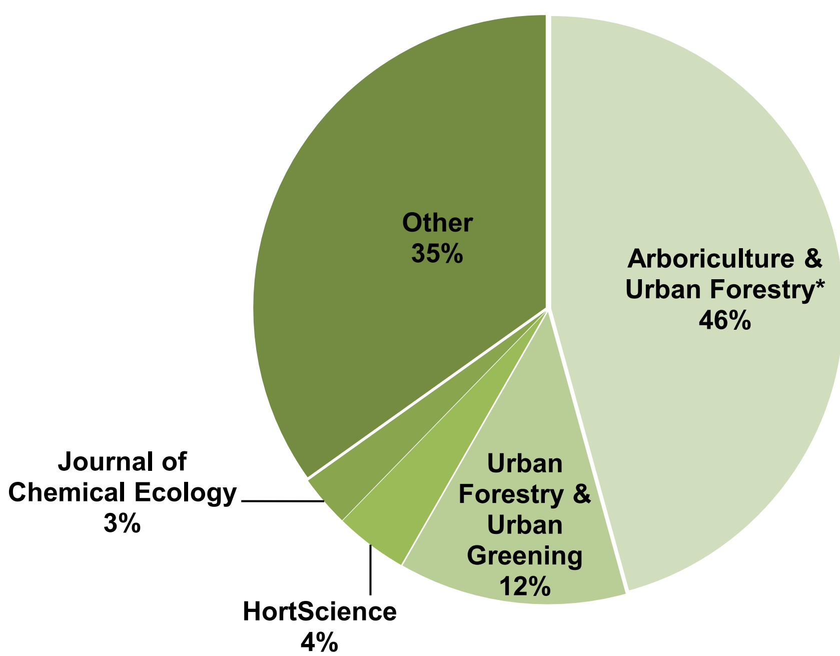

Figure 7. Most common peer-reviewed publication destinations for TREE Fund supported research.

While *Arboriculture & Urban Forestry* lacks an impact factor, it does offer the advantage of open access. All ISA members have access to both the latest issues and a full archive of the research published in *Arboriculture & Urban Forestry*. While non-ISA members cannot access the current year's issues, they can access all research articles in *Arboriculture & Urban Forestry* one year after publication. Over 56% of TREE Fund-sponsored research is freely available through open access publication policies. Some journals are completely open access (e.g., *Cities and the Environment*), while others have policies similar to *Arboriculture & Urban Forestry* where access to the most recent research is limited to subscribing libraries and members of their affiliated societies (e.g., *HortScience*), but the the larger body of archived research is freely available.

The issue of access highlights the importance of technology transfer. Though harder to search for than academic works, we found 46 technology transfer articles in the final reports and our searching of *Arborist News* and *Tree Care Industry Magazine* (Appendix D). These articles have the potential to reach a broader audience, especially if linked to continuing education units. Moreover, when research is restricted behind an academic publisher's paywall, the majority of tree care professionals will be unable to access the work without incurring significant costs. From this perspective, technology transfer works may be the only way for new knowledge to reach those who can benefit from it. Even when research is open access, presentations and popular articles may make the material more accessible to the industry.

In searching *Arborist News* and *Tree Care Industry Magazine* for funded works, we did notice several articles that could have been related to TREE Fund projects. However, the authors did not acknowledge TREE Fund specifically as a source of funding, and we opted to error on the side of exclusion. The editors of these publications could be approached to see if they could include a question regarding funding sources in their communications with authors. Most editors are already asking authors for biographical information. This would be an easy prompt to remind authors about the funding behind their research and outreach efforts.

On average, there were 0.91 articles published per project, though in reality there was some variability in the actual research deliverables produced per project. In the most extreme instance, a TREE Fund recipient attributed his $25,000 Hyland R. Johns grant as financial support for 14 papers (peer-reviewed and popular). However, when looking at all recipients who eventually published their results, it was most common to have a single peer-reviewed article for a project. There was no record of any deliverables for 37% of funded projects (Figure 8), though many of these instances occurred before TREE Fund required formal final reports. Nearly 74% of one-time TREE Fund research grant recipients had no records of research deliverables in the TREE Fund data with the work reported above including the intensive search for research products.

In reading the final reports, we noticed that many recipients reported articles as deliverables that did not acknowledge TREE Fund as a funding source. We recommend that TREE Fund request that only articles with this formal acknowledgment be included in the final reports. If this is communicated to awardees at the initial stages of the project, it will serve as a reminder to give TREE Fund the obligatory credit. It will also reduce potential final report inflation, where recipients may include papers on lines of inquiry where TREE Fund served as initial seed funding but were largely paid for by other means. To that point, TREE Fund's research dollars are often leveraged to obtain additional funding. For projects with data on additional funding (N=98 with one extreme outlier excluded), researchers brought in $2.63 in matching funds, on average, for every dollar invested by TREE Fund. This figure does not include material matches and other sources of in-kind contribution.

Presentation of research at professional meetings provides an important and effective way to transfer the findings directly to practitioners and academics. Over 400 professional presentations were used to transfer TREE Fund-sponsored research as reported by grant recipients. Annually this translates into nearly 30 presentations. The International Society of Arboriculture conferences and symposia were most commonly cited as professional forums for dissemination with 118 identified presentations. The regional chapters of the ISA had 12 identified presentations. Based on the experience of the investigators of this project, we believe this greatly underestimates the actual number of chapter presentations which is likely (at a minimum) on par with the total ISA presentations. A collective *other* category had 288 presentations. This catch-all group included a diverse set of organizations with examples including, but not limited to:

- American Society for Horticultural Science
- Canadian Urban Forest Conference
- Ecological Society of America
- Entomological Society of America
- International Urban Forestry Congress
- National Meeting of Ukrainian Society of Microbiologists
- Partners in Community Forestry Conference
- Society of Municipal Arborists
- Tree Care Industry Association
- Utility Arborist Association

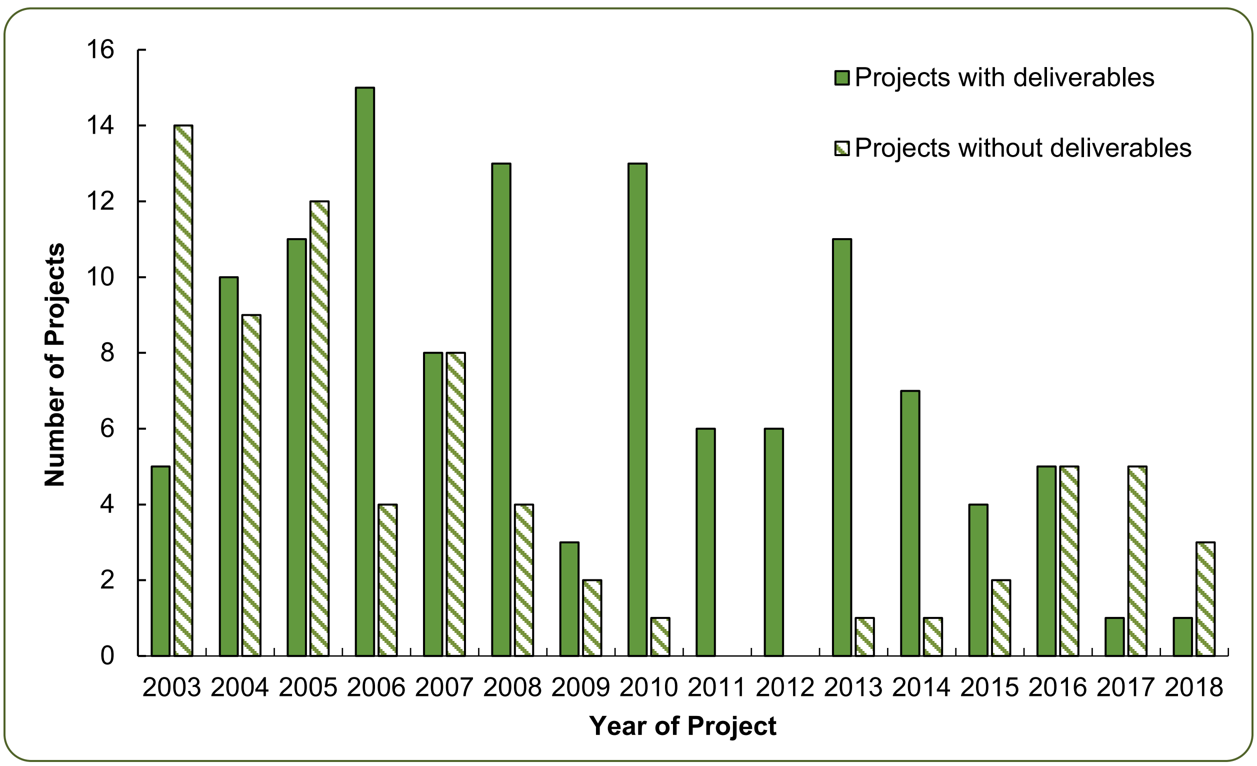

Figure 8. Trends in granted TREE Fund research projects and the achievement of project deliverables.

Finally, TREE Fund research projects often serve as thesis/dissertation chapters for graduate students at the master and doctoral level. This investment can have a lasting impact on the industry as these individuals may go on to become industry leaders, educators, or researchers for decades to come. TREE Fund research grants have supported at least 8 Ph.D. students and 28 M.S. students (Figure 9). Additionally, TREE Fund research has played a role in supporting undergraduate education opportunities (Figure 9). The number of supported students is based upon incomplete records supplied to TREE Fund by researchers.

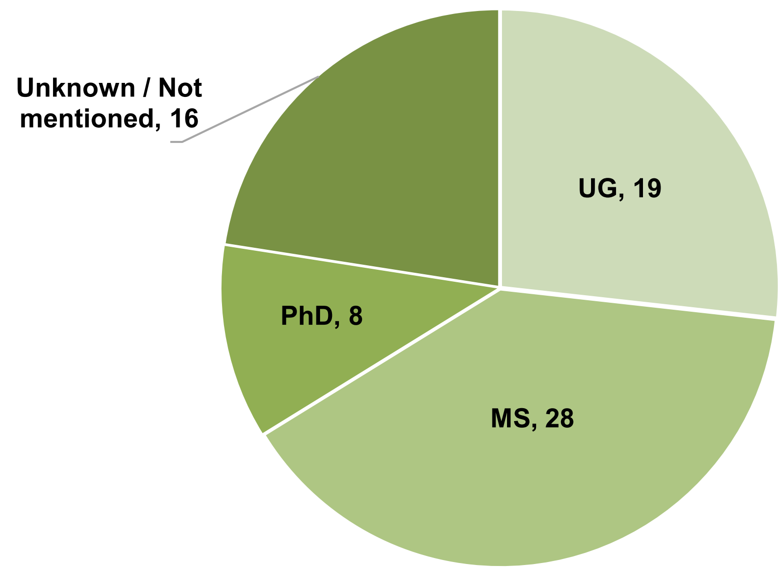

Figure 9. Number of reported students trained as part of a TREE Fund grant. (UG = undergraduate student, MS = master student, PhD = doctoral student)

Citation Search of Past TREE Fund Awardees

The publication of TREE Fund-sponsored research is critical for the advancement of science and practice of arboriculture and urban forestry. The creation of knowledge is conducted through research and the peer review process. Over time replication may serve as an additional check on the science and validity of the research findings. A total of 175 papers published in academic journals were found (Appendix C). The dissemination of knowledge is equally as important and occurs through publication in popular formats (e.g., *Arborist News*, *City Trees*, *Tree Care Industry Magazine*). In searching these trade publications, a total of 46 popular articles were found. This number likely underestimates the true impact as an extensive search of ISA Chapter publications was not within the scope of this project, and these articles typically do not become indexed in databases. These short article publications reach a wide audience (in the tens of thousands) in a format that usually resonates well with practitioners. Likewise, technology transfer through oral or poster presentations at academic or industry conferences was very difficult to track. We relied solely on the final reports when quantifying these contributions presented above. We also analyzed TREE Fund webinars and their impact is discussed in the webinar section later in this report (Appendix F).

Content Analysis of Published Research Titles, Abstracts, and Keywords

In the past 15 years, TREE Fund-sponsored research has contributed the following knowledge to arboriculture, urban forestry, and basic tree biology. These key findings from 18 research areas are as follow:

AMENDMENTS AND MULCHING

- Planting live oaks with the root collar at grade, in sandy top soils, and utilizing a raised bed planting system was shown to improve tree quality after establishment. (Bryan et al., 2011)
- Mulched soil-filled lysimeters only had a minor reduction in evaporation when compared to non-mulched soil-filled lysimeters. There was no difference between mulched and non-mulched lysimeters in any consecutive three-day period following an irrigation event. (Gilman et al., 2012a)
- Planting trees from smaller containers into landscapes allows roots to anchor sooner into the mineral soil outside the original rootball than planting trees from larger container sizes. (Gilman et al., 2013)
- Past literature supports ISA's recommendation of a 5-10 cm application of organic mulches around trees planted in the landscape. Applications of organic mulches can improve soil conditions and overall tree aesthetics. (Lugo-Perez and Lloyd, 2009)
- Regarding short-term post-transplant tree growth, no advantages were seen when composted media was added as backfill amendments. However, the addition of compost could be beneficial in improving chemical and physical properties of native soils. (Roberts, 2006)
- Seedlings treated with the Hydretain ES humectant treatment had higher levels of chlorophyll fluorescence and net CO_2 exchange than seedlings treated with the Ecosential humectant treatment. Authors attributed these results, in part, to lower levels of water stress in the Hydretain ES humectant treated seedlings. (Roberts et al., 2012)
- Tree species and production method influenced the degree to which the seedlings responded to different humectant applications for increasing days to wilting. (Roberts and Linder, 2010)
- The scoop and dump process of soil remediation has been shown to have the potential for improving soil quality over the long term. Over a 12-year period, remediated soils had lower bulk density, increased active carbon, and increased potentially mineralizable nitrogen. (Sax et al., 2017)
- The use of different organic amendments as horticultural substrates for growing trees in containers had no significant effect on root, shoot, and total biomass production for two tree species when compared to the unaltered horticultural substrates. However, changes in biochemical properties of the substrates were observed after 16 months with some of the organic amendment treatments. (Sax and Scharenbroch, 2017)
- Organic materials have been shown to have mostly positive impacts on shoot and root growth, tree physiology, and soil physical properties. Also, the types of organic materials and the mode of application of these materials to urban landscapes have differential effects on tree, soil, and other environmental properties. (Scharenbroch, 2009)

- Aerated compost teas can increase soil microbial biomass and soil K, but do not seem to be able to increase tree growth across multiple species at rates that would be cost-effective in the landscape. (Scharenbroch, 2013)
- Compost topdressing or applications of wood chip mulch to compacted urban soils were shown to be both effective and economical methods for improving soil quality and stimulating tree growth. (Scharenbroch and Watson, 2014)
- Fertilization is more effective at increasing soil nutrient availability in the short term. However, nutrient retention over the long term may be better preserved using an aerated compost tea. (Scharenbroch et al., 2011)
- The use of biochar and biosolids are acceptable, possibly preferred, alternatives to more commonly used soil amendments and mulches for improving urban soils and increasing tree growth. (Scharenbroch et al., 2013)
- The addition of compost amendments to the root zones of trees can increase the soil microbial activity. This alteration of microbial activity in the rootzone is believed to be sustainable due to stable C/N ratios. (Wiseman et al., 2012)

BIOMECHANICS

- Once primary branches of *Acer platanoides* extend beyond three meters in length lateral branching increases and branch slenderness decreases. This cue marks the transition from flexible sun branches to more rigid structural branches. (Dahle and Grabosky, 2010a)
- Branch stiffness is negatively correlated with the proportion of the cross section composed of water conducting vessels. Moving further down the branch way from the branch tips, branch stiffness increases as wood fibers become more abundant. (Dahle and Grabosky, 2010b)
- The majority of first-order branches are imbalanced which means trees must compensate for the torsional forces associated with gravity. Additionally, mass was strongly correlated with the diameter at the cut point, indicating cut size would be an appropriate means of specifying pruning dosage. (Dahle and Grabosky, 2012)
- Shaving the rootballs of container-grown *Acer rubrum* to remove root defects had no impact on tree growth after transplanting. In contrast, container trees treated with rootball shaving were more firmly rooted than similar trees planted with circling roots left intact. (Gilman et al., 2016)
- Tree branches provide a mass dampening effect which reduces dangerous harmonic sways and minimizes loads experienced in trees. As such, even small branches contribute to the mechanical stability of the tree. (James et al., 2006)
- The installation of cable systems, whether traditional steel cable or more dynamic polypropylene, does not limit branch movement to the point where wind-induced movement and response growth is affected in the species tested. (Kane and Autio, 2014)
- In Bradford pear, codominant limbs failed at half the stress of non-codominant stems. Similarly, failures of codominant limbs occurred at 45% of wood strength and failures for non-codominant limbs occurred at 79% of wood strength. (Kane and Clouston, 2008)
- Strain meters can be used to measure the dynamic movement of trees under normal and storm conditions. These meters can be used to measure trunk displacement wind loading. (Kane and James, 2008)

- Both pruning and the presence/absence of leaves on open-grown deciduous trees affect damping ratio and natural sway frequency. However, the impact of leaves was more pronounced. Pruning trees to reduce failure may not be of value in locations where severe winds occur primarily in the winter months. (Kane and James, 2011)
- Maple trees pruned to have an excurrent form had a higher natural frequency than trees pruned in a decurrent manner, however, damping ratios were similar between treatments. In contrast, trees pruned in a decurent manner had more of their branch mass in the upper half of the crown, potentially subjecting them to larger wind-induced stress in their trunks. (Miesbauer et al., 2014)

DEEP PLANTING

- Planting the root collar or main structural roots below grade was shown to have negative effects on the survival and growth of five species (a mix of seed-propagated and cutting-propagated materials). In some instances, planting above grade by 7.6 cm improved the growth of plants compared to those planted at or below grade. (Arnold et al., 2007)
- When looking at lacebark elm trees (*Ulmus parvifolia* Jacq.), tree growth was greater when planted at grade during the initial container production phase (10.8 L) and was reduced when planted 5 cm below grade. During the second container phase (36.6 L), tree growth was reduced when planted above grade compared with those planted at or below grade. During landscape establishment, trees transplanted at or slightly above or below grade were taller on average compared to those planted below or substantially above grade. (Bryan et al., 2010a)
- Baldcypress (*Taxodium distichum*) planted above grade had reduced relative growth rates with regard to height and diameter compared to those planted at or below grade. This was observed during the first growing season, regardless of transplant time of year. Sycamore trees (*Platanus occidentalis*) planted below grade showed increased mortality and decreased growth compared to those planted at or above grade, regardless of irrigation treatment. (Bryan et al., 2010b)
- When looking at the planting depth and soil amendment effects on live oak (*Quercus virginiana*) growth, researchers found planting at grade or below grade resulted in 0% mortality, while planted above grade resulted in 12.5% mortality. Trunk diameter growth and relative growth rates were lower for trees planted below grade, and visual quality of roots and shoots were greatest when trees were planted in raised beds with sandy topsoils. (Bryan et al., 2011)
- A study of Turkish hazel trees (*Corylus colurna*) showed deep planting did not affect trunk diameter growth over eight years; flooding five and six years after planting resulted in one tree loss each time. Additionally, photosynthetic rates declined for all trees after the first flooding treatment. There was a slight delay in the decline of trees which had undergone root excavation (remediation treatment) and those that were planted at grade. Girdling roots primarily appeared on unremediated trees and those planted 30 cm below grade. (Day and Harris, 2008)
- Planting depth did appear to affect root morphology in different nursery containers, and results differed by species and container size. Overall, the presence of a visible root flare was not related to the presence of root defects, and planting depth appears most crucial when shifting into a #15 container. (Gilman et al., 2010b)

- Excavation had no apparent effect on deeply planted red maple (*Acer rubrum*) and Northern red oak (*Quercus rubra*) growth. Potentially girdling roots were found in about half of the deeply-planted red maples and a third of the deeply-planted oaks, but planting depth did not appear to affect stability in either species. (Harris et al., 2016)
- Deeply planted red maple (*Acer Rubrum*) showed similar survival rates as those planted at-grade but had higher rates of circling roots. Deeply planted Yoshino cherry (*Prunus* x *yedoensis*) had lower survival rates than at-grade counterparts, but no significant difference in the number of circling roots. (Wells et al., 2006)

DIVERSITY/PLANT SELECTION

- Leaf essential oils in *Taxodium distichum*, *T. d.* var. *Imbricarium* and *T. mucronatum* varied by geographic region. Differences suggest that *Taxodium distichum* has two regional groups (Southcentral USA and Texas Hill Country), *T. d.* var. *Imbricarium* from Tampa, Florida are unlike those in Alabama, and *T. mucronatum* has two variants (Durango and Oaxaca-Guatemala) and the group from Bolleros, MX is more similar to *T. distichum* than other *T. mucronatum* specimens. (Adams et al., 2012)
- Researchers tested foliar chlorosis in alkaline soil of forty *Taxodium distichum* seedlings from different regions and found differences that suggest genotypes from Mexico and south Texas (and to a lesser degree, central Texas) are preferable when selecting material for alkaline sites. (Denny et al., 2008)
- Researchers compared EAB oviposition preferences and bark and canopy volatile organic compound emissions of resistant Manchurian ash and susceptible black ash, examining the relationship between oviposition and VOC profiles. Clear differences were found between the VOC profiles of the two ash species, EAB oviposition was significantly higher in black ash than in Manchurian ash, in which no eggs were laid, but EAB preference is probably based on a complex combination of VOCs rather than single compounds or groups of compounds. (Rigsby et al., 2017)
- Leaf water potential was calculated for 27 *Acer* genotypes during different seasons, confirming a wide range of tolerances to water deficits in the genus. Furthermore, the study outlines a process for screening new and traditional plant material for use in urban tree selection and nursery production purposes. (Sjöman et al., 2015)
- The study sought to understand the hypersensitive reaction in selected *Pinus strobus* seedlings to *Cronartium ribicola*, white pine blister rust, by comparing proteins present in resistant and susceptible seedlings that underwent inoculation and mock inoculation. Several proteins were found that are potentially linked to resistance. (Smith et al., 2006)

FERTILIZATION

- Fertilization applications following tree transplanting did not speed tree establishment periods and did not affect trunk growth, shoot extension, or leaf nitrogen content of red maple and little leaf linden trees. Also, there was no evidence that fall fertilization was more effective than spring applications and that fertilized trees experienced increased drought stress compared to unfertilized trees. (Day and Harris, 2007)
- A series of five different studies tested N rates on ten shade trees species (both field- and container-grown) that were transplanted to a range of urban sites. Results indicated overall

that fertilization at planting does not increase post-transplant growth, nor does it shorten the establishment period, regardless of site type. (Harris et al., 2008)

- The study evaluated silicon fertilizers, a resistance-inducing agent, and a conventional synthetic fungicide as treatments for apple and pear scab under field conditions. Results suggest a combination of the silicon fertilizer and resistance-inducing agent and the synthetic fungicide alone provided the best protection.(Percival and Barnes, 2005a)
- The uptake and partitioning of fertilizer in young and mature common hackberry (*Celtis occidentalis*) trees showed application rates and seasonal uptake varied. Application rates were 0, 0.49, and 1.47 kg N 100 m-2 of canopy coverage, respectively. Foliage, current season stem wood, stem wood, root, and fruit tissues were analyzed for total concentration [N] and nitrogen derived from fertilizer (NDFF). NDFF was highest in the tissues of young trees and trees receiving the 1.47 kg N 100 m-2 application rate. Mature trees relied upon previously assimilated N to meet the annual demand for N to a greater extent than young trees. (Werner and Jull, 2013)

NURSERY PRODUCTION

- Trees in smaller containers established faster than those in large containers. Slicing container root systems to reduce circling did not increase water stress. Field-grown trees were more drought resistant than similar sized container grown trees once planted. (Gilman et al., 2010)
- Trees planted from smaller containers grew faster and were better anchored into the surrounding soil than trees planted in larger containers. Rootballs from the larger container trees remained largely confined to their original volume which increased water stress. (Gilman et al., 2013)
- Container type (a range of solid and porous plastic products) had no impact on trunk diameter, tree height, or root cross-sectional area. This was consistent across three container sizes. Rootball shaving had the most significant impact on improving root system architecture and anchorage. (Gilman et al., 2016)
- Soil drenches of Hydretain ES and Ecosential led to reduced root growth after inducing drought on one-year-old container-grown seedlings due to the treated soil-medias ability to withhold moisture. Hydretain ES treatments resulted in higher levels of physiological activity than Ecosential treatments for the same species. (Roberts et al., 2012)
- Humectant treatments of Hydertain ES were applied to three different species and days to wilt were recorded. Hydertain ES applications generally improved the number of days to wilt, although not always significant and likely species specific. (Roberts and Linder, 2010)
- Container mixes containing green waste, biosolids, wood chips, biochar, aerated compost tea, and vermicompost performed the same as traditional soilless media used in container tree production. (Sax and Scharenbroch, 2017)

PLANT HEALTH CARE - DISEASE MANAGEMENT

- Claims that biostimulants have high potential in protecting plant species from certain pathogens were tested by evaluating the efficacy of seven different biostimulants against multiple foliar pathogens. None of the biostimulants evaluated lived up to the claims, indicating their limited use as a replacement for or supplement to other methods of disease management. (Banks and Percival, 2012)

- Oak wilt fungus, *Ceratocystis fagacearum*, demonstrated movement in more than two cardinal directions of infected trees in only one instance of twelve pairs of sampled *Quercus rubra*. Although inter-tree grafts were rare and the fungus was only found in a few root grafts, the overall distribution of the fungus in the roots was sporadic and unpredictable. (Blaedow and Juzwik, 2010)
- Propiconazole, a fungicide used for control of *Ceratocytis fagacearum*, generally remains in mature *Quercus rubra* roots at two years post-injection, although in sufficiently lower quantities due to fungicide degradation. Although there were measurable levels of fungal control on inoculated and injected trees, the fungus was always present. (Blaedow et al., 2010)
- Sixteen *Ribes. nigrum* cultivars demonstrated varying levels of susceptibility and resistance to *Cronartium ribicola*, the causal agent of white pine blister rust. The alternate hosts performed the same in the greenhouse as in the field, confirming the effectiveness of a specific resistant gene. (Burnes et al., 2008)
- Systemic fungicide uptake, movement, and persistence in *Cocos nucifera* varied with application type and concentration. While soil drench applications never showed up in palm rachises and only slightly in initial injections, increasing the rate of injections resulted in fungicide detections in all four replicate. (Elliot and Broschat, 2017)
- There were primarily three Nitidulidae beetles that transmit oak wilt fungus, *Ceratocystis fagacearum*, to recent wounds on healthy *Quercus spp.* in Missouri, United States. April was the most at-risk time for fungal transmission, due to higher beetle counts collected at this time. (Hayslett et al., 2008)
- *Scolytus schevyrewi* is an emerging bark beetle that serves as a potential carrier of the Dutch elm disease fungus. While this bark beetle demonstrated approximately 30% successful infection of *Ulmus americana* trees in-vivo and in-vitro, it did not appear any more efficient than other bark beetle carriers at successfully infecting trees. (Jacobi et al., 2013)
- Abamectin (Avid™) treatments on small and large *Pinus sylvestris* inoculated with pinewood nematode, *Bursaphalenchus xylophilus*, improved tree survival in comparison with non-injected trees. Preventative injections are sufficient in reducing instances of pine wilt. (James et al., 2006)
- This review of blister rust management in white pines addresses three categories of genetic resistance, their functions, and how this information may apply to management. The study calls for the use of new molecular techniques to investigate white pine blister rust due to the complexity of the genetic resistance to the disease. (King et al., 2010)
- *Gastrodia* antifungal protein, a lectin, was tested for its ability to limit nematode production and impact on *Phytophthora* root rot. As a result, some level of resistance was found, but the author calls for long-term studies. (Nagel et al., 2008).
- Systemic acquired disease resistance is based on multiple different natural defense mechanisms which make it less likely for a pathogen to develop resistance to it. (Percival, 2001)
- The use of systemic inducing resistance products may be a useful tool to add to existing methods of controlling apple scab. Biostimulant treatments as apple scab protectant compounds were shown to be limited. (Percival, 2010)

- A combination of silicon fertilizers, a resistance-inducing agent (based on salicylic acid) and a synthetic fungicide (penconazole), provided the greatest protection against apple and pear scab across two growing seasons in the field. (Percival, 2018)
- The synthetic fungicide penconazole provided the greatest protection of control of *Guignardia* leaf blotch. However, to be effective annual foliar sprays are required. (Percival and Banks, 2013)
- Film forming polymers have the potential to be a useful addition to existing methods of apple scab management. Applications of film-forming polymers or the fungicide penconazole, both resulted in higher apple yields over two growing seasons when compared to untreated controls. (Percival and Boyle, 2009)

PLANT HEALTH CARE - PEST MANAGEMENT

- Paper birch saw an increase in foliar concentrations of condensed tannins which lead to higher resistance of gypsy moth and whitemarked tussock moth after the second season of soil drench applications of paclobutrazol. However, applications of paclobutrazol and fertilizer treatments had no effect on foliar defensive chemistry levels in Austrian pine which in return did not increase resistance to the European pine sawfly. (Chorbadjian et al., 2011)
- Hydroxycoumarins and calceloariosides A and B (phenylethanoids) found in the phloem of Manchurian ash trees may represent a mechanism of resistance against emerald ash borer. (Eyles et al., 2007)
- The invasive wood-boring beetle *Anoplophora glabripennis* (Coleoptera: Cerambycidae) attacks and has the potential to kill a wide range of hardwood tree species. This beetle was introduced from China to North America and Europe from China in solid wood packing materials. (Morewood et al., 2005)
- *Anoplophora glabripennis* (Coleoptera: Cerambycidae) were most often observed resting and were least active early in the day with their activity increasing late in the day. Mating was not time-dependent with equal frequencies observed throughout the day and night. (Morewood et al., 2004a)
- *Achaearanea tepidariorum*, a common household spider, was confirmed to be able to prey upon adult *Anoplophora glabripennis*. These results exceed the previously thought maximum relative size of prey that the spider could handle. (Morewood et al., 2003)
- High larval mortality and slow larval growth of *Anoplophora glabripennis* in golden-rain trees (*Koelreuteria paniculata* Laxmann) appear to be due to abundant sap-flows. While the resistance of Callery pear (*Pyrus calleryana* Decaisne) against both larvae and adults is likely due to the chemical composition of the tree. (Morewood et al., 2004b)
- Sugar maple (*Acer saccharum* Marshall), Red maple (*Acer rubrum* L.), green ash (*Fraxinus pennsylvanica* Marshall), and red oak (*Quercus rubra* L.) should all be added to the potential host list of *Anoplophora glabripennis* (Coleoptera: Cerambycidae). (Morewood et al., 2003)
- Leaf lipids where the primary foliar chemistry that influenced Japanese beetle (*Popillia japonica*) and gypsy moth *(Lymantria* dispar) preference for Asian elm trees that are closely related with the David complex. (Paluch et al., 2006)
- Significant differences in the total phenolic content of foliage were found between 11 different elm species and two elm cultivars. However, no significant differences were

recorded for gypsy moth larval longevity, pupal fresh weight, or percentage adult emergence with respect to these different phenolic contents. (Paluch et al., 2009)

- The hovering, searching, and landing behaviors of *Agrilus planipennis* (Cleoptera: Buprestidae) suggest that the beetles most likely rely on visual cues to find mates. However, plant volatiles and pheromones might also influence mate finding. (Rodriguez-Soana et al., 2007)
- Drippy blight is an emergent disease of red oaks and is caused by the interaction between a kermes scale insect and a bacterium. Northern red oak (*Quercus rubra*), Shumard oak (*Q. shumardii*), and pin oak (*Q. palustris*) should all be included as new hosts for drippy blight. (Sitz et al., 2018)
- Pin oak kermes (*Allokermes galliformis*) have a 1-year life cycle, with egg eclosion in September to October, after that crawlers migrate to textured places on tree limbs to overwinter. Peak egg production for females occurs between mid-August and mid-September. (Sitz and Cranshaw, 2018)
- North American and European ash tree species are known to be inherently susceptible to emerald ash borer (EAB). However, research suggests that these species have dormant defenses that may not be induced naturally by EAB larval colonization. (Villari et al., 2016)

PLANT HEALTH CARE – OTHER

- Two outdoor experiments were conducted to determine the effectiveness of the use of sucrose to improve tolerance to and recovery from deicing salt in containerized *Ilex aquifolium* and *Quercus robur*. Sucrose was linked to increased tolerance and improved recovery in both species, possibly through the promotion of photooxidative antioxidant pigments and chlorophylls. (Al-Habsi and Percival, 2006)
- Antioxidants (and not just alkaloids) may be responsible for increased host tolerance to abiotic stress resulting from fungal endophyte colonization. (Hamilton and Bauerle, 2012)
- A visual vitality index used to estimate physiological stress was compared with bark and leaf chlorophyll fluorescence of *Eucalyptus* s*aligna* in different seasons. Ratings from the visual index were significantly similar to bark chlorophyll fluorescence, but not leaf fluorescence, indicating that chlorophyll fluorescence of the trunk could be used to assess vitality in this species and potentially others. (Johnstone et al., 2012)
- This study examined the effects of soil type, fertilization, and drought on carbon allocation to root growth and partitioning between secondary metabolism and ectomycorrhizae (EM) of *Betula papyrifera*. In both topsoil and subsoil, fertilization reduced root weight ratios, and EM abundance decreased with root soluble sugars, root phenolics, and lignin. (Kleczewski et al., 2010)
- Sucrose applied as a root drench at a rate of 50g was significantly linked to enhanced root vigor in three species, but was not strongly correlated with tree vitality measures or shoot growth. Overall, applications of sugar as a soil drench may aid in tree establishment by enhancing root vigor. (Percival, 2004a)
- This study shows that the testing of chlorophyll fluorescence of excised leaves can serve as a quick, reliable, and inexpensive way to estimate whole plant salinity tolerance. (Percival, 2005a)

- Alterations in the OJIP curve could be used to identify tree decline due to herbicide and heat, but not salt damage. The findings suggest that unique chlorophyll fluorescence profiles can be used as a quick, stress-specific diagnoses based on different tree species. (Percival, 2005b)
- Fall applications of calcium nitrate and calcium nitrate borate at 40g/m2 can increase the freezing and salinity tolerance of evergreen oak and holly, but N:P:K fertilization applications do not have the same effect. (Percival and Barnes, 2005b)
- Root drenches of different sugar types and varying concentrations on *Betula pendula* Roth. had varying effects on root and shoot growth and other physiological tree responses. Trees that were sugar-treated experienced lower mortality, indicating that sugar applications may be useful after transplanting. (Percival and Fraser, 2005)
- The researchers studied 1,204 strains of actinomycetes from the Crimean mountains to test their antimicrobial properties against phytopathogenic bacteria. They narrowed the sample down to 57 isolates that could be further screened for potential as biocontrol agents of typical tree infections. (Tistechok et al., 2017)

PLANTING AND ESTABLISHMENT

- Multiple container sizes were used for growing clonal replicates of an *Acer rubrum* variety, and growth was monitored for two years post-transplant to assess the return on investment of different container sizes. Trees from smaller containers established more quickly and grew at a faster rate than trees from larger containers. (Chance et al., 2017a)
- Clonal replicates of an *Acer rubrum* variety, *Vitex agnus-castus*, and *Taxodium distichum* were transplanted from various container sizes, and researchers monitored post-planting water stress, root growth, and above-ground growth for three years. Results indicate that smaller transplant sizes may overcome transplant stress more quickly and exhibit faster growth than larger container-grown trees. (Chance et al., 2017b)
- Landscape trees received different fertilization and irrigation regimes to test for an effect on establishment rate. The researchers found no evidence that fertilizer applications (with or without supplemental irrigation, applied in the spring or fall) had any influence on establishment times. (Day and Harris, 2007)
- *Acer rubrum, Vitex agnus-castus*, and *Taxodium distichum* were transplanted from multiple container sizes into two post-transplant environments to determine factors of recent transplant growth. In all cases, trees from smaller container sizes outperformed those from larger container sizes, while only one species was not significantly impacted by growing environment. (Garcia et al., 2016)
- To analyze the effects of transplant size, nursery production method, and slicing containerized nursery on growth and establishment, *Quercus virginiana* were planted and monitored for over one year after planting. While slicing root balls was insignificant, there was a trend in small trees outperforming large trees. (Gilman et al., 2010c)
- Field-grown *Quercus virginiana* are more stable in wind events after transplanting than are containerized nursery stock, while smaller containerized stock is more stable than larger containerized stock. Root slicing of containerized nursery stock does not have an impact on stability after transplanting. (Gilman and Masters, 2010)
- *Acer rubrum* planted from four different container sizes were observed six years after planting, with results indicating that large-container trees show reduced root growth into the surrounding landscape soil. Smaller trees are more likely to have roots grow into the

landscape soil and demonstrate stronger and quicker anchorage than larger trees. (Gilman et al., 2013)
- *Acer rubrum* growth was not impacted by container type and root pruning, while the impacts of container type and size were also negligible on anchorage. Root shaving during nursery production improved anchorage as opposed to not root pruning. (Gilman et al., 2016)
- Wire basket retention on two separate species of balled-and-burlapped nursery stock had little impact on tree growth in the first three years after transplanting. However, root-ball condition and planting time are influenced by the practice of removing or partially removing wire baskets at planting. (Koeser et al., 2015)
- Balled-and-burlapped *Acer rubrum* and *Acer platanoides* were subjected to isolated stress-inducing events that occur during the transplanting process. Twig growth reductions were observed in each successive during handling and transport, suggesting that these practices should be minimized during transplant. (Koeser et al., 2009)
- Measurements of chlorophyll fluorescence and electrolyte leakage can significantly predict bare-root tree performance in the landscape after planting. These findings indicate potential tools that can be used to predict future vitality and growth of transplanted trees. (Percival, 2004b)
- Tree stabilization products and systems should be prescribed based on site conditions, tree characteristics, and planting and maintenance practices. When assessing the need for tree stabilization at transplant, many factors should be considered, including costs, time, product persistence, and aesthetics. (Appleton et al., 2008)
- Pull tests mimicking wind-loading were conducted on live oak trees with different stabilization systems. Terra Toggle™, Brooks Tree Brace, and 2 x 2's anchoring the root ball withstood the largest forces when compared with no staking, T-stakes, dowels, Tree Staple™, and three different guying systems. (Eckstein and Gilman, 2008)
- One of three containerized species experienced increases in post-transplant growth resulting from treatments of composted media in a greenhouse setting. Although composted amendments enhance soil properties, results indicate that composts may not be of particular benefit in the short-term. (Roberts, 2006)

PRUNING

- Pruning maple trees at planting reduced the cross-sectional area of competing leaders and improved branch aspect ratios for large branches. This benefit did not come at a cost to tree height, though an 8% decrease in trunk diameter was observed. (Gilman et al., 2015).
- Greater levels of discoloration and decay were noted after the removal of codominant stems as compared to the removal of branches with smaller aspect ratios. Suppressing codominant branches prior to ultimate removal can result in the formation of a branch protection zone. (Gilman and Grabosky, 2006)
- Removing 25% to 50% of the foliage/branches of a co-dominant leader suppressed growth while allowing the competing leader to become dominant. More severe pruning rates (75%) led to an even greater reduction in diameter ratio for the two stems, though cross-sectional growth for the unpruned stem was reduced by this treatment. (Gilman and Grabosky, 2009)

- Under simulated wind conditions, pruning reduced trunk movement in *Quercus virginiana.* Thinning had the greatest impact on trunk movement. (Gilman et al., 2008)
- In pruning two oak species, branch aspect ratio, branch angle, and growth after pruning all impacted discoloration and decay. Findings suggest that branches can be reduced back to laterals as small as ⅓ of the diameter of the removed stem. (Grabosky and Gilman, 2007)

RISK ASSESSMENT

- Risk assessing trees during busier times of day (i.e., lunch or peak commuting periods) inflates occupancy ratings. This can be corrected by accessing or collecting occupancy data from traffic counting equipment. (Klein et al., 2016)
- Likelihood of failure ratings differed in tree risk assessment using limited visual, basic, and advanced assessment techniques. Limited visual ratings were the most different from the other methods. A basic risk assessment with a mallet led to likelihood of failure ratings that were similar to those derived from advanced assessments with a resistance recording drill and a sonic tomography. (Koeser et al., 2017)
- U.S. cities with a certified arborist on staff, a strategic plan, an updated inventory with risk data, and a past claim for damage or injury were the most likely to engage in regular risk management activities. The ISA BMP is the most common method for risk assessing urban trees in the United States. (Koeser et al., 2016)
- While the ISA Tree Risk Assessment BMP stresses the importance of assessing target and consequences of failure in assessing risk, defect severity can account for as much as 55% of a risk rating. Likelihood of impact as related to target proximity was only considered by arborists with advanced training and experiences. (Koeser et al., 2015)
- Arborists with advanced training and credentials have lower risk ratings than more novice arborists when looking at the same tree. Of the three inputs for risk assessments (i.e., likelihood of impact, likelihood of failure, and consequences of failure), the most consistent factor was likelihood of failure. (Koeser and Smiley, 2017)
- Five years after an ice storm, tree species (among three species of maples) was the most significant factor associated with removal - even more significant than the proportion of the crown lost in the storm or the age (size) of the tree. (Luley and Bond, 2006)
- Over 58% of *Acer* spp. street trees in upstate New York (United States) contain some level of decay in their trunks as measured by a resistance-recording drill. Decay was most common in large diameter trees and *Acer saccharinum* trees, though serious decay was found in only 3.2% of the sampled population. (Luley et al., 2009)

ROOT MANAGEMENT

- Ground-penetrating radar can effectively predict tree root locations under concrete pavements in both native and structural soils. (Bassuk et al., 2011)
- Growth reductions observed in trees that had trenching performed in their root zones are mainly due to reduced leaf gas exchange and less favorable water relations. Root loss from trenching induces mild water stress to trees even in years with high rainfall amounts. (Fini et al., 2013)
- Porous pavements may help mitigate urban heat island effects by enhancing evaporation when compared to traditional impermeable pavements. Pavements types had little effect

on newly planted small tree growth and physiology, but more research needs to be conducted to see how these pavement types may affect larger trees. (Fini et al., 2017)

- No notable differences were observed in the growth of trees 10 years after planting in a paved structural soil when compared to a grassy tree lawn. Higher mortality rates of trees were found in the tree lawn which are likely due to maintenance and infrastructure repairs. (Grabosky and Bassuk, 2008)
- Trees grown in structural soils under a concrete sidewalk were in similar size to trees grown in a tree lawn 17 years after planting. Structural soil mediums served as acceptable rooting environments for trees in urban areas. (Grabosky and Bassuk, 2016).
- Compacted stone-soil media had a comparable estimated plant available moisture content to a loamy sand soil. (Grabosky et al., 2009)
- Root abundance and distribution in the soil profile was similar under porous and impervious pavements. (Morgenroth 2011)

TREE BIOLOGY

- Electronic impedance technology used primarily for decay detection can also be used for assessing sapwood area for use in whole-tree water use studies. The technology works best on ring-porous oak species as compared to diffuse-porous *Acer rubrum.* (Benson et al., *in press*)
- Dendrochronology of live oak (*Quercus virginiana*) is extremely challenging but possible with careful sample preparation and analysis. (Bartens et al., 2012)
- In assessing the phloem chemistry of *Fraxinus mandshurica* and two North American ash species (F*raxinus americana* and *Fraxinus pennsylvanica*), differences in phenolic compounds were noted. For the former species (which co-evolved with emerald ash borer), three compounds were found that were not present in the North American ash tested which may confer some resistance to emerald ash borer. (Eyles et al., 2007)
- As soil nutrients increased, so leaf area and total plant biomass of *Betula nigra* seedling (despite a decrease in root biomass). Water stress reduced leaf area and root phenolics. (Kleczewski et al., 2012)

TREE WORKER SAFETY

- When a new rope is used in a cambium saver, the relative smoothness or roughness of the cambium saver ring is the best predictor of friction. However, as ropes wear with use, friction increases and the ring construction becomes less important in predicting ease of movement. (Kane, 2007)
- Ascenders were used on four different climbing ropes in a dynamic drop test. After completing 67 tests, arrest distance exceeded industry standards in all but 10 instances. The impact associated with this test averaged five kN (> 6kN is a backup friction hitch which was used as well). (Kane, 2011)
- In testing the breaking load of hitches, no one hitch performed better or worse than the others. In contrast, breaking load varied widely by rope used. (Kane, 2012)
- When performing rigging operations, the mass of the piece removed was the best predictor of measured force (as compared to limb length, rope length, fall length, and notch type). Forces for a given mass were greatest under “shock loading” conditions. (Kane, 2017)

- In ascent, foot locking induces lower loads than the use of a single or pair of foot ascenders. Use of two ascenders reduced load as compared to a single ascender. (Kane 2018)
- In rigging the removal of *Pinus resinosa*, the type of part removed (top vs trunk section) was the most significant predictor of rope tension and force exerted on the block. This was more significant than the mass of the piece removed, the fall distance, and the notch characteristics. (Kane et al., 2009)
- In testing the residual strength of four types of carabiners used by climbing arborists for one year, no product failed below its rated strength. With one exception, all used carabiners tested were as strong as new products. (Kane and Ryan, 2009)

URBAN FORESTRY

- Tree diameter, visual assessments of health, and infestation assessment data can be used to predict emerald ash borer-related mortality over a three-year projection period. These predictions can be used to help managers make more strategic decisions about future removal demands and costs. (Clark et al., 2015)
- Urban forestry management costs for communities experiencing emerald ash borer infestations begin to increase rapidly 5-8 years after initial detection. This gives communities four years to prepare for a projected $1.58 per capita increase in management costs associated with this pest. (Hauer and Peterson, 2017)
- In the United States, volunteer initiatives and urban forestry partnerships contribute as much labor as 714 full-time positions toward the care and management of urban trees. However, these efforts tended to be in communities with higher levels of urban forestry capacity - specifically with regard to planning, tree board presence, outreach efforts, and staffing. (Hauer et al., 2018)
- The Pest Vulnerability Matrix allows tree care professionals to assess the vulnerability of their urban forest (or desired urban forest) to forest pests and diseases - identifying both the most important pests and the most susceptible tree species. (Lacan and McBride, 2008)
- In an assessment of survival for 13,405 New York City trees, researchers found 74.3% of trees alive at the time of sampling, with the highest mortality occurring in the first few years after planting. Significant factors of tree mortality included land use type, tree stewardship, traffic, and tree pit modifications. (Lu et al., 2010)
- Tree measurements were taken with a low-cost consumer-grade camera utilizing structure-from-motion photogrammetry produced 2D (tree height, crown spread, crown depth, stem diameter) and 3D (volume) tree metrics with comparable accuracy to higher-end techniques like laser scanning. However, this potential low-cost alternative to remote sensing did tend to underestimate the size of the tree, and future research is needed to explore its suitability for more specific dendrometry applications requiring higher degrees of accuracy. (Miller at al., 2015)
- Paved environments coupled with drought-like conditions result in reduced tree growth in *Tilia cordata* while increases in precipitation result in increases of diameter growth when compared with more open, greener sites. Regardless of the drought-like conditions, *Tilia cordata* provided cooling through transpiration, indicating that a balance can be achieved between tree growth, transpiration, and cooling when selecting species with anisohydric water use behaviors. (Moser et al., 2016)

- The primary factors associated with survival and increased health of street trees in Toronto, Canada were low soil salinity, low crown light exposure, and few signs of physical damage, indicating that de-icing salt and irrigation water may be the cause of these stressors. (Ordońez et al., 2018)
- Estimates of carbon sequestration in urban trees should consider various factors related to potential carbon inputs and outputs, as well as tree-level characteristics. In an assessment of relative carbon index for 145 different species, results demonstrated that most urban trees have moderate potential as opposed to high potential for carbon storage (i.e., longer-lived, highly adaptable species). (Scharenbroch, 2012).
- The number of non-native species was higher than native species in both street and park environments for all 10 Nordic cities. The authors suggest exploiting local experiences of rare species from local urban foresters to help address greater diversity of genera and species. (Sjöman et al., 2012)
- Varying management strategies for emerald ash borer, *Agrilus planipennis*, have economic implications regarding cost for removal, replacements, and treatment while trying to balance future economic benefits. Primary findings indicate that preemptive removal without replacement is the least expensive management option, but also provides the least future benefit, providing a benchmark tool for economic justification of different emerald ash borer management strategies. Retention of ash trees with chemical treatment was the most economically favorable outcome with a greater net benefit and cost to benefit ratio than other management options. (Vannatta et al., 2012)

URBAN SOILS

- Soil rehabilitation practices like deep compost incorporation and breaking of compacted subsurface soils had little effect on soil aggregate size distribution in subsurface soils. However, these practices did increase both macroaggregate-associated C concentrations and subsurface saturated hydraulic conductivity. (Chen et al., 2014a)
- Typical land development practices, like topsoil replacement following the grading and compacting of a site, did not increase soil-atmosphere fluxes of major greenhouse gases when compared to undeveloped lands. However, post development soil rehabilitation practices resulted in greater greenhouse gas emissions when compared to both undisturbed soils and sites subjected to typical development practices. (Chen et al., 2014b)
- Undisturbed surface soils had greater total soil C than soils that had their native A horizon disrupted from land development and post-development soil rehabilitation practices. Soil rehabilitation practices like compost additions and subsoiling showed the potential to increase soil C storage in subsurface horizons. (Chen et al., 2013)
- Foliar damage was positively correlated to foliar magnesium and chloride concentrations across all tree species tested. High MgCl2 soil concentrations can lead to tree mortality in 2 to 4 years for some common roadside tree species. (Goodrich and Jacobi, 2012)
- Soil rehabilitation practices may be used as a tool for stormwater mitigation since they have the potential to alter plant and soil-water relations. In addition, soil rehabilitation practices accelerated the establishment and growth of urban trees planted in compacted urban soils. (Layman et al., 2016)
- Pavement treatments increased soil pH levels from slightly acidic to more neutral levels while decreasing concentrations of soil Al, Fe, and Mg and increasing soil Na

concentrations. Soils found under pavement treatments had higher moisture contents than soil tested from control plots with no pavements. (Morgenroth et al., 2013)

- Structural cells with de-icing salt contamination were reported to have high soil salinity and alkalinity levels resulting in lower nutrient concentrations in soils. Better foliar condition ratings were found on trees grown in soils with significantly lower salinity and alkalinity levels. (Ordońez et al., 2017)
- Abiotic factors like high soil salinity and alkalinity, sunlight exposure and signs of physical damage resulted in increased mortality rates and poor structural and foliar conditions for trees growing in highly urbanized areas. Modification to streetscape designs partnered with education aimed at increasing awareness about de-icing salt applications and irrigation practices may lessen tree decline in urban areas over time. (Ordońez et al., 2018)
- Urban soil properties are not only distinguishable from other systems but also variable within types of landscapes in urban environments. Time since initial site disturbance had the most significant effect on soil physical, chemical, and biological differences in soils collected from different aged urban landscapes. (Scharenbroch et al., 2005)
- A fine particulate organic matter measurement, with further testing and refinement, has the potential to be used to accurately predict soil nitrogen availability in urban landscapes. Urban landscapes were shown to be quite variable regarding nitrogen availability. Thus they should be evaluated on a per-site basis for nitrogen management. (Scharenbroch and Lloyd, 2006)
- Tree height, trunk diameter, crown area and age were all highly correlated to the urban soil quality index created in this project. Soil organic matter, pH, and soil texture were the most informative measures for soil quality in relation to urban tree performance. (Scharenbroch and Catania, 2012)
- The rapid urban site index (RUSI) was shown to accurately predict urban tree health and growth metrics in the midwest and the northeastern United States. This model was unable to accurately predict mean diameter growth but was significantly correlated with recent diameter growth. (Scharenbroch et al., 2017)
- Urbanization may have less impact on soil microbiology than previously expected for locations with homogeneous soil parent material and soil forming processes and adequate levels of soil carbon. No statistical differences were found on the decomposition of leaf litter between land uses with differing degrees of urbanization. (Turnquist et al., 2015).
- Roots samples from trees in landscaped areas had significantly lower arbuscular mycorrhizal fungi (AMF) colonization than tree roots sampled from adjacent forest sites. Differences in AMF colonization between the forested and landscaped trees appeared to be influenced more by soil chemical properties rather than inoculum potential. (Wiseman and Wells, 2005)

UTILITY ARBORICULTURE/FORESTRY

- Paclobutrazol applications to *Quercus virginiana* in Louisiana (United States) significantly reduces branch re-growth near utility lines when used in conjunction with pruning. Economic benefits of paclobutrazol applications are also realized in reduced pruning and chipping. (Haugen et al., 2016)

Key Informant Assessment of Outcomes

Key informants are a group of experts in a field of practice. They have expertise beyond the general population of professionals within a field and as such can provide valuable insight and evaluation of a set of research questions. A total of 25 key informants were asked to participate. Of these, 17 were able to participate and give their professional insight of TREE Fund research grant programs (Appendix E). This 68% response rate exceeded a minimum 50% response rate initially anticipated. In addition, all of our targeted sectors (i.e., academic, governmental, nonprofit, municipal, commercial, and utility) were well represented, exceeding a 60% response rate. It is our opinion that the sample set of participating respondents is reflective of the overall population of experts benefiting from TREE Fund grant programs. The conclusions that follow provide an expert-based evaluation of the importance and impacts of TREE Fund research grants.

Key informants were asked to rank the importance of TREE Fund research grants using a one (*very unimportant*) to seven (*very important*) ranked-ordered score. The mean value of this rank ordering provides a value known as an index score. An index score of four equated to a *neutral* opinion. The index score along with the frequency distribution of rankings provided a powerful means of evaluating key informant opinions. The majority (approximately 60%) of respondents rated the grant program as *very important* as a funding source (6.4 index score) for research (Figure 10). Likewise, the research funded by TREE Fund (6.5 index score) to date was also rated as *very important* (Figure 10). Likewise, the majority indicated an overall importance of TREE Fund grants (6.4 index score) with obtaining an outcome.

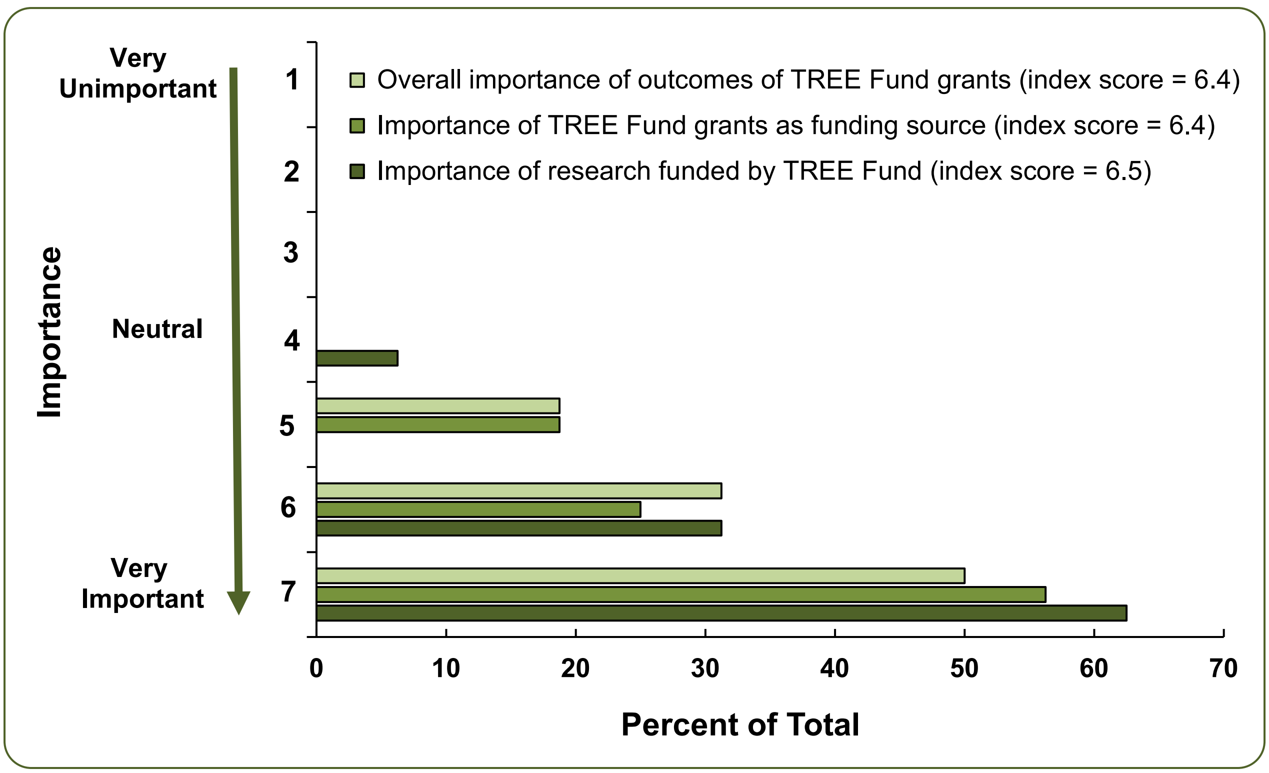

Figure 10. Importance ranking of TREE Fund grants as a funding source, research funded by TREE Fund, and the overall outcome of TREE Fund research grants. (n=17 key informants)

The impact of TREE Fund on areas of practice was ascertained with key informants being asked to rank from one (*very little*) to seven (*very much*) in each of eight areas. An index score of four again equated to a neutral opinion. Work place safety (5.0 index score) and the ability to work more efficiently (5.1 index score) were ranked *moderate* as areas impacted by TREE Fund (Figure 11). It is likely that these scores reflect the Safe Arborist Techniques Fund being relatively new and only two grants awarded to date, with one each in 2017 and 2018. Thus, it would not be expected to see an impact given that the research is ongoing and transfer of knowledge not yet fully achieved. Further, future work in this research area will be insightful to quantify an impact on promoting safe work practices for arborists and compare to this baseline.

In contrast, TREE Fund grants have a longer history of supporting work in traditional arboriculture and urban forestry practice areas that ranked higher (5.7 to 6.2 index scores). Propagation, planting, and establishment of plants ranked highest at a 6.2 index score. Root & soil management (6.0 index score), urban forestry (5.9 index score), pruning (5.8 index score), and pests/disease/invasives (5.7 index score) also rated towards *very much* as areas of practice being impacted by TREE Fund. The utility forestry practice area was perceived to have the least impact of TREE Fund grant programs with a 4.3 index score. This slightly above *neutral* ranking likely reflects that utility grants as a distinct grant area are relatively new with only five awards since 2012. All index scores can serve as benchmarks for future assessment of an impact. This is especially important with the Safe Arborist Techniques and Utility Arborist Research grant areas.

An important aspect of a key informant study is having the experts provide open-ended exchanges of key facets of a subject area. In our interviews, we asked them to provide examples of notable

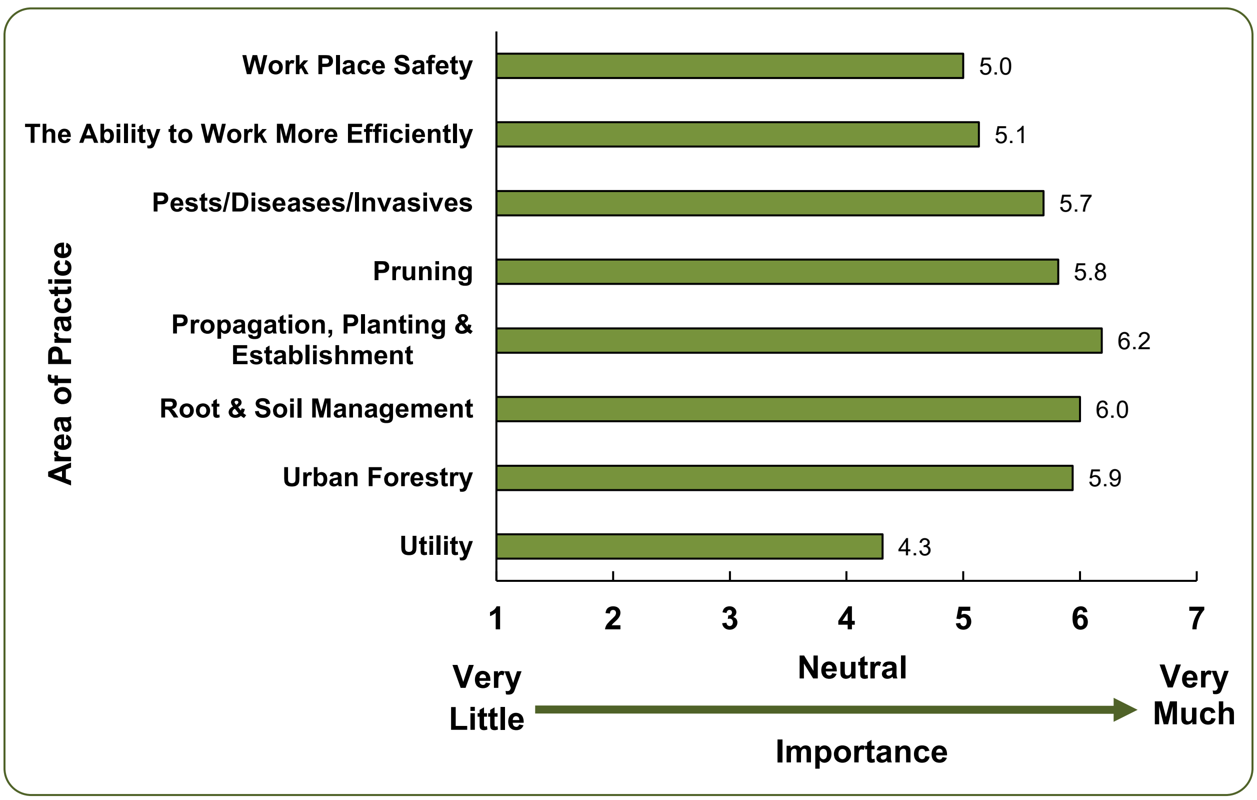

Figure 11. Importance ranking of TREE Fund grants as a funding source, of research funded by TREE Fund, and the overall outcome of TREE grants. (n=17 key informants)

outcomes to the following question: *Please list an example or examples of notable outcomes that have influenced the practice of arboriculture and urban forestry* (Appendix E, Table 3 and 4). We did not provide a list of past TREE Fund granted projects. Rather asked them to provide from memory the outcomes and how these influenced the practice of arboriculture and urban forestry. The statements were further organized as both themes of practice and themes of impacts as interpreted by the research team (Table 3). A theme of practice is defined as an application of arboriculture and urban forestry used to culture and maintain a tree. A theme of impact results in an outcome of the sponsored research that influences change in the industry. In addition, each statement is listed verbatim in a bulleted list of key informant statements.

A total of 17 themes of practice arose with 62 unique keywords (Tables 3 and 4). Urban forestry was most common theme with 10 citations linked to keywords such as "assessment of municipal programs," "urban forestry," "urban forestry survey," and "municipal tree care" presented in the provided statements. Planting (eight citations), safety (seven), utility (five), soils (three), and tree risk (three) were other examples of themes of practice cited by several key informants. The significance of these thematic areas provides evidence of noteworthy outcomes from past TREE Fund grants with respect to the practice of arboriculture and urban forestry. In addition to the areas of practice (e.g., tree planting and tree care) listed, the impacts of trees through benefits such as stormwater management, wildlife, and safety of practitioners and citizens were also provided as key words.

The themes of impacts provided evidence linking TREE Fund grants to 41 tangible outcomes (Table 4). One common theme was that funded research has become an important part of the creation and revision of industry standards. As an example, "the ANSI A300 standards for tree care operations", "local planting standards", "influencing decision-makers", "benchmarks", and "assessment protocols" were listed as words or phrases to describe the impact. As such the knowledge gained from TREE Fund-granted research, has influenced both local and international standards and provided much-needed information for the effective management of urban trees.

It was further evident that technology transfer was commonly cited as occurring with research findings. In particular, one key informant stated TREE Fund explicitly makes this clear as an expectation of transferring findings to others through academic- and practitioner-appropriate formats. The statements as listed by informants that describe their opinion of the impact of TREE Fund grants are as follows:

Key Informant Statements

- Structural soils, root development, transplanting establishment, and EAB (emerald ash borer) management.
- Research papers describing the historical evolution of urban forestry practices.
- Papers assessing arboricultural field practices.
- I have especially appreciated work on e.g.
  - ✓ the cost of not maintaining trees,
  - ✓ various tree establishment and pest management studies,
  - ✓ as well as work related to urban forestry assessment.

Table 3. Please list an example or examples of notable outcomes that have influenced the practice of arboriculture and urban forestry and resulting Themes of Practice.

Themes of Practice: (# times cited) – key word

Arboriculture (1) – arboriculture field practices
Benefits (1) – benefits of trees
Biomechanics (3) biomechanics, tree dynamics
Pests (3) – emerald ash borer, pest management, pest research
Planting (8) – girdling roots, planting practices, planting selection & installation, planting survival, root pruning container trees, transplanting establishment, tree establishment
Production (5) – container grown trees, nursery, nursery stock, producing trees, production-establishment
Pruning (5) – pruning, wind resistance/pruning
Roots (3) – root and planting research, root development, tree root systems
Safety (7) – ascenders on climbing lines, ergonomics for climbers, improving climber health, safety, productivity, worker safety, loading of limbs with climber's weight, safety
Soils (3) – rehabilitating compacted soils, soils, structural soils
Stormwater (2) – Stormwater, stormwater benefits
Support systems (1) – lag bolt attachment strength in cabling
Tree risk (3) – risk assessment, tree risk, tree risk assessment
Trees & Construction (1) – construction damage to trees
Urban forestry (10) – assessment of municipal programs, cost of not maintaining trees, historical evolution urban forestry practices, municipal forestry research, periodic survey of urban forestry programs, urban forestry, urban forestry assessment, urban forestry survey, municipal tree care
Utility (5) – branch impacts, business case for UVM, effectiveness of IVM, utility corridor work, vegetation management
Wildlife (1) – wildlife benefits

- TREE Fund has generally had a significant impact (for example, work on construction damage to trees and rehabilitating compacted soils by Dr. Day). TREE Fund allows … a researcher to really *direct* research towards practical outcomes.
- All research has to please the sponsor and feed the sponsor's agenda. TREE Fund is the only sponsor with advancing arboriculture and urban forestry as its explicit goal.
- There are other notable advances in research—but I do not know if they are TREE Fund funded or not.
  - ✓ Even if not, I imagine TREE Fund has had a role in leveraging or disseminating some of this work.
  - ✓ For example, we have a lot more understanding of biomechanics than in the past.
  - ✓ We also have a better understanding of tree root systems and how they respond during the production-establishment phase.
  - ✓ Really the outcomes are significant, and to catalog them I would have to go through the various grants funded.

- ✓ However, the increasing professionalization of arboriculture and increased public awareness of the professional knowledge required for both arboriculture and urban forestry are evidence enough of this.

- Finally, there is still a lot that needs to be learned.
  - ✓ The research needs are ongoing—some more fundamental and some responding to the management issues that change over time.
  - ✓ (for example, we care more about stormwater management than in the past and tree pit design options have greatly evolved, etc.).
- Over the years, TREE Fund has enabled contributions on nearly every facet of arboriculture and urban forestry. That stated, within the larger constellation of research community contributions, it is rather difficult to conjure specific studies without first looking back over the awards of TREE Fund and its predecessor and then weigh that against the rest of the support for any works and how the infusion of support influences or enabled the process.
- Mike Arnold's study of nursery stock is deep and broad, with implications throughout the industry.
- The periodic survey of urban forestry programs (Hauer & Peterson) is critical to the long-term understanding of the profession and its structure at the local level.
- Biomechanics week—some support from [TREE Fund]; many projects and ongoing research to further our knowledge of tree biomechanics AND with excellent technology transfer.
- Support of Dr. Brian Kane—one of our most prolific and high-quality researchers who works on a wide variety of research areas.
- Dr. Koeser's tree risk studies—essential to the further development and refinement of our assessment protocols.
- Dr. Hauer et al. mega urban forestry survey—a wealth of information to understand that sector of our profession.
- Dr. Watson's ongoing root and planting research—what works or doesn't in planting practices.
- Dr. Gilman's nursery research and wind resistance/pruning research—changes to industry practices.
- Bramble and Byrnes utility corridor work—wildlife benefits.
- Many pest research projects over the decades—treatments; resistance.
- Many benefits of trees studies—can be used to influence decision makers.
  - The primary benefit of TREE Fund Grants is they supply seed money that is leveraged to attract other large funders. It is the 'skin in the game,' that is funding provided by the industry to demonstrate the need and support for the research.
  - ✓ The Municipal Forestry Research by Hauer is a good example, TREE Fund was a minor funder of the research but has helped secure larger state and federal grants to support the lion's share of the cost.
  - ✓ Gilman's research on pruning is another good example; it has changed how trees are pruned

- ✓ James Urban's work with Perry on soils has influenced landscape architects and provided new ways to increase soil volumes for urban trees improving planting survival and service life. Urban's Book *Up By Roots* would not have been an ASLA award-winning publication without the research funded through TREE Fund.
- ✓ Kane and Ball research on worker safety is improving ergonomics for climbers and improving climber health, safety, and productivity.
- ✓ At the same time, the research is changing ANSI Standards for the better.

▪ Safety training workshops.

▪ Planting, selection, and installation – webinars.

▪ Stormwater research – urban forestry.

▪ Effects of producing trees in containers and how to modify said production procedures to lessen long-term problems.

▪ I am not a practitioner, but I do pay attention to communications across the industry.

- ✓ The research funded specifically in pruning has been influential in practice and in A300 discussions.
- ✓ And the study of tree planting practices has been influential in the development of local planting specifications.
- ✓ The urban forestry research, such as stormwater benefits and the assessment of municipal programs were highly regarded and heavily utilized in establishing local programs.

▪ Understanding of lag bolt attachment strength in cabling.

▪ Effect of ascenders on climbing lines when loaded.

▪ Loading of limbs with climber's weight and how distance from union affects the failure point of the limb.

▪ Girdling roots, planting depth, container grown trees, root "pruning" of container grown trees.

▪ In my applications as an instructor and extension specialist, the research has had an impact on my presentations and program development.

- ✓ I rely on current research and practices to provide solutions to current and emerging issues.
- ✓ The urban forestry, pruning, and risk assessment deliverables have been very helpful in my efforts.
- ✓ In my opinion, TREE Fund grants are critical to the success and continuation of research efforts in our industry.

▪ TREE Fund Grants have brought an awareness to the work that nonprofits can provide in the sector.

▪ The grants that provide for activities, work training, etc. have exposed a whole layer of citizens to urban forestry.

▪ Additionally, these grants give nonprofits the opportunity to help build their capacity to serve their constituencies or develop new programs without risk.

- Municipal Tree Care (Duling Grant, 2013), was built on previous research.
  - ✓ But due to the increase in electronic media, it stands alone as a new jumping off point for municipal programs giving them the opportunity to compare their programs nationwide.
  - ✓ Additionally, the research opened up other possible research topics in municipal forestry. This critical study gives all practitioners within urban forestry opportunities to develop benchmarks for their programs as well.
- The work by John Goodfellow (Development of a Business Case For Scheduling Utility Vegetation Management on a Preventative vs. Corrective Maintenance Basis) within the utility realm allows utility vegetation managers to speak from science, not anecdotally. Utilizing the results of these studies should support vegetation managers in developing their programs using approaches that have been studied and tested.
- To be honest, I can't recall any specific research that I can point to that has influenced my practice of arboriculture although I know it has. I have learned a great deal of knowledge from listening to presentations of several researchers funded in part with TREE Fund grants. I also have read articles in *Arborist News* that have been based on the research that many of the grant recipients have written or whose research has contributed to the knowledge of the subject matter.
- I don't read *Arboriculture & Urban Forestry* due to the lack of time to do so and the level of detail the articles go into. I understand that the articles need to go into the scientific and statistical detail that they do and appreciate that they do follow the scientific approach to report the results of research projects. I just wait for the presentation on the information at a conference or in an article in *Arborist News*. I would not want to lose the journal even if I don't utilize it as it contributes understanding to those that need to complete more research.

Table 4. Please list an example or examples of notable outcomes that have influenced the practice of arboriculture and urban forestry and resulting Themes of Impact.

Themes of Impact
Awareness of work by nonprofits – Biomechanics week – Changes to industry practices – Changing ANSI standards – Compare programs nationwide – Develop benchmarks – Development and refinement of our assessment protocols – Disseminating work – Field practices – Heavily utilized – Highly regarded – High-quality researchers – Impact on my presentations and program development – Implications throughout the industry – Increased public awareness – Influence decision makers – Influential in development of local planting specifications – Jumping off point for municipal programs – Leverage attract larger donors – Leveraging work – Long-term understanding – Lot that needs to be learned – Opened us to other possible research topics – Over the decades – Practical outcomes – Procedures to lessen long term problems – Professionalization of arboriculture – Programs based on approaches studied and tested – Pruning has been influential in practice and in A300 discussions – Rely on current research and practices to provide solutions – Research needs are ongoing – Safety training workshops – Seed money – Technology transfer – Speak for science not anecdotally – TREE Fund has explicit goal – Wealth of information – Webinars – What works or doesn't in planting practices – Work training

Key informants were also asked to provide anything else that they believed is important to describe the outcome(s) of TREE Fund grants to the following question: *Please add anything else that you believe is important to describe the outcome(s) of tree funded grants* (Appendix E, Table 5). Three themes arose and include funding, marketing, and technology transfer. With funding, seed money and leverage listed commonly as key words. This is not surprising considering these are common attributes of TREE Fund grant requirements.

Some interesting themes for future funding ideas arose. The encouragement for TREE Fund to develop ways to fund emerging scientists, young researchers, and those who have not been previously funded before were interesting ideas. As far as we know, this criterion is not currently used in evaluating research proposals. The idea presented to support researchers throughout the world is consistent with the Kimmel International Fund. It was stated to consider increasing applicant diversity, although the specifics were not provided. It was also suggested to remind organizations such as ISA or TCIA that TREE Fund is not a competitor, rather the research funding arm of these organizations. This is certainly consistent with the long history of TREE Fund, ISA, and TCIA developing the current TREE Fund grants from prior programs in the ISA and TCIA.

Marketing was a second theme that arose from the evaluation of key phrases. Developing an impact statement of research was provided as a novel idea. Linking tree care professionals to TREE Fund-supported research and marketing TREE Fund afield were given. This is consistent with the active promotion by TREE Fund and partners to transfer knowledge through webinars, publications (e.g., *Arborist News*, *Tree Care Industry Magazine*), and conference presentations and fits the resulting Technology Transfer theme.

As another important theme from respondents, technology transfer was stated as an expectation for delivering findings to relevant professionals, describing the significance of research, and promoting impacts in industry publications as important. Key informants also suggested that evidence exists for industry support of TREE Fund-supported research. Key informant statements that were added as additional information follows.

Key Informant Statements

- They provide seed funding
  - ✓ that is extremely helpful to researchers for leveraging larger federal grants,
  - ✓ as TREE Fund support provides tangible evidence of industry support, and
  - ✓ the significance of the research for the arboriculture and urban forest industry.
- TREE Fund serves as seed money
  - ✓ for other funding organizations and provides full funding for research.
  - ✓ funding for emerging scientists in arboriculture and urban forestry can also direct their efforts to our field.
- It would be great to see a wider range of urban forestry related studies funded,
  - ✓ e.g., connected to social and governance aspects.
  - ✓ also, specific support to researchers in the developing world could be a future priority, perhaps through a dedicated grant scheme.
- Just a note about my answers above: Some questions I didn't answer because I don't really know. Essentially, I don't pay close attention to some types of research since they don't have a significant impact on me (for example workplace safety). That doesn't mean I don't think this is extremely important; I just don't use it in my day-to-day operations that much because I don't work in a production arboriculture environment.

Table 5. Please add anything else that you believe is important to describe the outcome(s) of TREE Fund grants and resulting Themes That Arose.

Themes That Arose

Funding

Seed funding
Leverage
Seed money
Emerging scientist funding
Wider range urban forestry funding (e.g., governance, social)
Support for researchers in developing world
Few funding sources for arboriculture research
Focus funding "bullseye" of arboriculture and urban forestry
Encourage awarding of grants to new ideas and researchers not previously funded
Help young researchers gain funding that can be used as match
Increase applicant diversity
Many names repeated over and over as recipients
Remind TCIA & ISA that TREE Fund is not a competitor, rather research arm of both
Make it easy for an organization to manage and direct research and scholarship funds

Marketing

Marketing TREE Fund afield
Find better way to link tree care professionals and TREE Fund research
Impact statements from research
Kept our industry viable
Providing ways for donors to support projects

Technology Transfer

Research significance
Tangible evidence industry support
Expectation for technology transfer
Promotion of impacts in industry publications
Tapping into the industry's research needs, through surveys and outreach

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- One thing that I think is unique to TREE Fund grants that makes them more effective is the expectation that TREE Fund has for technology transfer. This really gets the work in the hands of practitioners.
- However, all the tech transfer I have done (for example) has not been funded by TREE Fund, but has been funded by other sources (either the university or the state, etc.)
- An extremely important consideration is that there are very few other sources of research funding for arboriculture,
  - ✓ and the amount TREE Fund has to offer is extremely limited.
  - ✓ This is why I have always taken a strong stance on focusing funding close to the "bullseye" of arboriculture and urban forestry.
  - ✓ Other sources may fund ancillary research.
- Promotion of impacts of TREE Fund research outcomes in industry publications

- ✓ like Arborists News, TCI Magazine, Arboriculture and Urban Forestry, Urban Forests and Urban Greening needs to be maintained and improved.
- ✓ As these organization's leadership shifts to a new generation the significance of TREE Fund will need to be communicated and maintained.

- Encouraging and awarding grants for new ideas and researchers not previously the recipient of an award – diversity of research and researchers
- Help younger researchers gain funding that can be used as matches for more funding to accomplish more complex projects.
- The marketing of TREE Fund opportunities may need to go further afield to increase the diversity of applicants.
- In reviewing the list of grants, many names are repeated over and over as recipients.
- I think we need to find a way or ways to help arborists and tree care professionals understand or better associate the link between our livelihoods and TREE Fund research.
- I think that there could be more promotion and awareness of grants that are available for AUF professionals and academicians. Also, the impact statements from research would be useful.
- TREE Fund grants have kept our industry visible in the world of academic research. It may not seem like vast amounts of money, but in many cases, a few thousand dollars is all that is necessary to fund a project, or to demonstrate the viability of an idea, leading to more funding from other sources.
- TREE Fund has done a good job of providing ways for donors to support projects that are important to them. Likewise, TREE Fund has done a good job of tapping into the industry's research needs, through surveys and outreach.
- TREE Fund should continue to market itself to the average arborist, through events at regional meetings. Something as basic as a 50/50 raffle can generate excitement and put the brand in front of a lot of different people.
- TREE Fund must continue to liaise with the boards of its benefactors, especially the TCIA and the ISA and its many chapters, to remind them that TREE Fund is not a competitor, but rather the research arm of both organizations. TREE Fund should make it easy for an organization to manage and direct research and scholarship funds.
- As a Board Member of the ISA, I appreciate the work of these grants and how they have supported our membership in so many different ways. Specifically, I believe the scientific research has shaped (and continues to shape) the practices of Arboriculture, Urban Forestry and Utility Arboriculture. It is always good to point to research as the basis for what arborists do in the field. Without these grants, some of the research that is utilized by practitioners today, would not exist.
- I believe I touch on everything in my answer above. I strongly support TREE Fund and will continue to do so. I believe that industry support of TREE Fund is critical to communicate to the government and others that the industry supports and needs the research that is being done.

Technology Transfer Through Webinars

Webinars are an important method to transfer knowledge to practitioners, educators, researchers, lay people, and others (Appendix F). As an example, Cooperative Extension has been instrumental in delivering relevant TREE Fund sponsored research projects. They not only transfer knowledge but provide a mechanism for obtaining continuing education credit (Table 6). Since April 2015 a total of 12 webinars jointly sponsored by TREE Fund have been hosted through universities at Utah State University and Alabama (A&M and Auburn Universities). The attendance at webinars will fluctuate during the presentation. Based on recorded registration and attendance records on average 402 people have attended all or part of a TREE Fund sponsored webinar. Thus, since 2015 an estimated 4800 viewers (1200 annually) have gained practical knowledge through these webinars. In comparison, the four webinars hosted annually would be the equivalent attendance at an annual International Society of Arboriculture conference. Additional webinars series (e.g., Emerald Ash Borer University) also promote TREE Fund research, however the exact number of reached participants was not found. The EAB University series did host at least two projects with research funded by TREE Fund. It is recommended to request TREE Fund grantees to provide information that document webinar presentations and estimates of participants.

Table 6. Example webinars co-sponsored by TREE Fund and administered by Cooperative Extension Service through Alabama A&M and Auburn Universities and Utah State University.

- Arboricultural Biomechanics, Dr. Brian Kane (University of Massachusetts, Amherst) – August 2018 (337 attended)
- Utility Arborist Research Fund: Work in Progress, Work to Come, J. Eric Smith, TREE Fund and Dr. Christopher Halle, Sonoma State University – May 2018 (not reported)
- Invasive Insects of Shade Trees: A 30 Year Perspective from Colorado, Dr. Whitney Cranshaw, Colorado State University – May 2018 (582 registered, 426 attended)
- Do Planting Stock Decisions Really Make Much Difference Down The Road?, Dr. Michael Arnold (Texas A&M University) – February 2018 (476 attended)
- Drought Tolerance in Trees – Improving Tree Selection for Challenging Urban Sites, Dr. Andrew Hirons (Myerscough College, U.K.) – November 2017 (809 registered, 550 attended)
- Municipal Forestry Baseline, Trends, and Dashboard, Dr. Richard Hauer (U. of Wisconsin – Stevens Point) – September 2017 (348 attended)
- Soil Profile Rebuilding: Rehabilitating Compacted Soils, Dr. Susan Day (Virginia Tech) – June 2017 (377 attended)
- Tree Risk Assessment – Perceptions, Reality, and Reliability, Dr. Andrew Koeser (U. of Florida) – April 2017 (494 attended)
- Soil Compaction and Urban Trees: Strategies for Gaining Ground, Dr. Bryant Scharenbroch (U. of Wisconsin – Stevens Point) – November 2016 (592 registered, 414 attended)
- An Approach to Pruning You Won't Forget, Dr. Ed Gilman (U. of Florida) – May 2016 (654 registered, 515 attended)
- Strategies for Successful Urban Tree Growth in Wet and Dry Sites, Dr. Nina Bassuk (Cornell University) – Sept 2015 (not recorded)
- Emerald Cash Borer: It Will Cost You Money-Ways to Manage the Ash Cash Flow, Dr. Rich Hauer (U. of Wisconsin – Stevens Pt.) – April 2015 (85 attended)

Summary of Findings and Conclusion

TREE Fund has led to significant impacts with the advancement of arboriculture and urban forestry, contributing to both the body of peer review and research outreach efforts. Key informants implicitly state that TREE Fund sponsored grants significantly impact the industry. The review of past grant recipients further revealed outcomes and impacts of TREE Fund sponsored grants. For example, the revisions of A300 standards for Tree Care Operations were a direct result of TREE Fund grants. Specifically, the recent pruning standard was significantly revised because of tree pruning research of Dr. Ed. Gilman. TREE Fund sponsored several of the tree pruning studies that led to changes in the 2018 update of the A300 Tree Pruning Standard.

TREE Fund sponsored the study on municipal tree care operations led to a technical report and over ten publications that document the baseline benchmarks for municipal forestry programs. It led to the first sectoral understanding of the number of fulltime employees (over 30,000) and the mean wages for municipal arborists which is at the mean pay of all occupations. The study further continued the longitudinal understanding of municipal forestry programs that date to the 1970's.

TREE Fund sponsored research focused emerald ash borer management has led to several significant findings. Treatment protocols to protect ash trees and the efficacy of treatments have resulted in practitioners being able to retain ash tree canopy in communities. Other TREE Fund sponsored projects have demonstrated the economic implications of various management options. In all cases it was shown that treatment options currently used are the most economically favored outcomes.

Research sponsored by TREE Fund has resulted in basic and applied research. These findings in themselves are critical for the advancement of science. The true test is the application into practical outcomes. The examples above and contained through the analysis of this study found scores of examples of research them that led to the advancement of science in arboriculture and urban forestry. In turn these studies have further led to the practical application of research findings. Sponsored research is regularly turned into demonstrated outcomes that get into the hands of practitioners to use.

In closing, this report summarizes the outputs, outcomes, and impacts of TREE Fund sponsored research grants. The life cycle of the grant starts with a research idea that is submitted for consideration. A small percentage of these get funded. The funded research supports students who get trained and in turn craft research into publications, presentations, and in many cases practical research that has made lasting impacts on the profession of arboriculture and urban forestry. The principal investigator reports the outputs to TREE Fund which was a source of information to start this investigation. We found that the work continues with many relevant outcomes through publications and presentations that occur, even after the final reports are submitted. The research further supports new research questions that arise and further spawn questions that are answered, sometimes funded by TREE Fund and other times not. This report provides tangible facts that support hundreds of publications that arose, hundreds of presentations given, thousands of citations from published work, industry changing impacts, and the leveraging of over two dollars for every dollar of TREE Fund sponsored research. We hope our findings provide TREE Fund Board of Trustees a useful set of information to guide the sponsored research programs in a continued future success.

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Appendix A – Research Impacts and Outcomes Study RFP

INTRODUCTION

Tree Research and Education Endowment (TREE) Fund is a 501(c)3 charitable organization that awards grants to enhance awareness and management of tree populations in urban settings, thereby improving community health, beauty, value and sustainability. TREE Fund has awarded a total of $3.2 million since 2002 for arboriculture and urban forestry research and education. See treefund.org/about for more information about our mission, history and programs.

TREE Fund is interested in better understanding the outcomes and impacts that 15 years of research grants have had on the awareness, knowledge and implementation of technology, practices and management of urban forests in the green industry. As TREE Fund seeks to grow it is important to more fully understand what contribution the organization's grants have made in the arboriculture and urban forest industries. Toward this end, TREE Fund's Trustees have authorized a one-time grant in 2017 to conduct a baseline review of impacts, outputs and outcomes of TREE Fund sponsored research programs. The maximum award for this project is $20,000.

PROGRAM PURPOSE AND DESIRED OUTCOME

TREE Fund desires that the subject report be made available to its Board of Trustees in November 1, 2018. The successful applicant(s) will conduct a comprehensive study, likely combining qualitative and quantitative research techniques, of all TREE Fund research grants awarded between 2002 and 2017. The desired outcome is a full report describing previously funded research outputs, outcomes and impacts on the management of urban forests towards healthier, safer and more resilient urban forests.

Measures to be collected might include:

- Research outputs, including:
  - Number of peer reviewed citations
  - Number of extension, industry and newsletter publication
  - Number of webpages, videos or other resulting media
- Research outcomes, including:
  - Number of transferable technologies, techniques or management recommendations
  - Adoption rates of resulting technology, techniques or management (inclusion of data in BMPs, Standards, etc.)
  - Changes in industry or public awareness brought on by research findings
  - Document the process of research implementation into arboriculture and urban forest management
- Research impacts, including estimated:
  - Economic impacts
  - Environmental impacts
  - Health Impacts

TIMELINE AND REPORT

Applications will be accepted only via TREE Fund's website (treefund.org) from July 6 to August 25, 2017. No advance letter of inquiry is required before applications may be submitted. All compliant applications will be reviewed and ranked by TREE Fund Board of Trustees' Research and Education Committee. A single award will be recommended by the Committee for approval by the Trustees on or before September 22, 2017. Notification of award will be made within two weeks of Trustee approval.

Recipients' signed agreements and requested support materials must be received within two weeks of award notification. The award letter will include a contract issued to the recipient's academic institution, which must be signed and returned within two weeks of the award notification date. Applicants are strongly encouraged to review the sample Grant Conditions and Agreement form (which can be viewed here) with their employers' financial or grant management offices, as appropriate, to ensure that the Agreement form can be signed expeditiously upon receipt. Potential difficulties with Agreement terms that are identified during the application process may be considered and negotiated more favorably than those presented after the grant award process. Grant recipients will also be required to submit a brief summary of their projects in lay terms, as well as a photo for use in TREE Fund and industry publications, prior to initial payment being disbursed. Upon TREE Fund's receipt of the signed contract and any requested supporting documentation, a first payment equaling the requested grant amount less $1,600 in retained funds will be sent to the recipient's Institution.

A final report listing the outputs, outcomes and impacts using qualitative and quantitative data is due by November 1, 2018. The report should outline project results by TREE Fund research priorities of: root and soil management, planting and establishment, plant health care, risk assessment and worker safety, and urban forestry. Upon receipt and approval of the final report, the $1,600 retained funds will be paid to the recipient's academic institution.

PROJECT BUDGET

The maximum cash award for this project is $20,000 and proposals must include at least a 10% matching component of in-kind or cash provided by others. Proposed costs must be broken down into the following categories:

- Compensation or Stipends (if benefits are included the proposal, identify them by dollar value and as a percentage of the total compensation/stipend cost);
- Travel or Transportation (specifically identify costs associated with travel beyond 150 miles of applicant's institution, and reason for such proposed travel);
- Materials and Supplies;
- Institutional Overhead (may not exceed 10% of total requested amount)
- Matching Component (must be at least 10% of total budgeted amount; unrecovered institutional overhead may be credited toward the match).

CRITERIA FOR SELECTION

Applications will be scored on the following scale:

- Proposal directly addresses each of the tasks described above (20 points)
- Methods for conducting and documenting the research are clear (30 points)
- The proposed team is qualified to conduct the requested work (30 points)
- Objectives are achievable within required time frame and proposed budget (20 points)

TREE Fund does not discriminate on the basis of race, color, creed, gender, sexual orientation, disability or national or ethnic origin. Current Trustees of TREE Fund or any member of the family of any such Trustees are ineligible to receive grants from TREE Fund. As an integral part of TREE Fund's mission, findings from this grant may be freely and widely distributed to any and all parties who may benefit from the work, with full credit provided to the report's author(s).

Source: https://treefund.org/research-impacts-and-outcomes-study

Appendix B – TREE Fund Grant Programs

Research Grant Programs assessed as part of this project. Description of each from TREE Fund as of November 2018 at https://treefund.org/researchgrants

Directed Grant Programs

TREE Fund's Board of Trustees may occasionally select a topic of interest and solicit proposals from specific researchers. The general terms and conditions of the Sponsored Grant Programs (above) will be applied to any Directed Grant Programs as well.

Hyland R. Johns Grant Program

Established in 1995 to honor one of the leaders in the arboriculture industry and a founder of the ISA Research Trust, the Hyland R. Johns Grant Program funds longer term research and technology transfer projects that have the potential of benefiting the everyday work of arborists. Projects are expected to be completed within three to five years, with a maximum award value of $25,000. No project may receive more than one award from this program.

Jack Kimmel International Grant Program

The Jack Kimmel International Grant Program, championed by the Canadian TREE Fund, honors the late Jack Kimmel who was the former Director of Parks for the City of Toronto. He is remembered for his contribution of 46 years of leadership to the ISA and its Ontario chapter. Jack Kimmel grants provide much needed funding to arboriculture and urban forestry researchers all over the world. This grant is administered by TREE Fund, with participation from the Canadian TREE Fund in the evaluation process. These grants are available to researchers whose work is primarily outside of the United States. Projects are expected to be completed within one to two years. Grant award amounts are limited to a maximum of $10,000 and will vary depending upon the adjudged value of the project relative to the needs of the arboriculture community. No project may receive more than one award from this program. Due to the similarity of the Jack Kimmel International Grant and John Z. Duling Grant, applicants may submit to only one of these programs per unique project funding cycle.

John Z. Duling Grant Program

The John Z. Duling Grant Program was established and funded by a bequest from the estate of John Z. Duling of Indiana, a strong advocate of research who in 1972 proposed the establishment of the ISA Research Trust. The goal of this program is to provide start-up or seed funding to support innovative research and technology transfer projects that have the potential of benefiting the everyday work of arborists. John Z. Duling Grants may be used to support exploratory work in the early stages of untested, but potentially transformative, research ideas and approaches. Examples may include application of new approaches to research questions, or application of new expertise involving novel disciplinary or interdisciplinary perspectives. Projects are expected to be completed within one to three years with a maximum grant award of $25,000. No project may receive more than one award from this program. Due to the similarity of the Jack Kimmel International Grant and John Z. Duling Grant, applicants may submit to only one of these programs per annual project funding cycle.

Safe Arborist Techniques Fund Grant Program

The Safe Arborist Techniques Fund (SATF) is a joint program of Tree Research and Education Endowment Fund (TREE Fund) and International Society of Arboriculture (ISA), established in 2015 to support research and development and technology transfer on the techniques and equipment that arborists use in climbing, rigging, and working on trees; and the means of identifying potential hazards, to provide a safer working environment. Grant-funded projects are expected to be completed within two years of initial fund disbursement. The maximum award value of SATF grants is $10,000.

Utility Arborist Research Fund Grant Program

Tree Research and Education Endowment Fund (TREE Fund) and Utility Arborist Association (UAA) established the Utility Arborist Research Fund (UARF) in 2010 to finance work with real importance and benefit to utility tree care professionals. In 2017, the UARF endowment reached its $1.0 million activation goal, and first grants will be awarded in 2018. TREE Fund manages the UARF endowment and administers all research grants awarded, while UAA's Research Committee advises TREE Fund with respect to research priorities. Given the immense scope of annual utility arboriculture work on a global basis, if UARF-funded research can generate even a 1.0% reduction in tree-related outages, customer complaints, vegetation management complexity or emergency tree work, the financial, public relations, and worker safety returns on investment will be immense. A total of $50,000 is available for award in 2019; the minimum award considered will be $10,000, the maximum $50,000, so that one to five grants may be awarded, subject to receipt of compliant applications. Work funded by UARF is expected to be completed within one to three years of award.

The following grant programs were not implemented as of 2018, with plans to initiate in 2019.

Bob Skiera Memorial Fund Building Bridges Initiative Grant Program

Supports projects which will help arborists and urban foresters communicate the value of trees and urban forests on a national basis through technology transfer and engagement with developers, builders, civil engineers, city planners, elected officials and other policymakers.

Barborinas Family Fund Grant Program

Supports projects focused on tree planting and transplantation techniques, and the improvement of tree varieties for urban conditions, to include investigations into root and soil science.
Award amount: up to $10,000 (minimum $5,000)

Appendix C – TREE Fund Research Citation List

Knowledge Creation

- 175 Peer-reviewed articles
- 3,641 Citations found as of 10/31/18

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143. Roberts, B.R. and R.S. Linder. 2010. Humectants as post-plant soil amendments: Effects on the wilting cycle of drought-stressed, container-grown tree seedlings. *Arboriculture & Urban Forestry* 36(6):275-280. (2 Citations)
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171. Whitehill, J.G.A., S.O. Opiyo, J.L. Koch, D.A. Herms, D.F. Cipollini, and P. Bonello. 2012. Interspecific comparison of constitutive ash phloem phenolic chemistry reveals compounds unique to Manchurian Ash, a species resistant to Emerald Ash Borer. *Journal of Chemical Ecology* 28(5):499-511. (49 citations)
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Appendix D – TREE Fund Trade Publications

Knowledge Dissemination

1. Arnold, M., E. Bush, R. Cabrera, G. Denny, J. Griffin, J. Iles, A. King, G. Knox, G. McDonald, C. McKenney, T. Montague, G. Niu, A. Owings, and D. Struve. 2010. Testing tolerances of *Taxodium*. Landscape Plant News 20(3):10-11.
2. Blaedow, R. 2010. Research update on propiconazole as an effective tool for managing oak wilt. Minnesota Turf & Grounds Foundation: Clippings Fall/Winter:6-9.
3. Dahle, G. 2011. A look back at Tree Biomechanics Week: A researcher's perspective. Arborist News 20(1):41-42.
4. Day, S.D. 2016. Soil profile rebuilding: an alternative to soil replacement. City Trees September/October:30-34.
5. Garcia, L.L., M.A. Arnold, L. Lombardini, R.T. Watson, S.T. Carver, and A.R. King. 2016. Is the old adage about small container-grown trees catching up to larger trees once they're planted in the landscape true? In the Shade: Newsletter of the ISA Texas Chapter 40(3):10-11.
6. Hauer, R.J. 2009. Trees and construction - A quarter century grey and green infrastructure battle. Minnesota Shade Tree Advocate 11(1):5-7.
7. Hauer, R.J. 2012. Emerald ash borer economics, management approaches, and decision making. Tree Care Industry Magazine 23(8):14-17.
8. Hauer, R., and W. Peterson. 2016. Building and growing professionals for trees: arboricultural standards and credentials. Arborist News 25(1):42-46.
9. Hauer, R., and W. Peterson. 2016. Municipal forestry budgets and employee compensation. Arborist News 25(5):58-61.
10. Hauer, R., J. Vogt, and B.C. Fischer. 2015. Growing arboriculture and urban forestry: one student at a time. Arborist News 24(5):68-71.
11. Hirons, A., and H. Sjöman. 2018. Species selection for paved environments: translating science into practice. City Trees July/August 54(4):32-36.
12. James, K.R. 2008. Trees, winds, and dynamic loads. Arborist News February 17(1):44-47.
13. Johnson, G., R. Hauer, W. Peterson, D. Karcher, and J. Gulick. 2016. Financing the urban forest: Volunteers as a source of revenue and program support. Arborist News 25(4):20-25.
14. Jones, G., and B. Rao. 2008. Challenges in establishing newly transplanted trees. Buckeye Arborists 39:1-14.
15. Jones, G., and B. Rao. 2008. Challenges in establishing newly transplanted trees. TREE Fund Newsletter October:6-7.
16. Kane, B. 2011. Compatibility of toothed ascenders with arborist climbing ropes. Arborist News 20(5):20-21.
17. Kane, B. 2016. Cabling affects trees. Tree Care Industry February 27(2):30-31.
18. Kane, B. and H.D.P. Ryan. 2012. Rigging ropes and hitch strength. Tree Care Industry 23(3):RS1-RS5.
19. Kocher, W. 2013. Biomechanics Week 2013. Arborist News 22(5):58-61
20. Koeser, A.K. 2010. Tree Biomechanics Week a resounding success. Arborist News. 19(5):62
21. Koeser, A.K., R.J. Hauer, A. Hillman, and W. Peterson. 2016. Risk and Storm management operations in the United States- How does your city compare? Arborist News 25(2):20-23.

22. Luley, C.J., D.J. Nowak, and E.J. Greenfield. 2009. Decay, defects and condition of street trees in four upstate New York cities. City Trees May/June:22-25.
23. Ness, E., and B.C. Scharenbroch. 2015. Getting to the root of urban tree health. Crops, Soils and Agronomy News Magazine 60:4-7.
24. Percival, G.C. 2004. Fertilisation of tree- is it really bad for them? EssentialARB. December Issue 13.
25. Percival, G.C. 2004. Safer solutions to tree diseases. Horticulture Week February 5th.
26. Percival, G.C. 2005. Searching for the super tree. EssentialARB. March Issue 14.
27. Percival, G.C. 2007. Coping with Phytophthora. EssentialARB. March Issue 21.
28. Percival, G.C. 2008. Overcoats for trees. protecting against salt damage. Tree Care Industry Magazine February 29(2).
29. Percival, G.C. 2010. Halting the loss of a national treasure. Certis Cropsafe News June Edition: 4-5.
30. Percival, G.C. 2010. What's new in honey fungus control? EssentialARB. Spring Edition 32:32-34.
31. Percival, G.C. 2017. Can we Vaccinate trees to protect against diseases? Part I: the science behind the theory. Ontario Arborist Magazine June/July:22-24.
32. Percival, G.C. 2017. Can we Vaccinate trees to protect against diseases? Part II: putting science into practice. Ontario Arborist Magazine August/September:20-22.
33. Percival, G.C. 2017. Controlling tree diseases: thinking outside the box. The ARB Magazine 176:42-46.
34. Percival, G.C., I. Barrow, I., and K. Noviss. 2010. Are we underestimating the impact of the horsechestnut leaf miner. The ARB Magazine. Summer Edition 149:20-25
35. Peterson, W. 2013. Trees strengths: A week under the microscope - Biomechanics Research Week 2013. Arborist News 22(3):44-45.
36. Peterson, W., and R. Hauer. Getting work done in the urban forest: community staffs, volunteers, and contractors. Arborist News 25(6):34-38.
37. Raupp, M.J., 2004. Merit vs. target pests and mites. Tree Care Industry Magazine 15(3):44-48
38. Raupp, M.J., and Davidson, J.A., 2017. Friend or Foe? Some Tricks For Identifying Insect Larvae on Woody Plants. Tree Care Industry Magazine 28(4):54-59
39. Raupp, M.J., and Herms, D.A., 2016. Invasive Insect Pests- What Do They Like To Eat? Lessons From Fearsome Fungi. Tree Care Industry Magazine 27(8):30-34
40. Raupp, M.J. and H. Martinson. 2015. Bye-bye big beetles in cities. Arborist News 24(6):70-73.
41. Ries, P., R. Hauer, and W. Peterson. 2016. Systematic management of the urban forest. Arborist News 25(3):46-49.
42. Scharenbroch, B.C., E.T. Smiley and W. Kocher. 2015. Managing soils that support urban trees. Part 1. Arborist News 24:12-18.
43. Shoemaker, T. 2008. Investigating loads & forces climbers put on trees. Tree Care Industry Magazine 21(11)48-53.
44. Siewert, A. 2010. Stone soup at Biomechanics Week. Arborist News 19(6):40-41.
45. VanNatta, A., and R. Hauer. 2012. Money and ash tree management: prioritizing decisions in the fate of EAB. Arborist News 21(4):42-44.
46. Wilson, K. 2012. Biochar for arborists. Tree Care Industry Magazine 23(9):22-26

Appendix E – Key Informant Survey

TREE FUND

UF | IFAS UNIVERSITY of FLORIDA

College of Natural Resources University of Wisconsin-Stevens Point

Instructions

Please complete the questions below to evaluate the outcomes of the TREE Fund Grant Program. As you are likely aware, the TREE Fund provides several research grants to support arboriculture and urban forestry research throughout the world. Please follow the instructions associated with each question. The few minutes of your time is vital to assisting the TREE Fund evaluate the outcomes and outputs of the grant program. Please return to rhauer@uwsp.edu

Start

1. How important is the research funded by the TREE Fund as it relates to the science and care of trees on a scale of 1 to 7 (with 1 being very unimportant to 7 being very important)?

(ENTER YOUR CHOICE BELOW)

1	2	3	4	5	6	7
Very Unimportant						Very Important

2. How important are TREE Fund grants as a funding source for arboriculture and urban forestry research on a scale of 1 to 7 (with 1 being very unimportant to 7 being very important)?

(ENTER YOUR CHOICE BELOW)

1	2	3	4	5	6	7
Very Unimportant						Very Important

3. Given research funded by the TREE Fund, have work practices in arboriculture and urban forestry changed? (SELECT ONE CHOICE ONLY)

   - ○ Yes
   - ○ No (if no please go to question 5)

4. On a scale of 1 to 7 (With 1 being very little to 7 being very much) did this change (or any other changes influenced by studies Funded by the TREE Fund) have a noticeable impact on:

	Raking Scale 1 = very little to 7 = very much (Mark one choice for each content area)						
Content Practice Area	*1*	*2*	*3*	*4*	*5*	*6*	*7*
Work place safety	( )	( )	( )	( )	( )	( )	( )
The ability to work more efficiently	( )	( )	( )	( )	( )	( )	( )
The quality or professionalism of your work as it relates to:							
Pests/Diseases/Invasives	( )	( )	( )	( )	( )	( )	( )
Pruning	( )	( )	( )	( )	( )	( )	( )
Propagation, Planting & Establishment	( )	( )	( )	( )	( )	( )	( )
Root & Soil Management	( )	( )	( )	( )	( )	( )	( )
Urban Forestry	( )	( )	( )	( )	( )	( )	( )
Utility	( )	( )	( )	( )	( )	( )	( )

5. Rank the overall importance of the outcome or outcomes of TREE Fund grants using a scale of 1 to 7 (with 1 being very unimportant to 7 being very important.

(ENTER YOUR CHOICE BELOW)

1	2	3	4	5	6	7
Very Unimportant						Very Important

6. Please list an example or examples of notable outcomes that have influenced the practice of arboriculture and urban forestry.

7. Please add anything else that you believe is important to describe the outcome(s) of tree funded grants.

Appendix F – TREE Fund Webinars

TREE Fund regularly works with researchers to give updates on sponsored research. Below are historical and current webinar examples.

Hungry for knowledge? Introducing TREE Fund Lunch & Learn Webinars

Between storm damage clean up, battles against invasive pests and routine pruning and planting it's hard for tree care professionals to find time to keep up with the latest advances in arboriculture. That's why TREE Fund is bringing the knowledge *directly to you*, through our new free webinar offerings. Internationally renowned scientists are discussing the topics that matter most to you – from tree risk assessment to EAB management to soil amendments – so you can stay on the leading edge of tree care and offer the best service to your customers.
TREE Fund webinars were the brainchild of Arnold "Beau" Brodbeck, PhD, TREE Fund Liaison for Southern Chapter ISA. Beau brought his idea to TREE Fund for the Trustee/Liaison Retreat in December 2014, where it was immediately embraced by the group and championed by TREE Fund Research Committee Chair Hallie Dozier, PhD. "Disseminating new knowledge in the fields of arboriculture and urban forestry is a key part of our organization's mission," explains Janet Bornancin, TREE Fund President and CEO. "We already share the knowledge gained through TREE Fund research in print publications and on our website and social media. Webinars are the next logical step in getting these important scientific discoveries out to the people who can use them."

With support from Utah State University and the Utah Division of Forestry, Fire and State Lands, the first TREE Fund webinar was broadcast on April 28, 2015. Dr. Richard Hauer of the University of Wisconsin-Stevens Point discussed "Emerald Ca$h Borer: It will Cost You Money – Ways to Manage the Ash Cash Flow." Dr. Hauer's research was partially funded by a John Z. Duling grant from TREE Fund. 79 arborists, city foresters, state and federal agency representatives and extension professionals logged on for Dr. Hauer's presentation on the economics of EAB management. CEU credits were available from ISA and the Society of American Foresters. The webinar is now archived and can be accessed through our website.

Dr. Nina Bassuk, founder of Cornell University's Urban Horticulture Institute, is on deck for TREE Fund's next webinar on September 23 at noon (MDT). Look for more details on our website later this summer.
TREE Fund webinars are currently conducted in partnership with, and hosted by, Utah State University Forestry Extension and the Utah Division of Forestry, Fire and State Lands. The program is set to expand in 2016 via collaborations with additional universities and extensions across the country. *Lunch & Learn Webinars* are supported by TREE Fund Crown Partners Bartlett Tree Experts and The Davey Tree Expert Company.

Source: https://treefund.org/archives/10331

TREE Fund WEBINARS

TREE Fund webinars bring you the latest in tree research, directly from the scientists themselves. These one-hour programs are free and offer 1 CEU credit from ISA, SAF or NALP. Pre-registration is highly recommended; in doing so, you'll receive a reminder email the day before the program.

Many thanks to our webinar hosts Alabama Cooperative Extension System and Utah State University Forestry Extension.

Upcoming Webinar

Emerald Ash Borer: Strategies for Conserving Ash in the Urban Forest

Dr. Dan Herms, VP of Research & Development, The Davey Tree Expert Company

November 28 at 12:00 p.m. Mountain (please note date change) – translate to your time zone

Register HERE

Learn about the research that provides the scientific basis for emerald ash borer (EAB) management and conservation of ash in urban environments. Dr. Herms will walk you through the results of multiyear insecticide trials with soil applied, trunk injected, and bark applied systemic insecticides which show that protection of even very large caliper ash trees is a viable option to consider as part of an integrated management program for EAB. See how the EAB Cost Calculator and tree inventories can be used to integrate treatments with removal schedules to develop proactive, strategic management programs for ash and the EAB "death curve" in the urban forest. If you are a municipal forester, city manager, arborist, consulting arborist, researcher, extension specialist, landscape manager, property owner, or land manager, you don't want to miss this program!

Dan Herms is Vice President of Research and Development for The Davey Tree Expert Company. Prior to joining Davey, Herms was a professor in the Department of Entomology at The Ohio State University (OSU) from 1997-2017. He received his B.S. in Landscape Horticulture from OSU in 1982, his M.S. in both Horticulture and Entomology, also from OSU in 1984, and a PhD from Michigan State University in Forest Entomology in 1991. His research and outreach programs have focused on the ecology and management of insect pests of trees in forests, urban forests, and ornamental landscapes.

We are grateful to Utah State University Forestry Extension for hosting this program.

Source: https://treefund.org/webinars