THE CENTER FOR TREE SCIENCE

Securing the future of trees

Around the world, trees are under threat in the wild and in urban areas. Only concerted effort can preserve tree diversity, urban forests, and the many benefits they provide to people and the environment. But those efforts are hampered by a lack of scientific understanding of the complex challenges faced by trees and forests and by a diminishing pool of people trained to meet those challenges. The Center for Tree Science at The Morton Arboretum catalyzes scholarship and training for the future of trees and people.

What is the Center for Tree Science?

The Center for Tree Science brings together experts from botanical gardens, universities, government, industry, and other organizations to participate in collaborations that generate new knowledge and provide training to address key challenges facing trees in urban areas and in the wild. The Center for Tree Science follows a simple consortium model and engages a Steering Committee to guide scientific objectives.

The Center works towards its goals by supporting the following activities in which collaborators can be involved: collaborative research projects; small grants; fellowships; internships; mini-courses; workshops; conferences; a program for undergraduates to gain research experience; and a research and demonstration area on the grounds of The Morton Arboretum to engage the public. By creating a nucleus of experts who regularly work together, exchange ideas, and use their collective achievements and strengths to increase research, training, and funding opportunities for tree science, the Center for Tree Science energizes tree science and serves as a primary source for expertise on trees.

Improving the quality of urban forests

Trees and forests in urban areas and in the wild provide essential benefits to society and the environment but face increasing challenges that put them at risk. The urban forest improves the lives of more than 220 million people in the United States alone, or 80 percent of the population, and with urban populations projected to grow, the number of people who benefit from trees in urban areas will increase (U.S. Census Bureau 2001; Nowak et al. 2010). Trees play important roles in the urban ecosystem. Trees clean pollutants from the air; reduce energy use and noise pollution; improve water quality and help control flooding; increase property values; provide wildlife habitat; mitigate changes in climate; and improve community health and well-being (e.g., Dwyer et al. 1992; McPherson et al. 1994; Westphal 2003; Nowak and Dwyer 2007). Although not usually included in municipal budgets, the services trees provide are worth millions each year (e.g., Nowak et al. 2008; Nowak et al. 2012). Increasingly, these services are being quantified and incorporated into infrastructure planning and municipal budgets (Nowak 2006). Demand for tree care services has increased over the past two decades (O'Bryan et al. 2007), and is projected to grow 26 percent over the next decade (Wiseman et al. 2011).

Despite their importance, urban forests face considerable threats. Budget constraints often limit municipalities' ability to hire skilled staff and dedicate adequate resources to properly care for trees. Urban forests often have low species diversity, are not planted with species tolerant to climate changes, and are vulnerable to pests and disease (Santamour 2004; Tubby and Webber 2010). In some cities, many of the large trees responsible for the bulk of important ecosystem services are legacies from the presettlement landscape and are now reaching the end of their natural lifespans (Fahey et al. 2012). We will lose much of the valuable services trees provide if we do not move to improve our ability to manage and care for the urban forest.

The Morton Arboretum

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Our aim should be a diverse, resilient, and climate change-ready urban forest. To achieve this we must understand how to grow trees successfully in these areas; determine how they function within the surrounding ecosystem; develop new tree varieties with traits for urban conditions; accurately quantify the value of trees; devise improved planting and care techniques for urbanized regions; and optimize urban forests for an uncertain future climate. The Center for Tree Science coordinates the type of collaborative, innovative research and dissemination of results required to tackle these issues and ultimately help secure the future of trees in urban areas.

Protecting global tree diversity

Worldwide, trees in the wild have tremendous ecological, economic, and cultural importance. They are the backbones of terrestrial biodiversity and provide vital ecosystem services like soil stabilization, groundwater purification, and nutrient cycling. Trees represent a rich evolutionary history and genetic reservoir, as roughly one in four flowering plant species is a tree. Globally, forests store more than 650 billion tons of carbon, more carbon than is present in the entire atmosphere (FAO 2010). Trees are also valuable sources of fuel, fiber, medicine, timber, and food for people.

Globally, 8,000 species, or 10 percent of all tree species, are threatened or endangered due to many factors such as habitat loss, overexploitation, and pressure from invasive species (Oldfield et al. 1998; Newton and Oldfield 2008). Climate change is further exacerbating the threats that tree species face (Oldfield and Newton 2012). Protecting global tree diversity requires an approach that incorporates a wide variety of complementary techniques that include both *ex situ* and *in situ* conservation (Maunder et al. 2004). These conservation strategies must be informed by tree science-based research such as species distribution mapping; reproductive biology; phylogenetics; germplasm storage; micropropagation and tissue culture; population genetics; conservation collection assessment; reintroductions; and restoration ecology (Falk 1987; Havens et al. 2006; Oldfield and Newton 2012).

Public gardens and arboreta have an increasingly important role to play in global tree conservation, yet their resources are often underutilized toward these ends (Maunder et al. 2004; Crane et al. 2009; Cibrian-Jaramillo et al. 2013). The Center for Tree Science facilitates tree conservation by supporting targeted research efforts and catalyzing global collaborations that combine diverse perspectives, expertise, and resources to safeguard tree species from extinction.

Gap in support for tree science

Considering the benefits trees provide, the threats they face, and the creative and challenging research needed to confront and overcome these threats, tree science requires increased support. Yet, in fact, support is declining. Resources for tree science research and training have been decreasing for two decades (Kramer et al. 2010; Hayes 2013—data for botany and horticulture in general), significantly diminishing the quantity of research and the number of students pursuing careers in tree science.

Government funding has fallen for federal agencies, land grant universities, and state departments of natural resources that once hosted robust research teams. In general, federal funding for research and development has declined 9.2 percent over the past five years and this trend is likely to continue (Yamaner 2013). The greatest decline in funding has been in environmental research, which is down 21.4 percent (Yamaner 2013). The vast majority of the remaining tree-related state funding is directed towards municipal tree planting, management, and inventory and is not available for research. Institutions such as the USDA are losing experts as those who retire are not replaced (BRP Final Report 2004). For example, the USDA Forest Service has lost 46 percent of its scientists since 1985 (Committee on National Capacity in Forestry Research 2002).

Large land grant universities have historically hosted stand-alone departments in horticulture and forestry, employing multiple tree experts. Over the last 20 years, these programs have lost faculty and have been collapsed into larger, more general departments, which means a reduction in research focused on tree science. These losses have resulted in a decline in new knowledge generated to support arboriculture, urban forestry, and tree conservation. For example, citations have fallen significantly over the past 20 years in ISI-indexed

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journals for core tree science topics such as "arboriculture" and "pathology." Tree science faculty now must look outside their institutions to form the meaningful collaborations necessary to tackle difficult research questions and train students in techniques vital to tree science (Hayes 2013; Hockenberry Meyer et al. 2010).

Not surprisingly, university programs now attract fewer students in arboriculture, horticulture, and other tree-specialist areas than they did 20 years ago (Kramer et al. 2010—data for botany and horticulture in general). In addition, university classes on plant identification and field work have been replaced by courses focusing on topics such as genetic methods that, while important, have resulted in a decline of students graduating with the knowledge necessary to document tree and plant diversity and understand evolutionary processes (Hayes 2013). These changes have resulted in a lack of skilled tree and plant professionals. For example, the availability of forest entomologists and forest pathologists is at an all-time low (Keathley 2003), even though threats to forests from pests and disease are at an all-time high, due to species introductions and global climate change. At the same time, the tree care industry is demanding not only more employees, but more employees with four-year degrees and supervised field experience (Elmendorf et al. 2005; Wiseman et al. 2011).

Opportunity to strengthen and energize tree science

With these grand challenges facing urban and wild trees, there is an urgent need for a leading botanical institution to invigorate tree-focused research and training. The Morton Arboretum is ideally positioned to fulfill this need by developing and supporting the Center for Tree Science. The Morton Arboretum's mission to encourage the planting and conservation of trees provides a strong foundation for the Center and ensures sustainable and enthusiastic institutional support.

The Center for Tree Science has the advantage of The Morton Arboretum's 90-year history in tree science, which provides a base of expertise and an extensive network of connections within academia, the green industry (arborists, nurseries, landscape management), the botanical garden and arboretum community, government, and environmental nongovernmental organizations. The Arboretum is known for its research on tree planting and establishment; urban soils; tree selection and improvement; tree biomechanics; forest dynamics; ecosystem management and restoration; biodiversity; endangered species recovery; historical vegetation patterns; and phylogenetics. Its living collection and herbarium hold important specimens and significant genetic resources for research and conservation.

While not all Center for Tree Science research and training is expected to occur at The Morton Arboretum, the Arboretum offers well-equipped laboratories, an herbarium, a world-renowned tree collection, field research plots, and large areas of restored and natural plant communities to support Center activities. Its facilities also include meeting spaces and staff to provide logistical support for classes, conferences, and workshops. The Arboretum provides opportunities to bring tree science research results to broad audiences, including its nearly 900,000 annual visitors. As part of the Center initiative, a research and demonstration area where research can be conducted, interpreted, and showcased to the public is being developed on Arboretum grounds.

As one of the leaders in establishing professional standards for tree-focused gardens, The Morton Arboretum coordinates ArbNet, an interactive community of arboreta that supports professional exchange and development. This network offers unique opportunities for collaboration, especially with smaller or nontraditional arboreta. The Morton Arboretum's Community Trees Program, which provides outreach on tree care and pest management to municipalities and homeowners, is leading a collaborative strategy to improve the vitality of Chicago's forest by 2040. Improvements in current practices developed through Center research can be disseminated through these channels.

The Morton Arboretum has a secure funding base and a history of innovative and effective resource development and program management, which will enable the Center for Tree Science to expand funding opportunities for tree-focused research.

Finally, the Arboretum is located in the midst of an urban forest in the Chicago metropolitan area that is home to 10 million people. The region has 157 million trees across an urban-to-rural gradient, as well as 225,000

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acres of protected natural areas, together providing a multitude of research opportunities. The Center is able to coordinate long-term studies in this model urban forest ecosystem.

Center for Tree Science strategy

The vision. The Center for Tree Science takes a focused approach to impact key areas of tree science. Research projects and training opportunities are directed towards the grand challenges facing trees and forests in urban areas and tree species in the wild. Work at the Center strives to make unique contributions within these two broad themes. It involves basic and applied research, connects experts and practitioners, and disseminates information to targeted audiences to influence best practices in science and conservation. The Center for Tree Science amplifies the efforts and achievements of all collaborators, making their endeavors more attractive to funders, as investments will produce greater impact than investing in one institution, laboratory, or researcher alone.

The structure. The Center for Tree Science has a simple consortium-based management model, so that all partners have ownership of innovative, successful research and training projects. The goal is to attract collaborators at the top of their fields; early-career scientists; students; practitioners eager to learn; and industry and institutional partners enthusiastic about advancing tree science and improving practices.

A steering committee composed of leaders in tree science guides the scientific objectives of the Center, sets specific targets for research and training endeavors, and assists in encouraging collaborators and tree experts to become involved with the Center for Tree Science.

There are several roles for involvement in the Center for Tree Science: as a member of the Steering Committee, an Affiliate, a Collaborator, or through the Fellowship Program. Center for Tree Science Affiliates have developed long-term affiliations with the Center. They can be collaborators involved with a number of collaborative research projects (CRPs); potential reviewers for CRPs under consideration for sponsorship; or professionals interested in Center research and training efforts. Collaborators are scientists involved with CRPs and may have short- or long-term involvement with the Center. The Fellowship Program offers sponsored opportunities to formally engage a range of researchers, from students and early career scientists to senior researchers, in specific CRPs. Other opportunities for involvement may simply be through participating in an internship, mini-course, conference, or workshop.

The work. The Center for Tree Science increases tree science research and training opportunities by supporting:

Collaborative Research Projects (CRPs). To generate new knowledge, the Center for Tree Science hosts and in some cases partially funds cutting-edge, cross-disciplinary projects that address aspects of the grand challenges to trees in urban areas and in the wild. Projects allow experts such as faculty at academic institutions, researchers from industry, and scientists from botanical gardens and government agencies to join forces and pool knowledge. The Arboretum provides administrative support for CRPs when needed and hosts working group meetings and conferences. The Center helps collaborators disseminate research results and best practices to appropriate audiences.

Research Fellowship Program. Early-career and senior scientists may receive support from the Center for Tree Science through the Fellowship Program. Research Fellows receive support to participate in CRPs or serve in advisory roles.

Undergraduate Research Fellowship Program. Undergraduate Research Fellows participate in a formal 10-week course at The Morton Arboretum that brings students through the steps of a scientific research project, including project development, data collection, analysis, and presentation. Each student has a designated mentor from a collaborating institution who is currently involved in a CRP. The program is designed to foster intellectual development, critical thinking, independence, self-confidence, and perseverance in students, as well as to contribute to ongoing Center for Tree Science research. A well-developed tracking, evaluation, and reporting program gathers feedback from students for continual program improvement.

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Internships. Students can get hands-on experience in tree science and arboretum collections through internships, either as Student Fellows receiving Center support or as interns with support from other sources. Internships are coordinated with Center activities, so that participants work on an aspect of a Collaborative Research Project or explore issues related to the grand challenges. Internships help fill the training gap in tree science, conservation, and collections, and provide the tree care industry with graduates who have hands-on, supervised experience.

Small grants. Modest grants allow students and early-career researchers to perform research or undergo training at collaborating institutions. Early-career grants encourage promising scientists to participate in Collaborative Research Projects. Small grants may provide leverage to attract additional funding, which can be especially important for early-career scientists and students. These grants have a large impact for a small investment.

Mini-courses. To further fill the training gap, the Center collaborates with partner institutions to develop mini-courses that communicate new knowledge and best practices. Mini-courses focus on topics being lost from traditional arboriculture and horticulture programs, as well as those related to the grand challenges and special to botanical garden and arboretum collections, such as managing collections for the conservation of tree species. Courses are held at the Arboretum or partner institutions and instructors are recruited from institutions interested in collaborating. These courses have high impact for relatively low investment. Students and young professionals in arboriculture, horticulture, arboretum management, and related fields are exposed to leading experts and cutting-edge knowledge in tree science, gaining experience and understanding that they will apply throughout their careers.

Workshops and conferences. The Center for Tree Science supports meetings that bring together experts to discuss research, disseminate new techniques to practitioners, and provide information to the public.

Research and demonstration area. An outdoor space at The Morton Arboretum is being designed specifically to support research initiatives and showcase Center for Tree Science research to a range of audiences. Research performed and exhibited in this area will catalyze discussion among industry experts and tree scientists, as well as demonstrate research objectives and results to the public.

Audiences, scope, and assessment. The Center for Tree Science works to understand its audiences and their needs, which is key to effectively communicating science outward. Research and collaborations at the Center for Tree Science may be regional, national, or international in scope. Research, training, and other activities are formally tracked and monitored using state-of-the-art practices, so that all Center activities involve a complete cycle of science, education, training, implementation, impact, assessment, and improvement.

Impact

Ultimately, the Center for Tree Science seeks healthier trees and forests in urban areas, tree species protected from the threat of extinction, and a well-trained next generation of tree scientists and professionals. For the Center for Tree Science to have maximum impact, it must influence changes in practice. This may mean implementing new techniques for the planting and care of trees or developing new models that change how collections are managed so they contribute more directly to tree conservation. As a result of Center for Tree Science work, more students will be exposed to tree science research and more professionals will be informed of and able to implement best practices in tree care and management. More botanical gardens and institutions will be engaged in promoting tree conservation and improving collections management to contribute to the conservation of threatened tree species.

Planning and implementation

The Center for Tree Science will build on early successes to garner support and collaborators. The Center currently has several CRPs underway (see p. 18), which are demonstrating best practices for future CRPs. Staff members of The Morton Arboretum are leading these initial projects and initiatives as the Center for Tree Science develops.

Development of the Center is being led by the Arboretum's Vice President of Science and Conservation, Dr. Nicole Cavender, and its Head of Research, Dr. Gary Watson. The Center's first Undergraduate Research Fellowship program was initiated in summer 2014 and included 8 students from

across the US. The students, with guidance from mentors, identified questions, conducted research, and presented their work. In addition, planning is underway to attract partners from arboreta, botanical gardens, universities, industry, and government organizations, as well as to build more specific and formalized collaborations to accomplish innovative tree science research and training. The first Center for Tree Science Steering Committee is being formalized.

The Center for Tree Science is also developing a plan for a multiyear, multicollaborator research initiative centered on oaks and their ecosystems in urban areas and threatened species in the wild, as another large-scale first-phase Collaborative Research Project.

A plan to improve space and equipment at The Morton Arboretum to support Center for Tree Science activities is being developed. A master plan for the research and demonstration area is underway, including interpretation space and expanded space for tree research on Arboretum grounds. The Morton Arboretum is also planning to hire a director and other researchers to help grow the Center for Tree Science.

The Center for Tree Science represents a major opportunity to marshal forces in tree science research and provide training opportunities to meet the grand challenges that threaten trees and the benefits they bring to people.

Literature Cited

Cibrian-Jaramillo, A., A. Hird, N. Oleas, H. Ma, A.W. Meerow, J. Francisco-Ortega, and M.P. Griffith. 2013. What is the conservation value of a plant in a botanic garden? Using indicators to improve management of *ex situ* collections. *The Botanical Review* 79: 559–577.

Committee on National Capacity in Forestry Research. 2002. National capacity in forestry research. National Academy Press, Washington, D.C. Available at: www.nap.edu/catalog/10384.html. Accessed 26 February 2014.

Crane, P.R., S.D. Hopper, P.H. Raven, and D.W. Stevenson. 2009. Plant science research in botanic gardens. *Trends in Plant Science* 14: 575–577.

Dwyer, J.F., E.G. Mcpherson, H.W. Schroeder, and R.A. Rowntree. 1992. Assessing the benefits and costs of the urban forest. *Journal of Arboriculture* 18: 227–234.

Elmendorf, W., T. Watson, and S. Lilly. 2005. Arboriculture and urban forestry education in the United States: Results of an educators survey. *Journal of Arboriculture* 31: 138–149.

Fahey, R.T., M.L. Bowles, and J.L. McBride. 2012. Origins of the Chicago urban forest: Composition and structure in relation to presettlement vegetation and modern land use. *Arboriculture & Urban Forestry* 38: 181–193.

Falk, D.A. 1997. Integrated conservation strategies for endangered plants. *Natural Areas Journal* 7: 118–123.

FAO. 2010. Global forest resources assessment, 2010—Main report. FAO Forestry Paper 163. Rome, Italy. Available at: www.fao.org/forestry/fra/fra2010/en/. Accessed 10 April 2014.

Havens, K., P. Vitt, M. Maunder, E.O. Guerrant, and K. Dixon. 2006. *Ex situ* plant conservation and beyond. *BioScience* 56: 525–531.

Hayes, V. 2013. Four case studies: Public gardens fill the void in botanical education. *Public Garden* 28: 6–9.

Hockenberry Meyer, M., S. Hokanson, S. Galatowitsch, J. Luby. 2010. Public gardens: Fulfilling the university's research mission. *HortTechnology* 20: 522–527.

Keathley, D.E. 2003. National graduate education needs and priorities in natural resources. An assessment by the National Association of Professional Forestry Schools and Colleges. October 2003. National Association of University Forest Resources Programs.

Kramer, A.T., B. Zorn-Arnold, and K. Havens. 2010. Assessing botanical capacity to address grand challenges in the United States. Available at: www.bgci.org/usa/bcap. Accessed 5 February 2014.

Maunder, M., E.O. Guerrant Jr., K. Havens, and K.W. Dixon. 2004. Realizing the full potential of *ex situ* contributions to global plant conservation. *In* E.O. Guerrant Jr., K. Havens, and M. Maunder. [eds.], *Ex situ* plant conservation: Supporting species survival in the wild 389–418. Island Press, Washington, D.C.

McPherson, E.G., D.J. Nowak, and R.A. Rowntree. 1994. Chicago's urban forest ecosystem: Results of the Chicago urban forest climate project. Gen. Tech, Rep. NE-186. USDA Forest Service, Northeastern Forest Experiment Station, Radnor, Pennsylvania.

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Newton, A.C. and S. Oldfield. 2008. Red Listing the world's tree species: A review of recent progress. *Endangered Species Research* 6: 137–147.

Nowak, D.J., and J.F. Dwyer. 2007. Understanding the benefits and costs of urban forest ecosystems. Pp. 25–26. *In* J. Kusner [ed.], Urban and Community Forestry in the Northeast. Spring Science and Business Media, New York, New York.

Nowak, D.J., D.E. Crane, J.C. Stevens, R.E. Hoehn, J.T. Walton, and J. Bond. 2008. A ground-based method of assessing urban forest structure and ecosystem services. *Arboriculture & Urban Forestry* 34: 347–358.

Nowak, D.J., R.E. Hoehn III, A.R. Bodine, D.E. Crane, J.F. Dwyer, V. Bonnewell, and G. Watson. 2013. Urban trees and forests of the Chicago region. Resource Bulletin NRS-84. USDA Forest Service, Northern Research Station, Newton Square, Pennsylvania.

Nowak, D.J. 2006. Institutionalizing urban forestry as a "biotechnology" to improve environmental quality. *Urban Forestry and Urban Greening* 5: 93–100.

Nowak, D.J., S.M. Stein , P.B. Randler, E.J. Greenfield, S.J. Comas, M.A. Carr, and R.J. Alig. 2010. Sustaining America's urban trees and forests: A forest on the edge report. Gen. Tech. Rep. NRS-62. USDA Forest Service, Northern Research Station, Newtown Square, Pennsylvania.

O'Bryan, C.M., T.J. Straka, S.R. Templeton, and J.D. Caldwell. 2007. Economic patterns in U.S. arboriculture. *Arboriculture & Urban Forestry* 33: 292–299.

Oldfield, S., C. Lusty, A. Mackiven. 1998. The world list of threatened trees. World Conservation Press, Cambridge, United Kingdom.

Oldfield, S., and A.C. Newton. 2012. Integrated conservation of tree species by botanic gardens: A reference manual. Botanic Gardens Conservation International, Richmond, United Kingdom.

Santamour Jr., F.S. 1990. Trees for urban planting: Diversity, uniformity, and common sense. *In* 7th Conference of the Metropolitan Tree Planting Alliance (METRIA), 57–65. The Morton Arboretum, Lisle, Illinois.

Tubby, K.V., and J.F. Webber. 2010. Pests and disease threatening urban trees under a changing climate. *Forestry* 83: 451–459.

U.S. Census Bureau. 2001. Statistical abstract of the United States, 2001. Table 1046. U.S. Department of Commerce, Census Bureau. Available at: www.census.gov/prod/www/statistical-abstract-us.html. Accessed 12 February 2014.

Westphal, L.M. 2003. Urban greening and social benefits: A study of empowerment outcomes. *Journal of Arboriculture* 29: 137–147.

Wiseman, E.P., J.W. Hoffman, S.D. Day, and T.L. Clements. 2011. A syllabus-based review of collegiate arboriculture course content in the United States. *Arboriculture & Urban Forestry* 37: 51–59.

Yamaner, M. 2013. Federal funding for research drops by 9% in FY 2011. National Science Foundation 13–336. Available at: www.nsf.gov/statistics/infbrief/nsf13336/. Accessed 6 February 2014.

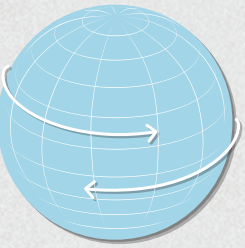
Infographic

THE CENTER *for* TREE SCIENCE

Rooted at The Morton Arboretum

A PRIMARY SOURCE FOR EXPERTISE ON TREES

To confront the complex challenges trees face in urban areas and in the wild, CTS brings together experts from diverse fields to catalyze innovative research and provide training opportunities.



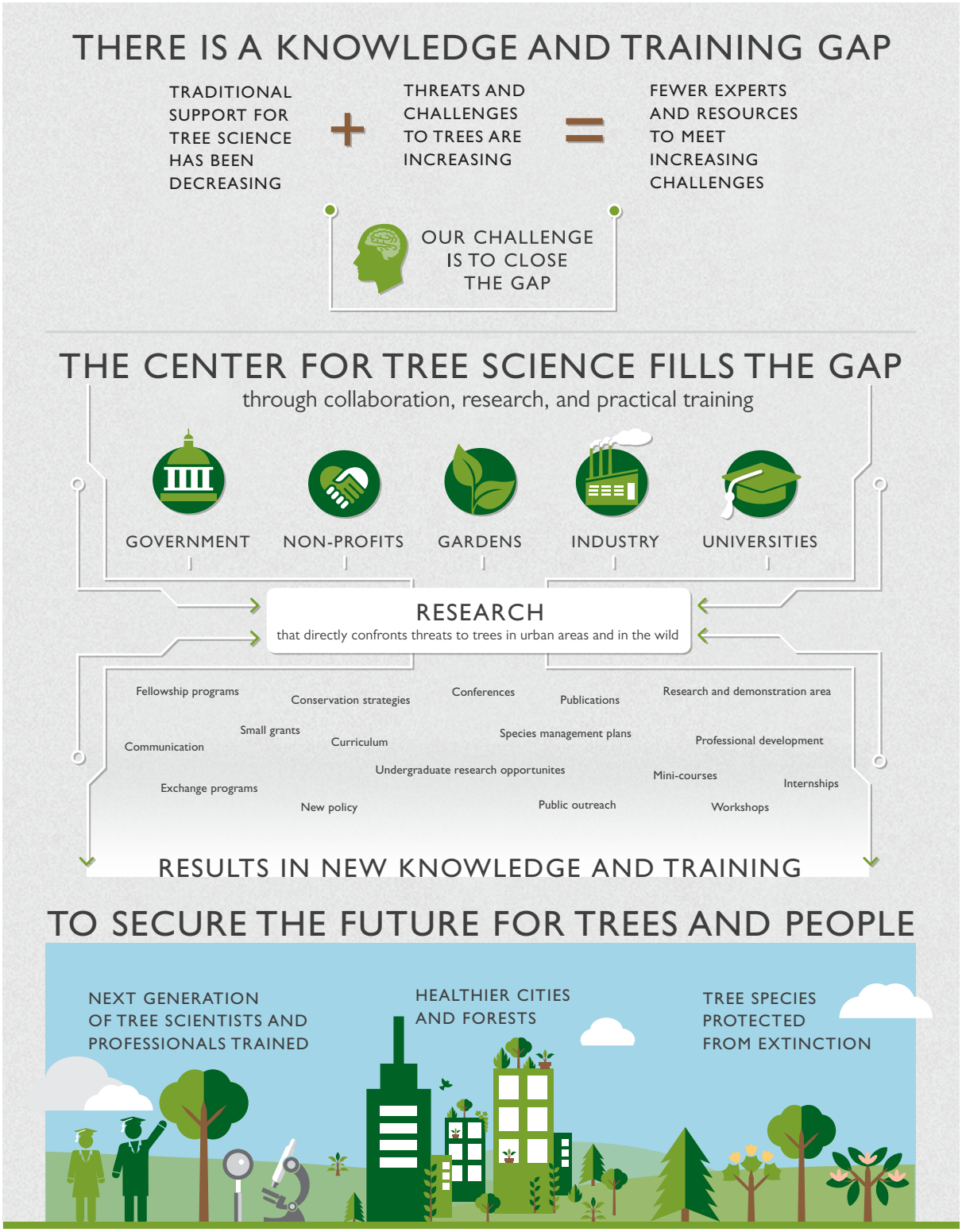
CTS energizes and expands tree science to develop new knowledge and find practical solutions to secure the future for trees and people.

PEOPLE DEPEND ON TREES BUT TREES ARE THREATENED

URBAN BENEFITS	URBAN THREATS
Clean pollutants from air	Low species diversity
Store carbon	Limited genetic diversity
Reduce energy use	Aging canopy
Reduce noise pollution	Short lifespan
Improve water quality	Difficult site conditions
Control flooding	Increased pest & disease pressure
Increase property values	Limited resources for care
Provide wildlife habitat	Air and soil pollution
Mitigate climate disruption	Habitat fragmentation
Improve community health and well-being	Climate change

WILD BENEFITS	WILD THREATS
Backbone of terrestrial biodiversity	Globally, 10% of tree species threatened
Store carbon	Species data deficiencies
Stabilize soil	Deforestation
Purify groundwater	Overharvesting
Cycle nutrients	Habitat fragmentation
Mitigate climate disruption	Invasive species
Genetic reservoir for agriculture	Increased disease pressure
Source of medicine	Loss of pollinators & seed dispersers
Support local and global economics	Climate change
Culturally and esthetically important	Soil erosion
Provide timber, food, fuel, and fiber	Exponential human population growth

Infographic



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Current projects

These are the first Collaborative Research Projects (CRPs) being undertaken in order to pilot this model for the Center for Tree Science. They illustrate the types of research that are aligned with the Center's goals. A brief description of each project is provided, along with lead investigators and their institutional affiliation.

Historic composition and distribution of the Chicago region oak ecosystem. Before European settlement, oak-dominated savanna, woodland, and forest characterized the woody vegetation ecosystem of the Chicago region. Gaining knowledge of the original characteristics and extent of this system is critical for understanding the magnitude of native vegetation loss, assessing management and restoration needs, and projecting effects of future ecological change on this system. The principal method for understanding these presettlement vegetation patterns is through analysis of data and maps compiled in the early 1800s by the US Public Land Survey. By combining GIS technology and ecological landscape analysis, the Arboretum has produced maps and technical reports describing the historical pattern and structure of woody vegetation of northeastern Illinois, and made this information available through an internet-based interactive map (plantconservation.us/plsmap.phtml). This project increases the scale and value of this work by partnering with the US Geological Survey and Paleo-Ecological Observatory (PalEON). It extends the vegetation map into the Lake Michigan watershed and adjacent morainal region of northwest Indiana, which will contribute to mapping the entire southern Lake Michigan ecoregion of Wisconsin, Illinois, and Indiana. This work provides a database of more than 10,000 bearing trees that provide historical context for documenting vegetation changes in natural and urban areas in relation to changing fire processes and climate change. It also contributes to larger-scale efforts by PalEON to quantify presettlement vegetation as a baseline for understanding how climate shaped the vegetation patterns of the Midwest prairie peninsula region, and how it may be altered by ongoing climate change. *M. Bowles, R. Fahey (The Morton Arboretum); J. McBride (Alaska Department of Fish and Game); N. Pavlovic (US Geological Survey); Paleo-Ecological Observatory (PalEON; paleonproject.org); Chicago Wilderness*

Developing management strategies to maintain oak dominance in Chicago-region woodlands. Oak woodlands have historically been the predominant forest type in northeastern Illinois, including the Chicago metropolitan region. Oaks are part of a unique ecological system that supports a wide variety of wildlife and plant species. Changes to landscape disturbance regimes in the Midwestern US have promoted the development of dense-canopied forests, which inhibit the regeneration of light-demanding oak species and promote dominance of shade-tolerant tree species and invasive shrubs. As a result, oak populations are not reproducing at a rate to keep pace with the decline of the older, mature oaks, which will likely result in widespread loss of oak-dominated woodland ecosystems in the region. Through the collaborative efforts of scientists at The Morton Arboretum, several Chicago-region universities, Chicago Wilderness, and the Lake County Forest Preserve District and its Sothern Des Plaines River Habitat Restoration Project, this project uses a large-scale replicated experimental design to examine the effects of forest restoration treatments on oak recruitment and growth. Results from this experiment will lead to the development of management strategies and tools that can be applied at a regional scale to enhance oak woodlands in the Chicago region. This project will act as a demonstration site to illustrate these practices to the regional management community, as well as provide opportunities to train undergraduates and graduate students. *R. Fahey (The Morton Arboretum); D. Goldblum, N. Barber (Northern Illinois University); D. Larkin (Chicago Botanic Garden/Northwestern University); D. Wise (University of Illinois at Chicago); L. Heneghan (DePaul University/Chicago Wilderness Science Team); S. Menke (Lake Forest College)*

Will interspecific gene flow help oaks adapt to climate change? Oaks play a critical role in global carbon sequestration, community dynamics, and the life cycles of fungi, insects, birds, and mammals. Yet we know little about how oaks will respond to climate change. This study will utilize next-generation DNA sequencing and genome mapping methods to investigate how oak genomes have responded to past climate changes as a way of forecasting the future. It integrates (1) a phylogenomic dataset of >100 New World oak species with (2) an oak genetic linkage map and (3) climatic niche data to investigate whether gene flow has facilitated adaptation to climate change. *A. Hipp (The Morton Arboretum); A. Kremer (French National Institute for Agricultural Research—INRA Bordeaux-Aquitaine); J. Cavender-Bares (University of Minnesota); A. González-Rodríguez (National Autonomous University of Mexico); P. Manos (Duke University); J. Romero-Severson (Notre Dame University)*

Getting the right tree in the right place: developing an urban site index. Many urban tree problems are derived in the soil. Unfortunately, urban landscape managers do not have the knowledge or resources to adequately identify urban soil problems inhibiting tree growth and health.

Current projects

Soil quality indices have long been used in agriculture and forestry to get an idea of the soil conditions without extensive laboratory testing. Given the strong linkage between urban soil quality and plant health, an urban site index would also have substantial application in arboriculture, horticulture, urban agriculture, and other fields. The Morton Arboretum Soil Science lab is developing a system to evaluate site and soil conditions and predict tree condition and growth in 400 plots across 10 cities. This Urban Site Index will merge two independently derived urban site assessments, one from The Morton Arboretum and one from urban foresters with the Ohio Department of Natural Resources, into a standardized, accurate, practical, and field-based framework for assessing urban site quality for trees. Data on soil, tree attributes, and growth rates will be collected and indicators will be interpreted to score values which will be integrated to an index value. A website will be created to host all products from this research including the urban site index protocols and publications derived from the research. This urban site index will save communities money by helping them plant the right tree in the right place for a healthier, more sustainable urban forest. This work is also part of the Chicago Urban Forest Study (p. 33). *B. Scharenbroch, R. Fahey (The Morton Arboretum); A. Siewert, S. Miller (Ohio DNR); N. Bassuk (Cornell University); S. Raciti, L. Hutyra (Boston University); R. Harper (University Massachusetts-Amherst); R. Pouyat, I. Yesilonis (USDA Forest Service Northern Region); S. Day (Virginia Tech); K. Fite (Bartlett Tree); L. Purcel (Purdue University); L. Werner, R. Hauer (Univeristy of Wisconsin–Stevens Point); G. Johnson (University of Minnesota).*

The biomechanics of tree risk assessment. Trees can pose real threats when trunks, root systems, or branches fail. Researchers studying tree biomechanics are constantly striving to understand why and how trees fail, and if it is possible to predict when a tree will fail. Zones of mechanical weakness (e.g., decay, splits, hollows, and poor anchorage) may be identified through analysis of surface strain distributions and soil surface movements. Locally high strains along the stem and roots are indicative of areas of mechanical weakness, but available technology limits advancements in this research. No effective system is available to track ground movement. A new technology, stereo photogrammetry, may be able to overcome these limitations. Through an international partnership, scientists are using digital imaging technology developed to measure stress in the skin of the space shuttle to study tree deformation and strain under static and dynamic loading. By understanding more about what goes on in a tree as it is stressed, this research has the potential to improve tree risk assessment methods. *G. Watson, J. Miesbauer (The Morton Arboretum); A. Stokes (French National Institute for Agricultural Research—INRA), T. Fourcaud (Agricultural Research for Development—CIRAD, France), M. Hoenigman (TREE Fund); M. Melis, J. Littell (NASA); E. Gilman (University of Florida); A. Detter (Brudi & Partner TreeConsult, Germany); P. van Wassenaer (Urban Forest Innovations, Canada); T. Mucciardi (Tree Radar, Inc.); P. Markworth (Wachtel Tree Service)*

Phylogeny as a framework for conservation of East Asian oaks. The ring-cupped oaks of *Quercus* subgenus *Cyclobalanopsis* comprise a key component of the woody plant diversity in East and Southeast Asia, with somewhere between 90 and 150 species, some critically endangered. However, their taxonomy and genetic relationships are not well known. Efforts to identify even major evolutionary lineages in the group have been problematic. A phylogenetic framework is crucial baseline data for understanding how many species there are in Cyclobalanopsis and for prioritizing conservation efforts in the group. This study utilizes a next-generation DNA sequencing approach to identify evolutionary lineages within this subgenus. *A. Hipp (The Morton Arboretum); M. Deng (Shanghai Chenshan Plant Sciences Research Center, Chinese Academy of Sciences, Chenshan Botanical Garden)*

Improving the conservation value of *ex situ* tree collections. In collaboration with Botanic Gardens Conservation International, the Global Trees Campaign, and collaborators at other leading botanical institutions, The Morton Arboretum will initiate a new research program to understand and improve the science and practice of maintaining *ex situ* tree collections of high conservation value. Using threatened oaks as a model group, experiments will be conducted that examine issues such as hybridization, pollen flow, propagation techniques, and the feasibility of assisted migration, all of which will improve our understanding of how to protect and care for threatened trees outside their natural environments. *M. Westwood, N. Cavender, A. Hipp, J. Rothleutner (The Morton Arboretum); S. Oldfield (Botanic Gardens Conservation International); P. Griffith (Montgomery Botanical Center); A. Kramer (Chicago Botanic Garden); A. Hird (Botanic Gardens Conservation International-USA).*