The Sustainable Urban Forest

A Step-by-Step Approach

Michael Leff
Davey Institute / USDA Forest Service
USFS Philadelphia Field Station

Funding and support provided by
The USDA Forest Service

DAVEY Institute
A Division of The Davey Tree Expert Company

The Sustainable Urban Forest

A Step-by-Step Approach

Michael Leff

Davey Institute / USDA Forest Service
USFS Philadelphia Field Station

September 27, 2016

Acknowledgements

I would like to acknowledge the many dozens of people who helped bring ***The Sustainable Urban Forest*** to fruition over the past several years. Contributions included general feedback, overall guidance, detailed review, tireless brainstorming, literature research, assorted resources, and a reader's eye – as well as moral support and encouragement. Many others served as guinea pigs as we field-tested the guide in various settings. Thank you all for your time and efforts.

A special thanks to the "Targets & Metrics Team" – Jim Clark, Joe Gregory, Andy Kenney, and Ed Macie. The team labored intensively, collaboratively, and good-humoredly over a period of more than six months to develop an enhanced and updated version of the urban forest sustainability criteria and indicators, as presented in **Part VI – Conducting the Evaluation.** (The original version of these measures was developed by Jim Clark et al in 1997, and revised by Andy Kenney et al in 2011.) Thanks also to the Morton Arboretum for hosting our team retreat, where we worked through our final revisions in April 2015.

– *Michael Leff* *August 28, 2016*
Davey Institute and
USFS Northern Research Station, Philadelphia Urban Field Station

Contributors:

Douglas Airhart, Tennessee Technological University
Brain Borkowicz, The Davey Tree Expert Company
Cara Boucher, National Association of State Foresters
Lindsay Campbell, USFS Northern Research Station, NYC Urban Field Station
Jim Clark, HortScience, Inc.
Chad Clink, The Holden Arboretum
Dana Coelho, USFS Urban and Community Forestry, Rocky Mountain Region
Jan Davis, USFS Urban and Community Forestry, Washington office
Meaghan Eastwood, Toronto and Region Conservation Authority
Alice Ewen, USFS Urban and Community Forestry, Washington office
Nancy Falxa Sonti, USFS Northern Research Station, NYC Urban Field Station
Burney Fischer, Indiana University
Kevin Frediani, Bicton College (UK)
Jason Fristensky, USFS Northern Research Station, Philadelphia Field Station
Mike Galvin, SavATree
Katie Gibbons, Seattle ReLeaf
Joe Gregory, Davey Resource Group
Jenny Gulick, Davey Resource Group
Alan Halter, City of Austin
Jason Henning, Davey Institute and USFS Northern Research Station, Philadelphia Urban Field Station
Jennifer Hinrichs, Sustainable Urban Forests Coalition

Dana Karcher, Arbor Day Foundation
Andy Kenney, University of Toronto
Michelle Kondo, USFS Northern Research Station, Philadelphia Urban Field Station
Larry Kotchman, National Association of State Foresters
Beth Larry, USFS Research and Development
Monica Lear, USFS Research and Development
Dexter Locke, Clark University
Pamela Louks, IN2Trees, Indiana
Sarah Low, USFS Northern Research Station, Philadelphia Urban Field Station
Ed Macie, USFS Southern Region
Scott Maco, Davey Institute
Charlie Marcus, Urban Forester, Tallahassee
Lauren Marshall, USFS Urban and Community Forestry, Washington office
Kyle Meister, SCS Global Services
John Melvin, CAL FIRE
Peggy Middaugh, Worcester Tree Initiative
Dave Nowak, USFS Northern Research Station, SUNY Syracuse
Thomas Omolo, USFS Northern Research Station, Philadelphia Urban Field Station
Jarlath O'Neil Dunne, University of Vermont
Chris Peiffer, Plan-it Geo
Michael Rains, USFS Northern Research Station
Phillip Rodbell, USFS Northeastern Area
Kenton Rogers, Treeconomics (UK)
Lara Roman, USFS Northern Research Station, Philadelphia Urban Field Station
Keith Sacre, Barcham Trees (UK)
Lydia Scott, Morton Arboretum
Becky Schwartz, Casey Trees
Lacey Shaver, STAR Communities
Nancy Stremple, National Urban and Community Forestry Advisory Council (NUCFAC)
Bill Toomey, The Nature Conservancy
Larry Wiseman, Sustainable Urban Forests Coalition
Kathleen Wolf, University of Washington and USFS Pacific Northwest Research Station

This project was made possible by funding from the USDA Forest Service Northern Research Station and a cooperative partnership with The Davey Tree Expert Company.

Cover photo credit: https://goo.gl/ci3Jqt

To comment on this report, email michael.leff@davey.com or call 330-673-9511.

Table of Contents

Part I – Exploring the Urban Forest 1
Overview 1
Vibrant Cities and Urban Forests 1
Sidebar: Recommendations from Vibrant Cities and Urban Forests: A National Call to Action 2
How to Use This Guide 2
Part II – Setting the Stage 4
What Is a "Sustainable Urban Forest"? 4
Sidebar: Sample Sustainability Initiatives 4
Sidebar: What Is a Sustainable Community? 5
Understanding Tree Benefits – or "Ecosystem Services" 6
Sidebar: What Are Ecosystem Services? 7
Sidebar: Estimating Ecosystem Services with i-Tree Design 8
Green Infrastructure in the Urban Forest 8
Sidebar: What Is Green Infrastructure? 8
Sidebar: Trees as Green Stormwater Infrastructure (GSI) BMPs 10
Refining Your Focus 10
Part III – Covering the Canopy 12
Why Consider Canopy Cover? 12
Sidebar: What Is 'Tree Canopy'? 12
What Is an 'Optimal Canopy Cover Level'? 12
Sidebar: Tree Canopy Cover Levels and Goals for Selected Cities 13
Sidebar: Search for Urban Forest Data 15
Setting Your Canopy Cover Goals 15
Pursuing Your Canopy Cover Goals 16
Part IV – Gathering the Information 19
Taking Stock 19
Sidebar: Key Ingredients 20
Forest Resource Assessments 21
Bottom-Up: Field-Based Assessments 21
Complete inventories 22
Sample-based inventories 22
Sidebar: Tree Inventories and Routine Management Software 22
Top-Down: Tree Canopy Assessments 23
National Land Cover Database (NLCD) satellite imagery 23
Aerial photo interpretation 23
High-resolution aerial or satellite imagery 25
Plans, Practices, Programs, Policies – and More 26
Part V – Constructing the Community Framework 28
Sidebar: We cannot separate sustainable urban forests from the people 28

Why Collaborate? 28
Sidebar: Independent action is inadequate 28
Sidebar: Possible Stakeholders – and Collaborators – to Consider 30
Internal Municipal Stakeholders and Relationships 32
Sidebar: Planning for Trees 33
Cross-Sector Stakeholders 34
Sidebar: Regulations for Trees at Development Sites 35
Sidebar: General Principle 3: Seek out Private and Civic Partners 37
Sidebar: Citizen Foresters in Clovis 38
Environmental Justice in the Urban Forest 38
Sidebar: Ensuring Equitable Distribution of Resources 39
Tools and Strategies for Engaging the Community 40
STEW-MAP 40
i-Tree Landscape 40
Sidebar: Communicating Your Message: "Trees Are the Key" Online Toolkit 41
Regional Collaboration: Developing a Strategy across Borders 42
Chicago Region Trees Initiative for the Seven-County Metropolitan Area 42
Sacramento Greenprint 44
Sidebar: Greenprint Goals for Growth 45
Wisconsin Statewide Urban Forest Strategy 45
Sidebar: Working Well in Wisconsin 46
Part VI – Conducting the Evaluation: Measuring Success 47
Aim for These Targets 47
Trees and Forest 50
Target T1: Relative Tree Canopy Cover 50
Target T2: Age Diversity (size class distribution) 51
Target T3: Species Diversity 53
Target T4: Species Suitability 54
Target T5: Publicly Owned Trees (trees managed "intensively") 55
Target T6: Publicly Owned Natural Areas (trees managed "extensively") 56
Target T7: Trees on private property 57
Community Framework 58
Target C1: Municipal agency cooperation 58
Target C2: Utilities Cooperation 59
Target C3: Green Industry Cooperation 60
Target C4: Involvement of Large Private and Institutional Landholders 61
Target C5: Citizen Involvement and Neighborhood Action 62
Target C6: General Appreciation of Trees as a Community Resource 63
Target C7: Regional Collaboration 64
Resource Management Approach 65
Target R1: Tree Inventory 65
Target R2: Canopy Cover Assessment and Goals 66
Target R3: Environmental Justice and Equity 67
Target R4: Municipality-Wide Urban Forest Management Plan 68
Target R5: Municipality-wide Urban Forestry Funding 69

Target R6: Municipal Urban Forestry Program Capacity 70
Target R7: Tree Establishment Planning and Implementation 72
Target R8: Growing Site Suitability 73
Target R9: Tree Protection Policy Development and Enforcement 74
Target R10: Maintenance of Publicly Owned, "Intensively" Managed Trees 75
Target R11: Management of Publicly Owned Natural Areas 76
Target R12: Tree Risk Management 77
Target R13: Urban Wood and Green Waste Utilization 78
Target R14: Native Vegetation 79

Part VII – Developing and Implementing the Plan 80

Setting Priorities and Creating an Action Plan 80

Assessing Risk and Planning for Change 80
Climate Change 80
Sea Level Rise 81
Wildfire 82
Pests, Disease and Invasive Plants 83
Natural Lifecycle Changes 83
Sidebar: End of the Lifecycle: Green Waste Utilization 85
Budget Cycles and Other Economic Considerations 85
Sidebar: The Financially Stable Sustainable Urban Forest 87
Changing Demographics 87
Sidebar: Taking No Chances with Risks 89

Monitoring for Urban Forest Change and Program Performance 89
Why Monitor 90
Ways to Monitor 91
Linking Monitoring to Community Outreach 92
Planning Ahead for Data Management and Analysis 92

Appendix A – Resources 94

Plans, Practices, Programs, Policies – and More 94

Part I – Exploring the Urban Forest

Overview

Increasingly, cities and communities of all sizes recognize the importance of their tree cover and the need for plans to manage that natural resource. Far fewer actually have such plans in place, and where they do exist, many of those plans fall short in one way or another. This guide is designed primarily to help municipalities assess the state of their urban forest, identify management concerns, and chart a path forward, step by step, toward long-term sustainability. It presents a scalable approach that can be adapted by any "community" that seeks to pursue a similar path in its realm of responsibility. This could include a county, city, park district, conservation district, university or corporate campus, homeowner association, or any other such entities.

Vibrant Cities and Urban Forests

In April 2011, the U.S. Forest Service convened an intensive three-day meeting "to explore the implications of integrated natural and built urban environments and their possibilities for the future." With peer input, the Forest Service assembled a national task force to guide the process, including 25 visionary and respected municipal and state officials, national and local nonprofit leaders, researchers, urban planners, and foundation and industry representatives.

Figure 1. Vibrant Cities & Urban Forests report (2011).

According to the definition set forth in the resulting report, *Vibrant Cities & Urban Forests – A National Call to Action:*

> ***Urban forests*** *are systems of trees, other vegetation, and water within any urban area. They can be understood as dynamic green infrastructure that provides cities and municipalities with environmental, economic, and social benefits. Urban forests are forests for people.*

As that definition makes clear, there's more to the urban forest than just trees. Unlike a lone specimen in a highly manicured landscape, the urban forest is a *system* of vegetation – including trees, shrubs, and herbaceous plants – as well as water and overall hydrology – and in fact, the surrounding air and certainly the underlying soil – on both public and private property. For that matter, wildlife, people, and the built environment are part of that forest system, too.

An urbanized area may not be a natural ecosystem, but it is nevertheless an **ecosystem** – defined as "a system involving the interactions between a community of living organisms in a particular area and its

nonliving environment."[1] In many places, the urban forest is perhaps the most important component of what characterizes the "urban ecosystem" and assures its viability.

The *Vibrant Cities* report outlines a dozen recommendations, along with suggested action steps for each one. The need for municipal "how to" guidance on achieving a sustainable urban forest evolved from Recommendation #12. (See sidebar below for a list of all recommendations and more information on the initiative.)

To make progress toward that goal, the U.S. Forest Service Northern Research Station and The Davey Tree Expert Company have sponsored this step-by-step guide for municipal managers and others who are involved in the planning and management of the urban forest. In addition to trees on public land, this guide also covers trees on private property, which represents the majority of land area in most communities and, as such, is a critical component of the urban forest.

Recommendations from Vibrant Cities and Urban Forests: A National Call to Action

1. Create a national education and awareness campaign.
2. Foster urban forestry and natural resources stewardship and volunteerism.
3. Create sustainable jobs in urban forestry and green infrastructure.
4. Cultivate partnerships between public and private sectors.
5. Develop new public administration models for urban ecosystems.
6. Create comprehensive, multi-jurisdictional Urban Regional Natural Resource Plans.
7. Integrate federal agencies' green infrastructure goals.
8. Establish energy efficiency programs that emphasize the use of trees.
9. Ensure equal access to urban forestry and green infrastructure resources.
10. Support collaborative urban ecosystem-focused research.
11. Encourage open access to and use of social assessment tools.
12. Establish national Vibrant Cities Standards.

For more information on the *Vibrant Cities & Urban Forests* initiative and to access the final report, go to http://treesarethekey.org. That online resource center provides a communications toolkit developed by the Sustainable Urban Forests Coalition (SUFC) as the culmination of the original process, now under the broader banner of "Vibrant Communities."

How to Use This Guide

Each municipality has its own array of assets, liabilities, goals, and concerns, as well as a great deal of regional variation concerning its urban forest. The approach outlined here is intended to be straightforward, methodical, and comprehensive, yet flexible enough that any community can use it. In addition to this introductory section, the basic structure of the guide is as follows:

Part II, Setting the Stage, provides background on several key concepts: a definition of the "sustainable urban forest," and how that fits in the context of a sustainable community; the value of tree benefits, or

"ecosystem services"; an introduction to "green infrastructure"; and guidance on how to define the overall scope of a management plan.

Part III, Covering the Canopy, addresses the issue of "optimal tree canopy cover" – showing how that varies from place to place, explaining the importance of *quality* of canopy cover in addition to overall quantity, and discussing how to set and achieve a canopy cover goal that suits a community's needs and location.

Part IV, Gathering the Information, presents the items you'll need to consider and assemble to develop a plan suited to the particulars of your situation. This part includes the essential baseline assessments of the forest resource itself, as well as a wide range of tools – plans, practices, programs, policies, and more – to guide your efforts and help you reach your goals.

Part V, Constructing the Community Framework, identifies key partners you'll need to engage for a successful outcome, including representatives from all sectors – government agencies, nonprofit organizations, private industry, utilities, large landholders, and diverse community groups and local neighborhood activists.

Part VI, Conducting the Evaluation & Measuring Success, uses the elements assembled above to evaluate your current standing – assets and liabilities – and track progress on numerous targets within three broad categories: **(1) Trees and Forest,** including such factors as canopy cover, age distribution, and species mix, **(2) Community Framework,** such as collaboration across public agencies and citizen involvement, and **(3) Resource Management Approach,** such as goals, plans, overall capacity, and assorted policies.

Part VII, Developing & Implementing the Plan, will provide an overview of the many considerations involved in setting and prioritizing specific goals based on the self-evaluation you performed in **Part VI.** Various topics are covered concerning planning for the future – including climate change, pests and disease, natural lifecycle changes, financing, and others. Finally, guidelines are presented for monitoring urban forest change and program performance.

Appendix A, Resources, includes links to a wide range of helpful resources that match the list of **"Plans, Practices, Programs, Policies – and More"** outlined in **Part IV.**

Part II – Setting the Stage

What Is a "Sustainable Urban Forest"?

Due to various economic, social, and environmental stressors, the push for sustainability has gained considerable momentum in recent years, reflected in a proliferation of sustainability plans and programs ranging from the local to global level. (See examples in box below.) This **Sustainable Urban Forest Guide** can either be used to complement broader sustainability programs by expanding on the urban forest components, or it can function as a standalone guide for any audience that is primarily concerned with the forest resource.

Sample Sustainability Initiatives

- **STAR** (Sustainability Tools for Assessing and Rating Communities) program for overall municipal performance (www.starcommunities.org)
- **Sustainable Sites Initiative** guidelines focused on landscape design, construction, and maintenance (www.sustainablesites.org)
- **LEED** (Leadership in Energy & Environmental Design) green building certification program, U.S. Green Building Council (www.usgbc.org/leed)
- **"Envision"** rating system for civil infrastructure, Institute for Sustainable Infrastructure (www.sustainableinfrastructure.org)
- **ICLEI –** Local Governments for Sustainability (www.iclei.org)
- **Green City Index** global comparisons on environmental performance, Economist Intelligence Unit, Siemens (http://www.siemens.com/entry/cc/en/greencityindex.htm)

In **Part I, Exploring the Urban Forest,** we defined and described the urban forest itself, but what makes the urban forest "sustainable"? Essentially, for our purposes:

The Sustainable Urban Forest *includes everything needed to assure that the entire forest system achieves and maintains a healthy overall extent and structure sufficient to provide the desired benefits, or ecosystem services, over time.*

While this definition is narrowly focused on the urban forest resource, it's important never to lose sight of the broader view that places the urban forest in the context of *overall* sustainability and a sustainable community. This can include such intersecting areas as waste reduction and recycling, stormwater management, energy use, air and water quality, wildlife habitat, public health, economic viability, social equity, overall livability, and so on. Clearly, the sustainable urban forest fits well within that conceptual framework.

What Is a Sustainable Community?

The path to sustainability is different for every community – but the common elements are **a healthy environment, a strong economy, and the well-being of the people living in the community**. When sustainability areas are addressed in tandem with each other, they have a powerful, positive effect on the quality of life and future of a community. By overlapping work in these areas, efficiencies emerge and better results are achieved.

– STAR (Sustainability Tools for Assessing and Rating Communities), www.starcommunities.org

At the local municipal level, of course, the underpinning financial resources themselves are often in great need of a sustainable supply. Historically, when budgets are strained or shrinking, many municipalities have viewed adequate care of the urban forest, beyond essential tree risk management, as a luxury they can't afford. But that picture is changing with increased awareness of the wide-ranging benefits of trees, especially when a dollar value is placed on those benefits. Recognizing and valuing the tangible services provided by the urban forest, it's clear that there's much to be gained by a healthy forest – and real, measurable, and inevitable costs if the investment is not made to maintain it.

Fortunately, whereas other forms of municipal "grey" infrastructure – such as treatment plants or stormwater systems – often address a single functional purpose, green infrastructure, including the urban forest, can play a role in advancing numerous sustainability goals simultaneously.

Consider **Philadelphia's "Greenworks" sustainability framework** (http://www.phila.gov/green/greenworks/pdf/Greenworks_OnlinePDF_FINAL.pdf), which includes 15 specific targets in five broad areas: Energy, Environment, Equity, Economy, and Engagement. One of those targets in particular – #11 – states "increase tree coverage toward 30 percent canopy in all neighborhoods" (up from the current citywide canopy cover of about 20 percent). Meeting that *single* Greenworks target would help advance half of *all* the other targets in *all five* categories.

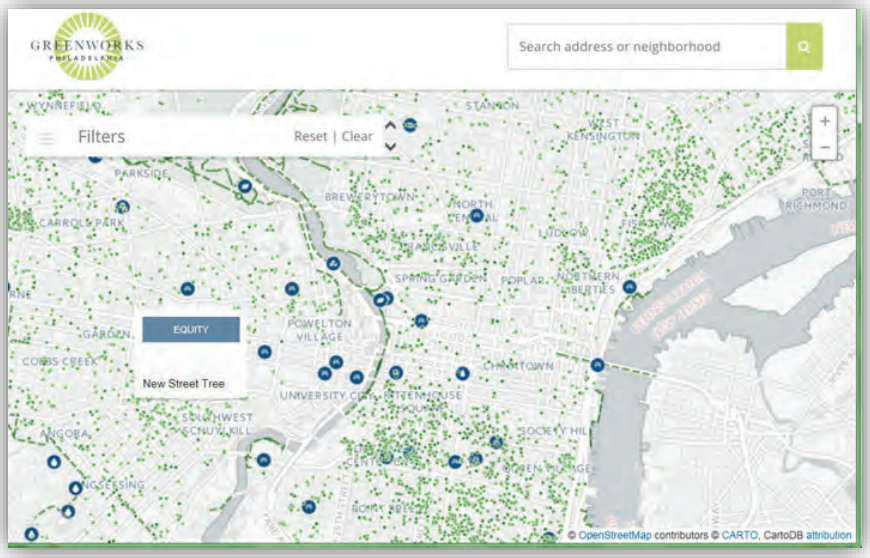

Figure 2. Philadelphia Greenworks interactive map.

For example, by **planting more trees on school grounds** – just one of more than a dozen actions planned to meet Target #11 – the City will also **help reduce citywide building energy use** (Target #2), **reduce greenhouse gas emissions** (#5), **improve air quality** (#6), **enhance green infrastructure** (#8), **provide outdoor amenities** (#9), **and create green jobs** (#14). Not surprisingly, the only other individual actions in the plan that stand to

benefit as many other targets as increased tree canopy cover does are those involving parks and other green space.[2]

Understanding Tree Benefits – or "Ecosystem Services"

Many urban dwellers can name the downside of trees, ranging from lifted sidewalks to storm damage. There is often less awareness and appreciation of the many benefits of trees, other than their natural beauty. Those benefits are varied and substantial, and impact all three areas of the so-called **"triple bottom-line"** – economic, environmental, and social. For example, consider this comprehensive, though by no means exhaustive, array of benefits:

Economic benefits

- Save energy and cut costs for summer cooling (shade) and winter heating (windbreak).
- Increase property values, benefiting homeowners and increasing local tax revenues.
- Boost commercial district activity.
- Support green industry jobs.
- Reduce costs to taxpayers for traditional "grey" infrastructure.
- Supply wood products – ranging from recycled material such as mulch, to hardwood furniture, and fuel for energy production.

Environmental benefits

- Improve air quality by absorbing and filtering pollutants.
- Reduce greenhouse gases by direct carbon sequestration and through avoided carbon emissions from reduced energy use.
- Save energy by directly shading buildings and through the cooling effects of transpiration.
- Mitigate overall air temperature extremes and reduce urban "heat island" effect.
- Help manage stormwater, reduce flooding, and improve water quality.
- Support wildlife populations and overall biodiversity.
- Reduce ultraviolet radiation levels.

Social benefits

- Promote public health and well-being.
- Encourage physical activity by creating attractive, shaded outdoor spaces.
- Discourage crime and create safe places to gather.
- Strengthen community engagement and revitalize neighborhoods.
- Promote social equity and environmental justice for neglected communities.
- Supply healthy edibles – fruit and nuts.
- Provide solace, spiritual sustenance, and a sense of place.

Those myriad tree benefits – environmental, economic, and social – can all be collectively considered "ecosystem services," an important concept that has gained prominence for its ability to reveal the hidden value of trees and other forms of "natural capital." (See sidebar below.)

What Are Ecosystem Services?

Ecosystem services are often defined as direct and indirect contributions of natural systems to human well-being.

Four categories of ecosystem services:

1. **Provisioning services** describe the material or energy outputs from ecosystems. These include food, water, various raw materials, and medicinal resources.
2. **Regulating services** create and maintain healthy environmental conditions by influencing such things as climate, weather extremes, pests, disease, air and water quality, soil fertility, and many others.
3. **Supporting services** provide habitat for plants and animals, and maintain genetic biodiversity, which is essential to the health and adaptability of species.
4. **Cultural services** connect people with ecosystems. Cultural services include spiritual, recreational, educational, emotional, and physical benefits, as well as economic benefits through cultural and eco-tourism.

– United Nations Environment Programme (UNEP), The Economics of Ecosystems and Biodiversity (TEEB), http://www.teebweb.org/resources/ecosystem-services/

Of course, many of those ecosystem services are not strictly for people – though benefits to other living creatures also benefit people, as we all depend on a complex and interconnected living Earth. Moreover, the natural capital that supplies those ecosystem goods and services must not be treated merely as resources that can be depleted faster than they're created – a mandate that essentially defines sustainability.

Identifying and appreciating the ecosystem services provided by the urban forest is a start. But putting a dollar value on those services can help turn appreciation into action. For that reason, various analysis and assessment tools have gained traction in recent years – in particular the **i-Tree tools** (www.itreetools.org) developed by the U.S. Forest Service and its partners,[*] to be discussed in more detail in **Part IV, Gathering the Information.** Because budget constraints are often a major obstacle to sustainable urban forest management, anything that can help secure adequate and stable funding is a huge boon. The **i-Tree** tools can provide the data needed to quantify both the state of the urban forest in terms of structure (tree count, canopy, condition, etc.) and – potentially even more important from a budgeting perspective – the economic value of the ecosystem services provided by the urban forest, now and in the future, depending on management actions taken.

By putting a dollar value on such ecosystem services as energy savings, carbon reduction, air quality improvement, stormwater management, and various health benefits, **i-Tree** assessments can help persuade decision-makers that maintaining and growing the urban forest is not an optional amenity for prosperous times, but an integral element of the city's basic infrastructure to sustain human health and well-being. Based on an **i-Tree** assessment, for example, the 2012 Pittsburgh Urban Forest Master Plan

[*] USFS i-Tree partners are: Davey Tree Expert Company, Arbor Day Foundation, Society of Municipal Arborists, International Society of Arboriculture (ISA), Casey Trees, State University of New York College of Environmental Science and Forestry (ESF), and Northeastern Area Association of State Foresters (NAASF).

put the annual economic benefit from the city's trees at more than $7.2-million. By comparing that to overall tree-related expenditures, the calculation was used to demonstrate that every dollar invested in street tree care actually yields a net financial gain of nearly twice that amount.[3] Using a similar analysis, New York City put that return at $5.60 in benefits for every dollar spent on tree planting and care.[4] In addition, many urban trees are not planted, but regenerate naturally in many locations, substantially reducing planting costs.

Estimating Ecosystem Services with i-Tree Design

i-Tree Design is a free web-based tool that allows anyone to make a simple estimation of the benefits of individual or multiple trees. By inputting location, species, tree size, and condition, users gain an understanding of tree benefits related to greenhouse gas mitigation (carbon emission reduction), air quality improvements, and stormwater interception. With the additional step of drawing a building footprint – and virtually "planting" trees around it – the impact on building energy use can also be evaluated. Among other things, **i-Tree Design** enables users to assess and plan the optimal placement of trees to maximize energy savings. Tree benefits are estimated for the current year, for a user-specified future year, and cumulatively over that timeframe. This tool is intended to serve as a simple and accessible starting point for understanding the value of individual or groups of trees to the community or a local landowner. For more information: www.itreetools.org/design.

Monetary valuation of ecosystem services shows that trees and other components of green infrastructure can reduce expenditures on the conventional grey infrastructure that would otherwise be necessary to meet clean air and water standards. Those mandated standards can be achieved with trees more efficiently and cost effectively than through some traditional methods. While trees alone are not sufficient, they are a key piece of the solution and can yield significant returns on investment.

Green Infrastructure in the Urban Forest

"Green infrastructure" utilizes vegetation to provide some of the functions of conventional grey infrastructure, such as water treatment plants and stormwater management systems, but with additional **environmental, economic, and social benefits.** Broadly defined, every tree and the entire urban forest can be considered green infrastructure, because they offer benefits across that **"triple bottom line."**

What Is Green Infrastructure?

"A strategically planned and managed network of natural lands, working landscapes, and other open spaces that conserves ecosystem values and functions and provides associated benefits to human populations."

– Benedict & McMahon (2006) as adopted by The Conservation Fund
http://www.conservationfund.org/what-we-do/strategic-conservation-planning/resources/green-infrastructure-resources

Green infrastructure can be designed to address a wide range of concerns, including water quantity and quality, air pollution, energy conservation, greenhouse gas emissions, and public health. In many parts of the country, green infrastructure is most often designed to address urban stormwater issues – hence the more specific term "green stormwater infrastructure," or GSI. (See sidebar that follows for more on GSI.)

Air quality. Strategic tree planting and tree canopy conservation have been endorsed by the U.S. EPA as voluntary measures to help communities meet federal air quality standards by mitigating ground level ozone formation, particularly through reduction of the urban heat island effect. Many states have incorporated those measures into their State Implementation Plans, which are required by the Clean Air Act.[5] (For more detail on using urban trees to obtain credit in State Implementation Plans, see this Information Summary from the USDA Forest Service: http://www.nrs.fs.fed.us/units/urban/local-resources/downloads/Emerging_Measures_Summary.pdf)

Energy savings. Trees can impact energy usage in a variety of ways, including providing shade, cooling the air through evapotranspiration, acting as a winter windblock, and allowing passive solar gain. To maximize those benefits, however, it's important to plan accordingly. On an individual property level, the Arbor Day Foundation's "Energy-Saving Trees" online mapping tool (http://energysavingtrees.arborday.org) shows where to strategically plant trees for the greatest energy- and money-saving benefits, based on simple information about a structure and its surroundings.

Carbon storage and sequestration. Recent years have seen increasing interest in carbon sequestration as a way to mitigate climate change. Carbon sequestration is the process by which atmospheric carbon dioxide is taken up by trees, grasses, and other plants through photosynthesis and stored as carbon in biomass (trunks, branches, foliage, and roots) and soils. The "sink" of carbon sequestered in forests and wood products helps to offset sources of carbon dioxide to the atmosphere, such as deforestation, forest fires, and fossil fuel emissions. Sustainable forestry practices can increase the ability of forests to sequester atmospheric carbon while enhancing other ecosystem services. Even urban forests play a role in the carbon cycle either through sequestration by trees or strategic placement around buildings for summer shading that reduces the need for cooling, resulting in decreased carbon emissions.[6] (For more information, go to http://www.fs.fed.us/ecosystemservices/carbon.shtml.) Accurate estimates are crucial for forest carbon management, carbon credit trading, and carbon reporting for state and regional greenhouse gas registries. Certain **i-Tree tools** (www.itreetools.org) can perform basic calculations to help quantify forest carbon for planning or reporting.

Figure 3. Plan view of linear stormwater tree pit. *(Watershed Forestry Resource Guide, Center for Watershed Protection and USFS Northeastern Area)*

Trees as Green Stormwater Infrastructure (GSI) BMPs

The goals of GSI installations – often referred to as stormwater best management practices (BMPs) – are to capture runoff, allow infiltration, promote evapotranspiration, and otherwise reduce or eliminate stormwater flow to waterways or sewage treatment plants. Trees can contribute to those GSI goals in a number of ways:

- Trees reduce stormwater runoff by capturing and storing rainfall in their canopy and releasing water into the atmosphere.
- Trees draw moisture from the soil ground surface, thereby increasing soil water storage potential.
- Tree roots and leaf litter create soil conditions that promote the infiltration of rainwater into the soil as well as reduce erosion and sedimentation.
- Trees help slow down and temporarily store runoff and reduce pollutants by taking up nutrients and other pollutants from soils and water through their roots.
- Trees break down pollutants into less harmful substances.[7]

The resources below provide guidance on incorporating trees into urban BMP sites as well as other facets of green stormwater infrastructure:

- **Stormwater to Street Trees: Engineering Urban Forests for Stormwater Management –** Useful information on various BMP types that incorporate trees, including tree trenches with structural soil or cells, interconnected curbside stormwater tree pits, permeable pavement, forested bioswales, and designs for "green streets." (http://water.epa.gov/polwaste/green/upload/stormwater2streettrees.pdf)
- **Control Stormwater Runoff with Trees –** Includes pointers on maximizing the stormwater management potential of trees in BMPs and other sites, from the Center for Urban Forest Research, USFS Pacific Southwest Research Station. (http://www.forestsforwatersheds.org/storage/CUFR_182_UFfactsheet4.pdf)
- **Types of Green Stormwater Infrastructure –** Describes and illustrates stormwater swales, curb "bumpouts," planters, rain barrels, green roofs, wetlands, and other BMP types that may or may not include trees. (http://www.nyc.gov/html/dep/html/stormwater/combined_sewer_overflow_bmps.shtml)
- **Watershed Forestry Resource Guide –** Covers a wide range of related information, including a section on "How Do We Measure and Provide 'Credit' for Stormwater Runoff Reduction by Trees?", which outlines a stormwater credit system based on reducing the stormwater management requirements a developer has to meet in exchange for conserving forests or using site design techniques that reduce the amount of paved surfaces created. (http://www.forestsforwatersheds.org/reduce-stormwater/

Refining Your Focus

In the broadest sense, there is no hard and fast boundary to define the outer edge of the typical urban forest. The surrounding regional landscape impacts the same ecosystem services supplied within the urban core. Moreover, pests, diseases, and invasive species spread easily across the entire rural-to-urban gradient unrestricted by property boundaries. For those reasons, planning must always occur in

the context of the larger landscape, and urban forest managers should take every opportunity to engage and collaborate with their counterparts in the surrounding region, as will be discussed in more detail in **Part V, Constructing the Community Framework**.

In practical terms, however, those who are responsible for urban forest management must prioritize their focus to the area or sites they can influence most directly – whether at a county, municipality, or neighborhood level, or even just within the bounds of a college campus or some other large property.

Notice the emphasis on *influence,* not *control.* To hope to achieve genuine sustainability – that is, the ability to reach and sustain a vigorous and extensive urban forest – it's important to consider *all* of the trees and forest resources within the defined area, not just street trees or even all public trees. Many municipal urban forest programs now include goals and actions targeting private property as well, which is often where the majority of trees and amount of urban land cover are located. Collaborative partnerships are extremely important in this respect. Within any community, there are typically individuals, groups, and organizations that can engage with private property owners. That doesn't let the municipality off the hook, however; there are many other measures – outreach, incentives, ordinances, and regulations – that it can take to build support for the urban forest and guide actions on private property.

In any case, the first step toward a sustainable urban forest is to define your focus area – and mark it on a map.

Part III – Covering the Canopy

Why Consider Canopy Cover?

Tree canopy cover represents the "footprint" of the urban forest. As many forest ecosystem services (discussed in **Part II, Setting the Stage)** are directly related to the amount of healthy and functioning leaves, the proportion of land covered by tree canopies – typically expressed as **percent canopy cover** – serves as a simple measure of the extent of the urban forest and the magnitude of services it provides. Essentially, percent canopy cover provides the equivalent of a two-dimensional aerial snapshot. It's an imperfect measure, to be sure, but it can be readily assessed, easily communicated, and highly useful for setting goals, prioritizing actions, and tracking progress. It's also often persuasive in building support for forest management activities.

What Is 'Tree Canopy'?

An *individual* tree's "canopy" is the total amount of leaves and branches on its stems or trunk – which would intercept rainfall, for example. *Collectively,* "tree canopy cover" is the footprint or surface area of the land covered by the combined leaves, branches, and trunks of all standing trees in a given area when viewed from above. An area's tree canopy cover is often called simply "tree canopy." In an urban setting, it's usually referred to as urban tree canopy.

Assessing, mapping, and analyzing percent canopy cover – in total and by selected focus areas (e.g., individual parks, natural areas, or corridors) – allows you to capture and share that simple metric. The information that can be gleaned from such efforts serves multiple purposes including the following:

- Establishing a baseline
- Adopting an overall tree canopy cover goal for the municipality.
- Setting finer canopy goals for individual neighborhoods or other management areas.
- Quantifying tree benefits, or ecosystem services.
- Prioritizing locations where tree canopy cover can be strategically increased to enhance those services.
- Identifying critical canopy cover for preservation or protection from development.
- Monitoring change in canopy cover over time.
- Comparing canopy cover between municipalities.

What Is an 'Optimal Canopy Cover Level'?

This is a bit of a trick question, as there is no set tree canopy cover level that would be considered "optimal" everywhere – or perhaps even in a single location. More important is how best to *optimize* canopy cover – weighing desired benefits against associated costs. Each community must adopt its own goals, depending on a number of considerations that are unique to its particular circumstances, including climate, geography, specific environmental concerns, local preferences, desired ecosystem

services, land cover and land use patterns, resources, and other factors. (For a range of canopy cover levels and goals, see table [BELOW].)

Of course, it's not always done that way. In many cases, tree canopy cover goals have been set by political fiat or educated guess, rather than methodical analysis. Setting ambitious canopy cover goals does have its advantages – such as communicating a simple message, engaging the public, motivating officials, securing funding, and encouraging stewardship. And more canopy cover is generally better, provided you have the means to maintain it – not to be underestimated, since *tree planting* is, in a sense, only the beginning of the cycle of costs involved.

It's far better to base those canopy cover goals on a solid understanding of two things: the current status of the urban forest and the desired future state – that is, what you hope to gain by achieving those goals. In **Part IV, Gathering the Information,** we'll present the main options for assessing the forest resource, including field-based assessments and aerial imagery. In the discussion below, we'll focus on the second part of that equation – what you hope to gain, and the various considerations involved.

Always remember that the canopy cover goal itself is not the be-all and end-all of sustainable urban forestry. Equally important are the many elements that go into setting that goal and the steps that are taken not only to achieve and maintain it, but even just to strive for it. In addition, bear in mind that the most meaningful measure of tree canopy cover in a given area at any given time may be its *relative* canopy cover – that is, the extent of canopy cover relative to the *desired* amount, or the particular goal for that area based on its optimal potential. (Note that **"Relative tree canopy cover"** is addressed by **Target T1** in **Part VI, "Conducting the Evaluation."**) There are no simple answers to these complex questions. But it's worth embarking on the quest.

Tree Canopy Cover Levels and Goals for Selected Cities

The table below illustrates existing canopy cover levels for various U.S. and two Canadian cities, as well as citywide canopy cover goals where available. According to one recent study, national results indicate that urban tree canopy (UTC) in the United States is on the decline at an average rate of about 0.2 percent per year, which equates to an annual loss of 4 million trees.[8] In major cities, the rate of decline was found to be several times greater than that – despite increased tree-planting efforts during those years. A comparable loss of urban forests has become a growing concern for municipalities worldwide as urbanization has led to land-use conversion, compounded by other pressures, such as pests and climate change. Setting ambitious but realistic canopy cover goals and developing the programs to support them are essential steps in reversing that downward trend.

	Initial Canopy Cover Level		Canopy Cover Goal	
City, State/Province[9]	UTC Cover	Year Assessed	UTC Cover	Target Date
Annapolis, MD	42.0%	2006	50%	30-year plan (2036)
Asbury Park, NJ	22.6%	2013	Increase	Ongoing
Atlanta, GA	47.9%	2008	Increase	Ongoing
Austin, TX	32.0%	2006	40%	Ongoing
Baltimore, MD	20.0%	2007	40%	2036

City, State/Province[9]	Initial Canopy Cover Level		Canopy Cover Goal	
	UTC Cover	Year Assessed	UTC Cover	Target Date
Boston, MA	29.0%	2006	49%	10-year plan (2016)
Cambridge, Ontario	27.0%	2013	N/A	2050
Cedar Lake, IN	33.8%	2011	Increase	Ongoing
Chicago, IL	17.2%	2007	25%	Ongoing
Denver, CO	16.4%	2010	31%	20-year plan (2025)
Detroit, MI	22.5%	2008	40%	Ongoing
Easton, MD	27.0%	2014	40%	Ongoing
Evanston, IL	36.9%	2010	Increase	Ongoing
Fort Bragg, NC	67.1%	2011	70%	Ongoing
Fort Wayne, IN	29.0%	2011	Increase	Ongoing
Goshen, IN	22.0%	2012	30%	Ongoing
Hartford, CT	25.1%	2013	35%	Ongoing
Holyoke, MA	26.5%	2014	30%	Ongoing
Howard Beach, NY	8.5%	2013	Increase	Ongoing
Indianapolis, IN	13.8%	2008	19%	10-year plan (2018)
Las Vegas, NV	8.6%	2012	20%	2035
Leesburg, VA	27.0%	2006	40%	25-year plan (2031)
Lexington, KY	24.6%	2013	30%	Ongoing
Los Angeles, CA	21.0%	2006	28%	2040
Louisville, KY	37.1%	2013	40%	Ongoing
Macedonia, OH	39.0%	2013	Increase	Ongoing
Milwaukee, WI	21.6%	2008	40%	Ongoing
New Haven, CT	38.0%	2009	Add 10K trees	5-year plan (2014)
New Orleans, LA	23.3%	2009	Increase	Ongoing
New York, NY	24.0%	2006	30%	2036
Philadelphia, PA	20.0%	2011	30%	15-year plan (2025)
Phoenix, AZ	8.0-10.0%	2007	25%	2030
Pittsburgh, PA	40.0%	2011	60%	20-year plan (2031)
Port Angels, WA	27.3%	2011	40%	Ongoing
Portland, OR	29.9%	2014	33%	Ongoing
Providence, RI	23.0%	2007	30%	10-year plan (2020)
Richfield, OH	58.0%	2013	Increase	Ongoing
Sacramento, CA	5.2-15.4%	1998	35%	Ongoing
San Francisco, CA	13.7%	2012	20%	20-year plan (2034)
Seattle, WA	23.0%	2007	30%	30-year plan (2037)
Stow, OH	41.1%	2013	Increase	Ongoing
Tacoma, WA	19.0%	2010	30%	20-year plan (2030)
Toronto, ON	27.0%	2008	40%	2060
Vancouver, BC	18.6%	2010	28%	20-year plan (2030)

City, State/Province[9]	Initial Canopy Cover Level		Canopy Cover Goal	
	UTC Cover	Year Assessed	UTC Cover	Target Date
Washington, DC	35.0%	2009	40%	20-year plan (2029)
West Memphis, AR	18.1%	2012	24%	Ongoing
Whitpain, PA	43.0%	2012	Increase	Ongoing
Winnetka, IL	52.7%	2010	Increase	Ongoing
Ypsilanti, MI	36.6%	2012	Increase	Ongoing

Note: Assessment and target dates may not match length of plans due to timing of goal establishment.

Search for Urban Forest Data

Urban forest data are being collected from across the United States based on top-down aerial approaches and bottom-up field data collection. (See **Part IV, Gathering the Information**.) The U.S. Forest Service offers links to that data as well as reports prepared at the state, county, municipal, and local community or place level. Visit this website to explore states or communities of interest and see what data are available: www.nrs.fs.fed.us/data/urban

Setting Your Canopy Cover Goals

Whatever tree canopy cover goal you set for your community must be attainable and sustainable. "Ambitious" and "inspirational" are important traits. But if a goal is impossibly beyond reach, it leads only to public disappointment, staff frustration, volunteer burnout, funder fatigue, and the like. An ambitious program to expand canopy cover by planting more trees *must* be accompanied by an equally ambitious program to sustain the additional trees over their lifetime.

The first consideration in setting challenging but reasonable goals should be the local or regional geographic framework. That means working within the natural limits of the environment. It doesn't mean that the "natural" regional landscape should dictate your decisions; in fact, in historically non-forested areas, urbanization can actually lead to *increased* canopy cover. Still, geography should certainly inform the decision-making process. (For example, compare Phoenix with Atlanta in the table of canopy levels and goals above.) Similarly, you need to consider the interrelations of the forest resource across the full rural-suburban-urban gradient, or whatever spectrum characterizes your locale. That means taking care that forest management strategies in one zone don't conflict with or jeopardize measures taken in another zone – for example, planting potentially invasive species in a managed urban area that might overrun a nearby natural area.

The distribution of tree canopy cover is generally not – and needn't be – uniform across a municipality or even identical in every neighborhood. A single overarching canopy goal has its merits; for one thing, it is easier to communicate and promote. But at a functional level, it's more important to break that down into more meaningful pieces, through a finer-scale analysis – by census tract, parcel, land ownership, sub-watershed, or other boundaries or land-use designations.

Always remember that whatever percent canopy cover goals you set – and whether municipality-wide or at a single block level – those are only stand-in metrics for the actual benefits or ecosystem services you hope to gain from that tree cover. So at root, the *quality* of the urban forest is as important as the number of trees that comprise it. "Quality" in that sense covers tree health, age and species diversity, strategic location, and other such factors – all intended to maximize the desired ecosystem services, whatever they may be.

To set meaningful canopy cover goals, you'll need to consider your municipality's particular needs, which can vary widely. Depending on the setting, you may be most concerned about heat reduction, energy savings, stormwater runoff, air quality, public health, economic development, environmental justice, social well-being, or some combination of those and other factors. That "needs assessment" could influence how many trees must be added, what kind of trees, and where to situate them. For example, to cut energy use for cooling a building, large trees must be placed close enough to shade the structure, particularly on the west or east sides; to boost economic development, trees can be added to barren commercial strips, which invites more leisurely shopping; to capture stormwater, engineered tree trenches may be most effective.

Determining the right mix of motivators and desired outcomes will require engaging a broad array of stakeholders, ranging from municipal agencies to community groups and individual residents. If a municipal or regional sustainability plan exists, there's a chance that some of those concerns may already have been identified – and, as noted previously, the urban forest can be managed to advance multiple sustainability goals, not just those that are specifically focused on parks and green space. Armed with all that information, you'll be better able to plan the particulars.

One of the many "good news" stories about urban forests is that the many benefits we derive from them aren't mutually exclusive. An extensive, diverse, and healthy urban forest will provide a complete suite of ecological, social, and economic benefits. So while your main objective may be energy conservation, for example, your community will still get all the co-benefits at no extra cost.

Pursuing Your Canopy Cover Goals

As noted above and detailed in **Part IV, Gathering the Information,** a comprehensive forest resource assessment is an essential first step in the goal-setting process. In addition to aerial canopy cover studies (the "top-down" approach), an overall assessment can include information gleaned through tree inventories and other field-based ("bottom-up") data collection. Taken together, that information will enable you to identify and consider opportunities for advancing your canopy cover goals.

In addition to studying the canopy level across the city as a whole, it can be even more helpful to analyze canopy cover in finer detail – classifying different areas by meaningful strata such as land use (industrial, commercial, residential, etc.), census tract, congressional district, or whatever might inform planning across various properties and land uses citywide. That could help you to determine, first, where additional trees *might* go, then to decide where they *should* go, and finally to prioritize where they *will* go.

New approaches and tools for conducting an urban tree canopy analysis, or UTC study, are being developed to facilitate such prioritization efforts, including a protocol from the USDA Forest Service.[10]

Designed initially for New York City and tested more recently in Baltimore and Chicago, this basic process can be readily adapted to other locations. (The City of Austin has also utilized this method to develop a tree planting prioritization analysis and map for guiding plantings on public property, which can be viewed here: http://austin.maps.arcgis.com/apps/StorytellingTextLegend/index.html?appid=1d073b8019fd4c419e4f81eb9e274af5.)

That approach is based on a fairly straightforward analytical framework that involves using detailed land cover mapping as well as various social, economic, and ecological datasets to explore "plantable" space – both existing and potential. Essentially, this involves a "3 Ps" framework for establishing goals based on these questions:

1. What is physically **possible** – that is, what lands can biologically support trees?
2. What is socially **preferable**? (For example, while you might be able to grow a tree on a pitcher's mound, that would not be socially acceptable.)
3. What is the **potential** plantable space?

Arriving at the ultimate **"potential"** plantable space is not simply a matter of taking the **"possible"** and subtracting what's not **"preferable."** For one thing, land cover can change – in either direction: Buildings can be razed, pavement can be removed; fields and forests can be developed, and so on. For that matter, while a tree may never be at home on a baseball pitcher's mound, other social preferences can change as well. Most importantly, fiscal resources are limited and will inevitably place limits on what can reasonably be considered true "potential" – which requires careful consideration of how and where to focus those resources for maximum – and equitable – impact.

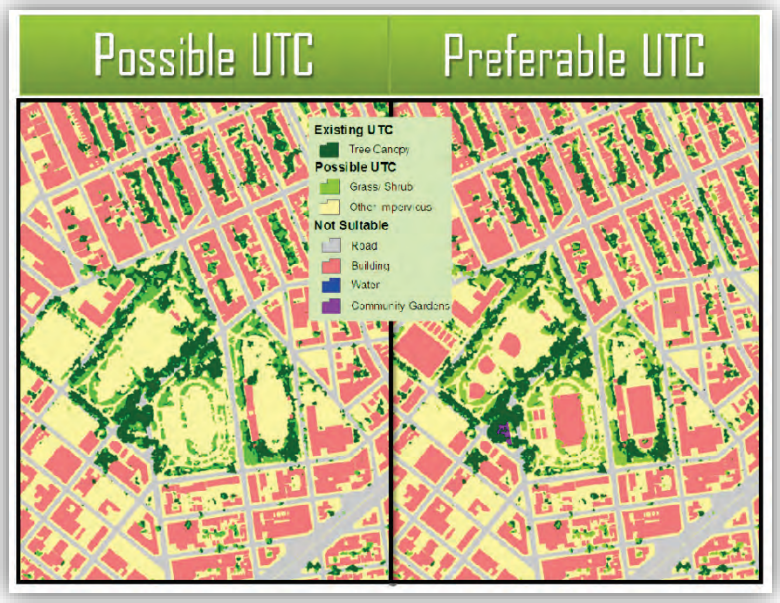

Figure 4. McCarren Park NYC, Possible and Preferable UTC sites.

Whatever tools or methods you use to tease apart the overall tree canopy, the resulting information can help guide decisions aimed at increasing tree benefits on all lands, including private as well as public property, based on flexible parameters of your own choosing. While that process may be primarily intended to find optimal places to add trees, it's equally useful for identifying high-priority locations for tree *protection* and stewardship, which are just as important to preserving and growing the urban forest. After all, there's no way to grow the overall canopy cover if you're losing trees as fast as you're planting them. (Obviously, losses from normal mortality and routine removals can also be expected and must be factored into the equation.)

The kind of parameters you might choose to guide your analysis can include anything that can be mapped – such as floodplain zones, impervious surfaces, open space, underserved communities, owner-occupied housing, heat island hot spots, etc. And the decisions you reach will reflect your municipality's particular needs and preferences, including desired ecosystem services, as described above. To be most effective for that purpose, however, broad-scale analyses must still be complemented by more precise assessments of ecosystem services provided. There are several analytical tools for that purpose, both from an aerial (top-down) view and a ground-level (bottom-up) survey, which we'll discuss in the **Forest Resource Assessments** section of **Part IV, Gathering the Information.** As you work in finer detail, you will be able to use all that information in determining specifics such as species selection, age distribution, tree placement, even development of possible ordinances and other policies, as well as many other such decisions.

Be sure to take full advantage of data already collected by other entities that might play into this decision-making process. In Chicago, for example, there's the Chicago Wilderness Green Infrastructure Vision, a map of high quality natural areas and opportunities for connectivity, and the Oak Recovery Plan mapping initiative, which identifies existing oak stands of one acre or more.

But spatial and numerical data alone will not suffice. Any attempt to set priorities must involve extensive input from diverse stakeholders – including individuals and organizations, across all sectors – and seeking to find opportunities for collaboration among them. That approach is covered in more detail in the **Part V, Constructing the Community Framework.** Further on, in **Part VII, Developing & Implementing the Plan,** we'll outline a process for considering how all these pieces might fit into the design of your overall Sustainable Urban Forest Plan.

Part IV – Gathering the Information

Taking Stock

To plan where you want to go and how to get there, you must first know where you are. So the first step toward a sustainable urban forest is to understand your municipality's current situation, both on the ground and on paper (or electronic equivalent).

The box below lists the key ingredients to assemble so that you can take stock of what you may already have and what you may need to develop. In **Part VI, Conducting the Evaluation & Measuring Success,** you'll use those ingredients to evaluate your municipality's urban forest on numerous targets in three broad categories: **(1) Trees and Forest, (2) Community Framework,** and **(3) Resource Management Approach.** With that baseline information in hand, you'll be able to gauge your strengths, identify the most pressing or promising areas for improvement, and then make the changes you choose as you move toward a sustainable urban forestry program that suits your situation.

Key Ingredients

Forest Resource Assessments

- Field-based inventories and assessments ("bottom-up" approach)
  - ♦ Tree inventory
    - – Complete inventory
    - – Sample-based
  - ♦ i-Tree Eco analysis
  - ♦ i-Tree Streets analysis
- Tree canopy assessments ("top-down" approach)
  - ♦ National Land Cover Database (NLCD) satellite imagery
    - – i-Tree Landscape
  - ♦ Aerial photo interpretation
    - – i-Tree Canopy
  - ♦ High-resolution aerial or satellite imagery
    - – Urban Tree Canopy (UTC) study

Plans, Practices, Programs, and Policies

- Urban Forest Management Plan (UFMP)
- Maintenance plans for street trees and other public trees
- Natural areas management plans
- Regional and statewide plans
- Emergency and disaster plans
- Relevant previous or historic plans
- Community tree programs
- Private property tree programs
- Educational materials, promotion and outreach
- Municipal urban forestry policies
- Municipal tree board/shade tree commission
- Municipal urban forest budget
- Municipal urban forest staffing
- Funding sources
- Maps
- Citywide urban forest GIS
- Comprehensive list of stakeholders
- Green jobs training programs
- Agroforestry / Trees for food
- State Urban & Community Forestry Council contacts
- Specifications and standards

Many of those ingredients are likely to be absent or inaccessible, and not all of them will be needed in every setting. Nevertheless, by assembling a compendium with as many of those elements as possible you will build the foundation for baseline evaluation, planning, action, and monitoring. And you will also create a comprehensive multi-purpose reference for your team and those who follow after you

(archiving everything is a critically important effort). For now, just round up the pieces, and make note of gaps to be filled as opportunities arise.

However, there are a few essential ingredients without which you won't be able to proceed very far – specifically, one or more of the "Forest Resource Assessments," discussed in detail below. If you are lacking that information, you should take steps to fill that gap right from the start. After describing those assessments, we'll provide references to useful resources on all the other ingredients.

Forest Resource Assessments

There are many reasons to assess the urban forest:

- Facilitate planning, management, and advocacy.
- Understand "tree benefits" and quantify ecosystem services (as discussed in **Part II, Setting the Stage**).
- Measure and monitor the extent of tree canopy cover (as defined in **Part III, Covering the Canopy**).
- Identify and prioritize tree planting locations in areas of greatest need and/or with greatest potential to maximize desired benefits.
- Promote resource stewardship through public outreach and education.
- Understand the changes that may be occurring (e.g., loss of canopy, invasive species, aging tree population, etc.).

Essentially, any assessment of the urban forest involves examining its structure and composition. There are two basic strategies:

- **"Bottom-up" approach –** uses field data collected "on the ground" to measure the physical structure of the forest.
- **"Top-down" approach –** uses aerial or satellite images to analyze tree canopy and other land cover.

The two approaches provide different types of information; ideally, your overall forest resource assessment will include some of both. There are a variety of options within the two approaches, each with its own advantages and disadvantages, as outlined below. The best approach or combination for your situation will depend on what sort of information you're hoping to gain, and how you plan to use it.

Bottom-Up: Field-Based Assessments

Based on either a complete or sample-based inventory, this approach provides the detailed information needed to support strategic resource management, planning, and advocacy. It does that by collecting forest structure attributes (such as tree species, numbers, sizes, locations, and conditions), calculating their associated ecosystem services and values, and connecting that data with management costs, risks, and needs. In addition to providing details on the current situation, these tools can be used for monitoring changes in forest composition and values.

Complete inventories involve collecting data on every tree in an assessment area. Because this can be time and labor intensive, and possibly costly, such an undertaking is generally reserved for circumstances that warrant that sort of investment – such as a complete inventory of all street trees in a community or other individually managed public trees, or where the defined assessment area is an arboretum, college campus, or other large property.

Sample-based inventories involve looking only at randomly selected portions (or plots) of the tree population in order to extrapolate findings to the overall area of interest. While they do not assess every tree, they can cover more geography than would be feasible with a complete inventory. For example, sample-based inventories extend into private property lands, where a full inventory is generally not possible. Moreover, a sample-based assessment may be all that's needed to answer the questions at hand, such as calculating the ecosystem services provided by the urban forest citywide.

Tree Inventories and Routine Management Software

Tree inventories also support the day-to-day management of an urban forest, which is outside the scope of this guide. Along with asset-management software and other operations-based tools, complete inventories can be used to help track routine activities such as hazard inspection and tree maintenance. Various software programs are available for those purposes.

Two publicly available assessment tools – **i-Tree Eco** and **i-Tree Streets** – were developed by the USDA Forest Service and its partner organizations to aid in conducting bottom-up assessments of urban trees and forests, and for calculating their ecosystem services and values. (Go to www.itreetools.org for more information on all **i-Tree** applications, which range widely in the amount of training required, type of data provided, and features offered.)

i-Tree Eco can assess an entire urban forest using sample-based field assessments, or discrete tree populations with complete inventory data. In either case, field data must be collected on each tree (and/or plot) following a specific protocol. The application models these data with meteorological inputs and other locally based data to provide detailed information on resource structure as well as ecosystem services such as air pollution removal, carbon storage capabilities, rainfall interception, and impact on energy use in adjacent buildings, plus pest risk analysis (www.itreetools.org/eco).

i-Tree Streets was designed for assessing the structure and benefits of street tree populations. Existing inventories, or new sample or complete inventories, can be utilized with this tool. In addition to providing resource structure information, ecosystem services and their value are assessed, along with management needs (www.itreetools.org/streets).

While the i-Tree tools are available for free, there are costs associated with collecting the detailed data required. Volunteers, students, in-house crews, and hired consultants have all been employed for collecting i-Tree data.

As an example, the typical citywide **i-Tree Eco** assessment requires 200 randomly generated one-tenth acre plots to achieve desirable statistical accuracy. At a contracted rate of $200-300 per plot for data collection, a consultant might charge a total of $40-60,000 for the project – or more, if including interpretation, reporting, and management recommendations. Data-collection costs could be half that much using student labor or even less with volunteers, though greater oversight will be necessary.

Under good conditions, a 200-plot sample typically yields a relative standard error of less than 15 percent for the total tree population estimate.[11] Sampling intensity (i.e., the number of plots) can be adjusted to suit the accuracy desired and resources available. (In addition, it's worth noting that by demonstrating the financial value of the ecosystem services provided *by* the urban forest, such an assessment can result in increased financial support *for* the urban forest – which also helps justify the up-front investment.)

Top-Down: Tree Canopy Assessments

The top-down approach is used to determine the amount and distribution of tree canopy cover, potential planting space, and prioritizing planting needs. As it is aerial-based, it does not obtain data on individual trees, such as species, size, and condition. So the top-down approach is valuable for broad-scale mapping, planning, prioritizing, and monitoring land cover – as well as for providing information about canopy cover on private property – but not as well-suited to assessing ecosystem services of individual trees.

There are three common methods for assessing urban tree canopy cover. While all three will map estimated tree canopy and other cover types in an area, they differ greatly in process, resolution, costs, and accuracy. As a result, there are various advantages and disadvantages to each method, as outlined below, in order of increasing cost and accuracy.

1) **National Land Cover Database (NLCD) satellite imagery –** Free maps and data for entire contiguous 48 states showing estimated percentage of tree canopy and impervious land cover.

   Advantages: The most recent NLCD data (2011) comes pre-loaded into **i-Tree Landscape** (www.itreetools.org/landscape) along with other data layers, including those acquired through Urban Tree Canopy (UTC) Assessments where available and various other base map layers. This allows mapping and planning tree cover distribution based on ecological and socio-economic factors. (For more on **i-Tree Landscape,** see **Part V, Constructing the Community Framework, Tools and Strategies for Engaging the Community**.)

   Disadvantages: Low resolution (30-meter pixels, or segments) cannot detect individual trees.
   ♦ Available only in the U.S.

   Accuracy: Typically underestimates tree cover in urban areas by approximately 10 percent.

   Cost: None, other than small amount of staff time, if experienced with GIS.

   Recommendation: Useful for cities and broader-scale regional analyses where canopy and land cover data are needed quickly and at little to no cost. ♦ Excellent engagement tool.

2) **Aerial photo interpretation –** Randomly generated points on digital aerial images are interpreted to determine cover type at each point center, resulting in estimates with a known degree of statistical error. Accuracy can be easily increased by sampling more points (see below).

Figure 5. Photo interpretation involves classifying random points within preselected cover classes (e.g., tree, impervious, water).

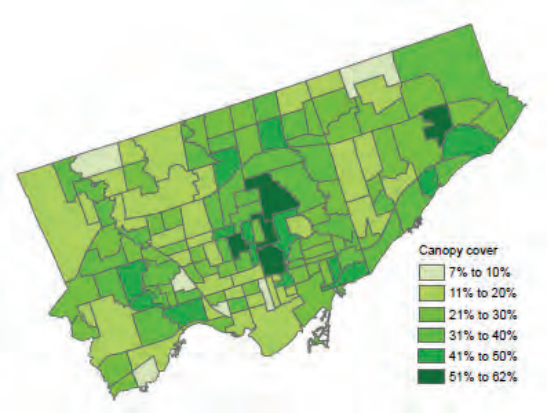

Figure 6. Neighborhood tree cover in Toronto, determined through photo interpretation

Advantages: The **i-Tree Canopy** program (www.itreetools.org/canopy) can be used to photo-interpret a statistically valid sample of cover points anywhere high-quality images are available in Google Maps. (This can also be done manually by GIS-experienced staff using other digital images supplied by municipal or other regional sources.) ♦ Allows quick assessment of land cover types (e.g., tree canopy, available planting space, impervious surfaces) and can produce analyses and maps by defined strata (e.g., neighborhoods, census blocks). ♦ Changes in land cover over time can be assessed by matching paired images from different dates.

Disadvantages: Cannot produce finely detailed maps of cover types, estimate full range of ecosystem services, or summarize data at multiple, finely defined scales. ♦ Available image quality may be poor in some locations.

Accuracy: A sample of 100 points (which can be interpreted in about 1 hour) will yield an estimate with a standard error of about 4.6 percent in an area with 30 percent canopy cover; increasing the sample to 1,000 points would reduce the error to 1.4 percent. ♦ To minimize errors introduced by misclassifying cover types, photo-interpreters must be trained and checked. Leaf-off imagery in particular can be difficult to interpret. ♦ Can also be useful for checking accuracy of other top-down methods.

Cost: Images are generally available for free or at low cost. ♦ Staff time depends on sample size, as noted above.

Recommendation: A good low-cost option for getting an initial top-down perspective on a city's urban forest and tracking change over time. Can be highly accurate, though not very detailed or flexible. Best method to estimate tree cover if you do not need to map it.

3) **High-resolution aerial or satellite imagery –** Automated techniques extract land cover features from high-resolution imagery (typically less than 1-meter pixels), yielding detailed maps of tree canopy and other cover types in a given area. (Source imagery for the entire United States is available from USDA.)

Figure 7. High-resolution (bottom) vs. 30-m NLCD imagery (top).

Figure 8. High-resolution land cover map.

Advantages: Data can be summarized at a broad range of scales (e.g., parcel to watershed), enabling user to relate tree canopy cover to a host of demographic, planning, and biophysical data. ♦ Among other purposes, can be used to locate and prioritize potentially available spaces to plant trees, and to monitor locations where cover is changing. ♦ Integrates well with GIS.

Disadvantages: Analysis and reporting requires highly trained personnel, specialized image analysis software, and significant time and effort. ♦ Requires additional modeling in order to estimate ecosystem services.

Accuracy: Accuracy varies but is typically 90 percent accurate for tree cover. ♦ Utilizing advanced remote-sensing technology, such as LIDAR (Light Detection and Ranging, or laser radar), and/or making manual corrections can increase the accuracy to over 95 percent.[12] ♦ Unless corrected, map inaccuracies can show false changes in tree cover over time.

Cost: Overall costs vary widely, depending on the size of the study area and the availability and quality of source data. ♦ Citywide assessments by professional consultants can cost anywhere from $5,000 to $60,000 or more.

Recommendation: Best method to map urban tree cover when expertise and financial resources are available; used for various Urban Tree Canopy (UTC) studies. For more information: www.nrs.fs.fed.us/urban/utc/.

Plans, Practices, Programs, Policies – and More

To assemble the many other important elements that you'll want to consider for your compilation, review the descriptions below and explore the references listed for each item, which you will find in **Appendix A, Resources.**

- **Urban Forest Management Plans (UFMP) –** A comprehensive plan should address goals and actions for the entire urban forest within the defined boundaries, on both public and private property. Topics covered may include maintenance standards, tree inventories and assessments, planting plans, tree selection standards, personnel training and development, community engagement, and many other items.

- **Maintenance plans for street trees and other public trees –** These plans address operational processes involving individually managed trees on public property such as streets, recreation centers, and other public places.

- **Natural areas management plans –** Surveys and stewardship plans for publicly owned natural areas include both broad and specific management goals for trees that are managed as a group or population, as opposed to individually like street trees.

- **Regional and statewide plans –** These could include existing plans or planning processes directly or indirectly related to aspects of the broader urban forest, such as open space, recreation trails, economic development, etc.

- **Emergency and disaster plans –** It's essential to prepare in advance for withstanding – and recovering from – emergencies and natural disasters that can impact the urban forest. Key elements of preparedness include planning, communications, advance inventory, training, handling vegetative debris, and assessing vulnerability.

- **Relevant previous or historic plans –** For purposes of comparison as well as to preserve "institutional memory" and avoid reinventing the wheel, it can be important to collect all previous planning efforts related to the urban forest.

- **Community tree programs –** These can include planting, stewardship, and training programs often managed by independent nonprofit organizations.

- **Private property tree programs –** Including tree giveaways and other municipally or independently managed incentive programs to promote tree planting and stewardship on private property.

- **Educational materials, promotion, and outreach –** In addition to the general public, key targets include large landholders, such as hospitals, schools, and other institutions or individuals.

- **Municipal urban forestry policies –** These can include a wide range of tools – guidelines, ordinances, laws, regulations – concerning such things as public agency cooperation, green industry collaboration, cooperative arrangements with utilities, protection and preservation of large and/or private trees, use of native species, etc.

- **Municipal tree boards/shade tree commissions –** Depending on their structure, these volunteer-based bodies may have advisory or even regulatory functions.

- **Municipal urban forest budget –** Without line items in the city budget, urban forestry activities are apt to be haphazard at best.

- **Municipal urban forest staffing –** With a budget in place and protected, adequate staffing is essential for making progress toward a sustainable urban forest. Of course, municipal capacity can get a tremendous boost from independent nonprofits, community groups, and individual volunteers. And increasingly, formal arrangements with commercial contractors can be an economical way to supplement or even substitute for municipal staff.

- **Funding sources –** Even with a standing budget line, you'll surely need supplemental funding wherever you can find it.

- **Maps –** Print and electronic maps at all scales – neighborhood, municipal, regional – are essential tools for planning and management purposes.

- **Citywide urban forest GIS –** To the fullest extent possible, seek to integrate urban forestry information within the structure of overall municipal GIS (Geographic Information System).

- **Comprehensive list of stakeholders –** To support your efforts, assemble a contact list of all key players, partners, and stakeholders (e.g., government representatives and agencies, nonprofit organizations, community groups, large or institutional landholders, utilities, etc.) – as well as what they each bring to the table (e.g., resources, issues, regulations, programs, etc.).

- **Others –** Additional items to consider compiling include sources on **green jobs** training programs, **agroforestry** (fruit and nuts), state **urban and community forestry** contacts and resources, and various **specifications and standards.**

> **Note:** An extensive array of sample materials for all of the above items can be found in **Appendix A,** along with hot links to the online resources.

Part V – Constructing the Community Framework

There is more to the urban forest than an assemblage of trees and other natural features. Focusing exclusively on the management of those resources neglects the community setting, which is what makes the forest "urban" – and what makes sustainability possible.

> **"We cannot separate sustainable urban forests from the people who live in and around them.…** Sustainable urban forests are not born, they are made. They do not arise at random, but result from a community-wide commitment to their creation and management. Obtaining the commitment of a broad community, of numerous constituencies, cannot be dictated or legislated. It must arise out of compromise and respect."
>
> – Clark et al, A Model of Urban Forest Sustainability, Journal of Arboriculture, 1997

Why Collaborate?

One obvious reason to foster cross-sector collaboration is that the trees that are within a municipality's control typically represent only a portion of the overall urban forest. So if you're working toward a sustainable urban forest and not just managing trees you own or manage, it's essential to enlist others in the effort on their own turf.

For that matter, even just managing those portions of the urban forest that do fall under your direct control – in the case of a municipality, street or park trees, for example – requires widespread popular support and buy-in from decision makers. There are also compelling arguments of resource equity, environmental justice, and basic democracy that demand broad inclusion of community stakeholders as you shape your tree agenda.

Moreover, municipal capacity is limited and changes with the economy, local elections, administrative leadership, and other unpredictable factors – including the weather. Bridging the lean times and handling the most demanding periods requires more than most municipalities can provide without tapping into external resources. That can include human resources in the form of volunteer labor as well as outside financial support. In fact, volunteer labor itself should be considered an important form of outside financial support, in the form of human resources.

> "**Independent action is inadequate**: no agency, organization, single landowner, or business has sufficient funds or land to achieve a city's [urban tree canopy] goal. Coordination and collaboration are needed and depend upon identifying common or complementary interests, categories of programs, or areas for action."
>
> – Locke et al, Cities and the Environment, 2013

Urban forestry stakeholders can be found in all sectors – public agencies and officials, private citizens, nonprofits, commercial firms, academic institutions, and so on – with varied interests spanning the full

spectrum of social, economic, and environmental issues. Even just within the municipal realm, there is a broad range of agencies with vested interests in trees – whether by means of regulations, programs, land holdings, or other areas of intersection. So don't limit your thinking exclusively to the those directly tasked with managing the urban forest.

The box that follows lists numerous possible stakeholders to consider consulting or recruiting from your community. Some are important by virtue of their direct control over properties which enables them to *manage* trees and urban forest land; others exert their *influence* by influencing others; some function in both roles.

Figure 9. Friends of the Urban Forest, San Francisco.

Possible Stakeholders – and Collaborators – to Consider

Whether you are simply reaching out for input from various parties or seeking to recruit a standing advisory or working group, you'll have plenty of places to look. The list below is neither exhaustive nor mutually exclusive; the terminology may not match your locale, and you may think of many other possibilities. Any or all of these stakeholders may have an interest in urban forestry concerns; many will play an essential role. When striving for a sustainable urban forest, it's better to err on the side of inclusivity.

Municipal Departments & Agencies

- Forestry
- Parks & Recreation
- Natural Resources
- Environment
- Shade Tree Commission
- Sustainability
- Planning
- Community Development
- Economic Development
- Housing
- Transportation
- Public Works
- Public Utilities
- Water
- Energy
- Police
- Fire
- Health
- Education
- Emergency Planning & Management

Stakeholders in Other Sectors

Regional and state agencies

- Regional planners
- Park districts, forest preserves
- Conservation districts
- Transportation agencies
- Public health agencies
- State urban forestry council
- DCR, DEP, etc.

Landholders

- Residential homeowners
- Homeowner Associations
- Institutional, commercial, and industrial

Private

- Developers
- Utility service companies
- Arborists and tree care companies
- Landscape architects
- Design and civil engineers
- Contractors
- Ecological restoration practitioners
- Green industry employers
- Small business associations
- Chamber of commerce
- Corporate sponsors

Public

- General public
- Community and neighborhood groups
- Faith groups
- Tree-planting volunteers
- Elected officials

NGOs

- Tree advocacy groups
- Bike trail coalitions
- "Friends of" park groups
- Watershed partnerships
- Community development organizations
- Environmental justice organizations
- Other related nonprofits

Academia

- Community colleges with tree or horticultural programs
- Local universities where students and faculty seek research and other projects
- Extension Service

The multiplicity of stakeholders is both an asset and a liability. On the one hand, it requires extra effort; on the other, it builds added capacity and enhances community buy-in. Good communication and coordination are the keys to maximizing the opportunity. While you can never have too many enthusiastic "tree champions," all engaged in advancing the common cause in their individual and overlapping spheres of influence, it's important to form and empower a core group that can kickstart a fledgling urban forestry initiative and help maintain the momentum of a program once it's up and running.

Broad, cross-sector involvement allows input on diverse needs, opportunities, perspectives, and preferences related to the urban forest. With that sort of engaged representation, you can identify individual *and* common goals – economic, social, and environmental – and then undertake the hard work of navigating sometimes competing interests and setting priorities. In fact, as noted in the previous section, any successful attempt to set priorities must necessarily involve extensive input from diverse stakeholders.

In its *Guide to Community and Urban Forestry Programming,* the Evergreen Communities Partnership in Washington State (http://www.commerce.wa.gov/documents/gms-eca-comm-urban-forestry.pdf) observes that "a community – residents and businesses alike – that is provided a clear picture of the priorities, scope, timing, and resources for achieving a thriving urban forest is more likely to invest their energy and resources to help achieve that vision." That holds true for stakeholders in other sectors as well – and all the more so where all stakeholders have had a hand in painting that picture.

Prioritizing action on tree planting and care involves many different though interrelated parameters, which generally fall into two broad categories:

- Land use / land cover / locations / sites
- Tree benefits / ecosystem services

In communities that have a comprehensive sustainability plan in place, some goals and priorities related to the urban forest may already have been established with considerable stakeholder input. That can provide a good foundation, but it does not eliminate the need for establishing connections and maintaining ongoing relationships with key stakeholders – not just to garner advance input, but to secure involvement and support over time.

There are a number of ways to get that initial input from diverse stakeholders and build upon the foundation for future collaboration. Broad-based and targeted questionnaires and surveys (print or online) can be an important step in the process – for example, providing information about the commonalities and differences across the multiplicity of stakeholders, identifying opportunities for communication and coordination, and spotting potential gaps in capacity as well as capacity to spare – and to share. Still, there's no substitute for actual in-person outreach in a variety of settings, ranging from one-on-one professional interviews to large-scale public meetings.

Whatever the method, it's important to strive for what the American Planning Association describes in its report, *Planning the Urban Forest: Ecology, Economy, and Community Development,* as "a planned and programmatic approach to the development and maintenance of the urban forest, including all elements of green infrastructure within the community, in an effort to optimize the resulting benefits in social, environmental, public health, economic, and aesthetic terms, *especially when resulting from a community visioning and goal-setting process* [emphasis added]."

Internal Municipal Stakeholders and Relationships

As Washington's Evergreen Communities Partnership points out, "Vital, livable communities have a number of responsibilities and requirements to fulfill toward their citizens, both residential and commercial. Community and urban forestry principles and practices should be integrated into the land use, transportation, parks and open spaces, and capital facilities plans and programs to maximize…ecosystem benefits…."

Within the municipal sector itself, the ideal situation would be one where all city departments cooperate and share common goals and objectives related to the urban forest. That may sound unlikely, but on closer examination, unexpected commonalities may be revealed. In one prioritization exercise conducted in Baltimore, U.S. Forest Service researchers noted that "the interests among public agencies were varied."[13]

> For instance, the Departments of **Transportation** and **Public Works** sought to reduce the amount of impervious surfaces in the City. **Housing** and **Community Development** considered greening to be a strategy for community stabilization and re-development. **Public Health** understood trees to be important for reducing cases of heat-related stress and asthma. **Education** sought to create greener and more attractive school campuses, while **Planning** considered trees to be important to a variety of sustainability goals from reducing energy consumption to improving water quality and reducing the severity of flood events.

One natural area of mutual interest across municipal departments in Baltimore that the researchers identified involved finding common ground – literally:

> Some agencies were "landowners," such as **Recreation and Parks,** and **Transportation.** These lands were often physically adjoining, which represents opportunities for coordination and collaboration. In other cases, agencies were "landless" such as **Planning, Public Works,** and **Health.** This fact represents an opportunity for collaboration among "landless" agencies, [who need] technical assistance and resources to meet their programmatic requirements, and landowner agencies who are in deep need for resources and additional expertise to better meet the City's diverse sustainability goals.
>
> – Locke et al, Cities and the Environment, 2013

There are often special collaborative opportunities just within the Planning Department in particular. For example, in preparing an Urban Forest Management Plan for the City of Clovis, California, the consultants found that while the **Public Utilities Department** has primary responsibility for managing and caring for public trees, other City agencies play critical roles in planning, preservation, and enhancement of the community's urban forest – chief among them, the **Planning and Development Services Department,** which is responsible for the planning, review, and acceptance of new development and redevelopment within the city. Here's how that department breaks down in Clovis:

- The **Review Unit** reviews and influences plans for new development projects, including the width of landscape strips and parkways, species selection, and number of trees per dwelling unit.

- The **Planning Division** directs the development of design code, specifications, and guidelines for new development – which may include elements of tree preservation and a parking lot shade ordinance as part of a Climate Action Plan.

- The **Capital Improvement Program** is responsible for public projects, including facilities, parks, and streetscapes that enhance the entire community and contribute to the quality of life for all residents.

Different municipalities handle those responsibilities differently, but the upshot remains the same: Integrating urban forestry concerns into community planning activities at all levels is an opportunity not to be missed. (See box that follows for more specifics on planning possibilities.)

All manner of municipal ordinances, by-laws, and other community regulations – ranging from the establishment of a tree commission to the protection of a specific historic tree – can be useful implements in the urban forestry toolkit. No single "model ordinance" or regulation can serve the goals or other particulars of all communities. (Some general guidance and samples can be found in the resources listed at the end of **Part IV, Gathering the Information**.) Most important to keep in mind: Even the best ordinance, by-law, or regulation is worthless without enforcement muscle to back it up.

Planning for Trees

Below the macro policy level, planners have numerous opportunities to work with their urban forestry staff to implement [tree program] goals. … The success of tree programs tends to lie in the details, which can include collaboration between both groups on all of the following:

- Requirements for detailing tree-planting plans in site plan submissions.
- Regulations regarding tree preservation procedures in the development process.
- Management of tree issues arising in the public hearing process on proposed developments.
- Review of site plans, which can include having an arborist check the plans for compliance on tree-related issues.
- Establishment of tree-planting and tree-preservation requirements in subdivision regulations.
- Development and enforcement of standards for tree planting and maintenance in parking lots.
- Monitoring of tree protection and proper planting during site development.
- Acquisition of open space or easements to preserve existing forest in urban areas.
- Metrics to calculate the amount of pollution removed by urban trees and the associated improvement in air quality.

– "Planning the Urban Forest," American Planning Association (2009)

Of course, one powerful motivating force behind municipal action is the weight of regulatory requirements. In particular, two sets of federal regulations – encompassed by the Clean Water Act and the Clean Air Act – present opportunities for making urban forestry part of mandatory compliance. As discussed in **Part II, Setting the Stage,** green infrastructure initiatives, including trees, can be incorporated into specific "best management practices" designed to reduce nonpoint-source pollutants carried by stormwater runoff in order to secure municipal stormwater permits. Enhancing the urban forest may also help attain air quality standards as well as mitigate climate change. Especially in coastal areas, various habitat protection regulations can support urban forestry initiatives.

Cross-Sector Stakeholders

There are a number of creative ways to motivate stakeholders in **the private sector** to take up the urban forestry cause – in addition to appealing to an altruistic sense of community involvement, which is not to be minimized. Possible incentives include such things as stormwater utility credits, certified wildlife habitat designation, building density or height bonuses, streamlined permit review, adjusted setback or parking requirements, and property or impact fee reductions. (See sidebar below for possible regulatory considerations at development sites.)

Regulations for Trees at Development Sites

Depending on local codes and ordinances regulating site design, several regulations may be met by preserving or planting trees at a development site. Additional voluntary or incentive programs may exist that can provide even more reasons to conserve trees, such as tax breaks or density bonuses. This table summarizes regulations related to conserving and planting trees at development sites.

Regulation	Description
Landscaping	Landscaping is typically required in parking lots in the form of a minimum percentage of the total area. Landscaped buffers may also be required to screen parking lots and other land uses from adjacent roads and developments. Street trees may be required along local roads. Conserving existing trees within these locations or planting new ones will meet most landscaping requirements.
Stormwater management	Through a stormwater credit program, developers can get credits for conserving tracts of forest and may be allowed to subtract this area from the total site area when computing stormwater runoff volumes to treat. In addition, required landscape areas can be used for stormwater treatment, meeting both landscaping and stormwater management requirements.
Forest conservation and preservation	Regulations may state that a certain percentage of forest must be preserved at each site or that trees of a certain size must be protected.
Conservation of natural areas	Certain regulations such as stream buffer ordinances and floodplain ordinances may exist that require natural areas such as stream buffers, floodplains, steep slopes, or otherwise unbuildable areas be protected and preserved during development.
Open space design for subdivisions	Requires clustering of homes on a development site to preserve a certain percentage of natural area such as forest.
Canopy requirements	Typically apply to parking lots or street trees and require a certain percentage of canopy cover to be met within a specified timeframe.
Erosion and sediment control	Temporary tree protections devices installed prior to construction can be combined with erosion and sediment control devices and potentially save money.

– "Urban Watershed Forestry Manual," by Center for Watershed Protection for USFS (2005)

Utility companies – including energy providers, but also telephone, cable television, internet, and other service suppliers – present special challenges and opportunities for growing and protecting the urban forest, whether working above or below ground. Proper siting and design of that infrastructure – along with proper selection and maintenance of the trees beneath overhead lines and above waterlines and other underground utilities – can minimize service interruptions, reduce conflicts when repairs or replacements are needed, and avoid barren or unsightly streetscapes.

For example, in the Village of Homer Glen just outside Chicago, long-deferred maintenance of an underground petroleum pipeline resulted in the removal of hundreds of trees from residential neighborhoods in 2007. On the other hand, utility corridors outside of residential areas, whether conveying underground pipes or overhead wires, can afford utility companies opportunities for urban forest stewardship in large and contiguous rights-of-way, which can sometimes double as extensive recreation trails. Transportation corridors can present similar opportunities.

Two particularly useful resources on trees and utilities are the Right-of-Way Stewardship Council (http://www.rowstewardship.org) and the Arbor Day Foundation "Energy-Saving Trees" online mapping tool (http://energysavingtrees.arborday.org).

Another important way to enhance the urban environment while also greatly benefitting the economic and social aspects of the "triple bottom line" is to develop a strong **green jobs workforce.** According to the *Vibrant Cities & Urban Forests* report:

> Providing quality training, employment opportunities, and career pathways in areas related to urban forestry and green infrastructure creates a mutually beneficial situation that can bolster local and regional economies, improve individual and public health and welfare, and promote lasting stewardship practices, even as new public funding may be constrained due to economic and political forces.
>
> There are many ways to generate additional job training, open doors and increase employment opportunities in this sector. Reassessing and repurposing existing programs and resources to expand their mandates to encompass efforts in urban forestry and natural resources management have been proven successful. The private sector can also be further encouraged to incorporate the multiple benefits of trees and sustainability elements into development and redevelopment efforts – necessitating a specialized workforce to create and maintain resulting assets. And, any number of existing jobs can be redefined to emphasize or include better stewardship practices for urban forests and green infrastructure.

Yet another motivational strategy involving multiple cross-sector players is to establish energy efficiency programs that emphasize the use of trees as a best management practice for energy conservation. As noted in the *Vibrant Cities* report, "a number of programs – including new initiatives advocated and supported by municipalities and utilities in collaboration with the Federal Energy Regulatory Commission and the U.S. Department of Energy, as well as state regulatory agencies – are ongoing or anticipated in cities across the country." The City of San Antonio, Texas, for example, offers the Green Shade Tree Rebate Program – a public-private, interagency partnership that rewards homeowners who plant qualified trees in strategic locations with a reimbursement of $50 per tree, for up to three trees.

Needless to say, **elected officials** can have a strong impact on any city program, and urban forestry is no exception. Their influence may be most direct in terms of financial support, which can make or break any municipal initiative. So it's important to build personal political relationships where possible. And even more so, it's essential to galvanize the popular support of the **general citizenry,** which has obvious influence over its elected officials and to some degree its appointed city officials as well, helping to shape public policy and strengthen political backbone where needed.

As noted in the APA's *Planning the Urban Forest,* "Effective urban forestry depends ultimately on the public policy supporting it – financially, administratively, and legally. Mayors and council members shape the programs and lines of authority within departments under which urban forestry programs must operate." By coming at the political realm from all sides, you're more likely to secure the kind of support that transcends a change in administrations, which can pull the rug out from under many initiatives that are identified too closely with a predecessor.

General Principle 3: Seek out Private and Civic Partners

"Ultimately, true success in maintaining the urban forest depends on the continuing support of homeowners, businesses, and leagues of dedicated volunteers in organizations such as local tree trusts. The most effective way to maximize the effectiveness of all private partners in combination is to develop and evolve a comprehensive strategy for programmatic relationships with them, knowing what strengths and capabilities each brings to the overall effort as well as their differences."

- **Volunteers and property owners –** "[At the] neighborhood level, such programs can enlist the active support of block clubs and community organizations interested in improving the livability of their city."

- **Business partners –** "One part of the business community that cannot be ignored is the media—in all forms. Print, broadcast, and electronic media all can play a part in disseminating information and cultivating public support."

– "Planning the Urban Forest," American Planning Association (2009)

Close connections and working relationships with **nonprofit organizations** and **community or neighborhood groups** may be the biggest boon of all, by way of boosting capacity and maintaining the momentum of a popular urban forestry program. Not only can that supply a cadre of energized volunteers and environmental stewards, but it can also provide access to and influence over areas that are outside the direct control of municipal workers – especially in the realm of private property, which typically encompasses most of the urban forest.

Citizen Foresters in Clovis

"The **Citizen Forester Program,** which began in 2011, is intended to educate and promote involvement in urban forestry issues. The program is a collaboration between the City of Clovis, Tree Fresno, the San Joaquin Valley Urban Forests Council, CalFire, PG&E, and the Fresno County Master Gardeners. Participants in the program are educated in tree biology, tree and site selection, tree identification, proper planting and pruning techniques, and basic tree care. Once trained, Citizen Foresters are expected to provide leadership and assistance with tree planting projects and other community urban forest activities."

– City of Clovis (CA) Urban Forest Management Plan 2012

Large private landholders deserve special mention, as individuals can have a disproportionate impact on the urban forest by virtue of their property ownership. Neglected, this sector can be a huge deficit; but properly nurtured, it can become a significant asset. With adequate personal attention, key individuals – people or entities – can be motivated to make decisions and take actions that boost the urban forest in their domain. So it's important to develop outreach that encourages those landholders to embrace citywide goals and objectives through comprehensive tree management plans on their properties. This outreach can involve technical advice, educational materials, and financial incentives.

Environmental Justice in the Urban Forest

Environmental justice is the fair treatment and meaningful involvement of all people regardless of race, color, sex, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies. It emerged as a concept in the United States in the 1980s as a response to the inequitable distribution of environmental burdens. More recently, the concept has been broadened to include inequities regarding urban forest benefits as these benefits have become more quantifiable. Trees provide environmental, economic, and social benefits that should be accessible to all. The extent of tree canopy cover corresponds to the magnitude of benefits provided by trees.

Efforts to address environmental justice have historically focused on remediating environmental burdens such as the clean-up of urban brownfields and industrial wastes. Fewer efforts have been made to increase environmental amenities such as ecosystem services or urban forest benefits. The key to equitable urban forest management is to focus on closing the gap between the neighborhoods or areas with the greatest benefits and those with the greatest need.

Equitable distribution of the resource and the benefits it provides can be measured in a number of ways. For example, using street tree inventory data, stocking level equity can be evaluated at the neighborhood level to determine what gaps exist for the provision of street trees. Urban forest benefits data can be evaluated across council districts to identify the need for particular benefits, such as improved human health or energy savings. Canopy cover data allows for a multitude of geographic analyses using different indicators of equity and environmental justice, such as income levels, race, population density, owner-occupancy rates, asthma rates, obesity rates, etc.

Gaps in urban forest benefits across a community can be identified and those areas can be targeted for urban forestry outreach and strategic planting projects to improve access to the urban forest resource. Incorporating the *need* for benefits into prioritization schemes adds a layer of sophistication to urban forestry management for equity. Measuring the need for benefits should be determined locally, but could include factors such as income inequality, public health rates such as asthma or mortality, or other locally important equity metrics. A composite of important metrics can also be considered along with canopy cover to identify areas with low canopy *and* a high need for tree benefits. For example, ranking each neighborhood in terms of canopy cover, population density, income, and age can reveal important trends in the equitable distribution of urban forest benefits. Each of these rankings can be used to establish a composite score, or overall ranking, which can help prioritize where outreach, support, and planting activities should occur, with the goal of lessening the gap between the areas with the most trees and those that need trees the most. Establishing target variation levels (i.e., how small the gap is) for the tree resource and the provision of benefits, and managing to reach those targets, is an optimal approach to managing the resource in terms of equitable distribution.

Note that the latest **i-Tree** tool, **i-Tree Landscape,** described below, can facilitate prioritization efforts based on socio-economic as well as environmental factors.

Ensuring Equitable Distribution of Resources

As defined by the EPA,

"Environmental Justice is the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies.

It will be achieved when everyone enjoys the same degree of protection from environmental and health hazards and equal access to the decision-making process to have a healthy environment in which to live, learn, and work."

An array of helpful resources on the subject can be found at http://www.epa.gov/environmentaljustice/.

"Outreach Services: Strategies for All Communities," a guidebook from the Alliance for Community Trees, is designed to help you work with diverse population groups in your community: http://actrees.org/resources/tools-for-nonprofits/community-outreach/. As stated on the ACTrees website, "Outreach is critical to sustain and expand programs and activities that engage all community members. New voices, new perspectives, and new populations of community residents bring life to any initiative. Take the opportunity to identify, understand, and involve varied populations when planning and executing any community activity or service."

Tools and Strategies for Engaging the Community

The three resources described in this section can promote a sustainable urban forest in several important ways. The first one, a system known as STEW-MAP, presents a method for tracking, promoting, and engaging local stewardship. The second item, **i-Tree Landscape,** is the latest addition to that suite of free-access urban forest software from the U.S. Forest Service. And finally, the assorted free materials compiled under "Trees Are the Key" (see sidebar) can greatly assist in efforts to communicate your message.

STEW-MAP

The Stewardship Mapping and Assessment Project (STEW-MAP) seeks to answer a big question: In taking care of the urban environment, who is doing what, and where? More specifically, what are the social and spatial interactions among civic groups who conserve, manage, monitor, advocate for, and educate the public about their local surroundings?

Based on a protocol developed by U.S. Forest Service researchers, STEW-MAP yields information-rich maps that display the presence, capacity, geographic turf, and social networks of environmental stewardship groups in a given city. In this way, these social infrastructure data are treated as part of a municipality's green infrastructure asset mapping. The project highlights existing stewardship gaps and overlaps in order to strengthen organizational capacities, enhance citizen monitoring, promote broader public engagement with on-the-ground environmental work, and build effective partnerships between stakeholders involved in urban sustainability.

There are two stages to implementing STEW-MAP. The first involves extensive data collection, in which the organizational population is inventoried, surveyed, and analyzed. This effort yields a database of stewardship organizations in the municipality, maps of where the organizations conduct stewardship activities, and social network analyses of the numbers and types of ties among groups. The second stage involves developing resources and tools to make that data easier to access and use. Collectively, this work is typically accomplished by collaboration among local partners from the study area, university partners, and Forest Service scientists.

To date, the model has been used by several cities to collect information from thousands of local stewardship groups – ranging from neighborhood block associations and kayak clubs, to tree planting groups and regional environmental coalitions, to nonprofit educational institutions and museums. To learn more about STEW-MAP, visit www.stewmap.net and browse these city sites – in particular, New York and Chicago, which are farthest along in the process so far:

Baltimore | Chicago Region | Los Angeles | New York City | Philadelphia | Seattle

i-Tree Landscape

This latest entry the **i-Tree** lineup (www.itreetools.org/landscape) allows you to explore tree canopy, land cover, and basic demographic information in a location of your choosing. With the information provided by **i-Tree Landscape,** you will learn about the benefits of trees in your selected location, see how planting trees will increase the benefits provided, and map the areas where you decide to prioritize your tree planting efforts.

The free web-based tool uses tree cover maps and other data to estimate ecosystem services (such as carbon sequestration, air pollution removal, and avoided stormwater runoff) provided by trees in any given spatial area. For example, you can choose to analyze data within census block groups, counties, congressional districts, watershed boundaries, and more. Data layers that are pre-loaded into **i-Tree Landscape** include tree canopy, impervious cover and other types of land cover (based on 2011 National Land Cover Data and, where available, Urban Tree Canopy Assessments), as well as base layers from Google, Bing, and Open Street Map.

After specifying an area of interest, users assign weights to various prioritization factors – such as tree cover per capita, tree stocking level, and percent of the population living below the poverty line. The tool then automatically maps optimal areas to plant or protect trees to support those factors according to their assigned relative importance. Reports generated can be used to facilitate planning efforts, explore different prioritization scenarios, and promote the benefits of trees to diverse audiences.

Communicating Your Message: "Trees Are the Key" Online Toolkit

To help promote the importance of the urban forest and persuade stakeholders to support and join the cross-sector collaboration, a communications toolkit has been developed by the Sustainable Urban Forests Coalition (SUFC). These free-access tools represent the culmination of a process that began with the release of Vibrant Cities & Urban Forests: A National Call to Action (https://vcuf.files.wordpress.com/2012/11/vcuf_report.pdf). (To read more about the strategic framework these materials are based on, now known as "Vibrant Communities," go to https://vcuf.files.wordpress.com/2013/06/vibrant-cities-plan.pdf.)

In brief, the goals of creating this toolkit are to:

- **Provide common language for discussing urban forestry issues**. Trees and urban forests are highly localized issues, and no "single message" will resonate across the board. These communications tools revolve around a "platform" of the 12 *Vibrant Cities & Urban Forests* recommendations – which encompass the work you're already doing – and strategies for using those recommendations to build on that work.
- **Share communications products that can add value to any size organization**. Both "branded" and "unbranded" copies of most of these materials are posted online. The goal is to enable smaller organizations with limited resources to use the materials "off the shelf," with little or no editing. Larger organizations can customize the materials in any way they choose.
- **Develop tools that can be used to broaden the circle of stakeholders advocating on behalf of urban forests**. These materials are intended to deliver clear and compelling messages to individuals and organizations working on complementary issues. Such areas include public health, economic development, environmental justice, and others. In the toolkit, you will find talking points, slides, and other materials that make the explicit connection between these issues and urban forest advocacy.

NOTE: All content in this toolkit is copyright- and royalty-free. You may use or modify the material in any way that suits your purposes.

– http://treesarethekey.org/trees-are-the-key-online-toolkit/

Regional Collaboration: Developing a Strategy across Borders

Urban forest initiatives developed within municipal boundaries can be greatly enhanced by recognizing the interconnection of ecological systems at the regional scale. After all, air, water, and other environmental features do not observe political boundaries, so what happens on one side of the border is bound to impact the other. While that may seem obvious, the significance of that interdependence is often overlooked. As pointed out in *Planning the Urban Forest: Ecology, Economy, and Community Development,* this deficit "places added emphasis on the importance of multijurisdictional, regional planning and cooperation for effective resource conservation."

Such a region-focused approach can have significant impact and potentially strengthen many local acupunctural efforts that are compatible with regional goals. For example, where improving water quality is a high priority, utilizing a watershed-wide systems approach can mean that regional governmental networks (e.g., a Council of Governments or COG) plan collaboratively to establish an overall tree canopy goal for the region – and to use that regional goal as a framework to set local municipal goals.

In short, a comprehensive framework should reach across municipal, county, and even state political jurisdictions to be most strategic, successful, and sustainable. The following are three examples of regional initiatives that have defied political boundaries with goal-focused prioritization.

Chicago Region Trees Initiative for the Seven-County Metropolitan Area

The Chicago Region Trees Initiative (CRTI) (http://www.mortonarb.org/science-conservation/chicago-region-trees-initiative) was formed to develop and implement a strategy for a healthier urban forest by 2040 and was born out of the leading collaborative efforts of the Morton Arboretum and Openlands, one of the nation's oldest metropolitan conservation organizations. In addition to those two organizations, the Executive Advisory Council of CRTI includes the Chicago Metropolitan Agency for Planning (CMAP), U.S. Forest Service, U.S. Fish and Wildlife Service, Metropolitan Mayors Caucus, Forest Preserve of Cook County, Illinois Landscape Contractors Association, The Nature Conservancy, and Chicago Wilderness (a regional alliance which itself comprises more than 300 organizations). Many other partners – including public and private landowners and managers as well as interested organizations and individuals – are collaborating on the development and implementation of the CRTI strategy and goals.

In 2004, Chicago Wilderness developed a Green Infrastructure Vision with the goal of "having green infrastructure considered on equal footing with traditional infrastructure and capital improvements." The alliance worked closely with CMAP to integrate that goal into the development of the comprehensive regional plan known as GOTO2040, which was intended "to help the seven counties and 284 communities plan together for sustainable prosperity." Ultimately, that collaborative effort led to the inclusion of a proposed green infrastructure network "that follows waterway corridors, expands existing preserves, and creates new preserves in the region."

Another component of the GOTO2040 plan staged the framework for the Chicago Region Trees Initiative.

> "The urban forest of trees that grow in our cities and suburbs needs protection and nurturing so we can harness its many benefits. But first, we need to understand it. To that end, The Morton Arboretum, in cooperation with the U.S. Forest Service, has conducted a tree census, or urban forestry assessment, in the seven-county Chicago region."

The results of the assessment, published in *Urban Trees and Forests of the Chicago Region,* informed the development of an overall strategy and the management programs needed "to integrate forests into plans to improve environmental quality in the Chicago region."[14]

The emphasis on regional strategic visions to support and impact local effort is succinctly captured in *The Role of Our Urban Forest in the Chicago Metropolitan Region's Future,* which points out that the shift to "a new, collaborative regional approach to urban and community forestry is essential for preparing for 2.8 million new residents by 2040."

Here's how the Morton Arboretum described the Chicago Region Trees Initiative, "a strategy to improve the vitality and sustainability of the region's trees," at its summer 2014 launch:

> "… the Arboretum has established a coalition of agency, industry, and community representatives to expand the understanding of the value of the region's trees and to make meaningful tree and forest improvements in the region. …
>
> "The 5-year vision of the Regional Trees Initiative is to ensure that the region's tree population is broadly understood, its collaborative management opportunities are identified and enacted, and a 2040 goal for the population is clearly underway, with interim actions understood and subscribed to by all partners.
>
> "The desired outcome after five years is measurable improvements in the health and vigor of the region's trees. Specific measures and targets will be developed for one- and five-year goals.
>
> "The myriad issues require considerable gathering, analysis and discussion in order to develop a strategy that is pragmatic, actionable, and measurable. Stakeholders across the region, both in the public and private sectors, including public and private landowners, must engage and take ownership in the steps necessary to ensure a healthy forest for the region."[15]

In 2014, Chicago Wilderness and the Morton Arboretum developed the Oak Recovery Plan, an 18-county effort to map remaining oak stands, one acre or larger, and compare these stands to pre-settlement oak populations in order to facilitate development of a strategy to improve the health and vitality of oak ecosystems across this area.

The CRTI Forest Composition Work Group is now gathering public and private tree inventories and Urban Tree Canopy data, and combining this information at the community scale with other mapping and planning efforts, including those described above, to create a meaningful snapshot of the forest composition of the seven-county Chicago region that will enable land managers and owners to make effective decisions. Several other CRTI Work Groups – Tree Stewardship and Planting; Industry and Associations; Trees and Green Infrastructure; Tree Risk Assessment and Management; Education;

Communication; Resources – are compiling and creating materials and training programs to facilitate improved management and care for the regional forest.

Sacramento Greenprint

An effective regional initiative requires not only developing a strategy that crosses jurisdictional boundaries, but also fostering collaborative and complementary efforts by multiple fields of expertise focused on achieving a mutually desirable outcome. In the instance of Sacramento, California, improving the air – both air quality and temperature – was the key driver that ultimately led to an exemplary urban forestry framework model. As reported by the Alliance for Community Trees (ACTrees):

> "Sacramento has consistently ranked poorly in air quality. Because of this and many other benefits of a healthy urban forest, in 2005, Sacramento region elected officials signed on to support the Sacramento Tree Foundation's 'Greenprint.' This regional urban forest initiative seeks to galvanize the Sacramento region around a goal of planting an additional five million trees for substantial improvements in summer peak temperatures and air quality."[16]

Subsequently funded by a $725,000 Federal Congestion Mitigation and Air Quality Improvement (CMAQ) grant, the Sacramento Tree Foundation teamed up with the U.S. Forest Service, the Sacramento Area Council of Governments and the Sacramento, El Dorado, Placer and Feather River Air Districts to study the effect of trees on air pollution. The goal of improving air quality has fostered collaboration across jurisdictions and agencies, where the results of the scientific study grounded and emphasized the regional urban forestry approach, Greenprint, for the Sacramento area.

Ultimately, the Greenprint was adopted by the 22 cities and six counties in the Greater Sacramento Area, with the clear and ambitious vision of serving as "a regional framework designed to build an optimal urban forest in every neighborhood, business district, park, school, and street." A few of the elements guiding implementation are:

- "Our bold vision to enhance the quality of life in our region by expanding the urban forest and maximizing the benefits of trees.
- "Our roadmap for mobilizing and empowering community partners and volunteers to plant 5 million trees in the Sacramento region.
- "Our proud partnerships with elected officials, service and faith groups, businesses, youth, and everyone who will help us reach our goal."

Fundamental to the Sacramento Greenprint, and likely any regional strategic initiative, is the recognition of specific challenges that each jurisdiction may encounter. For that reason, the Sacramento model introduced the creative guiding concept known as Growth Rings, which "represent increasing levels of commitment and benchmarks for progress. There is built-in flexibility for each city and county to determine their particular pathway for achieving progress in each of the growth rings." The provision of incremental stages along the path for each locale allows for emphasis to be placed locally within the context of the regional goal.

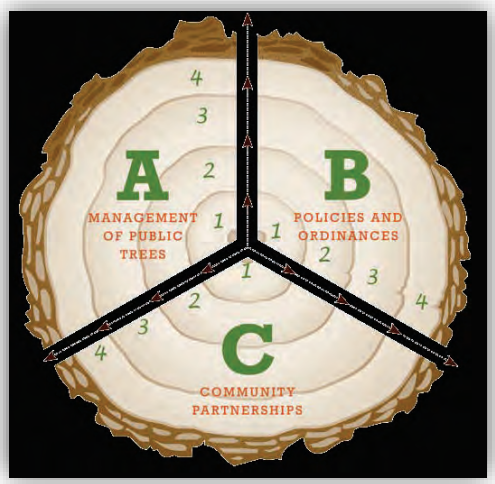

Figure 10. Sacramento Greenprint's three "Growth Rings."

Greenprint Goals for Growth

Sacramento's Greenprint established growth goals for three key areas, along with steps to align local efforts. Here are a few key actions within each area:

1. **Management of Public Trees**
   - Conduct an urban forest value assessment.
   - Convene interdepartmental urban forest stakeholder working group.
   - Adopt an urban forest master plan.
   - Form an urban forest department/hire an urban forest coordinator.
   - Conduct biannual urban forest department evaluations.

2. **Policies and Ordinances**
   "The Greenprint Clearinghouse will provide information, guidance, and workshops to develop model policies and ordinances that can be adopted throughout the region. This approach offers consistency throughout the region, creating a regional approach to the protection, replacement, and mitigation of trees."
   - Adopt street and park tree protection ordinance/policy.
   - Adopt street, median, and parking lot design guidelines.
   - Implement sustainable funding for urban forest activities.
   - Develop comprehensive urban forest ordinance components.
   - Adopt urban forest goals in the general plan and community plans.

3. **Community Partnerships**
   "The most significant element to creating a healthy urban forest is the role played by private property owners and volunteers, because 80 percent of the urban forest is located on private land. Cities and counties that create partnerships with their community members and businesses are more likely to succeed in their urban forest plans and programs."
   - Sponsor community and neighborhood tree plantings.
   - Conduct media events for tree projects and Greenprint milestones.
   - Develop and implement private partnership tree planting and grant programs.
   - Create partnerships with school districts for tree plantings.
   - Support NeighborWoods groups to develop neighborhood-level urban forest plans.

Wisconsin Statewide Urban Forest Strategy

The Wisconsin Department of Natural Resources (WDNR) is an example of a state agency that has developed multi-faceted initiatives that weave local and regional strategies together for a cohesive approach to urban forestry.

> "The WDNR provides urban forestry technical, financial, and promotional assistance to local and tribal governments along with nonprofit organizations through its Urban Forestry Working Group. Led by a State coordinator, a grant manager, six regional coordinators, and six half-time specialists, statewide policy development and implementation are managed with a team approach in partnership with the Wisconsin Urban Forestry Council."

The collective expertise found on the Wisconsin Urban Forestry Council strengthens the voice for urban forestry advocacy, and serves as "an advisory committee to the WDNR consisting of 24 representatives from the green industry, government agencies, municipalities, and nonprofit and trade organizations." (Information on the Urban Forestry Council for each state can be found at http://actrees.org/uncategorized/urban-forest-council-profiles/.)

Working Well in Wisconsin

The Wisconsin Urban Forestry Council (WUFC) has been integral in fostering partnerships and advancing implementation, as well as exploring the reciprocity of challenges and opportunities. Here, for example, is one matched set:

Challenge: Operating at the canopy level. "The DNR strategic direction shifts the urban forestry program focus to a 'community canopy' model. This task shifts the focus from the approximately 15% forest managed by municipalities to include the additional 85% privately controlled tree population. This represents a fundamental shift in scale and policy. The focus of scale is moving from local to regional, state, and multi-state scale."

Opportunity: Creating a greater impact. "Operating at the canopy level will create a greater overall impact to our state. More than ever before the State will need to grow networks and partnerships at the regional, state and multi-state scale. Operating at this larger canopy scale will result in greater environmental benefits for all citizens and greater economic benefits for private sector small businesses."

– WUCF 2013

The framework of WDNR also engages the regional and local communities' efforts through its Urban Forestry Working Group. This approach of funneling strategies from state, to regional, to local requires "networking efforts [that] continue to strengthen due to the numerous municipal networking group meetings and conversations … with a total of over 200 members, which include municipal tree managers and representatives from utility companies, universities, private consulting firms, and nonprofit organizations."

Many local jurisdictions across the country are challenged with allocating financial resources to additional infrastructural projects, and thus being able to reach across the boundary to a state agency for improving the local environment is a demonstration of the need for local and regional connectivity and alignment. The WDNR Urban Forests Division offers three tiers of grant funding to support local initiatives:

- **Regular grants –** to support new and/or innovative projects
- **Startup grants –** for communities to start, or restart, urban forestry programs
- **Catastrophic Storm grants –** to fund repair, removal, and replacement following a catastrophic event

Part VI – Conducting the Evaluation: Measuring Success

Aim for These Targets

In order to move toward a more sustainable urban forest, you first have to take stock of where you are on a number of criteria, or "targets." As detailed below, those targets are arranged in three categories:

1. **Trees and Forest –** Targets related to the status of the vegetation resource itself and/or knowledge of that resource.
2. **Community Framework –** The necessary engagement of stakeholders at all levels, and collaboration among them.
3. **Resource Management Approach –** Plans, practices, and policies to improve and sustain the forest resource.

In the material that follows, you'll find a brief discussion of each target, including information on how to evaluate your current status. The evaluation process involves measuring each target's **key objective** against four **performance indicators** – ranked Low, Fair, Good, and Optimal.

Of course, in practice, some items may not fit perfectly within each rating or you may not be able to get the level of detailed data specified. In those cases, don't get too hung up on precise indicator metrics. Instead, focus on the basic concept and the overall level of performance each rating represents. This is not intended to be an external "audit" for independent certification purposes; rather, it is a platform for assessing a wide range of important elements in order to identify needs and opportunities, and then determine where best to focus efforts and limited resources for improvement over time.

The evaluation itself can be conducted by any number of people, since various individuals may be the keepers of the necessary knowledge in your community. You might assemble a team of those who are in a position to hold different pieces of information or have important perspectives on various elements in one or more of the many targets. This can include municipal staff, community groups, individual citizens, and even outside consultants, where helpful. As you'll see, certain targets may have no single "right answer," so different perspectives may be all the more illuminating.

In conducting this evaluation, remember that the goal is to set a baseline position on each target, in order to identify gaps as well as assets and areas of achievement. The evaluation process can then be repeated periodically to track progress over time. While extensive, the process is intended to be relatively straightforward, based on readily available information wherever possible. The approach also allows for flexibility on goals and actions, and is intended for use by communities of any size and in any location. Many of the targets and metrics are designed for entire municipalities – whether small villages or large cities – but with a little creativity, they can also be modified, adapted, or skipped altogether as appropriate to suit other large land areas, such as an arboretum, neighborhood, college or corporate campus, or other properties that are being managed in the context of sustainable urban forestry – even at the county or regional level.

Acknowledgement: The targets and assessment method presented here are built upon the seminal work of Clark et al (1997)[17] as well as revisions made by Kenney et al (2011).[18] Specifics have been modified extensively throughout, and other targets have been added to the mix as well. The entire evaluation has been developed and revised in close consultation with a "Targets & Metrics Team" led by Michael Leff (Davey Institute/USFS) and composed of Jim Clark (HortScience, Inc.), Andy Kenney (University of Toronto), Ed Macie (USFS Urban Forestry South), and Joe Gregory (Davey Resource Group).

Figure 11. The Targets & Metrics Team at Morton Arboretum. (Left to right: Andy Kenney, Joe Gregory, Jim Clark, Michael Leff, Ed Macie)

Category:	Trees and Forest	Page
Targets:	T1 – Relative tree canopy cover	50
	T2 – Age diversity (Size class distribution)	51
	T3 – Species diversity	53
	T4 – Species suitability	54
	T5 – Publicly owned trees (trees managed “intensively”)	55
	T6 – Publicly owned natural areas (trees managed “extensively”)	56
	T7 – Trees on private property	57
Category:	**Community Framework**	
Targets:	C1 – Municipal agency cooperation	58
	C2 – Utilities cooperation	59
	C3 – Green industry cooperation	60
	C4 – Involvement of large private and institutional landholders	61
	C5 – Citizen involvement and neighborhood action	62
	C6 – General appreciation of trees as a community resource	63
	C7 – Regional collaboration	64
Category:	**Resource Management Approach**	
Targets:	R1 – Tree inventory	65
	R2 – Canopy cover assessment and goals	66
	R3 – Environmental justice and equity	67
	R4 – Municipality-wide urban forest management plan	68
	R5 – Municipality-wide urban forestry funding	69
	R6 – Municipal urban forestry program capacity	70
	R7 – Tree establishment planning and implementation	71
	R8 – Growing site suitability	72
	R9 – Tree protection policy development and enforcement	73
	R10 – Maintenance of publicly owned, “intensively” managed trees	74
	R11 – Management of publicly owned natural areas	75
	R12 – Tree risk management	76
	R13 – Urban wood and green waste utilization	77
	R14 – Native vegetation	78

Trees and Forest

Target T1: Relative Tree Canopy Cover

Key objective: Achieve desired degree of tree cover, based on potential or according to goals set for entire municipality and for each neighborhood or land use.

Performance indicators:

Low – The existing canopy cover for entire municipality is <50% of the desired canopy.
Fair – The existing canopy is 50%-75% of desired.
Good – The existing canopy is >75%-100% of desired.
Optimal – The existing canopy is >75%-100% of desired – at individual neighborhood level as well as overall municipality.

Notes:

- With the tools and methods discussed in **Part III** and **Part IV** (see **"X-refs"** below), you can calculate the relative value of "existing" canopy as a percentage of "desired" – at the overall and neighborhood level – and note your performance rating accordingly, as in the following example. (You can also rate your overall effectiveness at utilizing these methods and measures to drive urban forest policy and practice. See **Target R2,** referenced below.)

- Ideally, a community would strive to achieve 100% of what it has deemed to be best suited to its circumstances and needs – whatever that level may be. For example, if a community determines that its tree canopy cover should be 30% of total land cover, and its existing canopy is 20%, it would fall into the "Fair" rating category, since its existing canopy equals two-thirds (or 66%) of the desired level.

X-refs:

- **Part III, Covering the Canopy**
- **Part IV, Gathering the Information** / Forest Resource Assessments / Bottom-Up: Field-Based Assessments
- **Part IV, Gathering the Information** / Forest Resource Assessments / Top-Down: Tree Canopy Assessments
- **Part VI, Conducting the Evaluation** / Target R2 "Canopy cover assessment and goals"
- **Appendix A, Resources** / Urban Forest Management Plans (UFMP) / i-Tree Assessment Reports

Trees and Forest

Target T2: Age Diversity (size class distribution)

Key objective: Provide for ideal uneven age distribution of all "intensively" (or individually) managed trees – municipality-wide as well as at neighborhood level.

Performance indicators:

Low – Even-age distribution, or highly skewed toward a single age class (maturity stage) across entire population.
Fair – Some uneven distribution, but most of the tree population falls into a single age class.
Good – Total tree population across municipality approaches an ideal age distribution of 40% juvenile, 30% semi-mature, 20% mature, and 10% senescent.
Optimal – Total population approaches that ideal distribution municipality-wide as well as at the neighborhood level.

Notes:

- **Definition:** Trees managed individually, such as street trees, are considered to be "managed *intensively,"* according to arboricultural techniques – whereas trees in woodlands or other natural areas are typically "managed *extensively,"* as a group, according to silvicultural practices. Park trees or trees on institutional campuses can fall into either category, depending on how they are managed.

- Generally, the most accurate way to gauge age diversity is to compare current tree size in each species (in terms of diameter at breast height, or DBH) to the maximum diameter *for that species.* The goal would then be to maintain a tree population that is unevenly distributed among different age classes, as described in the table below.

- There are several possible sources of species-specific maximum DBH values, including literature review as well as local experience and judgment. If an extensive tree inventory has been conducted, that could help guide the development of reasonable maximums. Once maximum values have been established for each species, the ratio between actual diameter and maximum diameter can then be expressed as Relative Diameter at Breast Height (RDBH). However, while no generic size categories match every tree species, for purposes of setting goals and evaluating performance you could assign the four age classes (stages of maturity) to overall size ranges roughly as follows:

Age Class / Maturity Stage	Average Size (DBH)	Ideal Distribution
Juvenile	0-8"	40%
Semi-mature	>8-16"	30%
Mature	>16-24"	20%
Senescent	>24"	10%

[Source: Richards, N.A., 1982/1983.Diversity and stability in a street tree population. Urban Ecology 7, 159–171 – as cited in McPherson, Urban Forestry & Urban Greening 12 (2013) 134– 143.]

- For overall population stability, the number of newly planted or young trees must exceed the losses of death, removal, and maturity municipality-wide and neighborhood-wide. In addition, the higher proportion of smaller/younger trees is needed to offset establishment-related mortality.

- Although this particular target is aimed specifically at public trees managed individually, such as street trees, it is of course also important to strive for age diversity across the entire tree population – including public trees managed "extensively" (as a group) in parks and natural areas, as well as trees on private property. However, it is generally not possible to gauge age or size diversity across all land uses, and the management considerations vary widely.

X-refs:

- **Part IV, Gathering the Information** / Forest Resource Assessments / Bottom-Up: Field-Based Assessments
- **Part VI, Conducting the Evaluation** / Target R1 "Tree inventory"
- **Part VII, Developing & Implementing the Plan** / Assessing Risk and Planning for Change / Natural lifecycle changes
- **Appendix A, Resources** / Urban Forest Management Plans (UFMP)
- **Appendix A, Resources** / Natural areas management plans
- **Appendix A, Resources** / Urban & Community Forestry / State guide for U&CF contacts and resources

Trees and Forest

Target T3: Species Diversity

Key objective: Establish a genetically diverse tree population across municipality as well as at the neighborhood level.

Performance indicators:

Low – Five or fewer species dominate the entire tree population across municipality.
Fair – No single species represents more than 10% of total tree population; no genus more than 20%; and no family more than 30%.
Good – No single species represents more than 5% of total tree population; no genus more than 10%; and no family more than 15%.
Optimal – At least as diverse as "Good" rating (5/10/15) municipality-wide – ***and*** at least as diverse as "Fair" (10/20/30) at the neighborhood level.

Notes:

- Ideally, the array and location of suitable tree species would be so diverse that no single species would represent more than 5% of the tree population across the municipality or more than 10% in any given neighborhood. In a worst-case scenario, the entire municipality's forest would be dominated by no more than a handful of species.

X-refs:

- **Part IV, Gathering the Information** / Forest Resource Assessments / Bottom-Up: Field-Based Assessments
- **Part VI, Conducting the Evaluation** / Target R1 "Tree inventory"
- **Part VII, Developing & Implementing the Plan** / Assessing Risk and Planning for Change / Natural lifecycle changes
- **Appendix A, Resources** / Urban Forest Management Plans (UFMP)
- **Appendix A, Resources** / Natural areas management plans
- **Appendix A, Resources** / Urban & Community Forestry / State guide for U&CF contacts and resources

Trees and Forest

Target T4: Species Suitability

Key objective: Establish a tree population suited to the urban environment and adapted to the overall region.

Performance indicators:

Low – Fewer than 50% of all trees are from species considered suitable for the area.
Fair – >50%-75% of trees are from species suitable for the area.
Good – More than 75% of trees are suitable for the area.
Optimal – Virtually all trees are suitable for the area.

Notes:

- In addition to **"Age diversity" (Target T2)** and **"Species diversity" (T3)**, another component of protective tree diversity is **"Species suitability" (T4),** which involves selecting a broad array of species well suited to the urban and regional environment. Tree species suitability can be determined by consulting published guidelines that may exist for your region (search online for recommended species for urban sites in your hardiness zone) or through local experience and expert opinion. Either way, the determination should take into account concerns such as adaptability to local climate, invasive potential, soils, moisture demands, and management considerations.

- Obviously, the greater the proportion of suitable tree species, the better. For evaluation purposes, "Low" performance would be a case where fewer than half of all trees represent species considered suitable for the setting, and the best-case "Optimal" scenario would be one where virtually all trees are suitable.

X-refs:

- **Part IV, Gathering the Information** / Forest Resource Assessments / Bottom-Up: Field-Based Assessments
- **Part VI, Conducting the Evaluation** / Target R1 "Tree inventory"
- **Appendix A, Resources** / Urban Forest Management Plans (UFMP)
- **Appendix A, Resources** / Natural areas management plans
- **Appendix A, Resources** / Urban & Community Forestry / State guide for U&CF contacts and resources

Trees and Forest

Target T5: **Publicly Owned Trees (trees managed "intensively")**

Key objective: Current and detailed understanding of the condition and risk potential of all publicly owned trees that are managed intensively (or individually).

Performance indicators:

Low – Condition of urban forest is unknown.
Fair – Sample-based tree inventory indicating tree condition and risk level.
Good – Complete tree inventory that includes detailed tree condition ratings.
Optimal – Complete tree inventory that is GIS-based and includes detailed tree condition as well as risk ratings.

Notes:

- **Definition:** Trees managed individually, such as street trees, are considered to be "managed *intensively,"* according to arboricultural techniques – whereas trees in woodlands or other natural areas are typically "managed *extensively,"* as a group, according to silvicultural practices. Park trees or trees on institutional campuses can fall into either category, depending on how they are managed.

X-refs:

- **Part IV, Gathering the Information** / Forest Resource Assessments / Bottom-Up: Field-Based Assessments
- **Part VI, Conducting the Evaluation** / Target R1 "Tree inventory"
- **Part VI, Conducting the Evaluation** / Target R10 "Maintenance of publicly owned, "intensively" managed trees"
- **Appendix A, Resources** / Urban Forest Management Plans (UFMP) / i-Tree Assessment Reports

Trees and Forest

Target T6: Publicly Owned Natural Areas (trees managed "extensively")

Key objective: Detailed understanding of the ecological structure and function of all publicly owned natural areas (such as woodlands, ravines, stream corridors, etc.), as well as usage patterns.

Performance indicators:

Low – No information about publicly owned natural areas.
Fair – Publicly owned natural areas identified in a "natural areas survey" or similar document.
Good – Survey document also tracks level and type of public use in publicly owned natural areas.
Optimal – In addition to usage patterns, ecological structure and function of all publicly owned natural areas are also assessed and documented.

Notes:

- **Definition:** Trees managed individually, such as street trees, are considered to be "managed *intensively,"* according to arboricultural techniques – whereas trees in woodlands or other natural areas are typically "managed *extensively,"* as a group, according to silvicultural practices. Park trees or trees on institutional campuses can fall into either category, depending on how they are managed.

X-refs:

- **Part IV, Gathering the Information** / Forest Resource Assessments / Bottom-Up: Field-Based Assessments
- **Part VI, Conducting the Evaluation** / Target R11 "Management of publicly owned natural areas"
- **Appendix A, Resources** / Urban Forest Management Plans (UFMP) / i-Tree Assessment Reports

Trees and Forest

Target T7: Trees on private property

Key objective: Understanding of extent, location, and general condition of privately owned trees across the urban forest.

Performance indicators:

Low – No information about privately owned trees.
Fair – Aerial, point-based assessment of trees on private property, capturing overall extent and location.
Good – Bottom-up, sample-based assessment of trees on private property, as well as basic aerial view (as described in "Fair" rating).
Optimal – Bottom-up, sample-based assessment on private property, as well as detailed Urban Tree Canopy (UTC) analysis of entire urban forest, integrated into municipality-wide GIS system.

Notes:

- With the tools and methods discussed in **Part III** and **Part IV** (see **"X-refs"** below), you can gain an understanding of trees across the entire urban forest, including on private property. (You can also rate your overall effectiveness at utilizing these methods and measures to drive urban forest policy and practice. See **Target R2,** referenced below.)

X-refs:

- **Part III, Covering the Canopy** /
- **Part IV, Gathering the Information** / Forest Resource Assessments / Bottom-Up: Field-Based Assessments
- **Part IV, Gathering the Information** / Forest Resource Assessments / Top-Down: Tree Canopy Assessments
- **Part VI, Conducting the Evaluation** / Target R2 "Canopy cover assessment and goals"
- **Appendix A, Resources** / Urban Forest Management Plans (UFMP) / i-Tree Assessment Reports
- **Appendix A, Resources** / Private property tree programs
- **Appendix A, Resources** / Educational materials, promotion, and outreach

Community Framework

Target C1: Municipal agency cooperation

Key objective: All municipal departments and agencies cooperate to advance goals related to urban forest issues and opportunities.

Performance indicators:

Low – Municipal departments/agencies take actions impacting urban forest with no cross-departmental coordination or consideration of the urban forest resource.

Fair – Municipal departments/agencies recognize potential conflicts and reach out to urban forest managers on an *ad hoc* basis – and vice versa.

Good – Informal teams among departments and agencies communicate regularly and collaborate on a project-specific basis.

Optimal – Municipal policy implemented by formal interdepartmental/interagency working teams on all municipal projects.

Notes:

- For purposes of this evaluation, public school districts are considered to be a type of institutional landholder, covered by **Target C4 "Involvement of large private and institutional landholders."**

X-refs:

- **Part V, Constructing the Community Framework**/ Internal Municipal Stakeholders and Relationships
- **Appendix A, Resources** / Municipal urban forestry policies
- **Appendix A, Resources** / Municipal tree boards/shade tree commissions

Community Framework

Target C2: Utilities Cooperation

Key objective: All utilities – above and below ground – employ best management practices and cooperate with municipality to advance goals and objectives related to urban forest issues and opportunities.

Performance indicators:

Low – Utilities take actions impacting urban forest with no municipal coordination or consideration of the urban forest resource.

Fair – Utilities employ best management practices, recognize potential municipal conflicts, and reach out to urban forest managers on an *ad hoc* basis – and vice versa.

Good – Utilities are included in informal municipal teams that communicate regularly and collaborate on a project-specific basis.

Optimal – Utilities help advance urban forestry goals and objectives by participating in formal interdepartmental/interagency working teams on all municipal projects.

Notes:

- This assessment should encompass *all* utilities – both above and below ground – including electric, gas, water, cable, telephone, fiber optics, etc.
- Utilities are required to follow ANSI A300 standards for managing vegetation – including pruning branches, protecting roots, and performing overall management of trees and other vegetation that could impact their services. Municipal policies may also regulate certain utility management practices, such as overhead line clearance.

X-refs:

- **Part V, Constructing the Community Framework**/ Cross-Sector Stakeholders / Utility companies
- **Appendix A, Resources** / Urban Forest Management Plans (UFMP)
- **Appendix A, Resources** / Municipal urban forestry policies
- **Appendix A, Resources** / Specifications and standards

Community Framework

Target C3: Green Industry Cooperation

Key objective: Green industry works together to advance municipality-wide urban forest goals and objectives, and adheres to high professional standards.

Performance indicators:

Low – Little or no cooperation among segments of green industry or awareness of municipality-wide urban forest goals and objectives.

Fair – Some cooperation among green industry as well as general awareness and acceptance of municipality-wide goals and objectives.

Good – Specific collaborative arrangements across segments of green industry in support of municipality-wide goals and objectives.

Optimal – Shared vision and goals and extensive committed partnerships in place. Solid adherence to high professional standards.

Notes:

- The "green industry" is understood to encompass all professions and businesses that routinely support or engage in tree and vegetation management activities. Among others, these can include landscapers, nurseries, garden centers, contractors, maintenance professionals, tree care companies, landscape architects, foresters, planners, even developers.
- Utilities are assigned to a separate assessment, under **Target C2 "Utilities cooperation."**
- Close cooperation with the green industry presents an excellent opportunity for municipal urban forest managers to influence management of the forest resource on private property.

X-refs:

- **Part V, Constructing the Community Framework**/ Cross-Sector Stakeholders
- **Appendix A, Resources** / Urban Forest Management Plans (UFMP)
- **Appendix A, Resources** / Municipal urban forestry policies
- **Appendix A, Resources** / Green jobs training
- **Appendix A, Resources** / Specifications and standards

Community Framework

Target C4: Involvement of Large Private and Institutional Landholders

Key objective: Large private landholders embrace and advance municipality-wide urban forest goals and objectives by implementing specific resource management plans.

Performance indicators:

Low – Large private landholders are generally uninformed about urban forest issues and opportunities.

Fair – Municipality conducts outreach directly to landholders with educational materials and technical assistance, providing clear goals and incentives for managing their tree resource.

Good – Landholders develop comprehensive tree management plans (including funding strategies) that advance municipality-wide urban forest goals.

Optimal – As described in "Good" rating, plus active community engagement and access to the property's forest resource.

Notes:

- For purposes of this evaluation, public school districts are considered to be a type of institutional landholder – not a type of municipal agency, covered by **Target C1 "Municipal agency cooperation."**
- See the Arbor Day Foundation's "Tree Campus USA" program for suggested standards and strategies: http://www.arborday.org/programs/treecampususa/index.cfm

X-refs:

- **Part V, Constructing the Community Framework**/ Cross-Sector Stakeholders / Large private landholders
- **Appendix A, Resources** / Private property tree programs
- **Appendix A, Resources** / Educational materials, promotion, and outreach
- **Appendix A, Resources** / Municipal urban forestry policies

Community Framework

Target C5: Citizen Involvement and Neighborhood Action

Key objective: At the neighborhood level, citizens participate and groups collaborate with the municipality and/or its partnering NGOs in urban forest management activities to advance municipality-wide plans.

Performance indicators:

Low – Little or no citizen involvement or neighborhood action.
Fair – Some neighborhood groups engaged in advancing urban forest goals, but with little or no overall coordination with or direction by municipality or its partnering NGOs.
Good – Many active neighborhood groups engaged across the community, with actions coordinated or led by municipality and/or its partnering NGOs.
Optimal – Proactive outreach and coordination efforts by municipality and NGO partners resulting in widespread citizen involvement and collaboration among active neighborhood groups engaged in urban forest management.

Notes: N/A

X-refs:

- **Part V, Constructing the Community Framework**/ Cross-Sector Stakeholders
- **Part V, Constructing the Community Framework**/ STEW-MAP: Visualizing – and Engaging – Stewardship across the Urban Landscape
- **Appendix A, Resources** / Urban Forest Management Plans (UFMP)
- **Appendix A, Resources** / Community tree programs
- **Appendix A, Resources** / Private property tree programs
- **Appendix A, Resources** / Educational materials, promotion, and outreach

Community Framework

Target C6: General Appreciation of Trees as a Community Resource

Key objective: Stakeholders from all sectors and constituencies within municipality – private and public, commercial and nonprofit, entrepreneurs and elected officials, community groups and individual citizens – understand, appreciate, and advocate for the role and importance of the urban forest as a resource.

Performance indicators:

Low – General ambivalence or negative attitudes about trees, which are perceived as neutral at best or as the source of problems. Actions harmful to trees may be taken deliberately.

Fair – Trees generally recognized as important and beneficial.

Good – Trees widely acknowledged as providing environmental, social, and economic services – resulting in some action or advocacy in support of the urban forest.

Optimal – Urban forest recognized as vital to the community's environmental, social, and economic well-being. Widespread public and political support and advocacy for trees, resulting in strong policies and plans that advance the viability and sustainability of the entire urban forest.

Notes:

- *"Having public agencies, private landholders, the green industry, and neighborhood groups all share the same vision of the city's urban forest is a crucial part of sustainability. This condition is not likely to result from legislation. It will only result from a shared understanding of the urban forest's value to the community and commitment to dialogue and cooperation among the stakeholders."* – Clark et al, 1997
- There are many ways to gauge and demonstrate that sort of full-spectrum support. Possibilities include organizing popular Arbor Day celebrations, presenting recognition awards to businesses and elected officials, achieving Tree City USA designation, offering municipal programs that address problems (real or perceived) caused by trees, holding successful tree giveaways, and so on.

X-refs:

- **Part V, Constructing the Community Framework**
- **Part V, Constructing the Community Framework**/ Cross-Sector Stakeholders
- **Part V, Constructing the Community Framework**/ STEW-MAP: Visualizing – and Engaging – Stewardship across the Urban Landscape
- **Appendix A, Resources** / Community tree programs
- **Appendix A, Resources** / Educational materials, promotion, and outreach

Community Framework

Target C7: Regional Collaboration

Key objective: Cooperation and interaction on urban forest plans among neighboring municipalities within a region, and/or with regional agencies.

Performance indicators:

Low – Municipalities have no interaction with each other or the broader region. No regional planning or coordination on urban forestry.

Fair – Some neighboring municipalities and regional agencies share similar policies and plans related to trees and urban forest.

Good – Some urban forest planning and cooperation across municipalities and regional agencies.

Optimal – Widespread regional cooperation resulting in development and implementation of regional urban forest strategy.

Notes:

- By way of example, regional disaster management planning follows this type of model – and some funders require regional cooperation.

X-refs:

- **Part V, Constructing the Community Framework** / Regional Collaboration: Developing a Strategy across Borders
- **Appendix A, Resources** / Urban Forest Management Plans (UFMP)
- **Appendix A, Resources** / Regional and statewide plans

Resource Management Approach

Target R1: **Tree Inventory**

Key objective: Current and comprehensive inventory of tree resource to guide its management, including data such as age distribution, species mix, tree condition, and risk assessment.

Performance indicators:

Low – No inventory.
Fair – Complete or sample-based inventory of publicly owned trees.
Good – Complete inventory of publicly owned trees and sample-based privately owned trees that is guiding management decisions.
Optimal – Systematic comprehensive inventory system of entire urban forest – with information tailored to users and supported by mapping in municipality-wide GIS system.

Notes: N/A

X-refs:

- **Part IV, Gathering the Information** / Forest Resource Assessments / Bottom-Up: Field-Based Assessments
- **Appendix A, Resources** / Urban Forest Management Plans (UFMP)
- **Appendix A, Resources** / Urban Forest Management Plans (UFMP) / i-Tree Assessment Reports
- **Appendix A, Resources** / Citywide urban forest GIS

Resource Management Approach

Target R2: Canopy Cover Assessment and Goals

Key objective: Urban forest policy and practice driven by accurate, high-resolution, and recent assessments of existing and potential canopy cover, with comprehensive goals municipality-wide and at neighborhood or smaller management level.

Performance indicators:

Low – No assessment or goals.
Fair – Low-resolution and/or point-based sampling of canopy cover using aerial photographs or satellite imagery – and limited or no goal-setting.
Good – Complete, detailed, and spatially explicit, high-resolution Urban Tree Canopy (UTC) assessment based on enhanced data (such as LiDAR) – accompanied by comprehensive set of goals by land use and other parameters.
Optimal – As described for "Good" rating – and all utilized effectively to drive urban forest policy and practice municipality-wide and at neighborhood or smaller management level.

Notes:

- For such an assessment to be most valuable and effective, it must be maintained, repeated at regular intervals, utilized in a municipality-wide GIS system, and made freely available to public users.

X-refs:

- **Part III, Covering the Canopy**
- **Part IV, Gathering the Information** / Forest Resource Assessments / Top-Down: Tree Canopy Assessments
- **Part VI, Conducting the Evaluation** / Target T1 "Relative tree canopy cover"
- **Appendix A, Resources** / Urban Forest Management Plans (UFMP)
- **Appendix A, Resources** / Urban Forest Management Plans (UFMP) / i-Tree Assessment Reports
- **Appendix A, Resources** / Citywide urban forest GIS

Resource Management Approach

Target R3: Environmental Justice and Equity

Key objective: Ensure that the benefits of urban forests are made available to all, especially to those in greatest need of tree benefits.

Performance indicators:

Low – Tree planting and outreach is not determined equitably by canopy cover or need for benefits.
Fair – Planting and outreach includes attention to low canopy neighborhoods or areas.
Good – Planting and outreach targets neighborhoods with low canopy and a high need for tree benefits.
Optimal – Equitable planting and outreach at the neighborhood level is guided by strong citizen engagement in those low-canopy/high-need areas.

Notes: N/A

X-refs:

- **Part IV, Gathering the Information** / Forest Resource Assessments / Top-Down: Tree Canopy Assessments
- **Part V, Constructing the Community Framework** / Environmental Justice in the Urban Forest
- **Appendix A, Resources** / Urban Forest Management Plans (UFMP)
- **Appendix A, Resources** / Community tree programs
- **Appendix A, Resources** / Educational materials, promotion, and outreach

Resource Management Approach

Target R4: Municipality-Wide Urban Forest Management Plan

Key objective: Develop and implement a comprehensive urban forest management plan for public and private property.

Performance indicators:

Low – No plan.
Fair – Existing plan limited in scope and implementation.
Good – Recent comprehensive plan developed and implemented for publicly owned forest resources, including trees managed intensively (or individually) and those managed extensively, as a population (e.g., trees in natural areas).
Optimal – Strategic, multi-tiered plan with built-in adaptive management mechanisms developed and implemented for public and private forest resources.

Notes:

- Especially considering climate change and the increasing frequency and intensity of extreme weather events, a comprehensive urban forest management plan must include plans for preparation, multi-agency response, and recovery from natural disasters.

X-refs:

- **Part VII, Developing & Implementing the Plan**
- **Appendix A, Resources** / Urban Forest Management Plans (UMFP)
- **Appendix A, Resources** / Emergency and disaster plans
- **Appendix A, Resources** / Specifications and standards

Resource Management Approach

Target R5: **Municipality-wide Urban Forestry Funding**

Key objective: Develop and maintain adequate funding to implement municipality-wide urban forest management plan.

Performance indicators:

Low – Little or no dedicated funding.
Fair – Funding only for emergency, reactive management.
Good – Funding sufficient for some proactive management based on urban forest management plan.
Optimal – Sustained funding from public and private sources to fully implement comprehensive urban forest management plan.

Notes: N/A

X-refs:

- **Part VII, Developing & Implementing the Plan** / Assessing Risk and Planning for Change / Budget cycles and other economic considerations
- **Appendix A, Resources** / Urban Forest Management Plans (UMFP)
- **Appendix A, Resources** / Educational materials, promotion, and outreach
- **Appendix A, Resources** / Municipal urban forest budget
- **Appendix A, Resources** / Municipal urban forest staffing
- **Appendix A, Resources** / Funding sources

Resource Management Approach

Target R6: **Municipal Urban Forestry Program Capacity**

Key objective: Maintain sufficient well-trained personnel and equipment – whether in-house or through contracted or volunteer services – to implement municipality-wide urban forest management plan.

Performance indicators:

Low – Team severely limited by lack of personnel and/or access to adequate equipment. Unable to perform adequate maintenance, let alone implement new goals.
Fair – Team limited by lack of ***trained*** staff and/or access to adequate equipment.
Good – Team able to implement ***many*** of the goals and objectives of the urban forest management plan.
Optimal – Team able to implement ***all*** of the goals and objectives of the urban forest management plan.

Notes:

- A sustainable urban forest requires a well-trained group of professionals to plan and execute the goals and objectives of an urban forest management plan. This team may consist entirely of municipal staff, but most often it includes a mix of staff, contractors, nonprofit groups that support a particular facility, and nonprofits that provide services such as tree planting and early care.

- Whatever the composition of the team, members must be trained and maintain the appropriate industry credentials. Examples include International Society of Arboriculture (ISA) certifications, ISA tree risk assessment qualification, the American Society of Consulting Arborists registered consulting arborist, and Tree Care Industry Association certified safety professional. In addition to those industry standards, team members should pursue continuing education and professional development through high-quality training programs designed for their particular role on the team.

- Aside from people, a high-performing team must also have up-to-date, well-maintained equipment, which can range from field computers and software to chainsaws or large lift trucks.

X-refs:

- **Part V, Constructing the Community Framework**
- **Part V, Constructing the Community Framework** / Why Collaborate?
- **Part V, Constructing the Community Framework** / Internal Municipal Stakeholders and Relationships
- **Part V, Constructing the Community Framework** / Cross-Sector Stakeholders
- **Part VII, Developing & Implementing the Plan** / Assessing Risk and Planning for Change / Budget cycles and other economic considerations
- **Appendix A, Resources** / Urban Forest Management Plans (UMFP)

- **Appendix A, Resources** / Municipal urban forest budget
- **Appendix A, Resources** / Municipal urban forest staffing
- **Appendix A, Resources** / Funding sources
- **Appendix A, Resources** / Specifications and standards

Resource Management Approach

Target R7: Tree Establishment Planning and Implementation

Key objective: Comprehensive and effective tree planting and establishment program is driven by canopy cover goals and other considerations according to plan.

Performance indicators:

Low – Little or no tree planting; tree establishment is *ad hoc.*
Fair – Some tree planting and establishment occurs, but with limited overall municipality-wide planning and post-planting care.
Good – Tree planting plan is guided by municipality-wide goals, with some post-planting establishment care.
Optimal – Comprehensive tree establishment plan is guided by needs derived from canopy and other assessments, maintains species and age diversity, includes both planting and young tree care, and is sufficient to make progress toward canopy cover objectives.

Notes: N/A

X-refs:

- **Part III, Covering the Canopy** / Setting Your Canopy Cover Goals
- **Part III, Covering the Canopy** / Pursuing Your Canopy Cover Goals
- **Part VII, Developing & Implementing the Plan** / Assessing Risk and Planning for Change
- **Appendix A, Resources** / Urban Forest Management Plans (UMFP)
- **Appendix A, Resources** / Maintenance plans for street trees and other public trees
- **Appendix A, Resources** / Natural areas management plans
- **Appendix A, Resources** / Educational materials, promotion, and outreach
- **Appendix A, Resources** / Municipal urban forestry policies
- **Appendix A, Resources** / Municipal tree boards/shade tree commissions
- **Appendix A, Resources** / Specifications and standards

Resource Management Approach

Target R8: Growing Site Suitability

Key objective: All publicly owned trees are selected for each site and planted in conditions that are modified as needed to ensure survival and maximize current and future tree benefits.

Performance indicators:

Low – Trees selected and planted without consideration of site conditions.
Fair – Appropriate tree species are considered in site selection.
Good – Municipality-wide guidelines in place for the improvement of planting site conditions and selection of suitable species.
Optimal – All trees planted in sites with adequate soil quality and quantity, and with sufficient growing space and overall site conditions to achieve their genetic potential and thus provide maximum ecosystem services.

Notes:

- Where existing growing site conditions are poor, retrofitting can also be performed to improve soil volume, soil quality, and other limiting factors.

X-refs:

- **Part VI, Conducting the Evaluation** / Target T3 "Species diversity"
- **Part VI, Conducting the Evaluation** / Target T4 "Species suitability"
- **Appendix A, Resources** / Urban Forest Management Plans (UFMP)
- **Appendix A, Resources** / Maintenance plans for street trees and other public trees
- **Appendix A, Resources** / Municipal urban forestry policies
- **Appendix A, Resources** / Specifications and standards

Resource Management Approach

Target R9: Tree Protection Policy Development and Enforcement

Key objective: The benefits derived from trees on public and private land are ensured by the enforcement of municipality-wide policies, including tree care "best management practices."

Performance indicators:

Low – No tree protection policy.
Fair – Policies in place to protect public trees and employ industry best management practices, but inconsistently enforced.
Good – Policies and practices in place to protect public ***and*** private trees, generally enforced.
Optimal – Integrated municipality-wide policies and practices to protect public and private trees, consistently enforced and supported by significant deterrents.

Notes: N/A

X-refs:

- **Appendix A, Resources** / Urban Forest Management Plans (UFMP)
- **Appendix A, Resources** / Private property tree programs
- **Appendix A, Resources** / Educational materials, promotion, and outreach
- **Appendix A, Resources** / Municipal urban forestry policies
- **Appendix A, Resources** / Municipal tree boards/shade tree commissions
- **Appendix A, Resources** / Specifications and standards

Resource Management Approach

Target R10: Maintenance of Publicly Owned, "Intensively" Managed Trees

Key objective: All publicly owned, intensively (or individually) managed trees are well maintained for optimal health and condition in order to extend longevity and maximize current and future benefits.

Performance indicators:

Low – No maintenance of publicly owned trees, or on a reactive basis only.
Fair – Publicly owned trees receive only periodic inspection and maintenance.
Good – Publicly owned trees are inspected and proactively maintained on a cyclical basis.
Optimal – All publicly owned, intensively managed trees are routinely and thoroughly maintained on ongoing basis according to comprehensive management plan.

Notes:

- **Definition:** Trees managed individually, such as street trees, are considered to be "managed *intensively,"* according to arboricultural techniques – whereas trees in woodlands or other natural areas are typically "managed *extensively,"* as a group, according to silvicultural practices. Park trees or trees on institutional campuses can fall into either category, depending on how they are managed.

- Routine maintenance activities include structural pruning, supplemental irrigation, pest management, etc. (For evaluation of "Tree risk management activities," see **Target R12,** referenced below.)

X-refs:

- **Part VI, Conducting the Evaluation** / Target T5 "Publicly owned trees (trees managed 'intensively')"
- **Part VI, Conducting the Evaluation** / Target R12 "Tree risk management activities"
- **Appendix A, Resources** / Maintenance plans for street trees and other public trees

Resource Management Approach

Target R11: Management of Publicly Owned Natural Areas

Key objective: The ecological integrity of all publicly owned natural areas is protected and enhanced – while accommodating public use where appropriate.

Performance indicators:

Low – No natural areas management plans or implementation in effect.
Fair – Only reactive management efforts to facilitate public use (e.g., hazard abatement, trail maintenance).
Good – Management plan in place for each publicly owned natural area to facilitate appropriate public use.
Optimal – Management plan for each publicly owned natural area focused on sustaining and, where possible, improving overall ecological integrity (i.e., structure and function) – while facilitating appropriate public use.

Notes: N/A

X-refs:

- **Part VI, Conducting the Evaluation** / Target T6 "Publicly owned natural areas (trees managed 'extensively')"
- **Appendix A, Resources** / Natural areas management plans

Resource Management Approach

Target R12: Tree Risk Management

Key objective: Comprehensive tree risk management program fully implemented, according to ANSI A300 (Part 9) "Tree Risk Assessment" standards, and supporting industry best management practices.

Performance indicators:

Low – No tree risk assessment or risk management program. Response is on a reactive basis only.
Fair – **Level I** (limited visual assessment) inspection and follow-up conducted periodically.
Good – **Level II** (basic assessment) conducted periodically, resulting in scheduled follow-ups.
Optimal – **Level II** (basic assessment) conducted routinely, according to defined cycle and intensive follow-up (i.e., priorities and timelines for mitigation established based on the characterization of risk).

Notes:

- *"ANSI A300 standards are the generally accepted industry standards for tree care practices. They are voluntary industry consensus standards developed by TCIA and written by a committee called the Accredited Standards Committee (ASC) A300, whose mission is to develop consensus performance standards based on current research and sound practice for writing specifications to manage trees, shrubs, and other woody plants."* – Tree Care Industry Association (http://tcia.org/business/ansi-a300-standards)

- In 2011, the ANSI A300 tree care standards added "Tree Risk Assessment" to the array of professional best management practices. The basic measures noted in the ratings above refer to these elements of the new "Part 9" standards. Their overall purpose is to reduce the likelihood of total or partial tree failure, the likelihood of a failure impacting a target, and thus the consequences of failure.

X-refs:

- **Part VII, Developing & Implementing the Plan** / Assessing Risk and Planning for Change / Natural lifecycle changes
- **Appendix A, Resources** / Urban Forest Management Plans (UFMP)
- **Appendix A, Resources** / Maintenance plans for street trees and other public trees
- **Appendix A, Resources** / Municipal urban forestry policies
- **Appendix A, Resources** / Specifications and standards

Resource Management Approach

Target R13: Urban Wood and Green Waste Utilization

Key objective: Create a closed system diverting all urban wood and green waste through reuse and recycling.

Performance indicators:

Low – No utilization plan; wood and other green waste goes to landfill with little or no recycling and reuse.
Fair – While most green waste does not go to landfill, uses are limited to chips or mulch.
Good – The majority of green waste is reused or recycled – for energy, products, and other purposes beyond chips or mulch.
Optimal – Comprehensive plan and processes in place to utilize all green waste one way or another, to the fullest extent possible.

Notes: N/A

X-refs:

- **Part VII, Developing & Implementing the Plan** / Assessing Risk and Planning for Change / Natural lifecycle changes / Sidebar: "End of the Lifecycle: Green Waste Utilization"
- **Appendix A, Resources** / Urban Forest Management Plans (UFMP)
- **Appendix A, Resources** / Municipal urban forestry policies

Resource Management Approach

Target R14: Native Vegetation

Key objective: Preservation and enhancement of local natural biodiversity.

Performance indicators:

Low – No coordinated focus on native vegetation.
Fair – Voluntary use of native species on publicly and privately owned lands; invasive species are recognized.
Good – Use of native species is encouraged on a project-appropriate basis in all areas; invasive species are recognized and discouraged on public and private lands.
Optimal – Native species are widely used on a project-appropriate basis in all areas; invasive species are proactively managed for eradication to the full extent possible.

Notes:

- *"The degree of public policy support for native species use in intensively and extensively managed areas is an important performance indicator…. Project-appropriate use of native species is also [important]. Non-native plantings may be more appropriate in circumstances where poor growing conditions or limited space may prevent any native species from reaching their full genetic potential, or may significantly limit their longevity. The issue of plant invasiveness similarly [should be] considered as well. Optimal urban forest management will always account for project-specific considerations in tree establishment activities. While invasive plants should generally be discouraged, in some scenarios (e.g., away from natural areas), even potentially invasive trees may be preferable to no trees at all. Conversely, in growing conditions in proximity to natural areas but where no noninvasive trees will likely thrive, it may be preferable to forego tree establishment entirely."* – Kenney et al (2011)

X-refs:

- **Appendix A, Resources** / Urban Forest Management Plans (UFMP)
- **Appendix A, Resources** / Natural areas management plans
- **Appendix A, Resources** / Educational material, promotion, and outreach
- **Appendix A, Resources** / Municipal urban forestry policies
- **Appendix A, Resources** / Municipal tree boards/shade tree commissions

Part VII – Developing and Implementing the Plan

Setting Priorities and Creating an Action Plan

After completing the comprehensive evaluation outlined in **Part VI,** there are decisions to be made. To name a few:

- What key components of a sustainable urban forest plan are you lacking?
- Which gaps are worth the investment of time, money, and other resources that may be required to fill them?
- What do you want to enhance or achieve?
- What are your specific goals for tree benefits, or ecosystem services?

Those are some of the many questions to consider with your core group of urban forest planners. There are no right answers, only informed decisions based on sound judgment and solid information. After all, there is no defined straightforward path to a sustainable urban forest; rather, it's one that meanders with opportunities. That means you'll need to stay nimble and work dynamically, setting and then modifying prescribed strategies to suit your municipality's needs and changing circumstances.

Several fundamental aspects of planning for the future are described in the sections below: assessing risk, planning for change, and monitoring performance. All of those areas will require ongoing attention – in order to revise the plan as needed over time. In fact, make periodic review and reassessment part of the plan itself. That's the only way to make sure it thrives over time – which is a central tenet of sustainability.

Assessing Risk and Planning for Change

The urban forest exists in an environment that is undergoing constant change. Some of these changes pose direct threats to the health of the urban forest and its ability to continue to provide valuable benefits and services. The selected risks described below pose a particular threat or challenge that should be considered when managing a sustainable urban forest.

Despite your best efforts, of course, bad things do happen to good people and their urban forests. To improve your ability to bounce back from the inevitable setbacks, take care to engage the full community as much and as often as possible in all your urban forestry efforts – during planning, implementation, maintenance, monitoring, periodic reassessment, advocacy, celebration, every step of the way. Time and again, involvement in urban greening has been shown to be one of the most effective ways to build resilience into the social fabric that supports the urban forest and the overall community in the aftermath of whatever disturbance may occur.

Climate Change

Climate change threatens the health of the urban forest by creating an environment that is less hospitable to the plants and trees currently planted or naturally occurring in a given city. It will be helpful to identify potential vulnerability by examining your current species diversity and determining

the adaptive capacity that your community has or needs in order to reduce impacts from climate change. Because the impacts of climate change are not uniform across the landscape, it may also be helpful to establish localized levels of risk and the rate at which response will be necessary by utilizing tools such as USGS's NEX-DCP30 (http://www.usgs.gov/climate_landuse/clu_rd/nex-dcp30.asp), which generates county-level projections of changes in temperature and precipitation, or NOAA's U.S. Extreme Climate Index (http://www.ncdc.noaa.gov/extremes/cei/graph/ne/2c/01-12), which captures recent regional trends.

It is important to recognize that while trees can play a role in mitigating the impacts of climate change, they are also susceptible to its effects. New York City's PlanNYC is a comprehensive sustainability plan that includes tree planting and greening initiatives to help reduce the impacts of increased temperatures and better manage stormwater (http://www.nyc.gov/html/planyc/html/sustainability/sustainability.shtml). To help create an urban forest that will be adaptable to future conditions it may be necessary to include forest adaptability in design protocols and policy – for example, Solutions for Sustainable Urban Forest Governance and Management (http://www.indiana.edu/~spea/faculty/policy_briefs/fischer_mincey_solutions_sustainable_urban_forest_gov_mgmt.pdf) and Climate Change Adaptation Options for Toronto's Urban Forest (http://www.cleanairpartnership.org/pdf/climate_change_adaptation.pdf).

One of the key responses to climate change is to ensure that the next generations of trees are adaptable to future conditions. Tools such as the USDA Plant Hardiness Zone Map (http://planthardiness.ars.usda.gov/PHZMWeb/#) updated in 2012, the USDA Forest Service Climate Change Tree Atlas (http://www.nrs.fs.fed.us/atlas/tree/), and The ForeCast Project (Forecasts of Climate-Associated Shifts in Tree Species; http://www.geobabble.org/~hnw/global/treeranges3/climate_change/) can help identify species whose ranges maybe shifting dramatically and identify potential replacements.

However, climate change occurs at broad scales over relatively long periods of time and its effect on local, short-term weather and environment can be unpredictable. Best practices include maintaining species and age diversity while increasing the number of trees appropriate for future conditions. Proactive planning as recommended in *Urban Forests: A Climate Adaptation Guide* (http://www.retooling.ca/_Library/docs/Urban_Forests_Guide.pdf) and the *Template for Assessing Climate Change Impacts and Management Options* (TACCIMO; http://www.taccimo.sgcp.ncsu.edu/) can help ensure the long-term health of the urban forest, enabling it to both adapt to climate change and continue to provide benefits that help mitigate the effects of climate change on an urban population.

As part of the Climate Change Response Framework, a pilot project is now being developed in the Chicago area to help urban communities assess the vulnerability of their forests and to identify and develop tools to assist in the adaptation of urban forests to climate change. To learn more about or become involved in the project, explore http://www.forestadaptation.org/urban.

Sea Level Rise

Many urban centers are located along the coast; in fact, 23 of the 25 most populous U.S. counties are considered coastal. NOAA predicts with "…very high confidence that global mean sea level will rise at least 0.2 meters and no more than 2.0 meters by 2100." Such a rise in sea level has the potential to inundate large amounts of urban forest.

Coastal communities can evaluate their level of vulnerability to sea level rise using tools such as NOAA's Sea Level Rise and Coast Flooding Viewer (http://coast.noaa.gov/slr/). The Nature Conservancy's Coastal Resilience project (http://www.coastalresilience.org/) also offers tools to evaluate sea level rise around key urban areas including the ability to identify at-risk human populations by social and economic factors as well as areas where conservation of current habitat would be most beneficial. While it is possible to predict where sea level rise will threaten urban forests, the ultimate impact is less certain. In many cases the urban forest lost to sea level rise may represent a relatively small portion of a municipality's overall area; however, coastal forests, swamps, and other vegetation can play a key role in mitigating effects of stormwater surge and protecting water quality. That's why in coastal zones those "forest"-based water resources are generally a key infrastructure consideration.

Best practices for mitigating the risks of sea level rise to urban forests can vary widely based on the amount and type of forest likely to be affected. Low-lying coastal zones that are already dealing with the threat of sea level rise demonstrate possible responses. For example, the Virginia Beach Urban Forest Management Plan (http://www.vbgov.com/government/departments/parks-recreation/landscape-management/Documents/2013-ufmp.pdf) identifies several strategies, including setting aside space for new forests to offset losses, conserving forest migration land adjacent to currently threatened forest, minimizing forest fragmentation, and special focus on maintenance and expansion of healthy forest buffers.

Wildfire

Wildfire rates have increased due to historic management regimes, climate change, extreme weather events, and large-scale tree mortality due to pests such as bark beetles. Along with increased incidence of wildfire, human population growth around urban centers has increased the exposure of urban forests and residents to the risks of wildfire. In the U.S. there are significant efforts to assess and mitigate the risks of wildfire, increasingly focused on the wildlife/urban interface. Municipalities in wildfire affected areas may have to consider the impact of wildfires on urban infrastructure, including fouling drinking water sources, reducing recreation opportunities, and impact on transportation corridors. In Colorado, the municipal water supplier Denver Water has partnered with the U.S. Forest Service to restore burned lands and manage forests to minimize the size and impact of future wildfires (http://www.denverwater.org/SupplyPlanning/WaterSupply/PartnershipUSFS/).

Figure 12. Photo courtesy of Headwaters Economics, Bozeman MT

There are a number of tools to assess long-term and short-term fire risk on a variety of scales – for example, Wildland Fire Assessment System (www.wfas.net), Colorado Wildfire Risk Assessment Portal (www.coloradowildfirerisk.com), and Texas Wildfire Risk Assessment Portal

(www.texaswildfirerisk.com). Additionally, programs like Firewise Communities (http://www.firewise.org) provide tools and examples of preventative planning for wildfire on scales from single homeowner to the municipality. In managing urban forests for wildfire risk, focus efforts on fire prevention because response following a wildfire will be focused on human and monetary impacts with the rehabilitation of the urban forest lagging far behind.

Pests, Disease and Invasive Plants

Urban trees are expected to be under increasing risk from all three of those threats. That's due to many factors, including increased globalization, increased wildland/urban interface, along with increased tree stress and pest range expansion associated with climate change. Addressing the risks from pests and diseases has the potential to keep pests out of the urban forest, reduce the number of trees affected, and reduce costs associated with treatment and removal. Threats from pests and diseases can be monitored at a range of scales. At large scales, the U.S. Forest Service forest insect and disease reporting portal (http://foresthealth.fs.usda.gov/portal) along with the ForWarn change detection system (http://forwarn.forestthreats.org/) provide many resources for pest risk tracking. Field methods designed for pest detection and tree health monitoring are also under development by the Healthy Trees, Healthy Cities initiative of The Nature Conservancy (http://healthytreeshealthycities.org/). At more local scales, it can be useful to engage community groups and engaged citizens to help identify new threats and monitor existing populations.

In recent decades a growing number of communities have been forced to address threats from pests. In response, some communities and states have developed a "toolbox" to prepare and respond to forest pests (e.g., in Vermont, http://www.vtinvasives.org/tree-pests/communitypreparedness/toolbox, and in Wisconsin, http://dnr.wi.gov/topic/urbanforests/eabtoolbox.html). Such toolboxes can help facilitate a rapid response to pests and diseases and are readily adaptable for specific communities and threats. (Information about "Wood Utilization Options for Urban Trees Infested by Invasive Species" can be found here: http://na.fs.fed.us/werc/projects/finalreports/WERC-2009-DG-087_2.pdf.)

Natural Lifecycle Changes

To ensure a healthy urban forest, it is necessary to consider the age distribution of a community's trees. Uneven age distribution is important for sustainability because it spreads out the timing of all management activities – planting, maintenance, removal, and replacement – so they won't all come due at once. Similarly, it also helps pace the delivery of ecosystem services, or tree benefits, so there will be a steady supply at all times. That's especially important for large older trees, since a newly planted tree would require decades before approaching a comparable size and level of benefits. Similarly, the greatest risk associated with the natural life cycle of trees arises when a population is dominated by trees of a similar age likely to die at a similar time. This issue has become more prominent in recent years with large-scale tree planting campaigns juxtaposed against the increasing evidence of the importance of large trees.[19]

Conducting and maintaining a tree inventory is the best way to monitor and plan for the risks associated with the natural life cycles of trees. As noted under **Target T2 "Age diversity"** (in **Part VI, Conducting the Evaluation**), the most accurate way to gauge age diversity is generally to compare current tree size with estimated maximum diameter. The goal would then be to maintain a tree population that is unevenly distributed among different age classes, as described in **Target T2.**

Probably the single most important measure to diversify age across the entire urban forest is to make sure there are always plenty of healthy young trees from diverse species. For similar reasons, the overall mix of tree species across the area under consideration – whether a neighborhood, city, or entire region – is equally important as a measure of a high-functioning and sustainable urban forest. As indicated in **Target T3 "Species diversity,"** by establishing a well-adapted population of trees that are genetically diverse (by families, genera, species, varieties, and cultivars), the risk of loss due to the decline of any single species is minimized – whether due to pest invasion, temperature extremes, or other factors that may target individual species. And by maintaining that diversity at a highly localized level, the protective benefit is maximized.

(See sidebar below: **"End of the Lifecycle: Green Waste Utilization**.")

End of the Lifecycle: Green Waste Utilization

While alive, trees generate debris in the form of leaves, flowers, fruit, and small twigs. Along with tree pruning and removal activities, vast amounts of woody debris are generated each year. In natural areas, trees can be allowed to decompose in place unless they pose a risk or are needed elsewhere, but in many urban areas, removal is the only option. These materials are often termed "green waste," as they arise from living plants. Of course, that term, while descriptive, is a bit misleading – since it needn't be considered "waste" at all unless it's wasted.

Green waste was traditionally handled by placing it in a landfill. In recent years, a developing trend has been to consider this waste as a resource, to find ways to reuse and recycle a tree's component parts. There are several motivations behind this trend, including prohibitions against placing green waste in landfills and the costs of hauling waste. At the same time, there are intersecting societal goals to (1) reduce the volume of the solid waste stream (including green waste and tree residues) and (2) improve air quality by prohibiting burning of green waste.

A sustainable urban forest should present an opportunity for a closed system for green waste. Tree trunks, branches, leaves, even lawn clippings and other vegetation should not be placed in landfills but should be utilized as a resource. There are four general paths:

1. **Energy generation.** Both large-scale at cogeneration plants that produce electricity, and small-scale through firewood.
2. **Compost.** Green waste that has been decomposed by microorganisms. Generally used as mulch and soil amendment. Both woody and non-woody green waste can be composted, often after it has been put through a tub grinder.
3. **Wood chips.** Small diameter wood generated by pruning can be chipped on-site and distributed as mulch.
4. **Wood products.** Tree trunks may be harvested and milled into lumber of various dimensions. Common uses include furniture, flooring, millwork, and fine crafts.

Green waste utilization has a strong link to a broader view of sustainability as it is a part of the overall solid waste stream. Diverting solid waste of all types from landfills is a common goal of many communities. As such it links urban forest management with the broader goals for sustainability. For example, the Sustainable Sites Initiative (SITES®) recognizes that reduction, reuse, and recycling are more sustainable practices than simple disposal. In addition, waste management is one of the components of the Green City Index.

– www.sustainablesites.org / Economist Intelligence Unit, 2011. U.S. and Canada Green City Index. Siemens Inc. NY.

Budget Cycles and Other Economic Considerations

Budgets for urban forest management can be affected by a diverse set of factors including macro-economic conditions, local budgetary priorities, changes in community support, and changes in elected leadership. Predicting changes in these factors is generally not possible; however, it is still necessary to prepare for such changes especially during periods of adequate funding.

In order to be able to adapt to budgetary cycles, start with a realistic budget that includes all the costs of managing an urban forest. Local or state urban forest coordinators can offer tools and assistance to build an urban forest management budget (e.g., "Annual Budgets for Community Tree Programs" from Penn State Extension: http://pubs.cas.psu.edu/freepubs/pdfs/uh114.pdf). While the goal of many urban forest advocates is to increase the amount of urban tree canopy cover, it must be recognized that additional trees come with additional costs for maintenance and management. Failing to plan for future maintenance costs results in increased tree mortality as well as increased safety concerns when resources are lacking to properly manage trees in decline.[20]

In order to maintain a vibrant urban forest under changing budgetary conditions, it's important to prioritize staff resources and actions to ensure that the forest is well managed even in lean times. That also means recognizing and assuring the minimum funding needed to maintain a safe and effective tree program. Of course, diversifying funding sources can help minimize the impacts of funding cuts in any one source.

One increasingly common strategy for stretching limited municipal dollars is to assemble an urban forestry team that supplements municipal staff with external personnel, including contractors, nonprofit groups, and individual volunteers. Such an arrangement can also take some pressure off the need to own and maintain equipment, which may instead come with those partners. This can be a sensible and effective strategy, so long as the team is well coordinated and sufficiently skilled.

(See sidebar below: **"The Financially Stable Sustainable Urban Forest."**)

The Financially Stable Sustainable Urban Forest

"Urban forestry makes economic sense. Consequently, there is no reason not to put it on a sound financial footing. In the past, many tree programs have been viewed (and many still are) as cost centers, and the goal was to hold costs down while recognizing that such programs were politically popular because of their aesthetic value. The movement toward quantifying the economic benefits of trees at all levels (direct economic benefits but also indirect savings from environmental, health, and psychological benefits) suggests an entirely different model focused on trees as a wise public investment strategy—and through this lens, as a profit center. …
Most urban forestry programs will probably always rely heavily on general fund allocations, but other options exist that can provide a revenue stream more clearly dedicated to the stewardship and management of urban forests."

– "Planning the Urban Forest," American Planning Association (2009)

Some examples of creative funding:

- ***Capital improvement plan fund*** derived from ***real estate taxes*** and ***utility taxes.***
- Municipal portion of ***state motor fuel tax***.
- ***Fines*** – for example, on motorists who damage trees in accidents.
- ***Entrepreneurial activities*** – such as the self-supporting yard waste recycling center in Urbana, Illinois, which sells compost back to property owners.
- ***Donations*** for tree preservation funds.
- Partnering with ***nonprofit organizations*** to supplement tree funding – such as the Sacramento Tree Foundation, which receives funding from the Municipal Utility District.
- ***Development fees*** (including ***impact fees*** where legal) related to permit processing and enforcement – ideally written into ***zoning, subdivision, and landscaping codes,*** and then dedicated to benefit new development or redevelopment areas.
- Revenue from a ***tax increment financing district*** allocated to urban forestry improvements, which add proven value to new economic development.

Changing Demographics

Among the most important factors influencing the urban forest in any community are the humans who reside there, and ours is an increasingly urban world. According to the 2010 census, 80.7 percent of the U.S. population lived in urban areas. During the preceding 10-year period, that urban population had grown by 12.1 percent, outpacing the nation's overall growth rate of 9.7 percent for the same period.[21] To best understand how changing demographics affect the urban forest, you need to look at the conditions of your own municipality.

Some cities such as New Orleans and Detroit, experienced large decreases in population over the last several decades. Such population decreases represent both opportunity and challenge for urban forest management. Increased vacancy rates and abandoned housing may provide space for increasing forested areas. However, without management it is possible that such areas may become dominated by undesirable species and may ultimately create safety issues, unwanted change in species composition,

and a pathway for pests, disease, and invasive species. Managing large tracts of new urban forest can also strain budgets at times that the tax base is decreasing.

Conversely, many communities are experiencing urban population growth, which can provide both additional resources and additional demands for urban forests. Increasing populations can lead to development pressures and decreasing physical space for the urban forest. In addition, many municipalities are experiencing demographic shifts in race and ethnicity. Social and cultural norms can impact the way various groups react to and treat the urban forest.

Evaluating the impacts of changing demographics begins with an understanding of how demographics are changing locally, even at the neighborhood block level. Much of this information is readily available from the U.S. Census and local sources for any community. Adapting the urban forest to best serve a changing community may require changes in the spatial distribution of the urban forest and prioritization of tree management tasks. Outreach and education can help inform the public about the role of the urban forest and how they can help unsure a vibrant and beneficial forest resource for their city.

(See sidebar below: **“Taking No Chances with Risks**.**”**)

Taking No Chances with Risks

New and unforeseen changes will inevitably emerge that threaten the health of the urban forest and its ability to provide benefits and ecosystem services. There are a wide variety of risks and changes that are already impacting the urban forest. In many cases, while the changes and risks are diverse, there are some common tools that can be used to improve the response to change and the resiliency of the urban forest.

The following principles can help identify and manage the risks to the urban forest:

1. **Know your urban forest resource.** Conducting a forest inventory will allow you to determine the extent and make-up of your urban forest and related susceptibility to risk. A forest inventory provides the baseline data for planning and management.
2. **Understand your human capital.** Establish the network of available experts, on-the-ground practitioners, and volunteer organizations you can draw on to determine the types of changes occurring in your urban forest, how best to respond to them, and how to mobilize people to enact your plans.
3. **Manage your money.** Lack of adequate funding not only reduces your ability to manage your urban forest but it also reduces your ability to respond to risk. A realistic urban forest budget must include realistic planning for the maintenance and management of existing forest as well as planned expansion of the forest resource. Urban forest managers can also help minimize funding shortages and obtain funds to combat specific risks by searching for a diversity of funding sources.
4. **Establish a diverse and healthy forest.** Maximizing the species, age, and spatial diversity of your urban forest can minimize the portion of the forest at risk to any one agent. Expenditures on improving forest health can help minimize susceptibility to risk. Both health and diversity increase forest resiliency and ensure that even in the face of increasing risk a vibrant urban forest can be maintained.
5. **Think locally.** Broad principles can be a good starting point, but be sure to consider uniquely local risks and seek out the resources to address them.

Monitoring for Urban Forest Change and Program Performance

Monitoring is a key element of sustainable urban forest management. As suggested by Clark and colleagues, assessing the urban forest resource for sustainability entails “collect[ing] information about the urban forest on a routine basis.” This is more than a static “snapshot” inventory. A single, static inventory can be used to understand structure and function at a given point in time, but can quickly become outdated in a dynamic urban landscape. Systematic repeated inventories can serve as a city tree census. Similar to the U.S. Census which tracks changes in the human population, a city tree census can be used to describe and predict patterns in the urban forest over time. Indeed, recognizing the value of long-term field data, many municipal arborists and urban greening nonprofits are already engaged in monitoring.

Why Monitor

Monitoring can serve several management goals, including:

- **Evaluating planting program performance.** Tracking trees planted through a particular program can yield information about growth, survival, and maintenance, and suggest areas for program enhancement. For example, New York City Parks & Recreation collected data on street tree survival in relation to biological, social, and stewardship variables.[22]
- **Engaging local communities.** Field data collection for urban tree monitoring can be an excellent way to engage volunteers and local residents in urban forestry, or to provide actionable feedback to those who maintain trees. For example, some nonprofits recruit volunteers for tree-tracking field work, including Friends of the Urban Forest (San Francisco, CA) and Canopy (Palo Alto, CA). More municipalities should take advantage of such opportunities to extend that sort of training and collaboration with community volunteers.
- **Tracking population life cycles and managing tree risk.** This is especially relevant for the public street tree environment, which requires removals of aging and hazardous trees. Repeated street tree inventories can be accomplished with a regular pruning cycle (for example, prune a set portion of the town's street trees each year, and update the inventory with tree growth and mortality data at the same time). This kind of systematic inventory cycle ensures that records are up-to-date and allows for analysis of mortality and tree risk data. In addition, anticipating your changing maintenance needs will often allow greater cost efficiencies in all activities.
- **Detecting emerging threats from pests and diseases.** Monitoring for tree pests and diseases in the urban environment can provide valuable early warnings about threats to both urban and natural forest systems. Field methods designed for pest detection and tree health monitoring are under development by the Healthy Trees, Healthy Cities initiative of The Nature Conservancy (http://healthytreeshealthycities.org/). There is also an **i-Tree** module for recording pest detection data (http://pest.itreetools.org). In addition, the USFS Invasive Species Program website offers extensive assistance: http://www.fs.fed.us/invasivespecies/index.shtml
- **Assessing progress towards canopy cover goals.** Repeated canopy assessments allow for evaluation of canopy cover change, which can demonstrate the extent to which canopy cover goals are being met, or identify patterns related to canopy cover change. For example, recent studies of canopy cover change in New York City[23] and Massachusetts[24] describe factors related to canopy losses and gains.

Each of the above goals has associated data inputs, and it is essential to link your particular monitoring goals to data collection strategies. Neglecting to articulate up front clear monitoring objectives, plans for data analysis, and ways you intend to use the information can lead to the "data-rich but information-poor" scenario of environmental monitoring[25] in which analysts become "snowed by a blizzard of ecological details."[26]

As an example of appropriate linkages between goals and methods, a neighborhood planting program seeking to understand establishment-phase losses, and potential program alterations for enhanced survival, could monitor mortality and stewardship of recently planted trees. For that objective, additional field variables besides survival and maintenance should be used sparingly, especially if volunteers or interns with little prior experience are collecting the data. In another example, a municipality seeking to assess progress made toward desired canopy cover goals, and also concerned

about invasive pests and diseases, could document change through LiDAR or aerial photography, coupled with random plot data for tree pest detection.

A multifaceted monitoring approach might employ several goals and methods in tandem. The state of Wisconsin is doing just that, using three levels of data to optimize management: plot-based field monitoring using the **Urban Forest Inventory & Analysis (UFIA)** system of the U.S. Forest Service, remote sensing data to evaluate canopy, and aggregated tree inventory data from many municipalities. UFIA is the urban expansion of cyclical, programmatic forest inventories and monitoring across the U.S. through a national plot system, which until recently was limited to non-urban areas. UFIA shares many variables with the **i-Tree Eco** method.

Ways to Monitor

As discussed in **Part IV, Gathering the Information,** there are two distinct ways to gather urban forest monitoring data: bottom-up (field-based) and top-down (canopy cover assessments). Top-down monitoring is typically employed when managers want a city-, county-, or state-wide perspective on tree canopy cover and distribution. The urban tree canopy (UTC) assessment method utilizes LiDAR to produce a spatially explicit map of tree canopy cover. Aerial photointerpretation can also document change over time, based on a sample of points across the city. This method has been used to document canopy loss in 11 U.S. cities.[27] The canopy change studies from New York City and Massachusetts previously mentioned used Landsat imagery.[28] Repeated canopy assessments can assist managers evaluating progress towards canopy cover goals.

Field-based monitoring requires trained crews and potentially substantial staff time, but can provide detailed information on tree condition, site characteristics, and maintenance. Within field-based methods, there are several options. A **tree census** approach can be used for systematic repeated inventories, such as repeated street tree inventories or plot-based inventories. In contrast, a **planting cohort monitoring** approach is for tracking trees planted or distributed through a specific program. The term “cohort” refers to the collection of trees planted around the same time, and a program may wish to track a sample of trees planted each year.

A framework for field-based monitoring has been developed by the **Urban Tree Growth & Longevity (UTGL) Working Group** (www.urbantreegrowth.org), a network of researchers and practitioners that is affiliated with the International Society of Arboriculture, Arboriculture Research & Education Academy. A committee of researchers, municipal arborists, nonprofit leaders, and students devised a framework of monitoring protocols designed to be customized based on manager needs and available staffing (see Figure 1). These protocols are intended to generate data to evaluate trends in tree growth, mortality, and longevity. There is a minimum data set with the core variables necessary for any long-term monitoring project – such as tree location, species, and diameter at breast height. The field guide for the minimum data set is designed for novice users, such as minimally trained interns and volunteers. Supplemental data sets can provide greater detail in four areas: Tree, Site, Management, and Community. These supplemental data sets should be employed only when more highly trained staff and program resources are available. The minimum data set was pilot tested in summer 2014 to evaluate consistency and error rates across field crews of varying experience levels. Additional resources for field-based monitoring are listed in the “Resources for Field-based Monitoring” sidebar below.

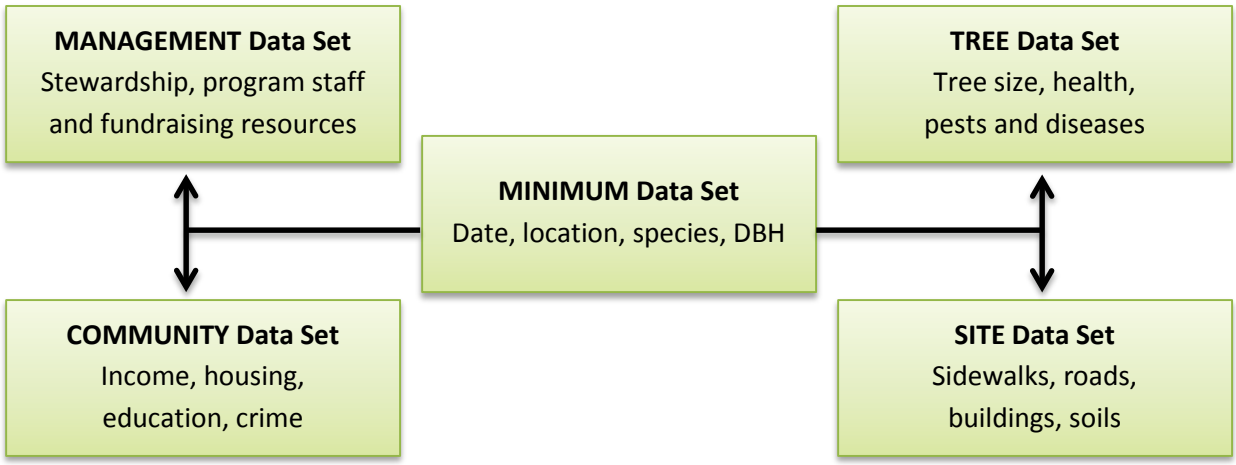

Figure 13. Framework and data sets for field-based urban tree monitoring developed by the Urban Tree Growth & Longevity (UTGL) Working Group.

Linking Monitoring to Community Outreach

For urban forestry organizations that plant trees, monitoring may go hand in hand with ongoing community outreach and stewardship. Some nonprofit tree planting programs utilize pruning clubs and tree steward programs to maintain young trees, and these maintenance actions can be done in tandem with data collection.[29] By serving as field crews, local residents become citizen scientists who contribute to knowledge production in the urban forest. Using volunteer or neighborhood-based citizen scientists can also increase environmental awareness and create a more informed constituency. For trees along streets and in front yards, observed maintenance issues by citizen scientists can be used to create "report cards" for each property with feedback on tree condition and recommendations for improved stewardship. Citizen science has been successfully used for ecological monitoring in areas ranging from ornithology (e.g., the "eBird" online tool from Cornell Lab of Ornithology and National Audubon Society, at www.ebird.org) to plant phenology (e.g., "Nature's Notebook" from the USA National Phenology Network, at www.usanpn.org). With appropriate training and quality control measures, urban foresters can also effectively utilize citizen scientists. (See also Vermont's "Forest Pest First Detectors" program: http://www.vtinvasives.org/first-detectors.)

Planning Ahead for Data Management and Analysis

Advance data management planning is extremely important for any successful monitoring initiative, as data integrity and locational accuracy from baseline inventories and planting records are essential. Problems can arise when baseline data are insufficient for monitoring purposes. For example, an organization seeking to track mortality and growth uses planting records from years past, but finds that location was only recorded in terms of address, lacking tree identification tags, site maps, or GPS coordinates to distinguish multiple trees at the same property. In another example, a municipality used random plots throughout the city to evaluate urban forest structure and ecosystem services using the **i-Tree Eco** model, and later wanted to revisit those plots to evaluate change. However, because plot centers were not permanently referenced, field crews could not reliably draw identical plot boundaries over the original plot locations. Another issue that can arise is difficulty linking monitoring data tree-by-tree over time: Sometimes two or more discrete inventories did not have unique tree identification numbers to facilitate connecting data at the level of the individual tree. These issues can be avoided, but

they require foresight at the initial data collection stage (e.g., planting list, first plot measurements, utilizing unique tree identification numbers) to ensure that monitoring goes smoothly.

Plans for data analysis should also be articulated at the beginning of a monitoring project. Some assessments can be done with program staff, such as summarizing mortality rates by neighborhood, species, and length of time after planting. However, for more advanced statistical analysis, it is often helpful to partner with university students, professors, and U.S. Forest Service researchers. Projects to collect and analyze urban forest monitoring data with a local partner can be very appealing to thesis students at the undergraduate, masters, or doctoral levels. Researchers can also advise on appropriate sample design and sample size to address monitoring study objectives. These kinds of collaborations can yield scientifically rigorous analysis to assess program performance and identify areas for improvement. Examples of such collaborations include analysis of survival and growth in planting initiatives from Florida (Koeser et al. 2014) and Indianapolis (Vogt et al. 2015), as well as tree giveaway program in Sacramento, California (Roman et al. 2014).[30]

Appendix A – Resources

The following resources match the list of **"Key Ingredients"** outlined in **Part IV, Gathering the Information.** Refer to that section for brief descriptions of each category where needed.

Plans, Practices, Programs, Policies – and More

Urban Forest Management Plans (UFMP):

- **Nationwide –** "Urban Forest Sustainability and Management Audit," USDA Forest Service, Urban Forestry South http://www.urbanforestrysouth.org/resources/files/UFS%20and%20ASC%20UF%20Audit%20Calc%20Tool%20-18Aug15%20v4.2beta.xlsx/view
- **Nationwide –** i-Tree Assessment Reports, USDA Forest Service http://www.itreetools.org/resources/reports.php
- **Nationwide** – "Urban Forest Management Plan Toolkit," California Urban Forests Council and Inland Urban Forest Council http://ufmptoolkit.com
- **Ann Arbor, MI –** "Urban & Community Forest Management Plan" (2014) http://www.a2gov.org/departments/field-operations/forestry/Pages/UFMP.aspx
- **Austin, TX –** "Austin's Urban Forest Plan: A Master Plan for Public Property" (2014) http://austintexas.gov/page/urban-forest-plan
- **Charlottesville, VA –** "Urban Forest Management Plan" (2009) http://www.charlottesville.org/Modules/ShowDocument.aspx?documentid=13979
- **Grand Rapids, MI –** "Urban Forestry Plan" (2009) http://grcity.us/public-services/Parks-Recreation-Forestry/Documents/Grand%20Rapids%20Urban%20Forest%20Plan%202009.pdf
- **New York, NY –** "Urban Forest Management Plans for NYC Communities and Parks" (2004-07) http://www.nycgovparks.org/trees (Scroll down to list at bottom of page.)
- **Phoenix, AZ –** "Tree and Shade Master Plan" (2010) https://www.phoenix.gov/parkssite/Documents/071957.pdf
- **Pittsburgh, PA –** "Urban Forest Master Plan" (2013) http://treepittsburgh.org/urban-forest-master-plan
- **Portland, OR –** "Urban Forest Management Plan" (2004) and "Urban Forest Action Plan" (2007) https://www.portlandoregon.gov/parks/60402
- **Santa Monica, CA –** "Urban Forest Master Plan" (2011) http://www.smgov.net/uploadedFiles/Portals/UrbanForest/Handout%206%20-%20Urban%20Forest%20Master%20Plan.pdf
- **Seattle, WA –** "Urban Forest Management Plan" (2007) http://www.seattle.gov/trees/docs/Final_UFMP.pdf
- **Vancouver, WA –** "Urban Forestry Management Plan" (2007) http://www.mrsc.org/govdocs/v35urbforestplan.pdf

Maintenance plans for street trees and other public trees:

- **Bloomington, IN –** "Tree Care Manual: A Manual for the Care of Public Trees" (2012) http://issuu.com/bloomingtonparks/docs/tree_care_manual_2nd_edition_feb_2012
- **New York, NY –** "Tree Services" http://www.nycgovparks.org/services/forestry
- **Oconomowoc, WI –** "Tree Care and Maintenance"http://www.oconomowoc-wi.gov/index.aspx?nid=556
- **U.S. Forest Service Northeastern Area –** "Sample Urban & Community Forest Management Plan & Guidebook" (1998) http://www.na.fs.fed.us/urban/inforesources/mgmtplanguide/mgmtplanguide.shtml
- **Waxhaw, NC –** "Tree Management and Maintenance: A Plan for the Town of Waxhaw's Public Trees for 2010-12" http://www.waxhaw.com/DocumentCenter/View/57

Natural areas management plans:

- **Charlottesville, VA –** "Invasive Plant Inventory" and "Invasive Species Removal Methods" (2007) http://www.charlottesville.org/Modules/ShowDocument.aspx?documentid=13978 http://www.charlottesville.org/Modules/ShowDocument.aspx?documentid=13975
- **Louisville, KY –** "Jefferson Memorial Forest Master Plan" (2009) http://www.louisvilleky.gov/NR/rdonlyres/C7D19169-5C61-4E99-8FF2-E9723E067AFB/0/JeffersonMemorialForestMP200resJuly09.pdf
- **New York, NY –** "Biodiversity Assessment Handbook for New York City" (2013) http://www.amnh.org/our-research/center-for-biodiversity-conservation/publications/general-interest/biodiversity-assessment-handbook-for-new-york-city
- **New York, NY –** "Reading the Landscape: A Social Assessment of Parks and Natural Areas in Jamaica Bay Communities" http://www.fs.fed.us/nrs/nyc/local-resources/docs/wp1_JamaicaBaySSA2013.pdf
- **Philadelphia, PA –** "Parkland Forest Management Framework" (2013) http://www.phila.gov/ParksandRecreation/PDF/PPR_Parkland_Forest_Mgmt_Framework.pdf

Regional and statewide plans:

- **Chicago, IL –** "GO TO 2040 Comprehensive Regional Plan" (2010), Chicago Metropolitan Agency for Planning (CMAP) http://www.cmap.illinois.gov/about/2040/
- **Chicago, IL –** Chicago Region Trees Initiative http://chicagorti.org/about-crti
- **Philadelphia and Delaware County, PA –** "Baltimore Avenue Corridor Revitalization Plan" (2007), Delaware Valley Regional Planning Commission http://www.dvrpc.org/reports/07051A.pdf
- **Sacramento, CA – "**Greenprint," Sacramento Tree Foundation http://sactree.com/pages/30
- **Treasure Valley, ID –** Treasure Valley (Idaho) Canopy Network http://www.tvcanopy.net/

Emergency and disaster plans:

- **Nationwide –** "Protecting Our Communities," FEMA http://www.fema.gov/protecting-our-communities
- **Nationwide –** Hazards Planning Center, American Planning Association https://www.planning.org/nationalcenters/hazards/

- **Nationwide –** "Urban Forestry Emergency Operations Planning Guide for Storm Response," USDA Forest Service, Urban Forestry South http://www.urbanforestrysouth.org/resources/library/ttresources/urban-forestry-emergency-operations-planning-guide-for-storm-response

Relevant previous or historic plans:

- **New York, NY –** "A Street Tree System for New York City" (1916) http://www.biodiversitylibrary.org/item/121416#page/11/mode/1up
- **Philadelphia, PA –** "Directions for the Planting and Care of Street Trees" (1913) https://archive.org/stream/directionsforpla00fair#page/n27/mode/2up

Community tree programs:

- **Nationwide –** "Healthy Trees, Healthy Cities," The Nature Conservancy http://healthytreeshealthycities.org/training-resources
- **Nationwide –** "NeighborWoods Program," Alliance for Community Trees http://neighborwoodsmonth.org
- **Atlanta, GA –** Trees Atlanta http://treesatlanta.org
- **Chicago, IL –** Chicago Region Trees Initiative http://www.mortonarb.org/science-conservation/chicago-region-trees-initiative
- **Chicago, IL –** "Community Trees Program," The Morton Arboretum http://www.mortonarb.org/trees-plants/community-trees-program
- **Philadelphia, PA –** Philly Tree People http://phillytreepeople.org/
- **Philadelphia, PA –** "PHS Tree Tenders," Pennsylvania Horticultural Society http://phsonline.org/greening/tree-tenders
- **Philadelphia, PA –** "Cooperative Community Greening," UC Green http://ucgreen.org/
- **Pittsburgh, PA –** TreePittsburgh http://treepittsburgh.org
- **Sacramento, CA –** "Community Shade Program," Sacramento Tree Foundation http://sactree.com/communityshade
- **Seattle, WA –** "Urban Forest Stewardship Plan" (2013) http://www.seattle.gov/trees/docs/2013%20Urban%20Fores%20Stewardship%20Plan%20091113.pdf
- **Vancouver, WA –** "NeighborWoods Stewards Program" http://www.cityofvancouver.us/publicworks/page/neighborwoods-stewards-program

Private property tree programs:

- **Baltimore, MD –** "Tree Keepers," Tree Baltimore http://treebaltimore.org/get-a-free-tree/
- **New York, NY –** New York Restoration Project and MillionTreesNYC http://www.nyrp.org/Greening_Sustainability/MillionTreesNYC/Tree_Giveaways
- **Philadelphia, PA –** "TreePhilly Program," Philadelphia Parks & Recreation http://treephilly.org/
- **San Jose, CA –** Our City Forest http://www.ourcityforest.org/programs
- **Washington, DC –** Casey Trees http://caseytrees.org/programs/planting/rebate/

Educational materials, promotion and outreach:

- **Nationwide –** Arbor Day Foundation https://www.arborday.org/index.cfm
- **Nationwide –** "Urban and Community Forestry – Outreach Services Strategies for All Communities" (2003), Alliance for Community Trees http://actrees.org/files/What_We_Do/OutreachStrategies.pdf
- **Nationwide –** "Healthy Trees, Healthy Cities," The Nature Conservancy http://healthytreeshealthycities.org/training-resources
- **Nationwide –** "Trees Are the Key" (2013), Vibrant Communities & Urban Forests http://treesarethekey.org/trees-are-the-key-online-toolkit/
- **Nationwide –** "Tree Owner Information," International Society of Arboriculture (ISA) http://www.treesaregood.com/treecare/treecareinfo.aspx
- **Nationwide –** Urban and Community Forestry, USDA Forest Service http://www.fs.fed.us/ucf/
- **Missouri –** "Trees Work," Missouri Department of Conservation http://mdc.mo.gov/discover-nature/trees-work
- **Ann Arbor, MI –** "Benefits of Urban Forests" and "What's Wrong with My Tree?" http://www.a2gov.org/departments/field-operations/forestry/Pages/UrbanForestBenefits.aspx
- http://www.a2gov.org/departments/field-operations/forestry/Pages/tree%20care.aspx
- **Baltimore, MD –** "How to Plant a Tree," Tree Baltimore http://treebaltimore.org/how-to-plant/
- **Chicago, IL –** "Retrofitting Large Landscapes for Sustainability" (2014), The Morton Arboretum http://www.mortonarb.org/trees-plants/community-trees-program/community-tree-resources/sustainable-large-landscapes
- **Chicago, IL –** "Selecting and Planting Trees" (2015), The Morton Arboretum http://www.mortonarb.org/files/15CTP_Tree%20Selection%20Planting_BRCH_ReaderSpread_0331_sm-1.pdf
- **Chicago, IL –** "Tree Tools" (2012-2015), The Morton Arboretum http://www.mortonarb.org/treetools
- **Chicago, IL –** "Landowner's Guide: Ravine and Tableland Preservation" (2013), Openlands http://www.greatlakes.org/document.doc?id=1380
- **Oakland, CA –** "Urban Forest Education & Stewardship Training Program" (2014), Urban ReLeaf http://www.urbanreleaf.org/our-programs/ufest-program
- **New York, NY –** MillionTreesNYC http://www.milliontreesnyc.org/html/home/home.shtml
- **Philadelphia, PA –** "PHS Tree Tenders," Pennsylvania Horticultural Society http://pennhort.libguides.com/content.php?pid=138497&sid=1185152
- **Vancouver, WA –** "Benefits of Trees" http://www.cityofvancouver.us/publicworks/page/benefits-trees
- **Washington, DC –** Casey Trees http://caseytrees.org/programs/education/curriculum/

Municipal urban forestry policies:

- **Nationwide –** "Urban Forestry Best Management Practices for Public Works Managers: Ordinances, Regulations, & Public Policies," American Public Works Association https://www2.apwa.net/Documents/About/CoopAgreements/UrbanForestry/UrbanForestry-3.pdf
- **Nationwide –** "Guidelines for Developing and Evaluating Tree Ordinances" (2001), International Society of Arboriculture (ISA) http://www.isa-arbor.com/education/onlineResources/treeOrdinanceGuidelines.aspx
- **Ann Arbor, MI –** "Trees and Development" (2013) http://www.a2gov.org/departments/field-operations/forestry/Pages/StreetTreesDevelopment.aspx

- **Charlottesville, VA –** "Best Management Practices for Tree Preservation, Transplanting and Removal" (2009) http://www.charlottesville.org/Modules/ShowDocument.aspx?documentid=20614
- **Culver City, CA –** "Approved Street Tree Master Plan Criteria, Policies and Implementation Guide" (2002) http://www.culvercity.org/~/media/Files/PW/STMPGuidelines%20pdf.ashx
- **Northbrook, IL –** "Tree Protection and Preservation, Vegetation" (1999) https://www.municode.com/library/#!/il/northbrook/codes/code_of_ordinances?nodeId=MUCO_CH25TRPRPRVE
- **San Francisco, CA –** "Tree Maintenance Transfer Plan" (2014) http://www.sfdpw.org/index.aspx?page=1478
- **Vancouver, WA –** "Tree Permits" and "Heritage Trees" http://www.cityofvancouver.us/publicworks/page/tree-permits-0 http://www.cityofvancouver.us/publicworks/page/heritage-trees
- **Georgia –** "Tree Ordinance Development Guidebook" (2005) http://www.gatrees.org/community-forests/planning-policy/tree-ordinances/2005TreeOrdinance-100.pdf

Municipal tree boards/shade tree commissions:

- **Charlottesville, VA –** Tree Commission http://www.charlottesville.org/Index.aspx?page=3298
- **Santa Monica, CA –** Urban Forest Task Force http://www.smgov.net/Portals/UrbanForest/content.aspx?id=16692
- **Vancouver, WA –** Urban Forestry Commission http://www.cityofvancouver.us/publicworks/page/urban-forestry-commission

Municipal urban forest budget:

- **Nationwide –** "Urban Forestry Best Management Practices for Public Works Managers: Budgeting and Funding," American Public Works Association https://www2.apwa.net/Documents/About/CoopAgreements/UrbanForestry/UrbanForestry-1.pdf
- **Charlottesville, VA –** "Invasive Plant Inventory Budget" (2007) http://www.charlottesville.org/Modules/ShowDocument.aspx?documentid=17772

Municipal urban forest staffing:

- **Nationwide –** "Urban Forestry Best Management Practices for Public Works Managers: Staffing," American Public Works Association https://www2.apwa.net/Documents/About/CoopAgreements/UrbanForestry/UrbanForestry-2.pdf

Funding sources:

- **Nationwide –** "Fundraising Tools for Nonprofits," Alliance for Community Trees http://actrees.org/resources/tools-for-nonprofits/fundraising-tools-for-nonprofits/
- **Nationwide –** "Urban & Community Challenge Cost Share Grants," National Urban and Community Forestry Advisory Council (NUCFAC), USDA Forest Service http://www.fs.fed.us/ucf/nucfac.html

- **Nationwide –** "Urban Forestry Best Management Practices for Public Works Managers: Budgeting and Funding," American Public Works Association https://www2.apwa.net/Documents/About/CoopAgreements/UrbanForestry/UrbanForestry-1.pdf
- **Nationwide –** Catalog of Federal Domestic Assistance (CFDA), U.S. Government https://www.cfda.gov/
- **Nationwide –** Foundation Directory Online, Foundation Center http://www.foundationcenter.org/
- **Chicago, IL –** ComEd Green Region Program, Openlands http://www.openlands.org/greenregion
- **University of North Carolina –** "Financing Urban Forestry" (2013), Environmental Finance Center http://efc.web.unc.edu/2013/08/09/financing-urban-forestry/
- **San Francisco, CA –** "Financing San Francisco's Urban Forest" (2013) http://www.sf-planning.org/ftp/files/plans-and-programs/planning-for-the-city/urban-forest-plan/UFP_Financing_Study_Exec_Sum_131216.pdf

Citywide urban forest GIS:

- **Grand Rapids, MI –** "Urban Forest Ecological Services Assessment" (2008) http://grcity.us/public-services/Parks-Recreation-Forestry/Documents/Grand%20Rapids%20Urban%20Forest%20Ecological%20Services%20Assessment%202008.pdf

Comprehensive list of stakeholders:

- **Ann Arbor, MI –** "Urban Forest Management Plan – Public Engagement Plan Summary" (2011) http://www.a2gov.org/departments/field-operations/forestry/Documents/Urban%20Forestry%20Management%20Plan/PEPsummary.pdf
- **Select cities –** "STEW-MAP: Stewardship Mapping & Assessment Project" http://www.stewmap.net/

Green jobs training:

- **Detroit, MI –** "Greening of Detroit" http://www.greeningofdetroit.com/what-we-do/job-training/
- **Philadelphia, PA –** "Tree Keepers," Philadelphia Parks & Recreationhttp://treephilly.org/treekeepers/
- **Philadelphia, PA –** "Roots to Re-Entry," Pennsylvania Horticultural Society http://phsonline.org/greening/roots-to-re-entry
- **University of Oregon –** "A Quick Guide for Creating High-Quality Jobs through Restoration on National Forests" (2012), Ecosystem Workforce Programhttp://ewp.uoregon.edu/sites/ewp.uoregon.edu/files/WCF_JobCreation_QG.pdf

Agroforestry / trees for food:

- **Alliance for Community Trees –** "Community Groves Guidebook" (2013) http://actrees.org/files/Publications/community_groves_guidebook.pdf

Urban and Community Forestry:

- **Alliance for Community Trees –** State guide for urban and community forestry contacts and resources http://actrees.org/resources/local-resources/whos-who-in-your-state/

Specifications and standards:

- **Nationwide** – "Planting Details and Specifications," Urban Tree Foundation http://www.urbantree.org/details_specs.shtml
- **Nationwide** – "Best Management Practices," International Society of Arboriculture http://www.isa-arbor.com/store/product.aspx?ProductID=139
- **Nationwide** – ANSI A300 Standards, Tree Care Industry Association http://tcia.org/business/ansi-a300-standards

Endnotes

[1] Collins English Dictionary online, http://www.collinsdictionary.com/dictionary/english/ecosystem

[2] "Greenworks Philadelphia" 2009 sustainability framework, Mayor's Office of Sustainability, summary pp 83-87. http://www.phila.gov/green/greenworks/pdf/Greenworks_OnlinePDF_FINAL.pdf

[3] Pittsburgh Urban Forest Master Plan, prepared for Tree Pittsburgh by Davey Resource Group, 2012, p 34.

[4] NYC's Urban Forest, Economic Benefits; Million Trees NYC, http://www.milliontreesnyc.org/html/about/forest.shtml

[5] "Strategic Tree Planting as an EPA Encouraged Pollutant Reduction Strategy: How Urban Trees Can Obtain Credit in State Implementation Plans." Information Summary, USDA Forest Service, Northern Research Station.

[6] "Carbon Sequestration" factsheet, Valuing Ecosystem Services, USDA Forest Service. http://www.fs.fed.us/ecosystemservices/carbon.shtml

[7] Watershed Forestry Resource Guide, http://forestsforwatersheds.org/reduce-stormwater/

[8] Nowak, D.J., and E.J. Greenfield. 2012. "Tree and impervious cover change in U.S. cities." Urban Forestry & Urban Greening, Vol. 11, 2012; pp 21-30.

[9] Various sources, from Internet search.

[10] Locke, D.H., J.M. Grove, W.T. Lu, A. Troy, J.P.M. O'Neil-Dunne, and B. Beck. 2010. Prioritizing preferable locations for increasing urban tree canopy in New York City. Cities and the Environment (CATE) 3(1), article 4, http://www.nrs.fs.fed.us/pubs/37293. Grove, J.M., J. O'Neil-Dunne, K. Pelletier, D. Nowak, and J. Walton. 2006. A report on New York City's present and possible urban tree canopy: Prepared for Fiona Watt, Chief of the Division of Forestry and Horticulture. New York Department of Parks and Recreation, USDA Forest Service, Northern Research Station. Raciti, S., M. F. Galvin, J. M. Grove, J. P. M. O'Neil-Dunne, A. Todd, and S. Clagett. 2006. Urban tree canopy goal setting: A guide for Chesapeake Bay communities. Annapolis, MD: USDA Forest Service, Northeastern State and Private Forestry, Chesapeake Bay Program Office. Battaglia, Michael; Buckley, Geoffrey L.; Galvin, Michael; and Grove, Morgan (2014) "It's Not Easy Going Green: Obstacles to Tree-Planting Programs in East Baltimore," Cities and the Environment (CATE) 7(2), article 6.

[11] www.itreetools.org/eco/resources/08%20plot%20size.pdf

[12] "A Guide to Assessing Urban Forests," USDA Forest Service, Northern Research Station, NRS-INF-24-13 https://www.itreetools.org/resources/content/guide_to_assessing_urban_forests_nrs_inf_24_13.pdf

[13] Locke, D.H., J.M. Grove, M. Galvin, J.P.M. O'Neil-Dunne, and C. Murphy. 2013. Applications of Urban Tree Canopy Assessment and Prioritization Tools: Supporting Collaborative Decision Making to Achieve Urban Sustainability Goals. Cities and the Environment (CATE) 6(1), article 7.

[14] Nowak 2012, http://www.fs.fed.us/nrs/pubs/rb/rb_nrs84.pdf

[15] http://www.mortonarb.org/science-conservation/regional-trees-initiative

[16] actrees.org/news/media-center/actreesnews/regional_tree_census_to_discover_canopy_cover/

[17] Clark, J.R., N.P. Matheny, G. Cross, and V. Wake. 1997. A model of urban forest sustainability. Journal of Arboriculture 23(1): 17-30.

[18] Kenney, W.A., P.J.E. van Wassenaer, and A.L. Satel. 2011. Criteria and indicators for strategic urban forest planning and management. Arboriculture & Urban Forestry 37(3): 108-117.

[19] Stephenson, N.L., A.J. Das, R. Condit, S.E. Russo, P.J. Baker, N.G. Beckman, D.A. Coomes, E.R. Lines, W.K. Morris, N. Rüger, E. Álvarez, C. Blundo, S. Bunyavejchewin, G. Chuyong, S.J. Davies, Á. Duque, C.N. Ewango, O. Flores, J.F. Franklin, H.R. Grau, Z. Hao, M.E. Harmon, S.P. Hubbell, D. Kenfack, Y. Lin, J.-R. Makana, A. Malizia, L.R. Malizia, R.J. Pabst, N. Pongpattananurak, S.-H. Su, I-F Sun, S. Tan, D. Thomas, P.J. van Mantgem, X. Wang, S.K. Wiser, and M.A. Zavala. 2014. Rate of tree carbon accumulation increases continuously with tree size. Nature. Geiger, J.R., C. King, and D. Hartel. 2004. The Large Tree Argument – The case for large-stature trees vs. small-stature trees. Davis, CA: Center for Urban Forest Research, Pacific Southwest Research Station, USDA Forest Service; 8p. Research summary.

[20] http://www.seattlepi.com/local/article/Report-Tree-canopy-declining-in-Seattle-s-parks-1309798.php#page-1

[21] "Growth in Urban Population Outpaces Rest of Nation, Census Bureau Reports," March 26, 2012 press release. (http://www.census.gov/newsroom/releases/archives/2010_census/cb12-50.html)

[22] Lu, J.W.T., E.S. Svendsen, L.K. Campbell, J. Greenfield, J. Braden, K.L. King, and N. Falxa-Raymond. 2010. Biological, social and urban design factors affecting young street tree mortality in New York City. Cities and the Environment (CATE) 3(1), article 5.

[23] Locke, D.H., K.L. King, E.S. Svendsen, L.K. Campbell, C. Small, N.F. Sonti, D.R. Fisher, and J.W.T. Lu. 2014. Urban environmental stewardship and changes in vegetative cover and building footprint in New York City neighborhoods (2000-2010). Journal of Environmental Studies & Science 4: 250-262.

[24] Hostetler, A.E., J. Rogan, D. Martin, V. DeLauer, and J. O'Neil-Dunne. 2013. Characterizing tree canopy loss using multi-source GIS data in Central Massachusetts, USA. Remote Sensing Letters 4: 1137-1146.

[25] Ward, R.C., J.C. Loftis, and G.B. McBride. 1986. The 'data-rich but information-poor' syndrome in water quality monitoring. Environmental Management 10: 259-262.

[26] Lindenmayer, D.B. and G.E. Likens. 2010. The science and application of ecological monitoring. Biological Conservation 143: 1317-1328.

[27] Nowak, D.J. and E.J. Greenfield. 2012. Tree and impervious cover change in U.S. cities. Urban Forestry & Urban Greening 11: 21-30.

[28] Hostetler et al. 2013. Locke et al. 2014.

[29] Roman, L.R., E.G. MacPherson, B.C. Scharenbroch, and J. Bartens. 2013. Identifying common practices and challenges for local urban tree monitoring programs across the United States. Arboriculture & Urban Forestry 39: 292-299.

[30] Koeser, A.K., E.F. Gilman, M. Paz, C. Harchick. 2014. Factors influencing urban tree planting program growth and survival in Florida, United States. Urban Forestry & Urban Greening 13: 655-661. Roman, L.A., J.J. Battles, J.R. McBride. 2014. Determinants of establishment survival for residential trees in Sacramento County, CA. Landscape and Urban Planning 129: 22-31. Vogt, J.M., S.L. Watkins, S.K. Mincey, M.S. Patterson, B.C. Fischer. 2015. Explaining planted-tree survival and growth in urban neighborhoods: A social-ecological approach to studying recently-planted trees in Indianapolis. Landscape & Urban Planning 136: 130-143.