Urban Tree Monitoring Protocols: Field Guide



Working Draft
Revised June 2015

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1 Introduction

Background

Why is a new *Field Guide* needed?

This manual, *Urban Tree Monitoring Protocols: Field Guide*, was developed by the Urban Tree Growth and Longevity (UTGL) Working Group. The UTGL Working Group is part of the Arboriculture Research & Eduction Academy of the International Society of Arboriculture. Our mission is to foster communication among researchers and professionals, enrich scientific exchange, and enhance the quality, productivity, and timeliness of research on tree growth, mortality and longevity through collaboration. The UTGL Working Group is accomplishing its mission by creating an urban tree monitoring protocol to standardize long-term data collection in cities across the United States. This *Field Guide* is the first piece of the protocol. This manual describes field collection procedures for a core set of variables that are essential to any long-term urban tree study – which we call the Minimum Data Set – including location, date, species, fine twig dieback, and diameter at breast height. These protocols do not "re-invent the wheel" regarding urban tree inventories. Rather, the methods described here draw from existing standards (e.g., i-Tree Streets, i-Tree Eco, and Forest Inventory & Analysis from the USDA Forest Service) with added emphasis on a user-friendly *Field Guide* for volunteers and interns, precise location information, and laying the foundation for long-term studies of tree growth, longevity, and mortality.

The standardized urban tree monitoring protocol will allow for longitudinal studies of urban tree mortality, growth, longevity, and health, and comparisons across programs. With the field data collected here, programs can assess tree survival and growth to evaluate change over time and performance of planting campaigns. While several dozen urban forestry programs already engage in tree monitoring, methods vary widely and there have not yet been coordinated efforts to collect data across many cities (Roman et al. 2014). This makes it challenging for managers and researchers to compare across cities and programs. Such comparisons would enable investigation of the factors associated with tree performance outcomes such as survival and growth (e.g., Roman et al. 2014, Koeser et al. 2014, Vogt et al. 2015), ultimately identifying key points of intervention by which performance could be enhanced. The *Urban Tree Monitoring Protocols: Field Guide* aims to solve that issue by providing local practitioners with a Minimum Data Set needed to take part in long-term research.

1 Introduction

Background

Designing a *Field Guide* for volunteers and interns

Urban tree monitoring, like many other large-scale environmental monitoring projects, is often conducted as a citizen science project – a project in which data are gathered by nonprofessional or amateur scientists with varying degrees of knowledge and experience. Citizen science projects create ways for the public to become involved in and help shape environmental projects in their community. Ecological monitoring studies also sometimes rely on student interns who may or may not have relevant past experience with the skills necessary for data collection. Urban tree monitoring would not be possible, in large and small communities alike, if volunteers and student interns were not involved, especially considering the limited funding available. Volunteers also help communities reach their environmental goals by establishing buy-in and a sense of ownership, both in the project and the betterment of the community. Engaging volunteers in a community's environmental goals also helps establish a proactive constituency base and a strong political voice (Bloniarz and Ryan 1996) that can be used to advance a community's environmental agenda. Volunteers play an important role in carrying out large-scale ecological monitoring projects in communities across the United States.

However, many challenges exist in citizen-science projects, including the training of data collectors, lack of funding, data quality, and timely data screening and validation (Bonter and Cooper 2012). Some studies have found that community members can produce forestry data comparable in quality to professionals and researchers (Bloniarz & Ryan 1996, Butt et al. 2013). To evaluate the error rates associated with urban tree inventories and monitoring studies conducted by minimally trained crews, a pilot test of this *Field Guide* was conducted in summer 2014. That assessment lead to a re-evaluation of the variables included and edits to enhance clarity in the text and images – changes that are reflected in this revised *Field Guide*.

This manual tackles the issue of data quality by taking complex, technical language and translating it into easy-to-use, step-by-step instructions written for volunteers and interns who may have limited training in these methods and little prior urban forestry experience. The use of real-world photos gives users important examples of variable definitions – such as mortality status and fine twig dieback – while the illustrations provide clear instructions for measurement.

Comments? Questions?

If you're using this *Field Guide*, please let us know! Contact UTGL through our website (www.urbantreegrowth.org) with any comments or questions.

Anyone interested in topics of urban tree growth, mortality and longevity is welcome to join UTGL. Sign up through the website to receive our newsletters, through which we send updates about the monitoring protocols project as well as articles highlighting the latest work from researchers and professionals on topics related to our core themes. Membership is free.

1.1 Data Sets Framework

Description

We have organized the monitoring protocols into a Minimum Data Set and four Supplemental Data Sets as follows. This *Field Guide* is focused primarily on the Minimum Data Set.

- Minimum Data Set: The core variables necessary for any urban tree monitoring project, including field crew information, tree species, location, site type, mortality status, fine twig dieback, and diameter at breast height
- Site Data Set: The site characteristics of the urban landscape surrounding the tree, including the planting site, built environment, and soils
- Tree Data Set: Tree size, growth, and health issues, including total height, crown spread, presence of pests and diseases, and maintenance tasks
- Management Data Set: Recommended tree care practices by local organizations, and stewardship actions observed on the ground, plus information about the programs and institutions that plant and care for trees
- Community Data Set: Socioeconomic information about the human community surrounding the tree, pulled from existing databases (such as the US Census) for variables including median income, housing value, and population density

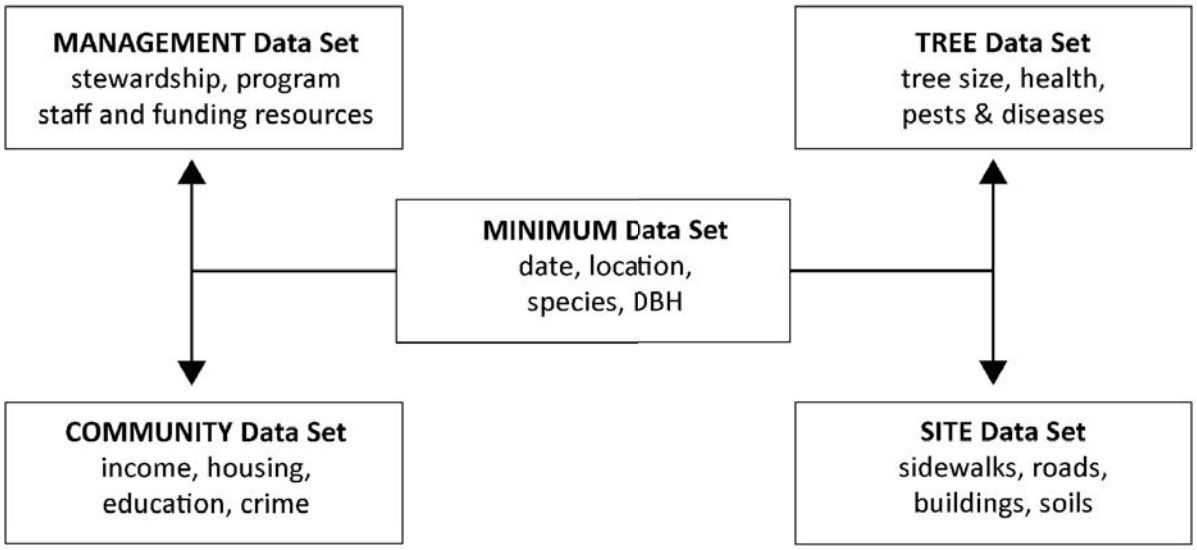
The structure of the Data Sets is intended to allow flexibility for practitioners based on monitoring project goals and organizational capacity (staff time and available funding). Connecting goals with appropriate data collection methods was a key recommendation from practitioners already engaged in urban tree monitoring (Roman et al. 2013). For example, if an urban greening non-profit wanted to track the trees that they plant, and figure out the extent to which recommended stewardship activities are being followed, they would do the Minimum Data Set plus Management Data Set. On the other hand, a municipal forester interested in repeated street or park inventories might be more inclined to use the Tree and/or Site Data Sets, which could allow for evaluations of site condition, tree health, and tree size. The Community Data Set's socioeconomic factors can be pulled from other databases, and does not require additional field work, but does require staff with GIS expertise.

1.1 Data Sets Framework

Note: In this *Field Guide*, we have included the Minimum Data Set and a limited number of supplemental variables from the Tree Data Set. These additional variables are specifically designed to track crown health, and have been developed to support the Healthy Trees, Healthy Cities initiative of The Nature Conservancy. This part of the *Field Guide* should only be used by crews with extra training.

For more information about the protocol development process, including guiding principles and a draft of each data set, see the *Project Overview & Data Sets Summary* here: www.urbantreegrowth.org/field-guide.html

For most urban forest managers, the Minimum Data Set explained in this *Field Guide* should be sufficient to meet monitoring program goals. However, if you wish to collect additional variables, see the *Project Overview* document or consult other resources and protocols listed on page 68.



1.2 Getting Started

Tips for Supervisors

This manual is meant to be used in the field while collecting data, and during training workshops. However, there are several steps that need to occur before training and data collection begin.

Local managers are encouraged to do the following before using this *Field Guide*:

Review the supporting documentation about the Urban Tree Monitoring Protocols. See the *Project Overview & Data Sets Summary* here: www.urbantreegrowth.org/field-guide.html. This includes frequently asked questions for project managers, and information about the four supplemental data sets (Tree, Site, Management, Community).

Articulate a specific set of goals for your urban tree monitoring project. These goals will determine what variables you collect, and help to decide whether or not your project should expand beyond the Minimum Data Set. For example, in this *Field Guide*, we include supplemental tree health metrics that are only appropriate for crews with training and supervision.

Make a plan for sampling your trees. For example, the monitoring project could sample all trees planted through a particular initiative, or a random or stratified subsample. Alternatively, the monitoring could be associated with a street tree inventory, with a plan to re-inventory the trees in future years, perhaps associated with maintenance cycles. We recommend contacting researchers or graduate students at universities and the USDA Forest Service for advice regarding sampling design for your specific project.

Decide how the term "tree" will be defined for your monitoring project. Emphasize this definition to your field crews – confusion over this issue can introduce substantial errors in the monitoring, as crews are unclear which plants are "in" or "out" of the study. See pg 9 for possible definitions of "tree" in urban tree monitoring.

Decide whether field crews should measure diameter at breast height to the nearest inch vs. nearest 1/10 inch. We strongly encourage all projects to use 1/10 inch. See pgs 17-18 in the *Project Overview & Data Sets Summary* for a discussion of this issue: www.urbantreegrowth.org/field-guide.html

Finalize methods for recording location in your study. In this *Field Guide*, we offer general guidance about location methods for various site types (pg 16), and we give more detailed protocols for street trees (pg 18). However, the best location methods used for your project will depend on what site types you have, what kind of field crews you have available, as well as what kind of equipment you're using to collect data (especially paper vs. mobile data collection). We urge the use of several complimentary methods of recording location, including photos of every tree when feasible.

Consider paper vs. mobile data entry. A template data collection sheet is provided in the Field Data Sheet section (pg 63). This is a default option for many urban tree monitoring projects because a comprehensive mobile app is not yet available. However, if your organization has the capacity to do data collection using a mobile platform (e.g., SmartPhone or Tablet), that would reduce logistical challenges with managing and entering paper records. For more information about mobile platforms, check out the Resources section (pg 62).

1.2 Getting Started

Defining Monitoring Project Type

There are two basic monitoring project types that this *Field Guide* can support. Project supervisors will need to define their project type ahead of time in order to decide on a definition of "tree" for the monitoring study (see page 9) and to facilitate comparing data across similar studies.

- Cohort monitoring: A cohort is a group of trees planted around the same time (e.g., same planting season or same calendar year). Cohort monitoring is usually intended to track trees planted within the same programs or initiatives. (See the Planted Tree Re-Inventory Protocol, page 68, for another example of field protocols for cohort studies.) With a cohort study, the total number of originally planted trees goes down over time as trees die or get removed. If replacement trees are planted, then those new cohorts can also be monitored.
- Repeated census or systematic re-inventory: Monitoring all trees within a given geographic area (e.g., plots, neighborhoods), regardless of who planted, is a systematic re-inventory. Examples include repeated inventories of all street trees in a specific neighborhood, or repeated inventories of all trees within i-Tree Eco plots. These studies represent a repeated census approach – observing all trees within a specific area, and repeating that over time. With this project type, trees can be both added to (via planting or natural regeneration) and removed (via death-in-place or human removal) from the census, so the total number of trees monitored may increase or decrease over time.

For both project types described above, tree growth, mortality and longevity can be analyzed. However, it is essential that all tree re-measurements can be linked to the first record of that tree in the database. If it is not possible to link the measurement or loss of the same tree across time it will not be possible to analyze the data for individual tree growth, mortality, or longevity.

1.2 Getting Started

What is a "Tree"?

The word "tree" does not have a standard botanical definition. Although "tree" is generally taken to mean woody plants with a distinct crown, differences in which plants are included in different urban forest monitoring projects could make comparisons across cities and programs difficult. Lack of a clear and consistent definition of "tree" for a given study can also confuse interpretation of change over time due to confusion over which plants are included and excluded from the study. Project supervisors should select which of the tree definitions below to use for the monitoring project.

Monitoring Project Type	Tree Definition Short Name	Description
Cohort monitoring	Program-specific planted trees	Tree is defined by inclusion in a program's planting list. Only trees planted through that program are monitored, and all are considered trees for inclusion in the study, regardless of size or growth habit (i.e., even species often considered shrubs like crape myrtles are included, if on program list)
Repeated inventories - general	DBH minimum 1 inch (2.54 cm)	Trees are defined as woody plants with a minimum 1 in (2.54 cm) DBH. This method is based on i-Tree Eco and Urban Forest Inventory & Analysis from the USDA Forest Service and has the benefit of being easy for data collectors to reliably determine in the field, but it may exclude some small recently planted trees while including species not typically considered trees for management purposes (e.g., spicebush, crape myrtle).
	Set list of species; no DBH minimum	Trees are defined by a set list of species, with species that are not of interest explicitly excluded. For example, a repeated inventory could exclude plants with shrubby growth habit (e.g., bamboo clusters, spicebush, buckthorn, privet, etc.).
	Height minimum 4.5 ft (1.37 m)	Trees are defined as woody plants with a minimum height of 4.5 ft (1.37 m). This is an alternative to the 1 in (2.54 cm) DBH cut-off. This height-based definition will capture more small, recently planted saplings in urban environments, but still exclude small whips and small volunteer seedlings.
Repeated inventories - street trees	Trees between sidewalk and street, and medians	Monitoring is limited to sidewalk cut-outs, raised planters and planting strips only if they are located between the sidewalk and the street, and trees planted in street medians. This is a more restrictive definition of street tree, but it may be more consistently applied across field crews over many years of monitoring.
	Trees in sidewalks and medians	Monitoring is limited to the following Site Types (pg 22): sidewalk cut-out, sidewalk planting strip, raised planters, and median. (Trees on lawns are not included, even if they are within the right-of-way.) This definition is most relevant to downtown areas and older cities where street trees are primarily managed as the trees in sidewalk space.
	Trees within right-of-way	Monitoring is based on a fixed distance from road center, curb, or edge of road bed (i.e., the right-of-way) as defined by local municipality. Any trees within that space are included for monitoring, regardless of whether Land Use is private vs. public land, or Site Type is front yard vs. in sidewalk.

IMPORTANT NOTE: For a repeated street tree census, project managers will need to decide BOTH whether "tree" has a minimum DBH cut-off vs. set species list, and whether "street tree" is defined by right-of-way vs. relationship to sidewalks and medians. The definition should be clear and concise with a focus on the ability to be consistently applied by field crews throughout all the conditions likely to be encountered in the area of interest.

1.3 Contributors

This draft of the *Urban Tree Monitoring Protocols: Field Guide* was written by members of the Urban Tree Growth and Longevity (UTGL) Working Group and designed by Lindsay Shafer and Jason Fristensky. UTGL members who developed the Minimum Data Set are Lara Roman, Jerry Bond, Emily King, Burney Fischer, Michele Bigger, Jennifer Karps, Doug Wildman, and Steve Kremske. Other UTGL participants who helped shape these protocols include Greg McPherson, Bryant Scharenbroch, Paula Peper, John Mills, Deb Boyer, and Sarah Mincey. We are grateful to these individuals and many other colleagues for valuable feedback on earlier drafts.

Revisions to this *Field Guide* in 2015 were based on a pilot test in summer 2014. UTGL members who lead local pilot testing were Lara Roman, Bryant Scharenbroch, Andrew Koeser, Lee Mueller, Johan Östberg, and Jess Sanders.

Variables in the Tree Health Metrics section were developed in partnership with The Nature Conservancy (Bill Toomey, Rachel Holmes) and the USDA Forest Service New York City Urban Field Station (Rich Hallett, Michelle Johnson) and Philadelphia Field Station (Lara Roman, Sarah Low, Jason Henning, Jason Fristensky).

The photos in this manual were taken by Erik Desotelle, Lara Roman, Bryant Scharenbroch, Lindsay Shafer, Jerry Bond, Zarah Wyly, and Jason Fristensky and should not be used without permission. Where noted, images were also downloaded from forestryimages.org, and cited per their standards. Original layout, line art and other illustrations were originally created by Lindsay Shafer (version June 2014). Text and illustrations were revised by Jason Fristensky (version June 2015).

Field Guide Versions

June 2015	Revisions to original Minimum Data Set draft and incorporation of Tree Health Metrics
June 2014	Original draft for pilot testing completed

2
Minimum Data Set

Photo: E. Desotelle

2.1 Field Crew

Identification

Description
Field crew identification is information about the individual(s) who collected field data on this tree. Crew names, initials, or team numbers may be used (but should be consistent within a given project).

Recorded for
All trees.

Experience Level

Description
Provide the experience level of the most experienced individual on the field crew team that collected data on this tree.

Recorded for
All trees.

Category	Description
Expert	Urban forest researchers and arboriculture professionals with extensive prior field experience with tree inventories and extensive knowledge of essential skills (e.g., species identification, stem diameter measurements).
Intermediate	Program staff, volunteers and interns with relevant past experience in urban forestry field work (at least 1-3 years) and some prior knowledge of essential skills (e.g., species identification, stem diameter measurements).
Novice	Program staff, volunteers and interns with little to no prior urban forestry field work experience (1 year or less) and little prior knowledge of essential skills (e.g., species identification, stem diameter measurements).

2.2 Date of Observation

Description
Date (year, month, day) of the field data collection.

Recorded for
All trees.

IMPORTANT NOTE: If your monitoring project involves tracking trees planted through the same program (i.e., monitoring a cohort), the database must also include planting date.

In contrast, planting date is not strictly necessary for monitoring projects that repeatedly inventory all street trees or all trees on random plots (regardless of who planted them and when). Nonetheless, planting date would be helpful in that situation as well, if available. Programs interested in tracking population cycles may also be interested in recording tree removal date.

2.3 Tree Record Identification Code

Description

Each tree record should have a unique identification code that remains with this tree during future monitoring. For projects that track recently planted trees, the identification code may link with planting records. The tree identification code should be distinct from site location information: for example, over many years, a series of different trees may exist in the same sidewalk cut-out. Project supervisors should instruct crews in identification codes useful to their management practices.

The identification code can be obtained from a tree tag (when present), tree cohort numbering within a discrete area as defined by a site map, or generated within the database after first inventory collection (typically done with a combination of address and location).This unique code for the tree should only be used once, and when a tree is dead or removed, that unique code should be retired from use to avoid future confusion. The portion of the unique code referring to the tree's location can be re-used for future trees, as long as the complete tree identification code for each individual tree at that location remains distinct.

Examples (see photos on next page)

Example 1: A tree tag, physically attached to the trunk of the tree, provides a unique identifier specific to that tree. On the University of Pennsylvania campus, trees are being tagged with their identification code which is a string combination of Location (based on grid and quadrant) and Sequence. In this identification code example, the grid is N34, the quadrant is 2, and the order sequence in which it was inventoried is 4. Resulting in a tree tag code of N34.2-4 (see photo below.)

Example 2: An existing campus inventory map created during continual data collection that allows for the generation of a tree identification code based on a defined geographically discrete area. The identification code is assigned to trees existing prior to the inventory, and to each tree as it is planted. Each unique identification code (accession numbers) has the year inventoried or planted (existing or new planting, respectively) embedded within the code. The identification code and precise location is also displayed for trees that have died and/or been removed. Also linked to the identification code are the previous Location and Sequence combination (as described in example 1) numbering system.

Example 3: A unique tree ID tag from the University City Green planting program in Philadelphia, PA. This ID number connects back to the list of planted trees and a site map.

Example 4: A site map for street trees, created prior to inventory data collection from a GIS base map. This allows for the generation of a tree identification code based on the sidewalk cut-out location. This identification code is assigned prior to the inventory, and the site map provided to the field crew.

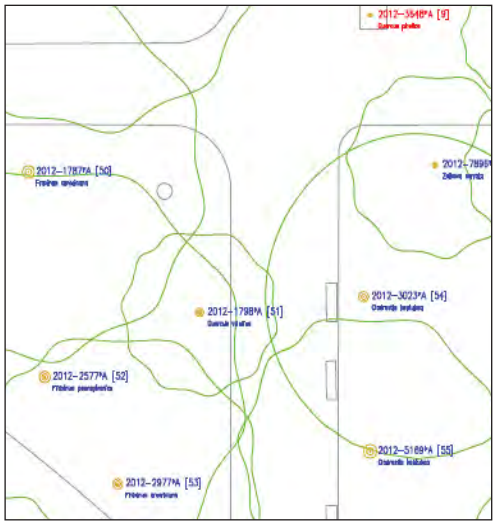
Recorded for

All trees.

2.3 Tree Record Identification Code

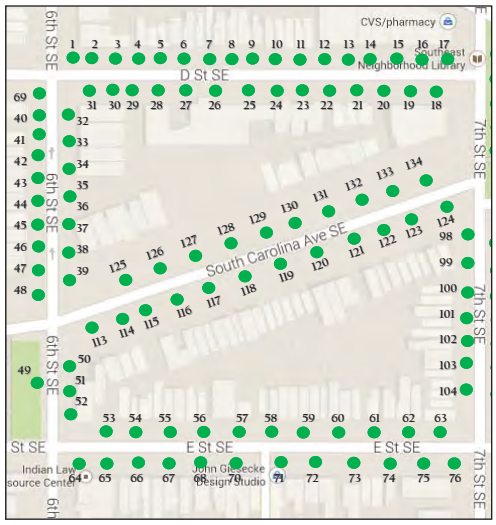
Identification Examples

Example 1: Tree Tag
University of Pennsylvania
Photo: J.P. Fristensky



Example 2: BGBase Inventory Map
Image: University of Pennsylvania FRES

Example 3: Street tree with unique ID tag
University City Green
Photo: L.A. Roman



Example 4: Site Map
Image: J. Sanders, Casey Trees

2.4 Location

General Guidelines

Description

Location information is used to reliably locate this tree for future monitoring, and to connect tree field data to other geospatial datasets. Location is one of the most essential pieces of data – without accurate location, this tree's data cannot be connected to future observations. Below are guidelines on appropriate location methods for various Site Types. These are only general guidelines – Your supervisor will instruct you on the location methods that have been selected for your project. Use at least 2 complementary location methods and see which methods are best for each site type (pgs 22-24) before beginning field work. For example, locating a street tree using Address and Site Code plus GPS coordinates. Whenever programs have the capacity to use identification tags, to-scale site maps, or GPS, these methods are highly recommended.

Recorded for

All trees.

IMPORTANT NOTE: Do not rely on GPS coordinates alone. When GPS coordinates are generated via street address, those coordinates typically fall into the center of a parcel (i.e., not where the tree is really located). When using GPS equipment in the field, even the best equipment can be off by several meters. Each location method has its own strengths and weaknesses, and the project supervisor must determine which 2 (or more) methods are best suited to your project.

Location Method	Definition	Relevant Site Types
Address	The property number and street name for the property on which the tree is located, or the property adjacent to the tree.	Sidewalk Cut-out; Sidewalk Planting Strip; Front Yard; Back Yard
Nearest Intersection	The nearest road intersection to the tree's location.	All Site Types that do not have an assigned address, especially useful for Parks and Natural Areas
Site Code	A location identification code or management unit that is useful for this particular program and city. This method is most commonly used for street trees. For example, F for front of the address, S for side of the building, M for median. See page 19 for additional details on address and site code protocols for street trees.	Sidewalk Cut-out; Sidewalk Planting Strip; Center Median; Front Yard
On, From, and To Streets (also known as 'blockside')	A system for noting the specific block segment on which a tree is located, best suited for street tree inventories on a gridded street system. "On" is the street the tree is actually on, "From" is the street at lowest end of block address #'s, "To" is the next street in ascending #'s. See page 19 for details and example.	Sidewalk Cut-out; Sidewalk Planting Strip; Center Median; Front Yards

2.4 Location

General Guidelines

Location Method (continued)	Definition	Relevant Site Types
Site Map	Site map drawn to scale illustrating trees and other useful landmarks in the landscape. Typically drawn by a professional arborist or landscape architect	All Site Types, but especially useful for Yards, Parks, and Natural Areas
Reference Objects	Distance and orientation to objects in the landscape that are unlikely to move for several decades. For example, with a yard tree, a reference object could be the northwest corner of the house exterior. The field crews would then measure distance and compass orientation to that house corner. This method is based on systems developed for plot-based inventories such as i-Tree Eco. For detailed protocols, see www.itreetools.org/resources/manuals.php	Yards; Parks; Natural Areas
GPS Coordinates	Latitude and longitude coordinates of the tree's location. When sharing data, note the accuracy level of GPS coordinates (e.g., accurate to 3 m, 10 m, etc.), units, and coordinate system (it is only necessary to record the level of accuracy, units and coordinate system once).	All Site types
Identification Tag	Identification tag with a code or number, typically affixed to young trees with plastic ties or nailed into large trees. Vandalism could be a problem for identification tags, but several tree planting programs have used tags successfully. Tagged tree monitoring is commonly used for research plots in forest ecology.	All Site Types
Street Tree Distance Survey	For gridded, linear street systems, this method involves measuring the distance from the street intersection to each tree. This method takes more time to set up compared to the address and site code system (see page 19) but it provides highly accurate location information for purposes of future monitoring. Distance is measured in a straight line from one intersection curb edge to next intersection curb edge with a landscaper's tape, surveyor tape, or measuring wheel. This method has been developed by TreeKIT and employed in New York City, NY (see pg 69).	Sidewalk Cut-out; Sidewalk Planting Strip; Center Median

2.4 Location

Street Tree Protocols - Address & Site Code

Description

The protocols described on this page are specifically for street trees. This combination of variables can be employed by municipal foresters or non-profits with paper and pencil; mobile data collection systems would help but are not absolutely needed. However, when using paper records, updating site codes for each address in subsequent years can be very cumbersome.

- Site Code
- Address
- On, From, and To Street
- Side of Street

Recorded for

Street trees.

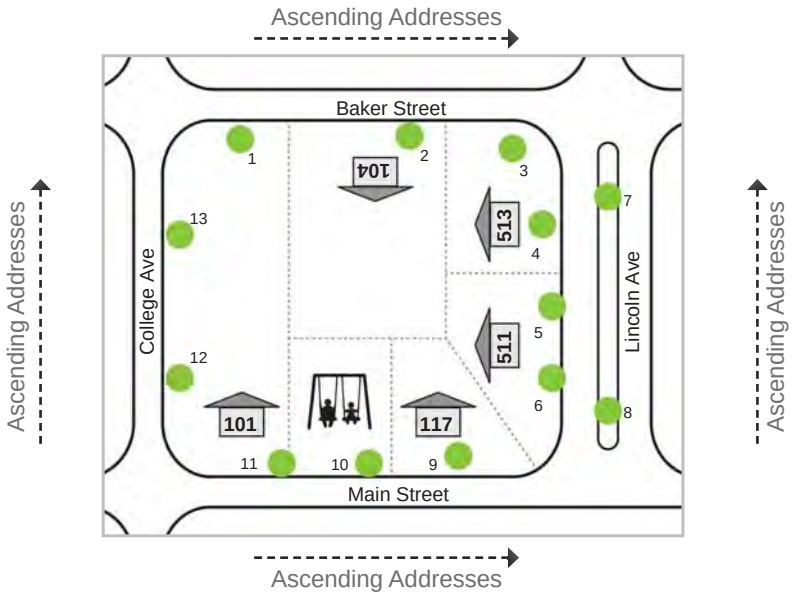
Location Method	Definition	Relevant Site Types
Address	The property number and street name for the property on which the tree is located, or the property adjacent to the tree.	Sidewalk Cut-out; Sidewalk Planting Strip; Front Yard; Back Yard
Site Code	A location identification code or management unit that is useful for this particular program and city. This method is most commonly used for street trees. For example, F for front of the address, S for side of the building, M for median. See page 19 for additional details on address and site code protocols for street trees.	Sidewalk Cut-out; Sidewalk Planting Strip; Center Median; Front Yard
On, From, and To Streets (also known as 'blockside')	A system for noting the specific block segment on which a tree is located, best suited for street tree inventories on a gridded street system. "On" is the street the tree is actually on, "From" is the street at lowest end of block address #'s, "To" is the next street in ascending #'s. See page 19 for details and example.	Sidewalk Cut-out; Sidewalk Planting Strip; Center Median; Front Yards

2.4 Location

Street Tree Protocols - Address & Site Code

The system below is specifically designed for a baseline inventory of street trees. Tree site codes are numbered sequentially on each side of a lot in the order of ascending addresses. Trees on the front of the property are indicated by an “F”, the side of the property are indicated by an “S”, trees at the rear by an “R” (this is used for lots that span the entire block), trees in an adjacent property without an address an “A” (e.g., vacant lots, small parks/gardens), and trees on a median by an “M”. Multiple trees and planting sites can exist at each address. For example, a given address could have trees 1F and 2F, and the next house would begin anew with 1F. For trees on the side, rear, or adjacent to the house itself, the numbering system goes in order of ascending addresses on the street where the tree is located. A separate series of tree site code numbers exists for each side of a property.

For the On, From, and To Street methods: The On street is referring to which street the tree is actually on (which can be different than the parcel street address). For From and To, the From street is the street closest to the lowest address, while the To street is the next encountered street in ascending addresses. Side of Street should be recorded as odd vs. even (or n/a for median trees).



Tree Number*	Site Code	Address # and Street Name	Block Side Information			
			On Street	From Street	To Street	Side of Street
1	1R	101 Main	Baker	College	Lincoln	Even
2	1F	104 Baker	Baker	College	Lincoln	Even
3	1S	513 Lincoln	Baker	College	Lincoln	Even
4	1F	513 Lincoln	Lincoln	Main	Baker	Odd
5	2F	511 Lincoln	Lincoln	Main	Baker	Odd
6	1F	511 Lincoln	Lincoln	Main	Baker	Odd
7	1M	513 Lincoln	Lincoln	Main	Baker	n/a
8	1M	511 Lincoln	Lincoln	Main	Baker	n/a
9	1F	117 Main	Main	College	Lincoln	Odd
10	1A	101 Main	Main	College	Lincoln	Odd
11	1F	101 Main	Main	College	Lincoln	Odd
12	1S	101 Main	College	Main	Baker	Even
13	2S	101 Main	College	Main	Baker	Even

* Tree Number is provided here only as a legend to aid in interpreting the map.

2.4 Location

Street Tree Protocols - Distance Survey

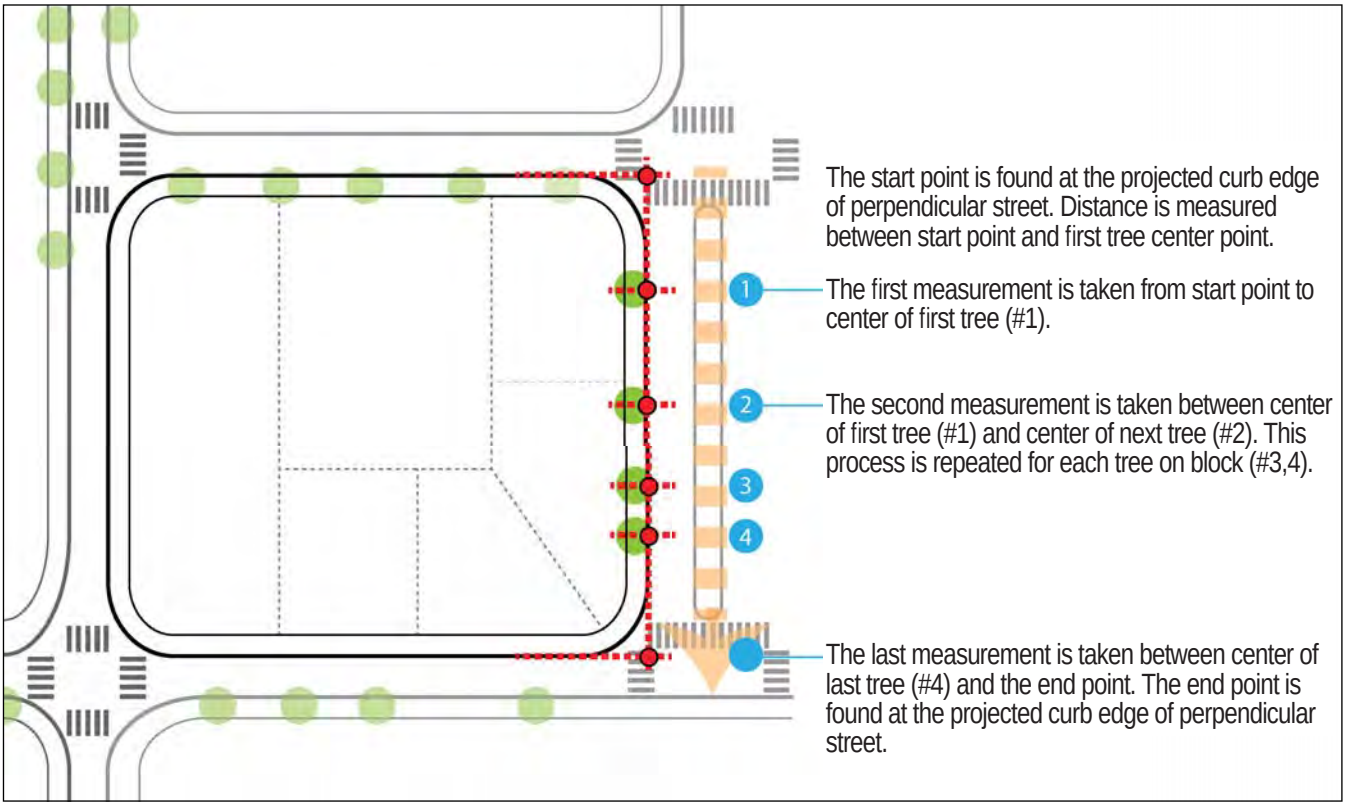
Description

For gridded, linear street systems, this method involves measuring the distance from the street intersection to each tree. This method takes more time to set up compared to the address and site code system (see page 19) but it provides highly accurate location information for purposes of future monitoring. Distance is measured in a straight line from one intersection curb edge to next intersection curb edge with a landscaper's tape, surveyor tape, or measuring wheel. This method has been developed by TreeKIT and employed in New York City, NY (see pg 69). See the diagram below for an overview of the distance measurement procedure.

For NYC, this technique has been optimized to produce a spatially accurate GIS map from the measured distances along the curb, however that functionality is not available for every city. Nevertheless, even without the mapping component, this technique provides detailed location information to help future field crews find the same tree without the occasional ambiguities that arise from the address & site code method.

Recorded for

Street trees.



Graphic by J.P. Fristensky

2.5 Tree Photo

Description

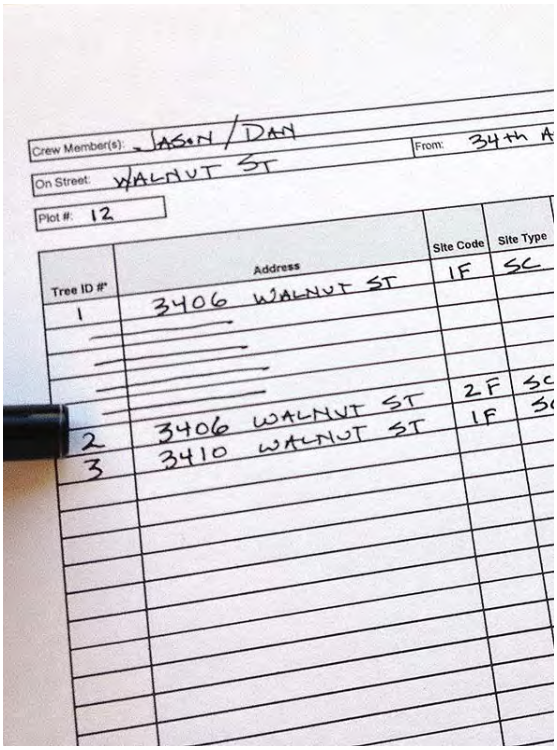
A photograph taken to show the entire tree (when possible) in the context of its immediate location and static objects in the landscape (e.g., buildings, light posts), with a view that would help future field crews reliably find the same tree.

It is strongly encouraged that any monitoring projects include pictures of the full tree whenever possible, however pictures for every tree are only feasible to manage on a large scale when smartphones and other mobile devices are used for field work. When it is not feasible within the resources of a project, a minimum requirement of taking photographs of unknown and questionable species is advised (see page 31).

Below is an example of documenting an entire tree within its context. This also can serve a dual purpose of species identification if species is in question. When photographing in the field with the smartphone camera, or hand held digital camera, it is invaluable to document the tree address and site code. This can be done by simply taking a photograph of the data sheet and drawing attention to the related specifics first, and the full tree photo second. This assists in reducing any confusion once uploading in the office.

Recorded for

All trees.



Tree Photo: Documenting Tree Record
Photo: J.P. Fristensky

Tree Photo : Full Tree in context
Photo: J.P. Fristensky

2.6 Site Type

Description
Site Type is a description of the tree's immediate location. There are two main reasons to record Site Type: each site type has recommended methods of recording tree location, and mortality and growth rates may vary across Site Type categories. The Site Type categories indicate broad information about the area surrounding the planting space (hardscape vs. open), maintenance (public vs. private), and controls on tree inputs and removals (human-dominated vs. natural). With each Site Type category below are recommended methods for recording location – this information is intended to assist project supervisors, who must decide which location method to use for your project. GPS coordinates are also appropriate for all Site Types, but should be used in conjunction with another method, as previously described in Location section, pages 16-18.

Recorded for
All trees.

Planting Space: Hardscape
Tree plantings and removals with these Site Types are human-dominated.

Category (code)	Description	Maintenance	Recommended Methods for Recording Location
Sidewalk Cut-out (SC)	Tree is located in a soil pit in the sidewalk. The cut-out can be anywhere in the sidewalk space (for example, adjacent to the curb, adjacent to a building). This kind of Site Type usually fits one tree. The dimensions are square, or close to square.	Public (right of way)	Address; Site code; On, From, and To Streets
Sidewalk Planting Strip (SP)	Tree is located in a planting strip next to the sidewalk. This planting strip can be anywhere in the sidewalk space (for example, between the sidewalk and curb, between the sidewalk and building). Planting Strips can fit multiple trees planted in a row (even if only one tree is present). The dimensions of a planting strip are generally at least 3 times longer than they are wide.	Public (right of way)	Address; Site code; On, From, and To Streets
Median (M)	Tree is located in a planting space in the center of the road between traffic lanes.	Public (right of way)	Nearest intersection; Distance and orientation to reference objects; On, From, and To Streets
Raised Planter (RP)	A raised planter box or circular raised planter. Only include raised planters that seem relatively permanent, such as heavy concrete planters. Omit planter boxes on wheels and others that seem easily movable.	Private or Public (right of way)	Address, Site Code, On, From and To Streets
Other Hardscapes (OH)	Tree is located in a hardscape other than a sidewalk or median, such as cut-outs in a park plaza or parking lot.	Private or Public (right of way)	Nearest intersection; Distance and orientation to reference objects; Site maps

2.6 Site Type

Planting Space: Open

Tree plantings and removals with these Site Types are human-dominated.

Category (code)	Description	Maintenance	Recommended Methods for Recording Location
Front Yard (FY)	Tree is located in the yard in front of a building (on the street side of the building). This includes side yards. Front yards are typically associated with residential properties but may also be associated with other land use types.	Private or Public (right of way)	Address; Site code; Distance and orientation to reference objects
Back Yard (BY)	Tree is located behind a building. Back yards are typically associated with residential properties but may also be in back of other land use types.	Private	Address; Site code; Distance and orientation to reference objects
Maintained Park (MP)	Tree is located in a maintained park or park-like setting, such as a city park or school campus. This category is specifically for trees in lawns and other landscaped areas; park trees located in hardscapes belong in the "other maintained hardscapes" category. *Note: Maintained Park is both a Site Type and Land Use.*	Public or Private	Nearest intersection; Distance and orientation to reference objects; Site maps; Tags
Other Maintained Landscaped Area (OM)	Tree is located in a landscaped area not described by the yard and maintained park categories. Use this category sparingly.	Public or Private	Nearest intersection; Distance and orientation to reference objects; Site maps; Tags

2.6 Site Type

Planting Space: Open

Tree plantings and removals with this Site Type are natural (e.g., natural regeneration and death-in-place).

Category (code)	Description	Maintenance	Recommended Methods for Recording Location
Natural Area (NAT)	Tree is located in a natural park, open space area, or vegetated vacant lot that has minimal human intervention. This includes remnant forest patches and other natural or unmaintained areas, regardless of property type (for example, forest patches on a residential property or institutional property are included here). Natural areas include forests, prairies, woodlands, and other natural or minimally managed habitats. *Note: Natural Area is both a Land Use and Site Type.*	Public or Private	Nearest intersection; Distance and orientation to reference objects; Site maps; Tags

2.7 Land Use

Description

Land Use is a description of the way the property around (or adjacent to) the tree is used by humans. Tree mortality and growth rates may vary across Land Use categories. Land Use is distinct from Site Type, although the two variables are related and there is some overlap in their definitions, particularly with parks and natural areas. This manual's Land Use variable refers to *land use at the property level*, not at the tree site. Land uses include areas associated with that property or parcel. For example, trees in a parking lot of a school, or in park-like college ground, have Institutional land use. The planting area itself is addressed in the Site Type variable. Land Use is recorded in the field by crews, in order to get the most current information. If desired, project supervisors can also link tree locations to land uses defined by municipalities and planning commissions.

Recorded for

All trees.

IMPORTANT NOTE: The Land Use categories should be classified as the current existing use and function (as opposed to original structure use, if different). For example, an industrial building which has been converted to apartments would be classified as Multi-family Residential.

Category (code)	Description
Single-family Residential - detached (SFR-D)	Detached residential structures intended for one family.
Single-family Residential - attached (SFR-A)	Attached single-family structures, such as twins, town homes, row homes, and duplexes.
Multi-family Residential (MFR)	Structures containing more than four residential units (includes apartment complexes).
Mixed Use (MX)	Single structure that has multiple uses, typically differentiated by floor. The common instance of this category is a commercial, civic, or retail use on main floor with multi-family residential units on floors above.
Commercial (COMM)	Downtown commercial districts, malls, strip malls, and shopping plazas. This category also includes stand-alone parking lots in downtown areas that are not associated with institutional or residential use.
Industrial (IND)	Factories, warehouses, and trucking businesses.

2.7 Land Use

Category (code)	Description
Institutional (INST)	Schools, colleges, hospital complexes, religious buildings, and government buildings.
Maintained Park (MP)	Maintained or landscaped public parks. *Note: Maintained Park is both a Site Type and Land Use.*
Natural Area (NAT)	Tree is located in a natural park or open space area that has minimal human intervention. Natural areas include forests, prairies, woodlands, and other natural or minimally managed habitats. *Note: Natural Area is both a Land Use and Site Type.*
Cemetery (CEM)	Self-explanatory
Golf Course (GC)	Self-explanatory
Agricultural (AG)	Crop land, pasture, orchards, vineyards, nurseries (for farm land that is fallow when the field work observations occur, the land use is still agricultural).
Utility (UT)	Power-generating facilities, sewage treatment plants, covered and uncovered reservoirs, and empty stormwater runoff retention areas, flood control channels, conduits.
Water/Wetland (W)	Streams, rivers, lakes, and other water bodies (natural or man-made); small pools and fountains should be classified based on the adjacent land use.
Transportation (TR)	Includes limited access roadways and related greenspaces (such as interstate highways with on and off ramps); railroad stations, tracks and yards; shipyards; airports. If a tree falls on any other type of road, or associated median strip, classify according to the nearest adjacent land use.
Vacant Lot (V)	Parcel with no obvious human use. The common instances of this are land which has yet to be developed, or was developed and the building has been since removed. A standing building that is unoccupied/abandoned should be categorized by its most recent apparent use.
Other (O)	Land use does not fit the categories provided. Please enter description in the Notes for Supervisory Review (see section beginning on page 48).

2.8 Site Type & Land Use Examples

The following pages contain photo examples of how to classify urban trees for Site Type and Land Use with the protocols. Please see sections for Site Type (pages 22-24) and Land Use (pages 25-26) for more information and examples of the categories. The Site Type and Land Use categories are listed below for your convenience.

Site Type Categories

- Sidewalk Cut-out
- Sidewalk Planting Strip
- Median
- Other Hardscape
- Front Yard
- Back Yard
- Maintained Park
- Other Maintained Landscaped Area
- Natural Area

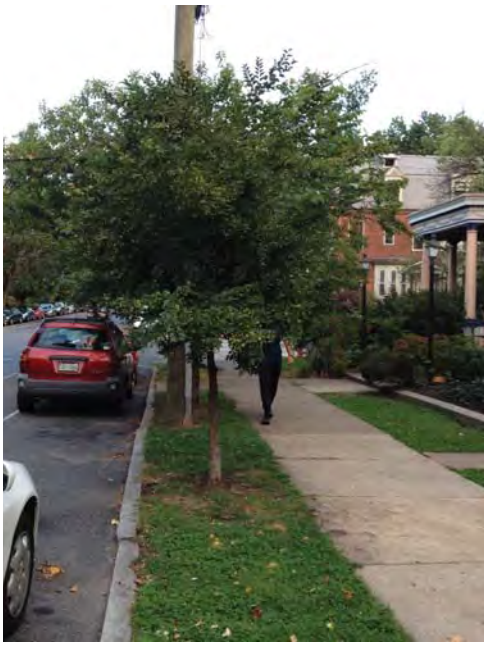
Land Use Categories

- Single-family Residential
  - Attached
  - Detached
- Multi-family Residential
- Mixed Use
- Commercial
- Industrial
- Institutional
- Maintained Park
- Natural Area
- Cemetery
- Golf Course
- Agricultural
- Utility
- Water/Wetland
- Transportation
- Vacant Lot
- Other

IMPORTANT NOTE: "Natural Area" and "Maintained Park" are both Site Types and Land Uses. A tree located on one of these Site Types will not automatically have the same Land Use, and vice versa.

2.8 Site Type & Land Use Examples

Site Type: Sidewalk Cut-out
Land Use: Commercial
Photo: B.C. Sharenbroch



Site Type: Sidewalk Planting Strip
Land Use: Single-family Residential - attached
Photo: L.B. Shafer

Site Type: Other Hardscape
Land Use: Institutional
Photo: L.A. Roman

Site Type: Sidewalk Cut-out
Land Use: Institutional
Photo: B.C. Sharenbroch

2.8 Site Type & Land Use Examples

Site Type: Sidewalk Cut-out
Land Use: Single-Family Residential - Attached
Photo: B.C. Sharenbroch

Site Type: Other Hardscape
Land Use: Commercial
Photo: L.A. Roman

Site Type: Planting Strip (foreground tree)
Land Use: Single-Family Residential - Detached
Photo: B.C. Sharenbroch

Site Type: Maintained Park
Land Use: Maintained Park
Photo: L.A. Roman

2.8 Site Type & Land Use Examples

Site Type: Sidewalk Cut-out
Land Use: Vacant Lot
Photo: J.P. Fristensky

Site Type: Sidewalk Cut-out
Land Use: Multi-family Residential
Photo: L.A. Roman

Site Type: Maintained Park
Land Use: Institutional
Photo: L.A. Roman

Site Type: Other Hardscape
Land Use: Single-Family Residential - Attached
Photo: J.P. Fristensky

2.9 Species

Description

Record species using standard botanical names, with both genus and species, or species codes from i-Tree. For example, red maple should be recorded as *Acer rubrum* or ACRU (i-Tree code). A detailed list of i-Tree species names and codes are available here:
www.itreetools.org/eco/resources/Eco_Species_List_Oct18_2012.pdf
www.itreetools.org/eco/resources/Eco_Species_List_Oct18_2012.xlsx

If you only know the common name for the tree, you can enter that in the field, but change to the botanical name before submitting to your project supervisor. Also enter cultivar only if known (e.g., cultivar is known from a baseline list of planted trees).

Recorded for

All trees.

Procedures for Unknown Species

If the species is unknown, but you at least know the genus, this can be recorded as *Acer sp.* or AC (i-Tree code). If the species is completely unknown, record as "unknown broadleaf," "unknown conifer," or "unknown."

Take pictures of the following: leaves; fruit, nut or flower; bark; and whole-tree profile. Pictures of leaves and flowers are clearer when taken on a white background (i.e., blank note paper). Be sure that all pictures are labeled with the tree's location. For example, you could take a picture of the field data collection sheet followed by pictures of the tree in question. Show the pictures to your project supervisor for assistance. Do not submit your complete records for this tree until the species identification problem is resolved, even if that resolution is simply leaving the species as unknown after consulting local experts. An example of pictures is found in the "Notes for Supervisory Review" section on page 49.

IMPORTANT NOTE: You should be familiar with the most common species in your city before field work begins, but you may encounter trees that you do not recognize. Bring tree identification resources with you into the field. Tree ID fact sheets customized to your city or region are especially helpful, and tree ID handbooks are available with dichotomous keys for experienced users. Program-specific tree ID guides are also quite valuable, tailored to species known to occur in your city. Your project supervisor should suggest resources appropriate to your project. For additional resources and assistance with species identification, see page 67.

2.10 Mortality Status

Description

Mortality Status is recorded separately from tree condition rating to distinguish between Standing Dead and Missing/Removed trees. If you ever have difficulty deciding how to classify a tree, you should record those details in the Notes for Supervisory Review section, pages 48-49.

Recorded for

All trees.

Category (code)	Description
Alive (A)	Includes any tree with green leaves - even a few leaves - and/or live buds, including extremely unhealthy trees.
Standing Dead (SD)	Trees classified as standing dead must be completely dead above-ground, with no green leaves and no live buds.
Removed/Missing (R)	Tree has been removed since the previous observation. This category is not relevant for a baseline inventory of trees (e.g., for a street tree monitoring project, Removed/Missing does not apply to the very first inventory, but would be relevant in future years).
Unknown (U)	Tree has unknown status (possibly due to issues in accessing the property, or confusion about location notes from the previous field notes). Note: If Unknown status, explain in the Notes for Supervisory Review (see section beginning on page 48). .

IMPORTANT NOTE: Throughout this protocol, we define "mortality" to include both trees that die in-place and those that are removed while still alive. This is consistent with recent urban tree mortality research. Furthermore, it is generally not possible for field crews to infer whether trees observed "missing" were dead or alive at the time they were removed. We have also not included a category for "replacement" trees, although some programs may find that information to be useful.

2.10 Mortality Status

Alive
Photo: B.C. Sharenbroch

Alive
Photo: Sacramento Tree Foundation

Alive
Photo: L.A. Roman

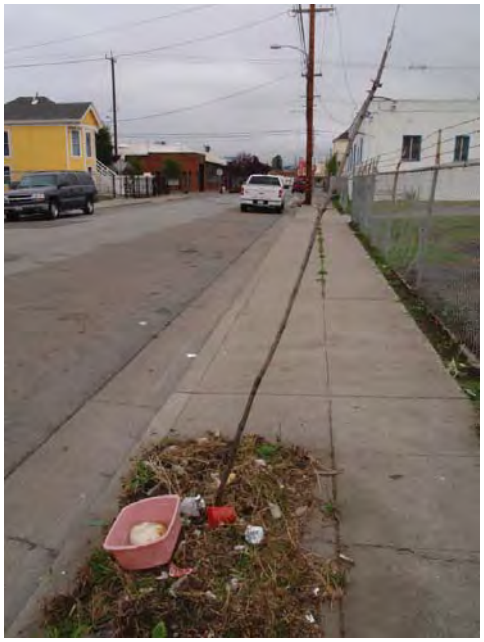
Alive (but unhealthy)
Photo: J. Bond

2.10 Mortality Status

Removed
Photo: L.A. Roman

Removed (empty pit)
Photo: J.P. Fristensky

Standing Dead
Photo: J. Bond



Standing Dead
Photo: L.A. Roman

2.11 Fine Twig Dieback

DEVELOPMENT IN PROGRESS

Description

Description

Fine Twig Dieback indicates death of tissues responsible for producing and supporting most of a trees leaf surface area and branch elongation. The amount of fine twig dieback is a reflection of the severity of recent stresses on the tree. This is a standard health metric used in USDA Forest Service inventory systems (i-Tree Eco, Forest Inventory & Analysis).

This variable reflects the percent of crown area affected. Therefore, a small crown with a small amount of dieback could have a high percent rating. Conversely, a large crown could have a greater quantity of dead twigs but a low Fine Twig Dieback rating. See pictures on the next page for examples.

Observe Fine Twig Dieback from several perpendicular locations around the tree and record the average.

Fine Twig Dieback does not include natural branch dieback (self-pruning due to crown competition or shading in the lower portion of the crown). Fine Twig Dieback also does not include older branch mortality – the variable is focused on recent stress response - nor does it include pruned sections. However, Fine Twig Dieback should only be measured where it is not due to longterm light limitations.

Dieback Class	Description		Dieback Class	Description
1	0-1% (none/trace)		55	51-55%
5	2-5%		60	56-60%
10	6-10%		65	61-65%
15	11-15%		70	66-70%
20	16-20%		75	71-75%
25	21-25%		80	76-80%
30	26-30%		85	81-85%
35	31-35%		90	86-90%
40	36-40%		95	91-95%
45	41-45%		99	96-99%
50	46-50%		100	100%

Recorded for

All live and standing dead trees. Do not record for removed/missing trees.

2.11 Fine Twig Dieback

Example

Photo: J.P. Fristensky

Class 5, 2-5% Fine Twig Dieback
Overlays: J.P. Fristensky

2.12 Trunk Diameter

Overview

Description

Trunk diameter is recorded either as diameter at breast height (DBH) or caliper, depending on the tree's characteristics. DBH is the measure of diameter at 4.5 ft (1.37 m) from the ground. Caliper is the diameter closer to the root collar, at 1 ft (30.5 cm) from the ground. While DBH is the standard way to measure trunk size for forest ecologists and most urban foresters, caliper is the common way to report sizes of nursery stock and newly planted trees (see page 70 for a field equipment checklist). There are also often practical problems measuring DBH on very small trees, such as branching and foliage at 4.5 ft (1.37 m). Throughout this protocol, the word "stem" means the same as "trunk", following convention from forestry and arboriculture.

For these protocols, record DBH for trees of at least 1 in (2.5 cm) diameter at 4.5 ft (1.37 m). For trees with stem diameter smaller than 1 in (2.5 cm) at 4.5 ft (1.37 m), the caliper should be measured at 1 ft (30.5 cm) above the ground instead. The flow chart on the next page will help you determine which method to use.

Recorded for

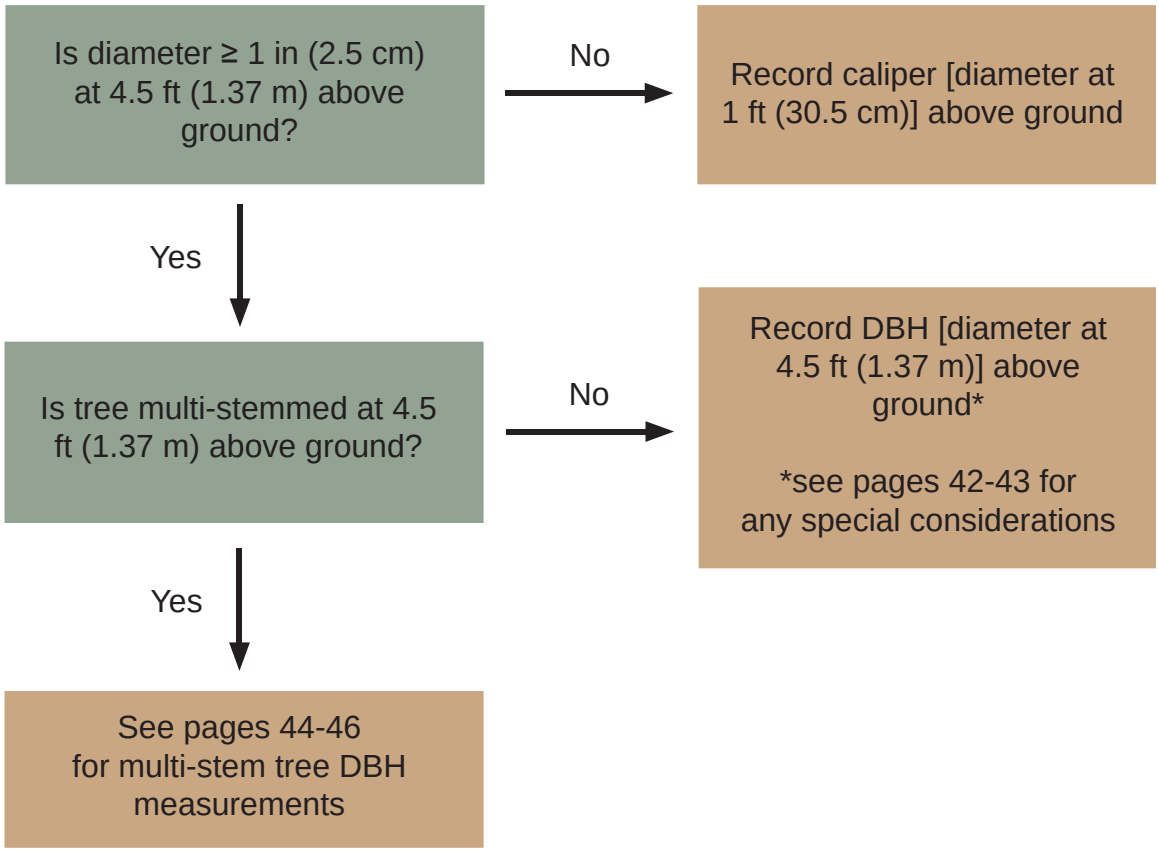
All live trees, and standing dead trees whenever possible.

Trunk Diameter - What to Record

1. Height at which trunk diameter is taken
   - This should be recorded for EVERY TREE that has a trunk diameter measurement. Do not leave blank assuming that 4.5 ft (1.37 m) is the default. Knowing the exact height of measurement is essential to accurate re-measurements for growth
2. Trunk diameter (DBH or caliper)
3. Units used to measure (record only once per field crew)
   - The field supervisor should determine a preferred unit of measurement for all crews as well as the level of precision (i.e. 1/10th inch, 1/2 cm, etc).
   - If this is a follow-up (or re-inventory) measurement, utilize the same units of measure (and height, if available) as the initial measurement

2.12 Trunk Diameter

Determining Height of Diameter Measurement



2.12 Trunk Diameter

Best Practices for Measurement

The next several pages provide a quick overview of best practices for measuring DBH and caliper. For a list of Field Equipment see page 70.

The precision of trunk diameter measurements has implications for data analysis. We provide two options for measuring diameter: nearest inch or nearest 1/10 in (0.25 cm). Most projects will use nearest 1/10 in (0.25 cm). Check with your project supervisor about which level of precision is required in your project, and be consistent in all of your field measurements. We strongly urge all projects to use nearest 1/10th inch.

DBH tape (d-tape) is the best piece of equipment for measuring DBH in most circumstances. Make sure that the d-tape you are using has the appropriate units and graduations (nearest 1/10 in, or appropriate metric equivalent).

Custom DBH Height walking sticks or height poles. A walking stick which has been cut to a height of exactly 4.5 ft (1.37m) can provide an efficient method for consistent field measurements and applicable to any trees that do not have special considerations (see pages 42-43) or are multi-stem (see pages 44-46) where the DBH height would need to be adjusted and recorded.

Caliper tools are appropriate for small diameter trees [< 1 in. diameter (2.5 cm) at 4.5 ft (1.37 m) above ground]. When using caliper tools, record two perpendicular measurements, which will be averaged when this tree's diameter is used in data analysis.

There are a variety of special considerations for recording DBH and common mistakes. Familiarize yourself with the instructions on the next few pages before beginning field work.

IMPORTANT NOTE: Caliper refers to both a measurement [diameter at 1 ft (30.5 cm)] and a piece of equipment used to measure diameter. Throughout this protocol, whenever we refer to the equipment, we use the phrase "caliper tool" to clarify.

IMPORTANT NOTE: Do not record "eyeballed" or visually estimated tree diameter. Measurements should be more precise for these protocols using d-tape or caliper tools. The only appropriate reason for "eyeballed" diameter is when an obstruction prevents you from physically measuring the tree, and this must be recorded in the notes. A d-tape provides the best balance of precision and efficiency. Caliper tools are recommended for small trees (diameter < 1 inch (2.5 cm) at 4.5 feet (1.37 m) DBH).

2.12 Trunk Diameter

Best Practices for Measurement

D-ape is easy to use but takes practice. Below are some tips for avoiding common mistakes with d-tape.

Measure diameter, not circumference. D-tape typically has two sides: one side is a regular measuring tape, from which you can measure circumference of the trunk; the other side is specially calibrated for diameter (diameter = circumference/pi). Make sure that you are using the correct side of the tape.

Make sure the tape is perpendicular to the trunk. Tape can get caught on bark, or get lopsided around large trunks. The tape should be perpendicular to the trunk (see page 39 for instructions about leaning trees).

Make sure the tape is pulled snug. The d-tape should be pulled snugly around the trunk. This is especially important if there is any loose bark.

If vines are present, position tape under the vines (if possible). DBH is supposed to measure diameter of the trunk, not diameter of the trunk and vines combined.

When in doubt, contact your supervisor, and take notes. DBH is one of the most important pieces of data in this protocol. If there are difficulties obtaining DBH for a particular tree, take notes (see pg 48-49 about Notes for Supervisory Review), and contact your supervisor for advice.

A common mistake when using the d-tape is reading the numbers from left to right, when you should be reading the numbers from right to left. Make sure you are reading the numbers in the proper direction. There are, however, different styles of d-tape. Make sure you know the style of d-tape you are using.

The correct diameter measurement is 4.3, when reading from right to left. Record the d-tape reading where the 0 mark overlaps.
Photo: E. Desotelle

2.12 Trunk Diameter

Best Practices for Measurement

Example of measuring DBH INCORRECTLY
d-Tape is too loose and should be perpendicular to trunk
Photo: E. Desotelle

Example of measuring DBH INCORRECTLY
d-Tape should go under any sprouting and also avoid any irregularities.
Photo: J.P. Fristensky

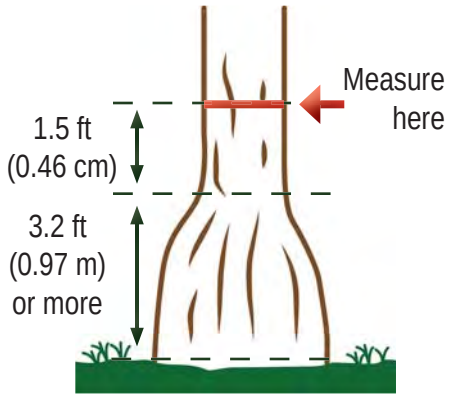
Example of measuring DBH CORRECTLY
d-tape is perpendicular to trunk
Photo: J.P. Fristensky

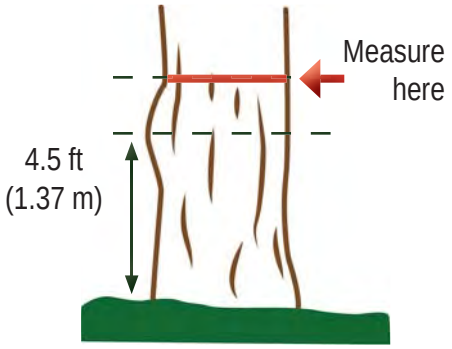
Example of measuring DBH CORRECTLY
d-Tape height adjusted to avoid trunk cavity and irregularity
Photo: J.P. Fristensky

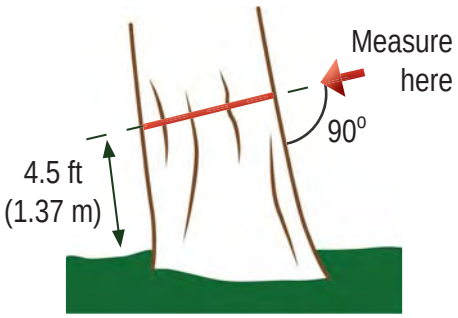
2.12 Trunk Diameter

Special Considerations for DBH

Tree with Buttswell or Bottleneck	Measure these trees 1.5 ft (0.46 m) above the end of the swell or bottleneck if the swell or bottleneck extends 3.0 ft (0.91 m) or more above the ground.
Tree with Irregularities at DBH	On trees with swellings, bumps, depressions, or branches at DBH height, measure immediately above the irregularity at the place the irregularity ceases to affect normal stem form.
Leaning Tree	Measure diameter at 4.5 ft (1.37 m) from the ground. The 4.5 ft (1.37) distance is measured along the underside face of the trunk, and measure diameter perpendicular to the trunk.







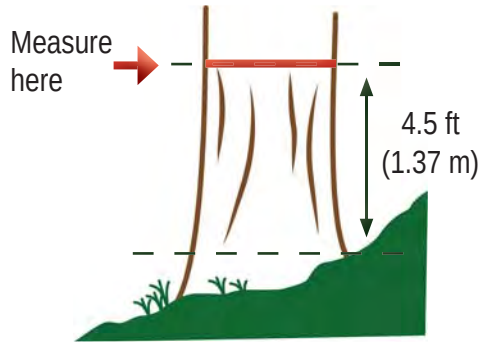
IMPORTANT NOTE: Always record the exact height of diameter measurement. Most commonly, you will record trunk diameter at 4.5 ft (DBH, 1.37 m), but sometimes other heights will be used due to these special considerations. You must record the height of measurement to allow future field crews to record diameter at the same spot on the tree so that the diameter growth can be calculated.

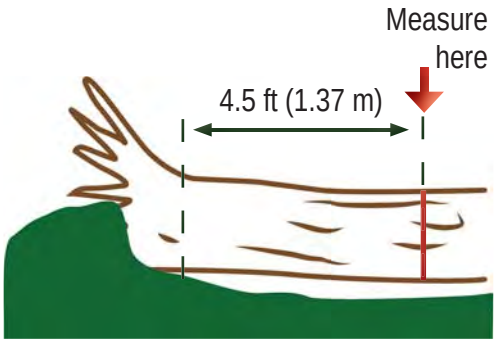
Graphics by L.B. Shafer

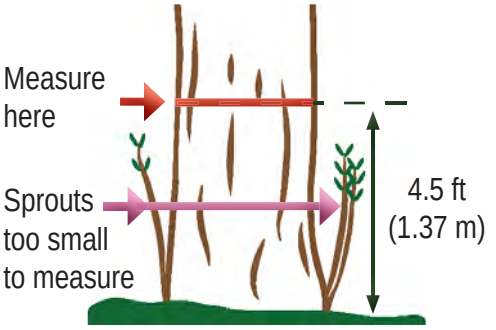
2.12 Trunk Diameter

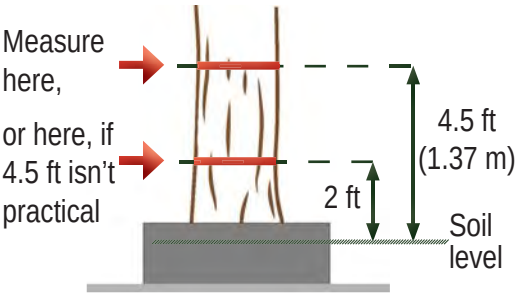
Special Considerations for DBH

Tree on Slope	Measure diameter at 4.5 ft (1.37 m) from the ground along the trunk on the uphill side of the tree. If the tree is leaning on the slope, measure diameter as noted under “Leaning Tree”.
Live Windthrown Tree	Measure from the top of the root collar along the length to 4.5 ft (1.37 m).
Root Sprouts	Root sprouts are handled the same as forked trees, with the exception that stump sprouts are not required to be 1/3 the diameter of the dead trunk. See pages 44-46.
Tree in Raised Planter	Height to DBH point is taken from the soil line, and DBH may need to be measured at 1-2 ft from soil for practical access.









Graphics by L.B. Shafer & J.P. Fristensky

2.12 Trunk Diameter

NEEDS EXTERNAL REVIEW

Multi-stem Trees

Multi-stem trees, also called forked trees, often require extra time and attention to detail. In order to qualify as a fork, the stem in question must be at least 1/3 the diameter of the main stem and must branch out from the main stem at an angle of 45 degrees or less. In other words, you should not record DBH for a low horizontal branch.

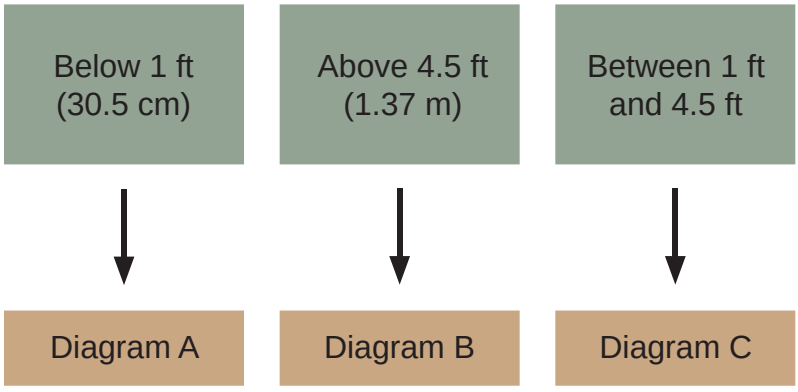
IMPORTANT NOTE: The main purpose in recording DBH is to get precise growth re-measurement data. In many instances we can record just one stem on a multi-stem tree. Use this as your guiding principle when deciding where to measure DBH for particular trees. Use the diagrams below to help you determine where to record DBH on multi-stem trees.

For the illustrations about multi-stem trees, the dashed lines indicate the pith – the tissue at the center of each stem. Noting where the stems fork and imagining where the piths intersect with multi-stem trees is the first step in figuring out how to record DBH for multi-stem trees. You will have to take your best guess about where the piths intersect, but do not stress over it. As long as the exact height of measurement is recorded, future field crews will be able to measure at the same spot on the tree.

IMPORTANT NOTE: As with all DBH measurements, always record the exact height at which you measured diameter, to ensure consistency with future data collection. For multi-stem trees, you will record the DBH and height of DBH separately for each stem.

When measuring the DBH of multi-stem trees, record the stems in clockwise order, beginning with the largest.

Where do the piths intersect?



2.12 Trunk Diameter

NEEDS EXTERNAL REVIEW

Multi-stem Trees

Diagram A Piths intersect below 1 ft

When the tree forks close to the ground – when the piths intersect below 1 ft (30.5 cm) – measure several stems at 4.5 ft (1.37 m). Measure up to 6 stems total. Begin with the largest stem and continue clockwise for other stems.

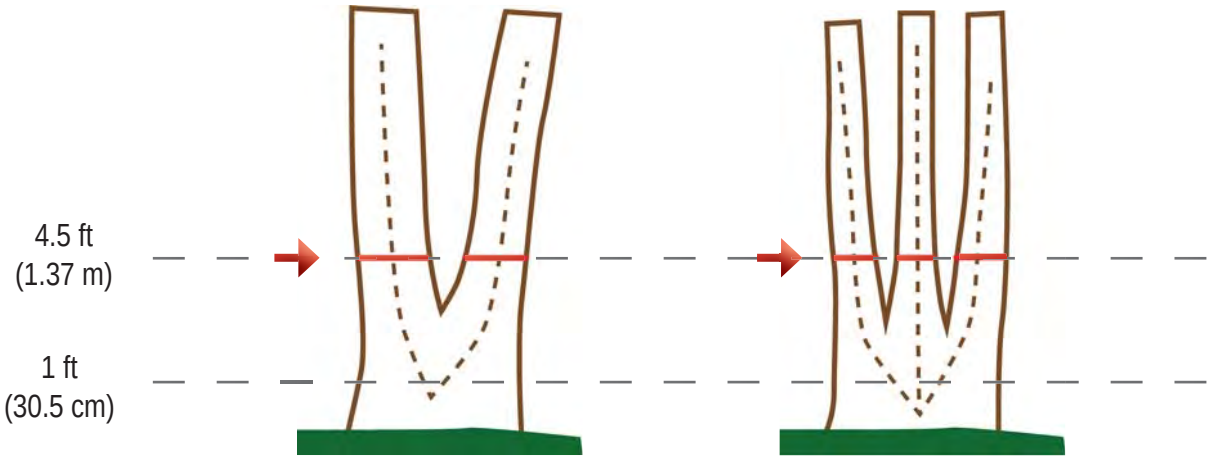
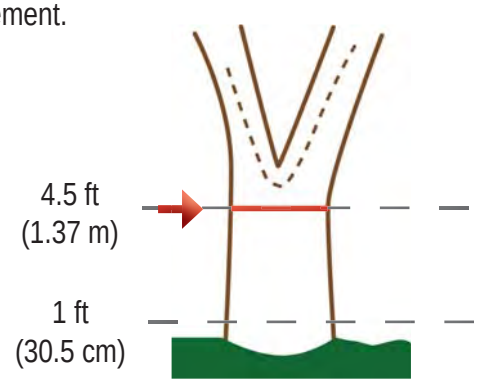


Diagram B Piths intersect above 4.5 ft

Trees that have pith intersection at or above 4.5 ft (1.37 m) are treated as a single main trunk for DBH measurement. Record just one DBH (in other words, such trees are not considered multi-stem here). If there is any swelling from the fork that would inflate DBH at 4.5 ft (1.37 m), record diameter just beneath the swelling and record height of DBH measurement.



Record DBH at the red line

Graphics by L.B. Shafer

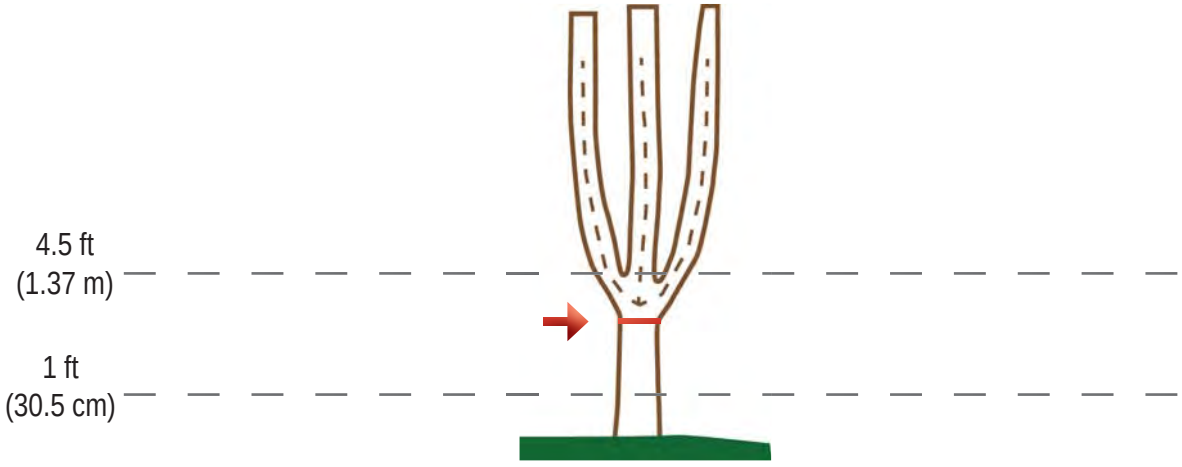
2.12 Trunk Diameter

NEEDS EXTERNAL REVIEW

Multi-stem Trees

Diagram C Piths intersect between 1 ft and 4.5 ft

When the piths intersect between 1 ft and 4.5 ft, measure below 4.5 ft. Specifically, measure DBH for the main trunk as close as possible to 4.5 ft (1.37 m) above the ground while avoiding any irregularities or swelling from branches or trunk forks. It is acceptable to record as low as 1 ft. This same principle applies to trees with abundant small branches that interfere with DBH measurements near 4.5 ft.



Record DBH at the red line

Graphic by J.P. Fristensky

This instruction is appropriate for the following genera:

- Pears (*Pyrus spp.*)
- Plums and Cherries (*Prunus spp.*)
- Crabapples (*Malus spp.*)
- Zelkova (*Zelkova spp.*)
- Hawthorne (*Crataegus spp.*)

Pyrus spp.

Prunus spp.

Malus spp.

Zelkova spp.

Crataegus spp.

Photos: J.P. Fristensky

2.12 Trunk Diameter

Examples

Below are some pictures to illustrate DBH measurements in action. Use the instructions on pages 42-46 to guide you through the rules regarding special circumstances.

DBH for single-stem tree measured at height of 4.0 ft (1.22 m); the piths meet above 4.5 ft (1.37 m) but height is lower to avoid swelling
Photo: J.P. Fristensky

DBH for single-stem tree that has irregularities, measure above bulge and record height of measurement.
Photo: J.P. Fristensky

DBH for multi-stem tree where first fork piths meets between 1.0 and 4.5 ft, thus DBH is measured below fork and record height
Photo: J.P. Fristensky

DBH for Specific multi-stem tree species (*Zelkova spp.*) where piths meet around 4.5 ft (1.37 m), measure just below swelling and record height
Photo: J.P. Fristensky

2.13 Notes for Supervisory Review

Description

Whenever you encounter a challenge with a tree that cannot be resolved in the field, take notes for your supervisor. This is a place to note difficulties with species identification, DBH measurements, or other variables. By entering a note here, you are flagging this tree for review by the project supervisor. Recording special challenges with trees can also be helpful for data analysts and future field crews. For example, even something as seemingly simple as Mortality Status is not always straightforward. There are rare cases of "zombie trees" that were classified as Standing Dead one year, and Alive in a later year.

Values

On the field data collection sheet, check one or more items listed below to signal to your supervisor what kind of issue you encountered. By knowing which variable(s) your comment is about, supervisors and researchers can identify and resolve common problems across the project.

- Location
- Site Type
- Land Use
- Species
- Fine Twig Dieback
- Trunk Diameter
- Mortality Status

Recorded for

Any trees that have special issues that require supervisor's feedback, would be helpful for data analysts, or would be useful for future field crews.

IMPORTANT NOTE: Please only record notes for supervisory review when absolutely necessary. Whenever possible, resolve issues in the field. If notes are deemed necessary, keep the notes as concise as you can.

2.13 Notes for Supervisory Review

Mortality Status: Alive
Notes: Cut back to 2 ft tall, main trunk still alive but no DBH
Photo: L.A. Roman

Mortality Status: Alive
Notes: Dead main stem with basal sprouts, no crown
Photo: L.A. Roman

Species: Unknown
Notes: Need help with ID, pictures of characteristics taken
Photo: J.P. Fristensky

DBH and DBH Height:
Notes: Stem DBH larger than 1", measurement taken at 1ft height on both stems, closest to road is DBH1
Photo: J.P. Fristensky

3
Supplemental Tree Health Metrics

Photo: R. Hallett

3 Supplemental Tree Health Metrics

Overview

This section covers supplemental Tree Health Metrics. These methods are specifically designed for use by field crews with extensive training and close supervision. We do not recommend using these variables with novice field crews that have minimal training and background experience. This section is NOT part of the Minimum Data Set.

These variables concern crown health, as well as signs and symptoms of diseases and pests. These methods were developed to support the Healthy Trees, Healthy Cities initiative of The Nature Conservancy (TNC), in partnership with the USDA Forest Service.

The Nature Conservancy

3.1 Crown Health

needs attn

3.1.1 Vigor

Description

Vigor is a holistic assessment of crown health based on several signs of stress (dieback, discoloration, defoliation). This rating mirrors the common condition ratings used in urban forestry (good / fair / poor / dying) but provides more detailed definitions, and is limited to crown health (not whole tree or crown and wood combined).

Vigor Class	Description
1	Tree appears to be in reasonably good health; no major branch losses; less than 10% cumulative fine twig dieback, defoliation, and/or discoloration present
2	Major branch losses, fine twig dieback, and/or foliage discoloration present in 10-25% cumulative of the crown
3	Major branch losses, fine twig dieback, and/or foliage discoloration present in 26-50% cumulative of the crown
4	Major branch losses, fine twig dieback, and/or foliage discoloration present in more than 50% cumulative of the crown
5	Tree is standing dead – same definition as standing dead in mortality status (pg 32). Tree is completely dead above-ground, with no green leaves or live buds.

Recorded for

All live and standing dead trees. Do not record for removed/missing trees.

3.1 Crown Health

3.1.2 Transparency

Description

Foliage transparency is the amount of skylight visible through the live, normally foliated portion (where you see foliage, normal or damaged, or the remnants of its recent presence) of the crown.

Record transparency by taking 4 vertical pictures through the tree's crown. This will allow for digital processing to estimate transparency, which is more accurate than visual estimation.

Recorded for

All live and standing dead trees. Do not record for removed/missing trees.

Transparency Vertical Photo #1
Photo: J. Bond, *Albizia saman*

Transparency Vertical Photo #2
Photo: J. Bond, *Albizia saman*

Transparency Vertical Photo #3
Photo: J. Bond, *Albizia saman*

Transparency Vertical Photo #4
Photo: J. Bond, *Albizia saman*

3.1 Crown Health

3.1.3 Discoloration

Description

Leaf discoloration is a symptom of some diseases, can indicate a nutrient imbalance, and can be a symptom of drought stress. Consider the combined leaf area of the crown when estimating discoloration percent in the crown. For example, a tree that has 100% of its leaves with a small spot on them is not 100% discolored.

This metric should only include deviation from the normal healthy color of leaves for the target tree's species and cultivar. For example, 'Crimson King' maples are typically maroon.

Discoloration Class	Range
1	0-1% (trace)
2	2-25%
3	26-50%
4	51-75%
5	76-100%

Recorded for

All live and standing dead trees. Do not record for removed/missing trees.

3.1 Crown Health

needs attn

3.1.4 Chlorophyll Fluorescence Performance Index

Description

Chlorophyll fluorescence meters can be used in the field to measure photosynthetic efficiency. Collect 5 “sun” leaves from different parts of the crown, and follow procedures taught during training to use the chlorophyll fluorescence meter.

Values

The values you record for this tree will be:

- A performance index from the instrument
- The instrument serial number

Recorded for

All live trees.

NEED IMAGE

Collecting Sun Leaves
Photo:

NEED IMAGE

Meter
Photo:

3.2 Crown Light Exposure

Description

Crown light exposure (CLE) is the number of sides of the tree receiving sunlight from above. There are 5 sides considered: the top of the tree is counted as one side, plus four equal vertical sides of the tree. Count the number of sides that would receive direct light it the sun were directly above the tree. A sliver of a side receiving light does not qualify.

Crown Light Exposure Class	Description (from i-Tree Eco User's Manual v. 4.1.0)
0	The tree receives no full light because it is shaded by trees, vines, or other vegetation.
1	The tree receives full light from the top or 1 side.
2	The tree receives full light from the top and 1 side (or 2 sides without the top).
3	The tree receives full light from the top and 2 sides (or 3 sides but not top).
4	The tree receives full light from the top and 3 sides.
5	The tree receives full light from the top and 4 sides.

Recorded for

All live trees. Do not record for removed/missing trees.

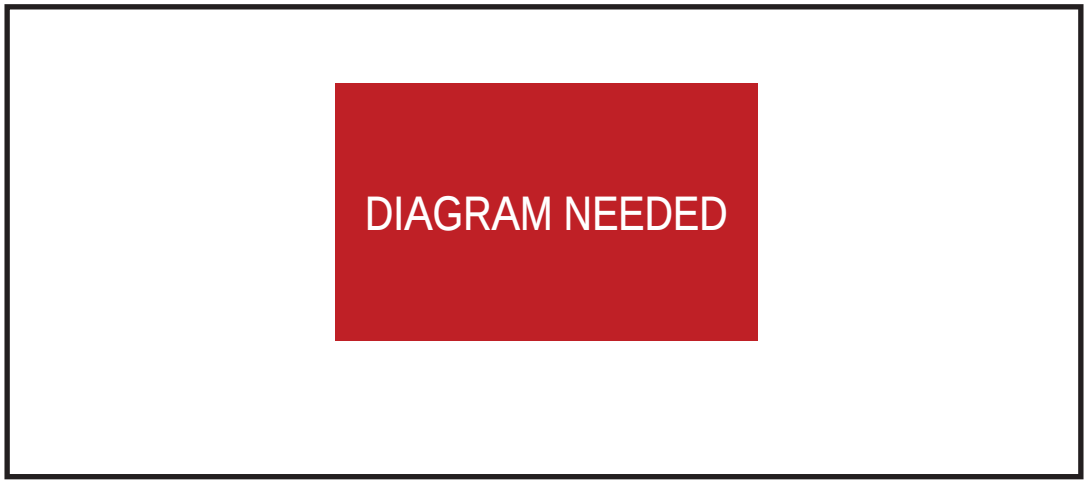


Diagram of urban conditions

Diagram:

3.3 Pests and Diseases

Early Pest Detection

Description

The following signs/symptoms are those commonly found as a result of thirteen insects or pathogens on a list vetted by several forest health professionals involved with TNC's Forest Health Protection Program: Emerald Ash Borer, Asian longhorned beetle, Balsam woolly adelgid, citrus greening (huanglongbing), gold-spotted oak borer, gypsy moth (European, Asian and Rosy), hemlock woolly adelgid, oak wilt, polyphagous shothole borer, sirex woodwasp, sudden oak death, thousand cankers disease, viburnum leaf beetle, winter moth. This information has been in part adapted from the US Forest Service's iPed Field Manual: Pest Evaluation and Detection published in May 2010 available at www.na.fs.fed.us.

Sign or Symptom	Description	Rating Information
Exit Holes	Tunnels through the bark of the branch or trunk as a result of the insect leaving. The shape and size are indicative of the type of insect(s), specified by the rating class.	0 : None 1 : Pencil-width round exit holes 2 : Small, D-shaped exit holes 3 : Multiple exit holes the size of a pen tip 4 : Tiny holes surrounded by cankers 5 : Other
Exudation	A substance that oozes from a damaged area on the tree, often sticky, powdery, or slick, which causes discoloration of the bark.	0 : None 1 : Red or black staining ("ooze") 2 : Black fungal mat present below cracked bark 3 : Brown fungal mat present in sapwood 4 : Wet or dry discoloration around exit holes 5 : White powdery substance around exit holes 6 : Black or reddish ooze around cankers 7 : White woolly egg masses, undersides of leaves
Eggs / Egg Sites	The collection of eggs, typically found on the bark of twigs and branches, around crevices, or around existing wounds.	0 : None 1 : Waxy, woolly white egg masses at needle base 2 : Fluffly brown egg masses on trunk 3 : Clusters of small oval eggs 4 : Shallow, round discolored 'divots'
Frass	The powdery excrement of insects created by chewing on bark, stems, and leaves, typically found in crevices or at base of trunk. Similar in appearance to sawdust.	Binary: Present/Absent
Epicormic Sprouts	A weak branch attachment that is growing at the base of the tree, along bole (trunk), or on branches. Can be caused by topping, insect infestation, or other disease.	Binary: Present/Absent
Woodpecker Damaged (Bark Sloughing)	Holes drilled into the bark, often resulting in large sections of missing bark along the bole (trunk). Note: sapsuckers drill holes in close proximity, forming neat horizontal rows.	Binary: Present/Absent

3.3 Pests and Diseases

Early Pest Detection

Sign or Symptom	Description	Rating Information
S-shaped Galleries	The winding tunnels and pathways caused by feeding insects that are found beneath the bark.	Binary: Present/Absent
Presence of Insect (Any Stage)	Adult insect (e.g., beetle, moth), larvae (e.g., caterpillar), or pupa found on or just below the bark, or on foliage.	0 : None 1 : Moth with white to light brown wings 2 : Black beetle with white spots and long antennae 3 : Small emerald green beetle 4 : Small brown beetle with orange spots on its outer wings 5 : Caterpillar with three sets of blue spots, six sets of red spots 6 : Tiny brown beetle (PSHB) 7 : Bright green winged insect (Citrus psyllid)
Bark Fissures/Cracks	Splits in the bark along the bole (trunk), often vertical, under which tissue has been damaged.	Binary: Present/Absent
Cankers	A local, often sunken, depression of dead plant tissue found on a twig, branch, or trunk.	Binary: Present/Absent
Galls (on twig, branch, leaves)	A swelling or growth of plant tissue that has developed as the result of feeding activity of insects or mites.	Binary: Present/Absent
Fruit/Bud Damage	The shape deformation or blotchy discoloration of buds or fruits.	0 : None 1 : Misshapen fruits 2 : Discolored fruits 3 : Buds appear shriveled
Premature Leaf Loss	The loss of leaves prior to expected seasonal declines.	Binary: Present/Absent
Leaf Defoliation	Portions of the leaf missing due to insect feeding. This can occur on the outer edges or inner parts (usually near midrib or veins) of leaves.	0 : None 1 : Holes on leaves are near outer edge of leaf 2 : Holes are closer to the central vein (midrib) of the leaf
Wilted or Browning Leaves	A weakness of leaf rigidity or loss of color due to the reduction of internal water pressure. This typically results from insect damage, environmental or chemical stress, root damage, or poor soil conditions.	Binary: Present/Absent

3.3 Pests and Diseases

Examples

Exudation
Photo: E. L. Barnard, Florida Department of Agriculture and Consumer Services, Bugwood.org

Frass
Photo: Pennsylvania Department of Conservation and Natural Resources - Forestry Archive, Bugwood.org

Eggs
Photo: W. Cranshaw, Colorado State University, Bugwood.org

Exit Holes
Photo: J. R. Meeker, USDA Forest Service, Bugwood.org

3.3 Pests and Diseases

Examples

Epicormic Sprouts
Photo: J. O'Brien, USDA Forest Service, Bugwood.org

Woodpecker Damage
Photo: G. Csoka, Hungary Forest Research Institute, Bugwood.org

Galleries
Photo: D. Herms, The Ohio State University, Bugwood.org

Bark Fissures
Photo: E. L. Barnard, Florida Department of Agriculture and Consumer Services, Bugwood.org

3.3 Pests and Diseases

Examples

Adult Insect or Larvae
Photo: L. L. Hyche, Auburn University, Bugwood.org

Cankers
Photo: N. Tisserat, Colorado State University, Bugwood.org

Galls
Photo: R. Routledge, Sault College, Bugwood.org

Leaf Defoliation
Photo: R. S. Kelley, Vermont Department of Forests, Parks and Recreation, Bugwood.org

4
Resources

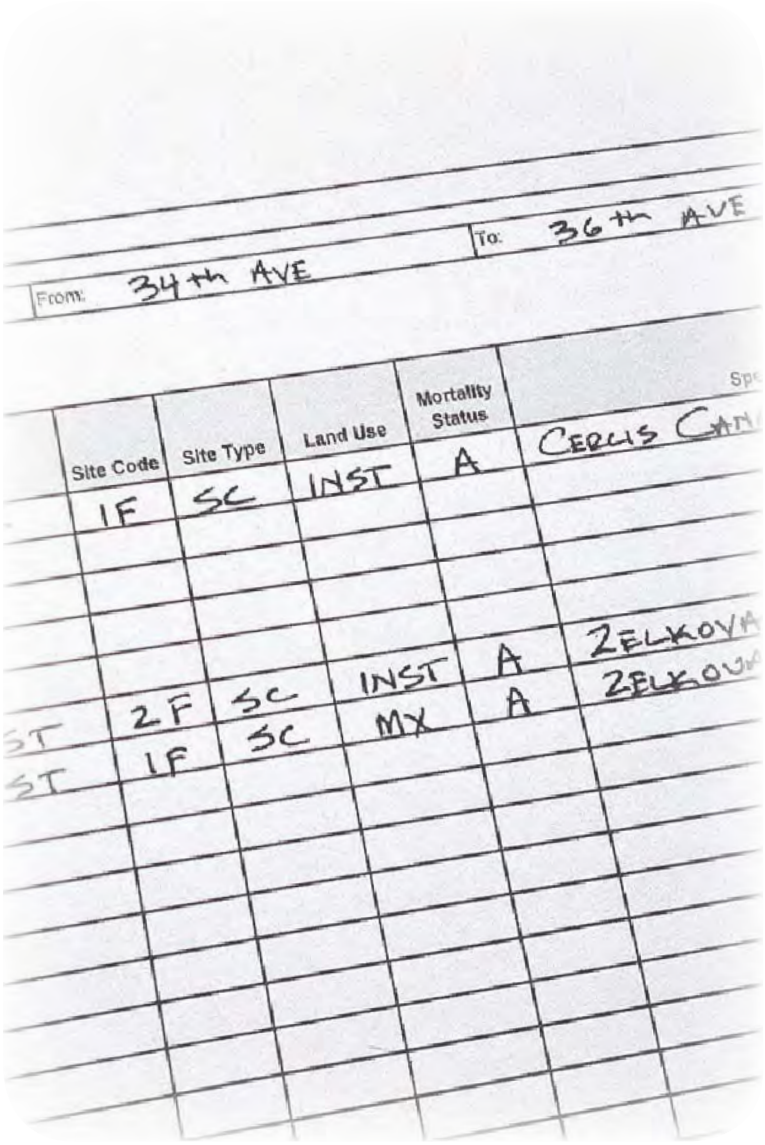


Photo: J.P. Fristensky

4.1 Field Data Sheets

The following three pages are field data collection sheets, optimized for STREET trees, and are formatted to allow collecting data on an entire block. One sheet is for the Minimum Data Set variables, as described in this *Field Guide,* with an example sheet filled in to demonstrate data collection of a multi-stem tree. The third sheet is for data collection of the Supplemental Tree Health Metrics (Tree Health Metrics & Pests).

In the example sheet illustrating multi-stem DBH, it is recommended to record the DBH and DBH Height of each stem in subsequent rows. This will allow for clarity of measurements and draw attention to a multi-stem tree.

NOTE: These field collection data sheets are available on the UTGL website, and have been formatted for printing in addition to database entry with pre-populated codes from the *Field Guide*. These Minimum Data Set files can be found at: www.urbantreegrowth.org/field-guide.html

Crew Member(s):	Experience Level:	Date:

On Street:	From:	To:

Units (circle one): cm in m ft

Tree ID #*	Tree Tag ID (if avail.)	Dist from Ref	Street Side	Side of Center-line	Address	Site Code	Site Type	Land Use	Mort. Status	Species	DBH**	DBH Height**	Fine Twig Dieback
			ev odd	left right									
			ev odd	left right									
			ev odd	left right									
			ev odd	left right									
			ev odd	left right									
			ev odd	left right									
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			ev odd	left right									
			ev odd	left right									

** record multi-stem DBH & DBH Height for stems on subsequent rows

Tree ID #*	For Variable	Notes for Supervisory Review

* Tree Id # begins anew with each plot. This ID # is used only to facilitate record-keeping with paper data sheets for the current field season. Use Tree ID # to link tree data to the notes section as needed

Site Type: Sidewalk Cut-out (SC), Sidewalk Planting Strip (SP), Median (M), Other Hardscape (OH), Front Yard (FY), Back Yard (BY), Maintained park (MP), Other Maintained Landscaped Area (OM), Natural Area (Nat)

Land Use: Single-family Residential - attached (SFR-A), Single-family Residential - detached (SFR-D), Multi-family Residential (MFR), Mixed Use (MX), Commercial (COMM), Industrial (IND), Institutional (INST), Maintained Park (MP), Natural Area (NAT), Cemetery (CEM), Golf Course (GC), Agricultural (AG), Utility (UT), Water/Wetland (W), Transportation (TR), Vacant (V), Other (O)

Minimum Data Set Sheet - Sample Multi-stem

Crew Member(s): JASON / DAN | Experience Level: INTERN | Date: 06/18/2015

On Street: WALNUT ST | From: 34TH AVE | To: 36TH AVE

Units (circle one): cm (in) | m (ft)

Tree ID #*	Tree Tag ID (if avail.)	Dist from Ref	Street Side	Side of Center-line	Address	Site Code	Site Type	Land Use	Mort. Status	Species	DBH**	DBH Height**	Fine Twig Dieback
1	—	18'	(ev) odd	(left) right	3406 WALNUT ST	1F	SC	INST	A	CERCIS CANADENSIS	3.7	4.5	25
			ev odd	left right							3.1	4.5	
			ev odd	left right							2.6	4.5	
			ev odd	left right							3.2	4.5	
			ev odd	left right							2.1	5.3	
2	—	38'	(ev) odd	(left) right	3406 WALNUT ST	2F	SC	INST	A	ZELKOVA SP	13.7	5.2	10
3	—	58'	(ev) odd	(left) right	3410 WALNUT ST	1F	SC	MX	A	ZELKOVA SP	14.5	4.5	5
			ev odd	left right									
			ev odd	left right									
			ev odd	left right									
			ev odd	left right									
			ev odd	left right									
			ev odd	left right									
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			ev odd	left right									
			ev odd	left right									
			ev odd	left right									

Record multi-stem DBH and DBH Height on descending rows and per protocol specific to your project

** record multi-stem DBH & DBH Height for stems on subsequent rows

Tree ID #*	For Variable	Notes for Supervisory Review
2	DBH / DBH HEIGHT	DBH HEIGHT @ 5.2' DUE TO DAMAGE AT 4.5'

* Tree Id # begins anew with each plot. This ID # is used only to facilitate record-keeping with paper data sheets for the current field season. Use Tree ID # to link tree data to the notes section as needed

Site Type Sidewalk Cut-out (SC), Sidewalk Planting Strip (SP), Median (M), Other Hardscape (OH), Front Yard (FY), Back Yard (BY), Maintained park (MP), Other Maintained Landscaped Area (OM), Natural Area (Nat)

Land Use Single-family Residential - attached (SFR-A), Single-family Residential - detached (SFR-D), Multi-family Residential (MFR), Mixed Use (MX), Commercial (COMM), Industrial (IND), Institutional (INST), Maintained Park (MP) Natural Area (NAT), Cemetery (CEM), Golf Course (GC), Agricultural (AG), Utility (UT), Water/Wetland (W), Transportation (TR) Vacant (V), Other (O)

Mortality Alive (A), Standing Dead (SD), Removed/Missing (R), Unknown (U)

Tree Health Metrics & Pest Sheet

Tree ID #*	Vigor Class	Leaf Discoloration	CLE	Exit holes	Exudation	Eggs	Frass	Epicormic Sprouts	Woodpeck. Damage	S-shaped Galleries	Adult Insect or Larva	Bark Fissures	Cankers	Galls	Fruit/ Bud Damage	Premature Leaf Loss	Leaf Defoliation	Wilted/ Brown Lvs
									`									

Tree ID #*	For Variable	Notes for Supervisory Review

* Tree Id # begins anew with each plot. This ID # is used only to facilitate record-keeping with paper data sheets for the current field season. Use Tree ID # to link tree data to the notes section as needed

4.2 Species Identification

Below is a small sampling of available resources to assist with tree genus and species identification:

Arbor Day Foundation's What Tree Is That?
www.arborday.org/trees/whattree/mobile.cfm
A free step-by-step app that guides the user through tree species and genus identification using dichotomous key characteristics

New York City Street Tree Leaf Key
www.nycgovparks.org/sub_your_park/trees_greenstreets/treescount/2005_Census_Leaf_Key_Final.pdf
Reference sheet of Common Street Trees within NYC using pictures of leaf and fruit

Leafsnap
www.leafsnap.com
A free electronic field guide using leaf photographs to narrow list of potential tree species
From Columbia University, University of Maryland, and Smithsonian

vTree
www.dendro.cnre.vt.edu/dendrology/main.htm
A free step-by-step app that assists user in local tree species and genus identification using dichotomous key characteristics
From Virginia Tech

Stikky Trees
Reference guide with images of common trees within United Stated to assist in species identification
Published by Laurence Holt Books, Inc.

Audobon Trees - A Field Guide to North American Trees
http://www.audubonguides.com/index.html
A low-cost app with images and search function by leaf shape, region, bark, and other advanced options to assist in North American tree species and genus identification

4.3 Other Protocols and Tools

The *Urban Tree Monitoring Protocols* document you have before you builds on past work from a variety of researchers and professionals. The resources below offer related protocols for urban tree inventories and monitoring, as well as additional data collection tools.

i-Tree - Tools for Assessing and Managing Community Forests

www.itreetools.org

For those interested in monitoring change across the entire urban forest – to represent citywide characteristics – randomly located tenth-acre plots using the i-Tree Eco methodology may be most appropriate. This well-established protocol produces a summary of urban forest structure, functions, and services based on a single static inventory, but it can also be used for ongoing monitoring.

Urban Forest Inventory and Analysis

www.nrs.fs.fed.us/fia/data-collection/urban/

The US Forest Service's Forest Inventory and Analysis (FIA) program is a long-term permanent plot network encompassing all of the nations closed canopy forest. The goal of the FIA program is to create an accurate and timely inventory of the nation's forests, to monitor current forest conditions, and to facilitate sustainable management. Recently, the FIA program has added methods for assessment of urban forests that incorporate the statistical and scientific rigor of traditional FIA plots with methodology appropriate for urban settings. When fully implemented Urban FIA will provide a nationwide network of urban forest monitoring plots. In the meantime the methods can be readily adapted to a variety urban tree and forest monitoring projects

Planted Tree Re-Inventory Protocol

Developed by Bloomington Urban Forestry Research Group

www.iub.edu/~cipec/research/bufrg_protocol.php

This field protocol was developed by the Bloomington Urban Forest Research Group at the Center for the Study of Institutions, Populations and Environmental Change. The methods are specifically designed for neighborhood-based planting projects, and include data on the planting site, tree growth and observed maintenance.

rePhoto

www.projectrephoto.com

A mobile app developed to assist in taking sequential photos of the same object over time from the same location. The previous and current pictures can be spliced together to demonstrate change. For those interested in documenting tree growth, decline, or seasonal change.

4.3 Other Protocols and Tools

needs attn

EarthWatch Urban Forests Initiative
and MyTreeTracker App
www.earthwatch.org/expeditions/exploring-bostons-urban-forest
www.mytreetracker.org/cwis438/websites/MyTreeTracker/About.php

The data collection process relies on volunteer squads of local residents, or citizen scientists. Earthwatch organizes events where volunteers learn about the value of urban trees and are trained in the data collection methods.These citizen scientists are then assigned trees to measure the species, diameter, and health. The data is entered into www.mytreetracker.org where volunteers can see the trees they measured and the benefits provided.

TreeKIT Collaborative Mapping Method and App
www.treekit.org
digitalcommons.lmu.edu/cate/vol6/iss1/3/

[Ask Phil Silva to review to make sure we're summarizing his program properly]

Urban Tree Inventory Standard – Sweden
www.treeinventory.nu/
www.urbantreegrowth.org/uploads/1/1/1/7/11172919/stberg2014.pdf

The standard has been well received by the industry and surprisingly few have argued against the definitions. The main reason for this is probably the large benefits of having a national standard to refer to, which previously was lacking in Sweden. Conducting inventories that follow the standard has made it possible to take further steps in urban tree management. These included making national recommendations on how to create a tree management plan, how to work with hazard trees and helping the industry to get more coherent language and terminology.

Software Requirements for Urban Tree Monitoring

[this is a place-holder to link to the reports from Azavea for the UTM contract they have with PHS/FS… at some point in late spring those reports are supposed to be publically released, and if they are out in time, they should be mentioned here. Check with Sarah Low & Deb Boyer in April to see if the final reports will be ready in time for us to link within this *Field Guide*.]

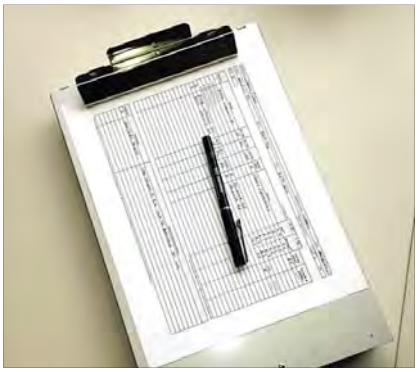
Tree Risk Assessment - Level 1
Developed by Texas A&M Forest Service (TFS)
https://itunes.apple.com/us/app/tree-risk-assessment-level-1/id917769134?mt=8

"The Level 1 Tree Risk Assessment app helps perform a limited visual tree assessment. It maps those trees with obvious defects that have a Probable or Imminent likelihood of failure and identifies treatment. Designed for pre-and post-storm use this app can store tree assessments locally, export them via email or can be connected to ArcGIS Online."

4.4 Field Equipment Checklist

The following is a list of equipment that should be taken into the field:

- *Field Guide*
- Species ID resources
- Clipboard
- Pen
- Data collection sheets
- d-tape (with 1/10th inch increments)
- Caliper tool
- Camera
- Contractor grade measuring tape
- Custom-cut 4.5' height pole
- Hard Hat
- Safety Vest
- Any project-specific equipment (e.g., Chlorophyll Fluorescence Meter and throw bag)



Pen and Clipboard
Photo: J.P. Fristensky

Field Guide and Species ID resources
Photo: 2005 NYC Street Census

Hard hat and safety vest
Photo:

DBH tape (d-tape)
Photo: L.A. Roman

Caliper tool
Photo: J.P. Fristensky

4.5' height pole
Photo: Friends of Grand Rapids Parks

5 Glossary

Caliper - diameter of the trunk at 1 ft (30.5 cm) from the ground. Caliper also refers to a measurement instrument.

Condition - condition reflects the health (foliage) and stability (wood) of a tree; for purposes of this protocol, condition is evaluated in terms of fine twig dieback (Bond 2010)

DBH - diameter of the trunk at breast height (4.5 ft or 1.37 m from the ground)

DBH tape - also known as d-tape; the best piece of equipment for measuring trunk diameter that is ≥ 1 inch

Fine Twig Dieback - "recent mortality in the upper and outer portion of the crown, and reflects the severity of recent stresses on a tree" (FIA, 2011)

Land Use - description of the way the property around (or adjacent to) the tree is used by humans

Pith - the tissue at the center of each stem, used for nutrient storage and transport; visualizing the pith in multi-stemmed trees helps determine where to measure

Site Type - description of the tree's immediate location or planting site

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