A Step-by-Step Guide to Taking Urban Forest Inventory Measurements

Sea Grant Mississippi-Alabama

Mississippi State University Extension

This publication provides a step-by-step guide to conducting measurements for use in an urban tree inventory. In general, this guide reflects the measurements included in the U.S. Forest Service's i-Tree Eco software program; however, measurements are fairly standard variables used in bottom-up urban forest inventories.

Urban Tree Inventories, i-Tree, and Equipment

What is a community tree inventory?

A community tree inventory performs three primary functions:

1. As a ***database*** consisting of information about individual trees. This information includes tree location, diameter, height, canopy width, condition, and hazards.
2. As a ***maintenance tool***, the community tree inventory enables managers to identify trees that need to be pruned, staked, fertilized, cabled, or removed. Urban forest managers use the inventory to periodically review trees that have been identified as hazards.
3. As a ***management tool***, the inventory enables aggregation of individual tree data to provide information about a population of trees—also known as the urban forest. Tree population information includes species distribution and canopy cover. A tree map enables community forest managers to identify and prioritize community canopy goals (e.g., planting and maintenance), while accounting for condition of the community forest (i.e., dead, critical, poor, fair, good, very good, or excellent).

   Creating a visual map of how urban forest benefits are distributed across the landscape is known as benefit mapping. A key aspect of benefit mapping is applying a dollar value to trees based on their individual characteristics. Using computer software, economic value can be assigned to ecosystem service benefits of urban trees such as pollution removal (e.g., ozone, sulfur dioxide, nitrogen dioxide), carbon sequestration, and energy savings.

What is a bottom-up tree inventory?

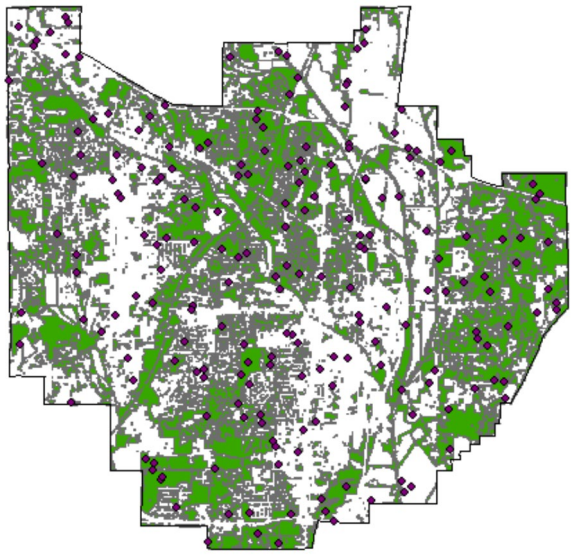
A bottom-up inventory generates primary data from on-the-ground inventory methods as opposed to aerial or satellite imagery (i.e., top-down inventory). This approach requires a process of measuring individual tree characteristics and quality assurance/control. Field data collection requires extensive planning, management, and time. Although it can be somewhat costly, the results can provide more information than possible through top-down analyses. For these reasons, it is beneficial to perform a bottom-up inventory at some stage of the community tree inventory.

What is the scope of the bottom-up inventory (or how much is enough)?

The scope, also known as the sample, is one of the most important decisions made in planning a bottom-up urban forest inventory. Determining the scope of the survey depends on available resources and goals. Inventory projects have ranged from parks to small neighborhoods to cities to counties.

A statistical representation of the urban forest requires a random sample, whereby plots are placed randomly across the landscape within boundaries of the study area (e.g., the official city limits). A ***simple*** random sample is the most basic form of random sample. A simple random

sample, however, may not provide a true picture of forest cover since the urban forest is usually not distributed across the landscape randomly.

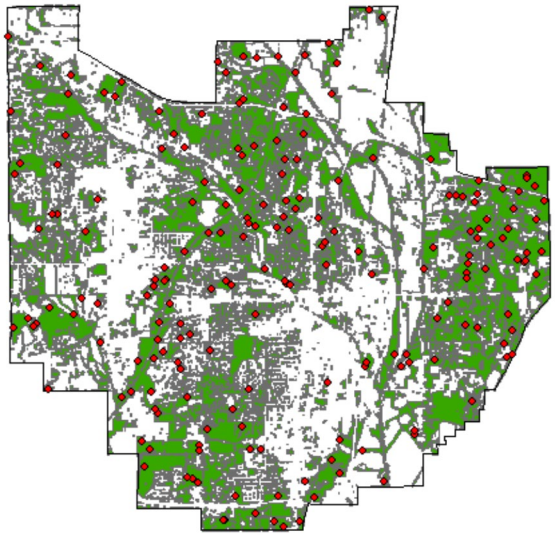


Simple random sample in Tupelo, MS (N=200). The green areas represent trees.

A ***stratified*** random sample offers an alternative statistical representation with plots randomly allocated according to land use. A stratified random sample decreases the number of plots wasted on sites with little or no trees (e.g., large commercial parking lots and agriculture fields). However, because such sites are important characteristics of any populated place, some plots will still be placed there.

Research has found that 200 tenth-acre plots in a given area typically provide enough information for statistical inference and benefit mapping while also maintaining an acceptable level of costs associated with data collection (Nowak et al. 2008). Fewer points may be appropriate for a small area, but a greater number of points decreases error in the sample. A statistical sample mitigates the effects of data collection error and landscape variation. The project facilitator will add 5–10 percent more plots as "extra plots" in case some of the original 200 are inaccessible. Once the community determines the scope, the project facilitator will locate plots on a map using Geographic Information System (GIS) technology. Plot center geo-coordinates and the map will then be distributed to volunteers.

Finally, a ***full inventory*** (also called a 100 percent inventory) is often used to measure street trees, parks, and other public areas. This project scope measures each tree in the designated area. A full inventory is usually not a practical alternative for assessing the urban forest. Because a full inventory is unlikely to be implemented across the entire community, it does not usually provide a true representation of the urban forest.



In a stratified random sample in Tupelo, MS (N=200). The green areas represent trees. There are more points located in tree areas than in the simple random sample.

What is i-Tree?

Several urban forest inventory software packages are available. Some are freeware (licensed to use free of charge), while others can be fairly expensive. Inventory software should have some basic data entry fields such as Global Positioning Systems (GPS) coordinates and tree species. Preferably, additional entry fields would include tree height, diameter, crown width, crown missing, dieback, land use, and ground cover attributes. Canopy measurements are needed to assess canopy attributes.

One of the most commonly employed programs is the USDA Forest Service's i-Tree, available online at *www.itreetools.org*. i-Tree is a software suite produced with the collaboration of private and public partners. Currently, there are six applications: Eco, Streets, Hydro, Vue, Design, and Canopy. Each application focuses on specific objectives. For example, Eco provides a broad spectrum of data fields that, when combined with air pollution and meteorological data, quantifies community forest structure and environmental effects and applies a monetary value to tree benefits. By contrast, Hydro simulates the effects of changes in tree and impervious cover characteristics on stream flow and water quality.

The i-Tree software suite is peer-reviewed, public domain, easy-to-use software that allows for scalable analysis. In other words, results can be generalized from individual trees to neighborhood to city levels based on a sample inventory. From this information, users can make management recommendations such as species selection, address invasive species, and perform storm damage assessment. The remainder of this article focuses on the data entry variables found within i-Tree Eco.

How is data recorded?

Example data sheets and respective "cheat sheets" for the plot inventory (Appendices 1 and 2) and the full inventory (Appendices 3 and 4) can be found in the appendix to this document. The advantage of paper data input sheets is there is no risk of technological failure, however, paper data sheets are somewhat cumbersome to use and are susceptible to other problematic factors such as getting wet while working in the field. Due to the number of variables being recorded, the data sheet must be printed on 8.5 by 11 inch paper. In addition, paper requires an additional step—entering data into an electronic database—after measurements are taken. To address these deficiencies in paper data sheets, MSU Extension offers a smartphone application called MSUES TreeMetrics that includes each variable found in the paper data sheet. The app is downloadable to iOS and Android platforms from the MSU Extension app store.

In addition to groundcover, stem, and canopy measurements, we include at least a basic (yes/no) hazard observation measure. If desired, a positive response to this measure on the data sheet indicates the need to complete the hazard identification sheet (Appendix 5). Each of the measurements found on these data sheets will be explained in the following sections.

What equipment is needed?

MSU Extension recommends four pieces of equipment to conduct a basic volunteer inventory:

1. diameter tape
2. compass
3. clinometer
4. GPS unit

Diameter tape

Clinometer

Compass

GPS unit

While additional or more expensive equipment could be used, we find this equipment is appropriate for limited budgets and for use with volunteers. If available, smartphone apps may be used instead of the handheld compass and GPS.

Procedures

Note: We suggest urban forest inventory facilitators create an online public folder (e.g., Dropbox, Google Drive) where volunteers can access maps, documents, PowerPoint presentations, literature, and additional information on procedures.

Recording data onto the data sheet. Always use a pencil.

Plot Information

The first measurements describe the plot where the tree(s) is found (Appendix 1 and Appendix 2, page 1). Plots are one-tenth of an acre, or 37.2 feet in radius. Once plot center is found using a GPS unit, the data collectors measure a radius of 37.2 feet from plot center using a

Making a waypoint using GPS.

diameter tape. Every tree with at least half the stem falling inside the radius is considered within the plot and should be measured. The following is replicated from the Sample Plot Cheat Sheet (Appendix 1). If a plot is located on private property, access must be granted by the owner (Appendices 6 and 7).

PLOT ID: Enter plot ID. As mentioned above, plots are randomly created within the border of a given area. The plot ID is assigned by GIS software. The facilitator describes the plot location using roads and other geographic landmarks. A copy of a large-scale photo helps volunteers get reasonably close to the plot. Then, GPS is used to close in as much as possible to the plot center.

PLOT WP: Enter GPS waypoint of plot (not trees). Typically, a handheld GPS unit is used (if the MSU Extension urban inventory app is not used), which typically incorporates error up to around 30 feet. The volunteer attempts to get as close as possible to the GPS coordinates. At this point, the volunteer marks a "center point" of the plot using a landscaping flag, stick, rock, or some other object. The plot is then measured using a radius of 37.2 feet (37 feet and 13/32 inches), or one-tenth of an acre. Different-sized plots can be used, but Nowak et al. (2008) suggest one-tenth acre is most effective for i-Tree statistics. Trees are considered within the plot if at least half the stem at 4½ feet (known as diameter at breast height or DBH) lies within the radius measure.

DATE: Enter date of work.

CREW: Enter crew ID. A unique crew ID is assigned by the facilitator.

GPS UNIT: Enter GPS unit ID. Crew ID and GPS unit ID are used to trace the data back to volunteer collectors as part of quality control. If using the smartphone app, not applicable (NA) can be entered here.

PLOT ADDRESS: If the plot (or any portion) is located on private property, enter the plot address, including street number, street, and zip code.

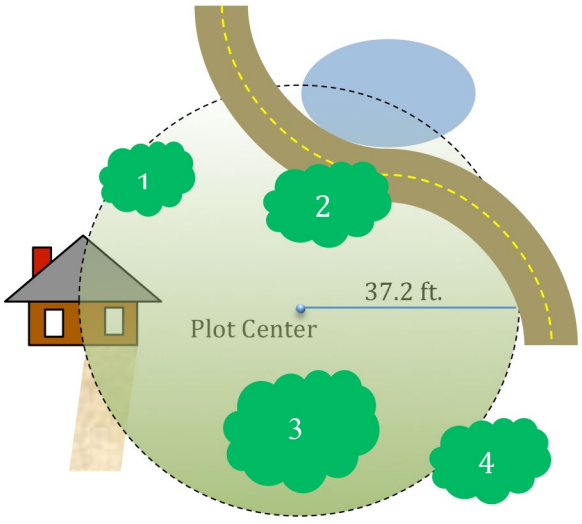
PLOT PHONE: If the plot (or any portion) is located on private property, enter the telephone number. The telephone number will be available after the property owner has consented to the procedure (Appendices 6 and 7). In some cases, special permission will need to be granted to access public property. In such cases, the same permission documentation should be used with access granted by the supervising authority.

OWNER NAME: Record the name of the owner of property (if public, note government entity).

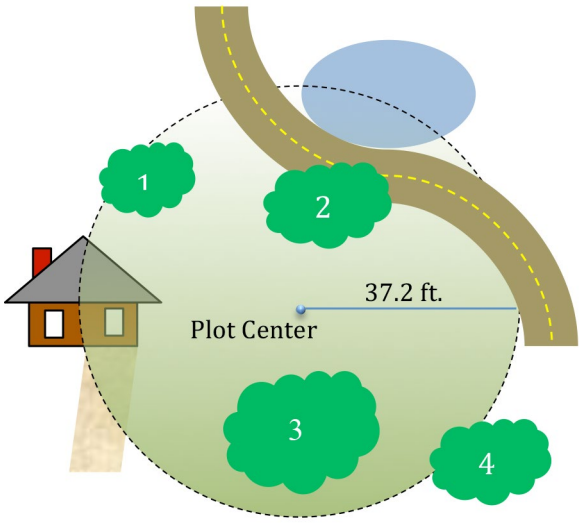
NOTES: Record anything noteworthy here. Record lack of access (e.g., property owner refusal or environmental conditions).

ACTUAL LAND USE AND PERCENT IN: The letter from the list below is recorded along with percent of each land use that falls within the plot. Proportions are recorded in increments of 1–5 percent, then every 5 percentage points. As with other qualitative estimates in the inventory, land use should be discussed and agreed upon by team members. Up to four land uses can be recorded. Below are the land uses recognized by i-Tree.

Residential (R)
Multi-family residential (M)
Commercial/ Industrial (C)
Park (P)
Cemetery (E)
Golf Course (G)
Agriculture (A)
Vacant (V)
Institutional (I)
Utility (U)
Water/wetland (W)
Transportation (T)
Other (O)



This one-tenth-acre plot has three trees. Tree number four is more than halfway out of the plot, while tree number 1 has more than half the stem inside the plot boundary.



This plot has approximately 4% T, 1% W, 95% R.

The number of trees on a plot can range from none to many.

PLOT TREE COVER: Record the estimated percent of tree canopy over the plot. This is another qualitative estimate that should be discussed among team members.

SHRUB COVER: Record the estimated percent of shrub cover in the plot. The facilitator will inform the volunteers what is classified as shrub cover.

GROUND COVER: Record the percent ground cover in plot, which must total 100 percent. The crew notes the percentage of the plot ground area that is covered by the materials below. Estimation may be facilitated by dividing the plot in halves or quarters, then summing the proportions of each section.

Building (B)

Concrete (C)

Tar (T): Blacktop/asphalt

Rock (R): Pervious rock surfaces such as gravel, brick, or flagstone walkways or patios (without mortar).

This category includes sand in playgrounds or added as topping to existing soil. Large solid rock outcrops should be listed as concrete.

Bare soil (S)

Duff/mulch (D)

Herbs (H): Herbaceous ground cover, other than grass, including agricultural crops

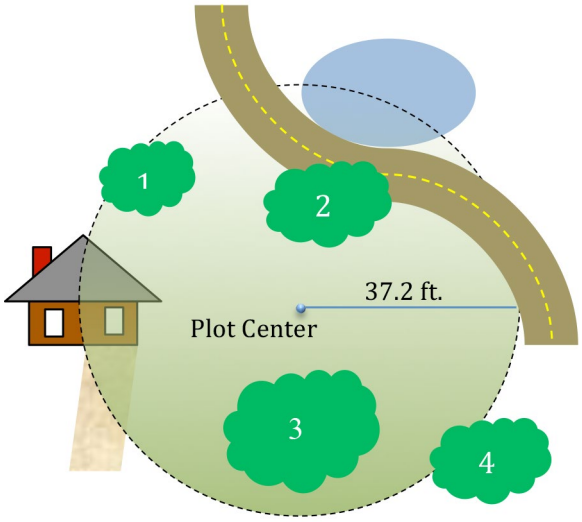
Maintained grass (MG)

Unmaintained grass (UG)

Water (W)

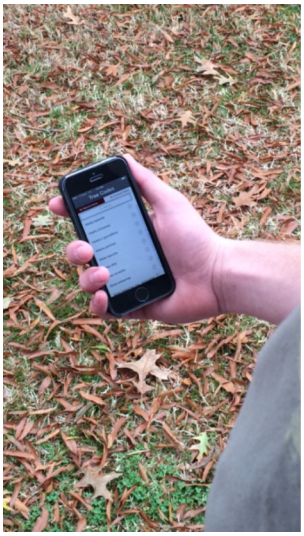
The following metrics are for individual trees within the plot (Appendix 1 and Appendix 2, page 2). Data collection for living and dead trees starts with the tree closest to due north and proceeds in a clockwise direction.

PLOT ID: Enter the plot ID from page 1 (Plot Information) so that the individual tree information can be linked to the correct plot.



This plot has approximately 40% tree cover, 0% shrub cover, 2% T, 1% C, 1% W, 1% B, 95% MG.

Ground covers in this plot include tar, maintained grass, and some mulch around the tree. The land use is institutional.



Using the tree code app to record the tree ID UFORE abbreviation.

PLOT WP: Enter the GPS waypoint for the plot from page 1.

TREE ID: Record tree species (U if unknown, and take a photo and send to the facilitator) using the UFORE abbreviations (www.itreetools.org/eco/resources/ufore_species_list_apr30_2012.pdf).

STATUS: The crew should discuss and come to consensus about whether the tree was:

P: Planted—the tree was planted intentionally (often characterized by orderly patterns, e.g., rows, and landscaping);

I: Ingrowth—the tree naturally regenerated;

U: Unknown—planted vs. ingrowth cannot be determined.

Record dead trees as -1 and skip to the site variable.

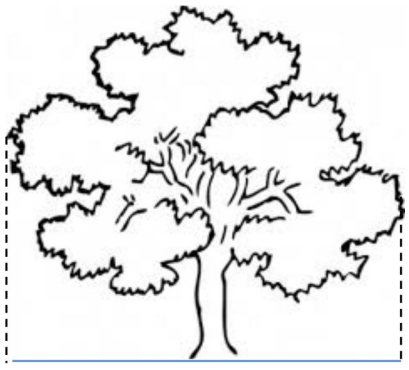
DR: Record direction of the tree from the center of plot using azimuth in degrees. DR and DS are used as geographic references in addition to the plot center waypoint. Geographic references are important for future inventory updates.

A smartphone app makes recording direction easy.

DS: Record tree distance from plot center to the edge of the trunk.

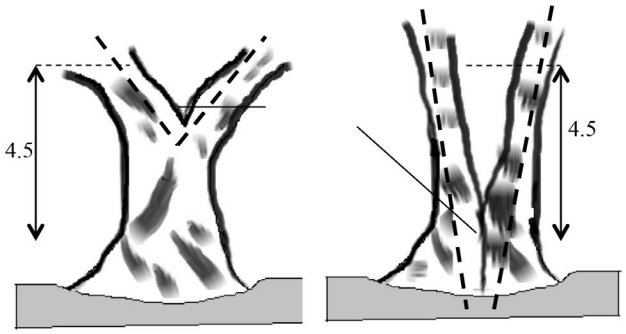
LAND USE: The previous land use metric indicated land use within the entire plot; this metric records land use under individual tree canopies in the plot. Record land use to drip line. The drip line is the very edge of the crown. Most of the time, this will be the same as the land use recorded for the plot. The following land uses are used in the i-Tree software.

Residential (R)	*Commercial/ Industrial (C)*	*Cemetery (E)*
Multi-family residential (M)	*Park (P)*	*Golf Course (G)*
		Agriculture (A)
Vacant (V)	*Utility (U)*	*Transportation (T)*
Institutional (I)	*Water/wetland (W)*	*Other (O)*



Dripline

DBH: Record DBH (a relevant tree must be greater than or equal to 1 inch at 4½ feet) on the uphill side to the nearest 0.1 inch/cm. Record up to six stems (≥1 inch) if the pith union is belowground. If more than six stems, lower the measurement height to 1 foot aboveground and record the DBH of the six largest stems. See Appendix 8 for DBH measuring procedures.



Measuring DBH in multistemmed trees.

TREE HEIGHT: i-Tree requires three height measurements (Appendix 9).

Total tree height: Measure height of the tree to the highest visible branch (alive or dead).

Height to live top: Measure height to the highest visible live branch. This height will be the same as total tree height unless the tree is alive but the top of the crown is dead.

Height to crown base: Measure the tree height to the base (the lowest live foliage) of the crown. If the base is not reachable using the diameter tape, the clinometer must be used and measured using the same procedure as measuring total height.

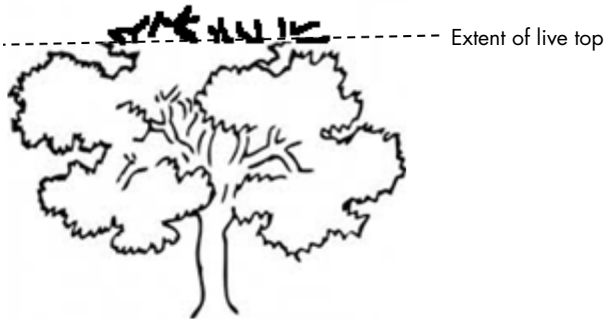
Using the diameter tape to measure DBH. Follow the correct procedure to hold the tape (Appendix 9).

CROWN

Crown width: Measure the width of each tree's crown (to the nearest foot). Two volunteers are needed to measure crown width. Making sure the diameter tape touches the tree stem to approximate the diameter of a circle encompassing the crown, hold each end of the tape to the drip line and record the measurement. This procedure should be repeated in two perpendicular directions: north–south and east–west.

Percent canopy missing: This metric estimates percent of branches and foliage absent due to pruning, defoliation, uneven crown (i.e., irregular due to damage or some other negative abiotic or biotic impact), or dwarf or sparse leaves.

Crown dieback (DB): Record percent branch dieback on each side and top of crown area. Dieback is a condition in which a tree or shrub begins to die from the tip of its leaves or shoots backward, resulting from disease, an unfavorable environment, or an unbalanced root to shoot ratio.



If the tree does not have any dead branches at the top, the height to live top is the same as total height. In the case of this tree, height to live top is shorter than total height.

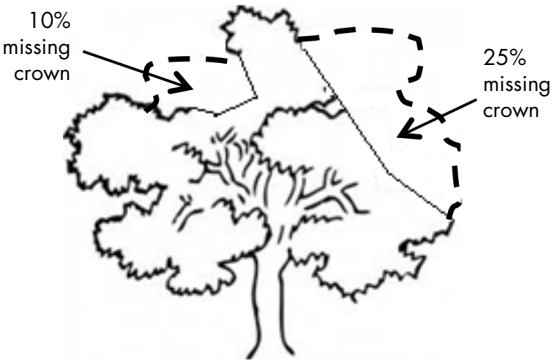
Crown light exposure (CLE): Record the number of sides of the tree receiving sunlight. The maximum is five (four sides and top). As a rule of thumb, include each side that receives at least 50 percent sunlight.

IMPERVIOUS SURFACE: Estimate the percent of area beneath the dripline that is impervious to water. Often, this will reflect the single tree metric for land use (above). An impervious surface is one that does not allow water to penetrate into the soil. Greater areas of imperious surface result in increased runoff.

Measuring tree height using a clinometer. Follow the correct procedure to hold the clinometer (Appendix 10).

Measuring height to crown base using a diameter tape.

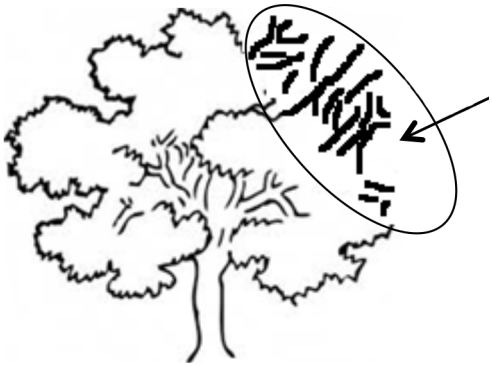
Measuring crown width east and west.



This tree has approximately 35% of its crown missing.

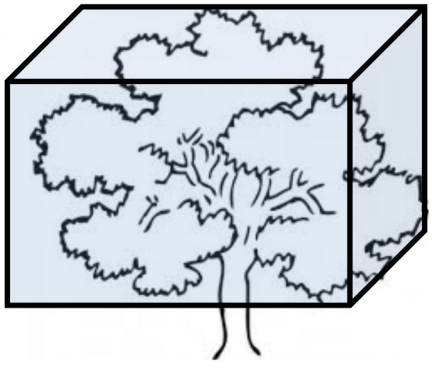
TREES NEAR BLDGS: Identify trees (≥20 feet tall) that are located within 60 feet of space-conditioned residential or commercial buildings that are three stories or fewer in height (e.g., two stories and an attic). Record the ***direction*** (D = azimuth in degrees) to the closest part of the building and the ***distance*** (S = if >60 ft., just note >60 ft.). These metrics are needed for calculating energy savings.

SITE: Indicate whether the tree is a street tree (yes = Y) or not a street tree (no = N). A street tree is any tree or part of a tree, including the canopy and root systems, that lies on or has grown onto or over public property, or in a public right of way.



This tree has approximately 25% crown dieback.

Measuring crown width north and south.



Imagine a box covering the crown to measure CLE. A tree can have up to five sides exposed to sunlight.

Measuring distance to the closest building using a diameter tape.

HAZARD: Mark yes or no to indicate whether the overall tree, foliage, branches/bole show indications of pest, disease, or if tree/branches could be a hazard. A hazard is any tree/part of tree that may cause harm to people or property (e.g., car). It is important to understand that only a certified arborist should conduct a complete tree risk assessment due to liability concerns. However, because they are observing many trees, volunteers are invaluable for identifying obvious, major problems. If a tree is a hazard, complete the additional hazard identification form (Appendix 5). If a hazard is indicated, arborists will return to the tree to assess it.

Additional Reading

David J. Nowak, Jeffrey T. Walton, Jack C. Stevens, Daniel E. Crane, and Robert E. Hoehn (2008) Effect of Plot and Sample Size on Timing and Precision of Urban Forest Assessments. Arboriculture & Urban Forestry, 34(6):386–390.

David J. Nowak, Daniel E. Crane, Jack C. Stevens, Robert E. Hoehn, Jeffrey T. Walton, Jerry Bond (2008) A Ground-Based Method of Assessing Urban Forest Structure and Ecosystem Services. Arboriculture and Urban Forestry, 34(6):347–358.

Brady Self. (2019). Community Forestry: Another Way of Thinking about Forest Management, IS1958. MSU Extension Service.

Jason Gordon. (2017). Conducting a Community Tree Inventory, P2811. MSU Extension Service.

US Forest Service. (n.d.) i-Tree Streets User's Manual v5.x.. Retrieved January 19, 2015, from www.itreetools.org/eco

UFORE Methods (n.d.) Retrieved January 19, 2015, from http://www.itreetools.org/eco/resources/UFORE%20Methods.pdf

Appendix 1. Image of data sheet (page 1, Plot Data) to be used for sample plots inventory.

Plot ID	Plot WP	Date	Crew	GPS Unit

Plot address	Plot phone	Owner Name

Notes

ACTUAL LAND USE	PERCENT IN	PLOT TREE COVER(%)	SHRUB COVER(%)
ACTUAL LAND USE	PERCENT IN		
ACTUAL LAND USE	PERCENT IN		
ACTUAL LAND USE	PERCENT IN		

	%BLDG	%CMNT	%TAR	%ROCK	%SOIL
GROUND COVER	%HERB/IVY	%MAIN. GRASS	%UNMAIN GRASS	%H20	%DUFF/MULCH

Appendix 1 (continued). Image of data sheet (page 2, Tree Data) to be used for sample plots inventory.

Plot ID Plot WP

					DBH						HEIGHT			CROWN						TREES NEAR BLDGS							
Tree ID	STAT	DR	DS	Land Use	1	2	3	4	5	6	TOT	LIVE TOP	CROWN BASE	N-S	E-W	%MISS	%DB	CLE	%IMP	D1	S1	D2	S2	D3	S3	SITE	HAZ

Appendix 2: Cheat sheet to be used for sample plots inventory data sheet
PAGE 1 (Plot data)

PLOT ID: Enter plot ID

PLOT WP: Enter GPS waypoint of plot (not trees)

DATE: Enter date of work

CREW: Enter crew ID

GPS UNIT: Enter GPS Unit ID

PLOT ADDRESS: Self explanatory

PLOT PHONE: Self explanatory

OWNER NAME: Owner of property (if public, note government entity)

NOTES: Record anything noteworthy here. Record lack of access (e.g., property owner refusal, poor environmental conditions)

ACTUAL LAND USE AND PERCENT IN: Record land use and percent in plot.

Residential (R)	*Golf Course (G)*	*Water/wetland (W)*
Multi-family residential (M)	*Agriculture (A)*	*Transportation (T)*
Commercial/Industrial (C)	*Vacant (V)*	*Other (O)*
Park (P)	*Institutional (I)*	
Cemetery (E)	*Utility (U)*	

PLOT TREE COVER: Record percent tree cover in plot.

SHRUB COVER: Record percent shrub cover in plot.

GROUND COVER: Record percent ground cover in plot. Must add to 100%.The crew notes the percentage of the plot ground area that is covered by the following materials:*Building (B)*

Concrete (C)

Tar (T): Blacktop/asphalt

Rock (R): Pervious rock surfaces such as gravel, brick, or flagstone walkways or patios (without mortar). This category includes sand in playgrounds or added as topping to existing soil. Large solid rock outcrops should be listed as concrete.

Bare soil (S)

Duff/mulch (D)

Herbs (H): Herbaceous ground cover, other than grass, including agricultural crops

Maintained grass (MG)

Unmaintained grass (UG)

Water (W)

PAGE 2 (Tree data)

Data collection for living and dead trees starts with the tree farthest to the north and proceeds in a clockwise direction.

PLOT ID: Enter plot ID from page 1

PLOT WP: Enter GPS waypoint for plot from page 1

TREE ID: abbreviated tree species (U if unknown, and take photo and send to coach)

STATUS: *P*: Planted—the tree was planted intentionally

I: Ingrowth—the tree is naturally regenerated

U: Unknown—planted vs. ingrowth cannot be determined

Record dead trees as -1 and skip to Site.

DR: Direction of tree from center of plot (azimuth in degrees)

DS: Distance of tree from plot center to edge of trunk

LAND USE: Record land use to drip line

Residential (R)	*Golf Course (G)*	*Water/wetland (W)*
Multi-family residential (M)	*Agriculture (A)*	*Transportation (T)*
Commercial/Industrial (C)	*Vacant (V)*	*Other (O)*
Park (P)	*Institutional (I)*	
Cemetery (E)	*Utility (U)*	

DBH: Record the tree's DBH (≥ 1 inch at 4.5 feet) on the uphill side to the nearest 0.1 inch. Record up to 6 stems (≥1 in) if the pith union is below ground. If more than 6 stems, lower measurement height to 1 ft above ground and record DBH of up to the 6 largest stems.

TREE HEIGHT: Total tree height: Measure the height to top (alive or dead) of tree. Height to live top: This height will be the same as total tree height unless the tree is alive but the top of the crown is dead. Height to crown base: Measure height to base of live crown.

CROWN

Crown width: Measure crown width (to nearest foot) in two perpendicular directions: north-south and east-west.

Percent canopy missing: Estimate the percent foliage absent due to pruning, defoliation, uneven crown, or dwarf or sparse leaves.

Crown dieback (DB): Percent branch dieback on side(s) and top of crown area.

Crown light exposure (CLE): Number of tree sides receiving sunlight from above (maximum of five).

Percent impervious surface under the tree: Estimate percent area beneath the dripline that is impervious.

TREES NEAR BLDGS

For trees (≥20 ft. tall) located within 60 ft. of space-conditioned residential buildings that are three stories or fewer in height (two stories and an attic), record the direction (D = azimuth in degrees) from the tree to the closest part of the building and the distance (S = if >60 ft, just note >60 ft).

SITE

Indicate street tree YES (Y) or NO (N) if tree is located on edge of street.

HAZARD

Mark YES (Y) or NO (N) if overall tree, foliage, branches/bole show indications of pest, disease, or if tree/branches could be a hazard. A hazard is any tree/part of tree that may cause harm to people or property (e.g., car). We are looking for obvious, major problems here. If tree is a hazard, complete additional hazard identification form. If a hazard is indicated, arborists will return to the tree to assess it.

Appendix 3. Image of data sheet to be used for 100 percent inventory.

DATE OF INVENTORY:						CREW:				GPS Unit:				LOCATION:						LAND USE:										
			Ground Cover				DBH						HEIGHT			CROWN						TREES NEAR BLDGS								
WP	Tree ID	STAT	1	2	3	4	1	2	3	4	5	6	TOT	LIVE TOP	CROWN BASE	N-S	E-W	%MISS	%DB	CLE	IMP	D1	S1	D2	S2	D3	S3	SITE	HAZ

Appendix 4: Cheat sheet to be used with 100 percent inventory data sheet

100 Percent Inventory Cheat Sheet

DATE: Enter date of work

CREW: Enter crew ID

GPS UNIT: Enter GPS Unit ID

LOCATION: Enter location – "Miller Park"

LAND USE: Record the predominant (>50%) land use in which the trees are located

Residential (R)
Multi-family residential (M)
Commercial/Industrial (C)
Park (P)
Cemetery (E)
Golf Course (G)
Agriculture (A)
Vacant (V)
Institutional (I)
Utility (U)
Water/wetland (W)
Transportation (T)
Other (O)

WP: Enter GPS waypoint

TREE ID: abbreviated tree species (U if unknown and take photo)

STATUS: *P*: Planted—the tree was planted intentionally

I: Ingrowth—the tree is naturally regenerated

U: Unknown—planted vs. ingrowth cannot be determined

-1: Dead trees

GROUND COVER: Must add to 100%. The crew notes percentage of the plot ground area covered by the following materials (up to 4):

Building (B)
Concrete (C)
Tar (T): Blacktop/asphalt
Rock (R): Pervious rock surfaces such as gravel
Bare soil (S)
Duff/mulch (D)
Herbs (H)
Grass (MG)
Unmaintained grass (UG)
Water (W)

DBH: Record the tree's DBH (≥ 1 in at 4.5 ft) on the uphill side to the nearest 0.1 inch/cm.

Record up to 6 stems (≥1 in) if pith union is below ground. If more than 6 stems, lower measurement height to 1 ft above ground and record DBH of up to the 6 largest stems.

TREE HEIGHT: Total tree height: Measure height to top (alive or dead) of tree. Height to live top: This height will be the same as total tree height unless the tree is alive and the top of the crown is dead. Height to crown base: Measure height to base of live crown.

CROWN

Crown width: Measure crown width (to nearest ft or m) in two perpendicular directions: north-south and east-west.

Percent canopy missing: Estimate the percent foliage absent due to pruning, dieback, defoliation, uneven crown, or dwarf or sparse leaves. Do not include normal interior crown voids due to leaf shading.

Crown dieback (DB): Percent branch dieback on side(s) and top of crown area.

Crown light exposure (CLE): Number of tree sides receiving sunlight from above (maximum of five).

Percent impervious surface under the tree: Estimate percent area beneath the dripline that is impervious.

TREES NEAR BLDGS

Trees near buildings: Enter the direction (D) and distance (S) to the three closest buildings (if >60 ft, note >60 ft).

SITE

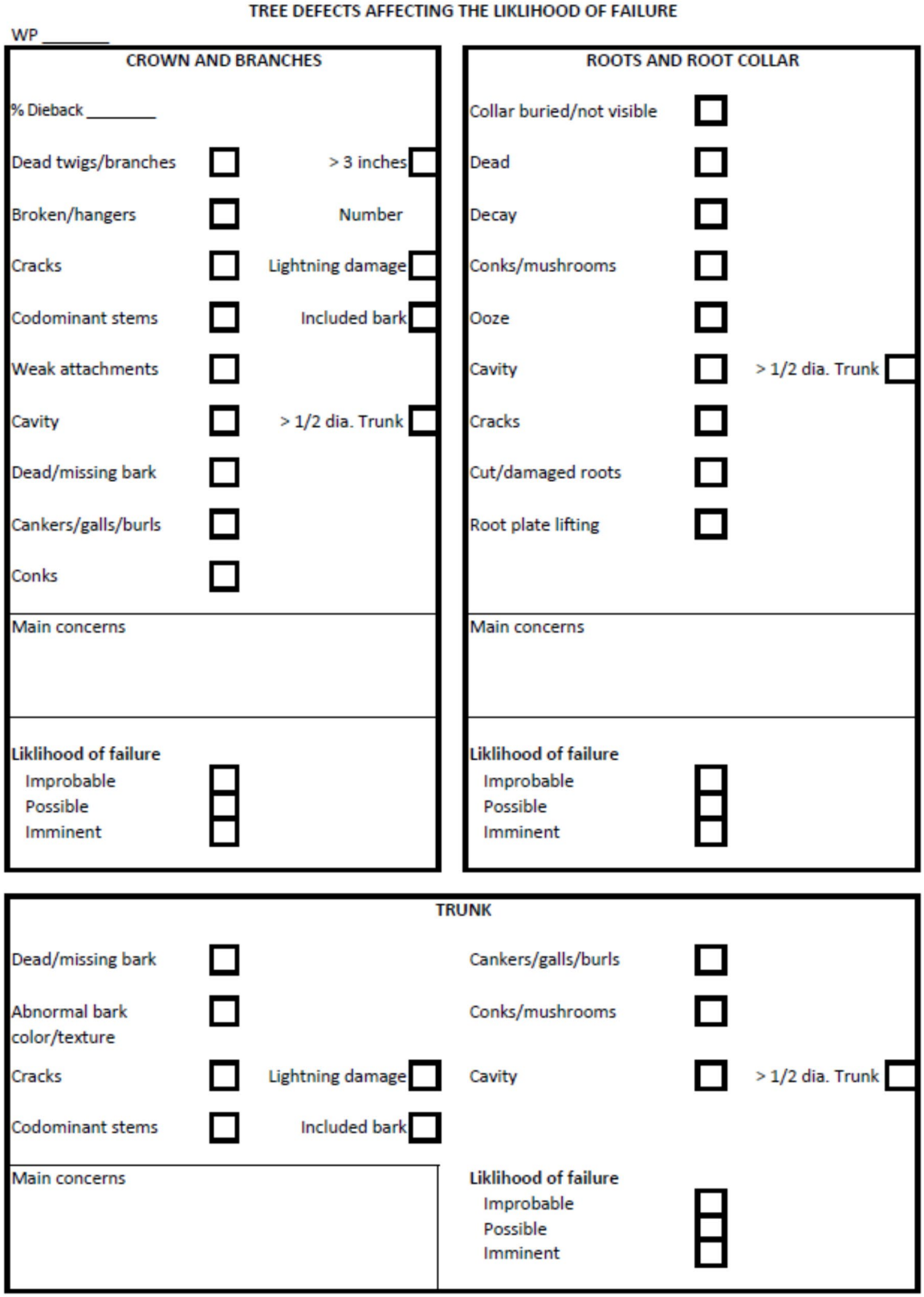
Indicate street tree YES (Y) or NO (N) if tree is located on edge of street.

HAZARD

Mark YES (Y) or NO (N) if overall tree, foliage, branches/bole show indications of pest, disease, or if tree/branches could be a hazard. A hazard is any tree/part of tree that may cause harm to people or property (e.g., car). If tree is a hazard, complete additional hazard identification form.

Appendix 5. Tree hazard data sheet for volunteer-based urban forest inventories.

(Explanation is provided during tree hazard training.)



Appendix 6. Property access request form.

Dear Homeowner:

Local volunteers representing [sponsor] will be conducting an urban tree inventory throughout [timeline]. This project will utilize the i-Tree Eco - Urban Forest Effects (UFORE) Model developed by the US Forest Service to quantify the composition (tree type, size, health, etc.) and environmental benefits of [city]'s trees. Statewide, urban trees are worth billions of dollars and annually provide millions of dollars' worth of environmental benefits. In addition, these volunteers will assess health condition of trees so that [city] can prioritize pruning and removals. Altogether, this information is needed to develop a comprehensive urban forest management plan for [city].

Approximately 200 randomly distributed 1/10 acre sample plots have been identified throughout [city]. One of these plots (or a portion thereof) is located on your property. **We are requesting permission to access your yard** to collect information on trees within the sample plot including tree type, size, crown coverage and density, and overall health. There are no immediate benefits to you; however, if one or more of your trees is determined to be in poor condition, a certified arborist will contact you to offer a professional opinion.

Measurements will not harm the trees in any way and only trees within the plot will be measured. The volunteers conducting the activity assume full responsibility for any risks of loss or injury to person or property that may be sustained and waive any and all liability, claims, demands, actions and causes of action, whatsoever arising out of or related to any loss, damage, or injury while conducting the inventory on your property. If you agree, **please sign the enclosed form indicating your permission or denial for the urban inventory personnel to enter your property for this specific purpose.** Please contact Project Coordinator, [name], at [phone number] with any questions or concerns you may have. You can keep this letter for your records.

Thank you very much for your consideration. Don't miss this opportunity to have your trees represent [city]!

Sincerely,

[City] Urban Tree Inventory Team

Appendix 7. Property access consent form.

Urban Tree Study

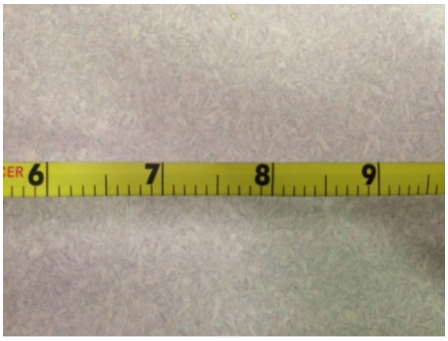
We need your help in gathering data on your city's trees. Please help by completing the information below and returning this form to the volunteer. Please contact project coordinator [name] at [phone number] with any questions or concerns you may have.

DATE	
NAME	
ADDRESS	
ZIP CODE	TELEPHONE

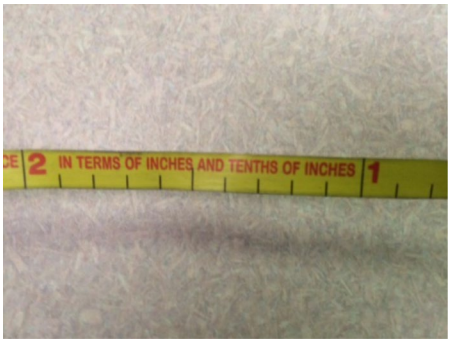
Check	
	Yes, I authorize the urban tree inventory volunteers to access my property today for the purpose of collecting inventory data from trees on or adjoining my property.
	No, I do not want my trees included in this important study.

Appendix 8: Measuring Tree Diameter for Urban Tree Inventories

Measuring DBH of a tree is easy when you have a diameter tape. A few points are important to keep in mind. First, a diameter tape (D-tape) is a somewhat fragile instrument. If you are not careful, the spring inside the housing can break, resulting in inability to retract. Second, the metal strip can be sharp, so be careful when handling the tape. Third, MSU Extension recommends a 100-foot "logger's" tape with distance in tenths of feet and diameter increments in tenths of inches. One side of the tape can measure distance, while the other side of the tape is calibrated to pi in order to measure diameter.



Diameter tape: Inches side of measurement.



Diameter tape: Diameter side of measurement.

Measure diameter at about 4½ feet above the base of the tree.

Cross hands as in the photo so that the zero at the end of the tape lines up with the diameter metric.

Hold the end of the D-tape with the left hand while holding the casing with the right hand.

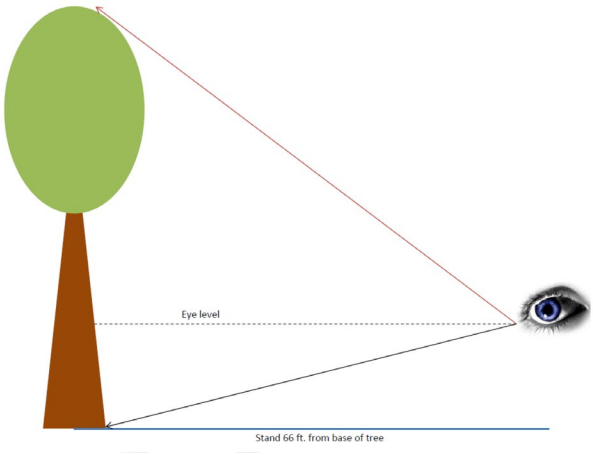
Stand upslope from the base of the tree.

Procedure

Standing up-slope from the base of the tree, use your right hand to hold the casing and your left hand to hold the end of the tape. Wrap the tape around the tree, remembering to measure at 4½ feet above where the tree meets the ground while keeping the tape level. Avoid wrapping the tape around vines or deformities. If the tree has a deformity (such as a burl) at breast height, measure the diameter just above the deformity. Line up the end of the tape (zero) with the corresponding metric on the diameter side of the tape. The matching metric is the tree's DBH. Depending on the measurement's objective, you may want to record to the nearest tenth or nearest inch.

Appendix 9: Measuring Tree Heights for Urban Forest Inventories

Note: These instructions are for SUUNTO clinometers with a topographical scale (feet).



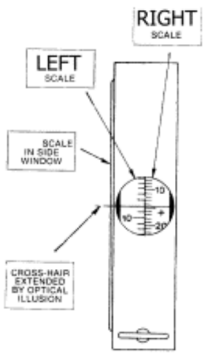
A clinometer is an instrument that measures slope.
The concept of the clinometer is rooted in trigonometry of a right triangle. The volunteer measures slope (the hypotenuse, or rise over run) twice. First, measure to the top of the tree. If you stop here, you have only measured the tree starting at the height of your eye. So, you must then measure to the base of the tree (where the tree meets the ground), creating two right triangles. Add these two measurements together to get height.

Step 1: Use the "logger's" tape and measure 66 feet from the base of the tree. Be sure to walk up-slope and have a clear line-of-sight to the top of the tree (if you are down-slope from the tree, a different calculation must be used).

Step 2: Standing 66 feet from the tree, use the clinometer to measure to the topmost green leaf that you can see. The dot on the clinometer should be on the top side, facing the tree. The brass loop should be on the bottom, facing the user. The clinometer should be held in close proximity to your eye as possible. Keep both eyes open when looking into the peephole. This produces an optical effect that transposes the cross hair onto the tree you are measuring.

If you tilt the clinometer up and down, you will notice the scales have positive and negative numbers. The scale to the right is the topographical scale in feet. Note the negative scale (–) appears when you tilt the clinometer down) and the positive scale (+) appears when you tilt the clinometer up. You must always be aware of whether the number is positive or negative.


Dot is barely visible in this photo.



Source: SUUNTO


Tilt the clinometer to the top of the tree and measure.

Step 3: Remaining 66 feet from the tree, measure the base of the tree. This measurement represents the lower triangle in the graphic above. Add the two measurements, in feet, together. The sum is the total height. For example, you get 30 feet to the top, and negative 5 feet to the bottom. The total height of the tree is 35 feet.

This YouTube video might be helpful:
https://www.youtube.com/watch?v=5H8s2zNRRv8

Tilt the clinometer to the base of the tree and measure. Add the two metrics to complete the height measurement.

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