Title: Field Tree Data Collection Protocol
Project: Climate-Ready Trees
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Last updated: 8-2-16

Data file: Climate-ready trees data x-xx-16.xlsx

Column	Variable	Description	Units	Changes in use
1	Park	park name	none	
2	Crew	initials of field crew	none	
3	Date	date of observation	none	
4	Id	unique number assigned to each tree (numbered north to south)	none	
5	spcode	2-letter code consisting of the first letter of the genus name and the first letter of the species name	none	
6	Status	tree's existence	none	
7	crownvig	considers cumulative vigor of crown in relation to twig dieback, defoliation, discoloration & branch loss	none	Only used in 2015
8	dbh1	diameter-at-breast-height (dbh) of tree (first stem if there are multiple). • For trees of at least 2.5 cm diameter at 1.37 m or smaller but with single leader: record dbh with tape. See Fig. 1. • For trees with stem diameter smaller than 2.5 cm at 1.37 m, the caliper should be measured at 30.5 cm (1ft) above the ground instead. When using caliper tools, record two perpendicular measurements, which will be averaged when this tree's diameter is used in data analysis. See Fig. 2 Diagram A. • For multi-stemmed trees, measure each stem (i.e. dbh1, dbh2, etc.) and record ht (i.e., dbhht1, dbht2, etc.). See Fig 2 Diagrams B-E for directions on where to measure.	cm	
9	dbhht1	height at which dbh of main stem was measured	cm	
10	dbh2	second dbh (if needed for multiple stems or as second caliper measure). See Eq. 1 in Appendix to calculate aggregate diameter.	cm	

11	dbhht2	height at which dbh2 was measured	cm	
12	dbh3	third dbh if needed for multiple stems	cm	
13	dbht3	height at which dbh3 was measured	cm	
14	treeht	tree height from ground level to tree top (omit erratic leader as shown in Fig. 3)	m	
15	base	average distance between ground and lowest foliage layer (omitting erratic branch)	m	
16	cdiam1	crown diameter from north-south (occasional erratic branch should not be included, see Fig 4)	m	
17	cdiam2	crown diameter from west-east	m	
18	treearch	intrinsic architecture of the particular species (central leader tree or lack of leader dominance)	none	
19	branchangle	acute vs. wide branch angles	none	
20	folhealth	defoliation, discoloration and damage	none	added in 2016
21	folinjury	apparent cause(s) of damage to foliage	none	added in 2016
22	brhealth	branch/twig dieback, discoloration and damage	none	added in 2016
23	brinjury	apparent cause(s) of damage to branch(es)	none	added in 2016
24	trhealth	percentage of trunk circumference with wood decay at the point of decay; in the case of multiple points, where decay is greatest	none	added in 2016
25	trinjury	apparent cause(s) of damage to trunk	none	added in 2016
26	pestdisease1 (or 2 or 3 if applicable)	only note the pest/disease symptoms that are present. See Fig. 5 for examples	none	
27	mulch	average mulch depth to soil surface measured at 0.5 m from trunk (n=none, d=deep (>2”), t=thin (<2” or sporadic)	cm	added in 2016
28	Photo	photo number (unique for the date of observation) of photo showing entire tree in context of its immediate location and static objects in the landscape (e.g. buildings)	none	
29	Lat	latitude	decimals, degrees	
30	Long	longitude	decimals, degrees	
31	Notes	note any management needs	none	

CODES

Variable: park
Description: 2-letter code representing park name

Code	Description
CP	Reference plot (UCD)
FL	Fisherman's Lake
KB	Kohl's bikepath
LC	Laguna Creek
RP	Regency Park
UR	Reference plot (UCR)
HB	Holleigh Bernson Memorial Park
HD	Hansen Dam Recreation Area
VP	Valley Plaza Recreation Center
WP	Woodley Park
VD	Vista Del Mar
JG	Jim Gilliam Recreation Center
BO	Bogdanovich
WE	Westchester
SC	Reference plot (South Coast)

Variable: spcode
Description: 2-letter code representing species name

Code	Description	
AA	Acacia aneura	Mulga
AS	Acacia stenophylla	Shoestring acacia
CF	Cedrela fissilis	Brazilian cedarwood
CR	Celtis reticulata	Netleaf hackberry
CL	Chilopsis linearis ‘Bubba’	Desert Willow
CP	Corymbia papuana (formerly known as Eucalyptus papuana, EP)	Ghost gum
DS	Dalbergia sissoo	Rosewood
EE	Ebenopsis ebano	Texas ebony
HF	Hesperocyparis forbesii	Tecate cypress
MP	Maclura pomifera ‘White Shield’	White Shield Osage Orange
PB	Mariosousa willardiana	Palo blanco
PD	Parkinsonia x ‘Desert Museum’	Desert Museum palo verde
PR	Pistacia 'Red Push'	Red Push Pistache
PG	Prosopis glandulosa x Maverick	Thornless honey mesquite
PI	Prunus ilicifolia subsp. lyonii	Catalina cherry
QC	Quercus canbyi	Canby’s oak
QF	Quercus fusiformis	Escarpment live oak

QT	Quercus tomentella	Island oak
UP	Ulmus propinqua	Emerald Sunshine elm

Variable: status
Description: description of tree's existence

Code	Description	
A	Alive	includes any tree with green leaves - even a few leaves - and/or live buds, including extremely unhealthy trees
Sd	standing dead	must be completely dead above-ground, with no green leaves and no live buds
R	removed and missing	tree has been removed since the previous observation with no new tree in its place
Rr	removed and replaced	previously inventoried tree has been removed since the previous observation and a new tree is in its place
U	Unknown	tree has unknown status (possibly due to issues in accessing the property, or confusion about location notes from the previous field notes).

Variable: treearch
Description: tree architecture (leader dominance)

Code	Description
c	Central leader tree: single main trunk with smaller branch diameters. vs
b	Branches vigorous- spreading or codominant: branch size equal to or greater than leader, no single main trunk.

Variable: branchangle
Description: overall tree branch angle

Code	Description
a	acute: 0°-30° from vertical
w	wide: 30°-45°

Variable: folhealth
Description: Percentage defoliation, discoloration and damage

Code	Description
1	<5% no damage
2	5-20% slight damage
3	20-40% moderate damage
4	40-70% severe damage
5	>70% very severe damage

Variable: folinjury
Description: Apparent cause(s) of damage to foliage

Code	Description
A	Air pollution
B	Boron toxicity
D	Drought
E	Excess water
F	Frost/freezing damage
I	Insects
M	Mechanical damage
P	Parasitic disease
SA	Salinity/leaf burn
SB	Sunburn/sunscald
U	Unknown
V	Vandalism
W	Wind

Variable: brhealth
Description: Percentage branch/twig dieback, discoloration & damage

Code	Description
1	<5% no damage
2	5-20% slight damage
3	20-40% moderate damage
4	40-70% severe damage
5	>70% very severe damage

Variable: brinjury
Description: Apparent cause(s) of damage to branch(es)

Code	Description
A	Air pollution
D	Drought
E	Excess water
F	Frost/Cold damage
I	Insects
M	Mechanical damage
P	Parasitic disease
SA	Salinity
SB	Sunburn/sunscald
U	Unknown
V	Vandalism
W	Wind

Variable: trhealth
Description: Percentage of trunk circumference with wood decay at the point of decay; in the case of multiple points, where decay is greatest.

Code	Description
1	0-25% decay
2	26-50% decay
3	51-75% decay
4	76-100% decay

Variable: trinjury
Description: Apparent cause(s) of damage to trunk

Code	Description
A	Air pollution
D	Drought
E	Excess water
F	Frost/freeze damage
G	Girdling
I	Insects
M	Mechanical damage
P	Parasitic disease
SA	Salinity
SB	Sunburn/sunscald
U	Unknown
V	Vandalism
W	Wind

Variable: pestdisease1, pestdisease2, pestdisease3
Description: Code consists of 2-letter issue and severeness (Y/N). E.g. EH1, FRY)

Code	Description	
n	No evidence of pests or diseases	
AR	Armillaria -	0 – No 1 - Yes
EH	Exit holes - potential signs or symptoms indicating presence of a boring insect infestation or disease	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

EX	Exudation: Indicates the potential presence of insects (e.g., GSOB, oak wilt, PSHB, sirex woodwasp)	1 - Red or black staining ("ooze")
		2 - Black fungal mat present below cracked bark
		3 - Brown fungal mat present in sapwood
		4 - Shallow, round discolored 'divots'
		5 - Wet or dry discoloration around exit holes
		6 - White powdery substance around exit holes
		7 - Black or reddish ooze around cankers
		8 - White woolly egg masses, undersides of leaves
EG	Eggs / Egg Sites = Indicates the potential infestation of an egglaying insect of concern (e.g., HWA, GM, EAB/ALB)	0 – No 1 - Yes
FR	Frass = Indicates potential infestation by barkboring insect (e.g., EAB, ALB)	0 – No 1 - Yes
ES	Epicormic Sprouts = Indicates signs/ symptoms of a tree under stress caused by either insects, disease, or anthropogenic causes	0 – No 1 - Yes
WD	Woodpecker Damage = Indicates the potential presence of bark-boring insects	0 – No 1 - Yes
SG	S-shaped Galleries = Indicates the presence of a bark-boring insect	0 – No 1 - Yes
AL	Adult Insect or Larvae presence = Indicates the potential infestation of an egglaying insect of concern (e.g., HWA, GM, EAB/ALB)	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, sets of red spots 6 - Tiny brown beetle

		(PSHB) 7 - Bright green winged insect (Citrus psyllid)
CR	Bark Fissures/Cracks = Indicates potential internal damage to inner bark/phloem as a result of insect or pathogen	0 – No 1 - Yes
CA	Cankers = A sign of death of the cambium due to pathogen exposure and/or sunburn.	0 – No 1 - Yes
GA	Galls = Galls are swellings or tumors that can be on twig, branch, leaves. Indicates exposure to pathogen or response to insect infestation.	0 – No 1 - Yes
FB	Fruit/Bud Damage = Indicates potential exposure to pests or diseases that affect fruit trees (e.g., citrus greening), and tree buds in general	1 - Misshapen fruits 2 - Discolored fruits 3 - Buds appear shriveled
LL	Premature Leaf Loss = Indicates that the tree is under stress due to pest infestation or exposure to pathogen	0 – No 1 – Yes
LD	Leaf Defoliation = Leaf defoliation is caused by insects that feed on leaves. Certain insects feed on the outer edges of leaves, others feed on the inner parts of the leaf (nearest the midrib).	1 - Holes on leaves are near outer edge of leaf 2 - Holes are closer to the central vein (midrib) of the leaf
WB	Wilted or Browning Leaves = Wilted leaves are an indication that the tree is not receiving enough water either through lack of watering (human), drought, disease or other sources of damage limiting water uptake.	0 – No 1 – Yes

APPENDIX

A) Equation 1:

Multi-stemmed tree diameter = SQRT [SUM (stem diameter^2)]

E.g., a multi-stemmed woodland tree with stems of 12.2, 13.2, 3.8, and 22.1 would be calculated as:

$= \text{SQRT} [(12.22)^2 + (13.22)^2 + (3.82)^2 + (22.12)^2]$
$= \text{SQRT} (825.93)$
$= 28.7$

B) Best practices for measuring diameter of a tree (and special considerations):

2.12 Trunk Diameter

Best Practices for Measurement

D-tape 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 43 for instructions about leaning trees).

Make sure the tape is pulled snug. The d-tape should be pulled as 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 49-50 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.
Photo: Erik Desotelle

Figure 1A. Best practices for measuring dbh

Example of measuring DBH **INCORRECTLY**
D-Tape is too loose and should be perpendicular to trunk
Photo: Erik Desotelle

Figure 1B. Example of measuring dbh incorrectly

If your trees exhibit any of the following, please adapt your measurements accordingly:

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.

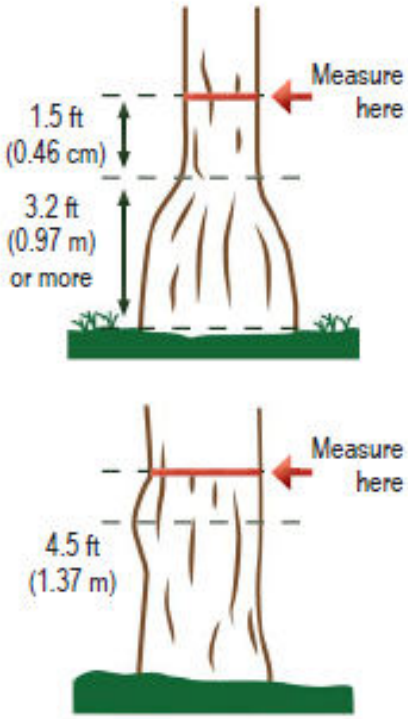


Figure 1C. Special considerations for dbh

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.
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.

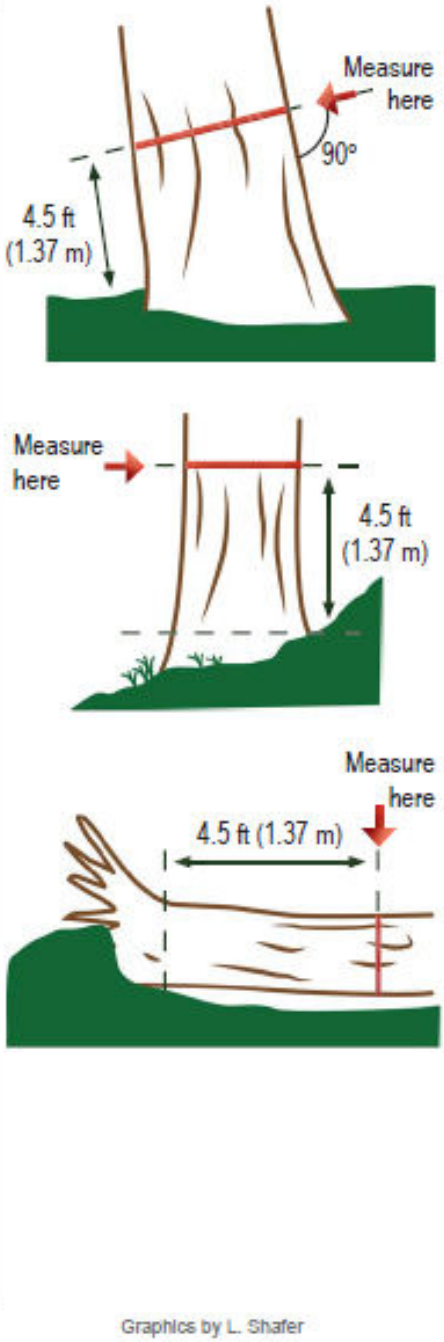


Figure 1C (cont'd). Special considerations for dbh

C) 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. Multi-stem trees are handled differently depending

on whether the fork originates below 1.0 ft (30.5 cm), between 1.0 ft (30.5 cm) and 4.5 ft (1.37 m), or above 4.5 ft (1.37 m). Use the diagrams below to help you determine how 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.

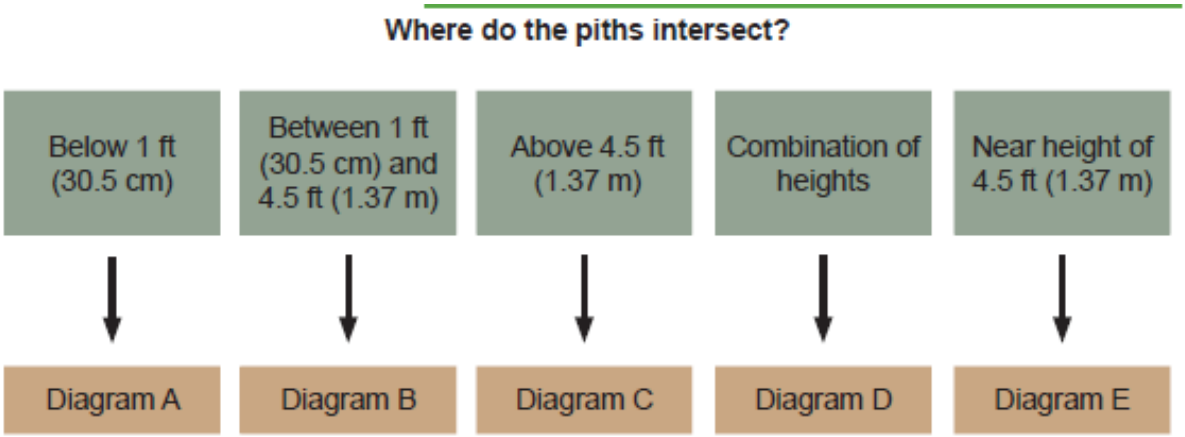


Figure 2.

Diagram A Piths intersect below 1 ft

When the piths intersect below 1 ft, measure DBH for each stem at 4.5 ft (1.37 m) above the ground, for stems ≥ 1 in (2.5 cm). In cases of caliper (trees with <1 in (2.5 cm) caliper at 4.5 ft (1.37 m) height above ground) measurement for multi-stem trees, measure largest calipr stem first and continue clockwise for other stems.

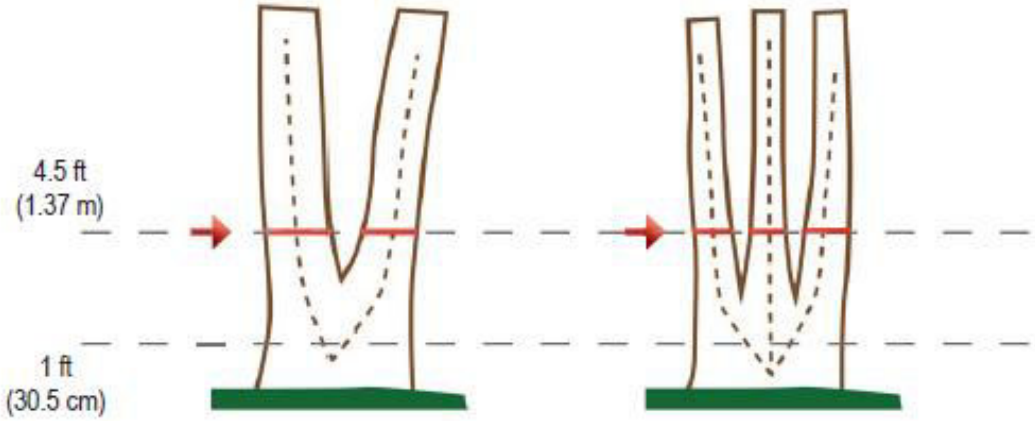
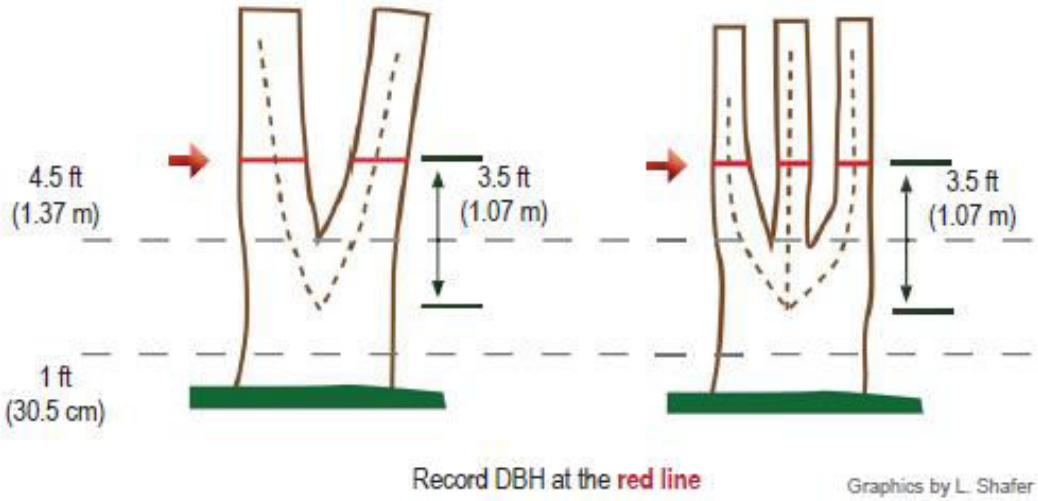


Diagram B Piths intersect between 1 ft and 4.5 ft

When the piths intersect between 1 ft (30.5 cm) and 4.5 ft (1.37 m), measure the DBH of each stem 3.5 ft (1.07 m) above the pith intersection (or as high up as is feasible for the field crew to reach).



Record DBH at the red line

Graphics by L. Shafer

Figure 2 (cont'd).

Diagram C 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.

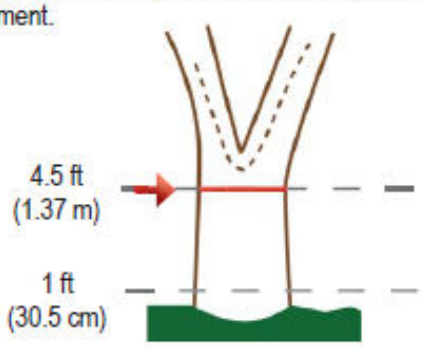


Diagram D Combinations of forked stem issues

Various combinations of multi-stem tree issues can arise. The diagrams below indicate where to record DBH under a variety of circumstances. If you are confused about where to measure, take your best guess, and record the heights where DBH was measured. **If there are many forks separating around 4.5 ft** (1.37 m) **and crowded together (e.g., Pyrus calleryana), it is acceptable to move the point of measurement below the forks, and record DBH only for the main stem.** **See page 47 for Diagram E.**

Once a stem is tallied as a fork that originated from a pith intersection between 1.0 (30.5 cm) and 4.5 ft (1.37 m), do not recognize any additional forks that may occur on that stem. Measure the diameter of such stems just below the base of stem separation as shown in Figure 2 (i.e., do not move the point of diameter the entire 3.5 ft (1.07 m) above the first fork).

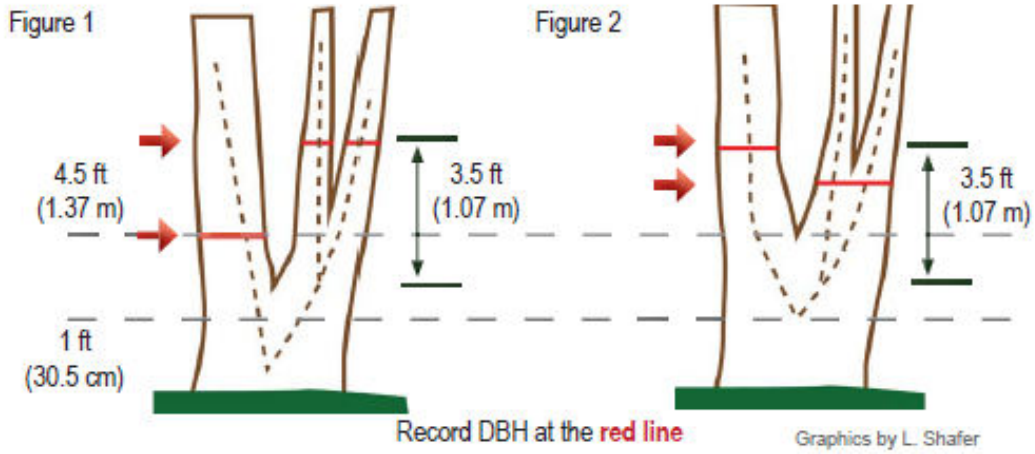


Figure 2 (cont'd).

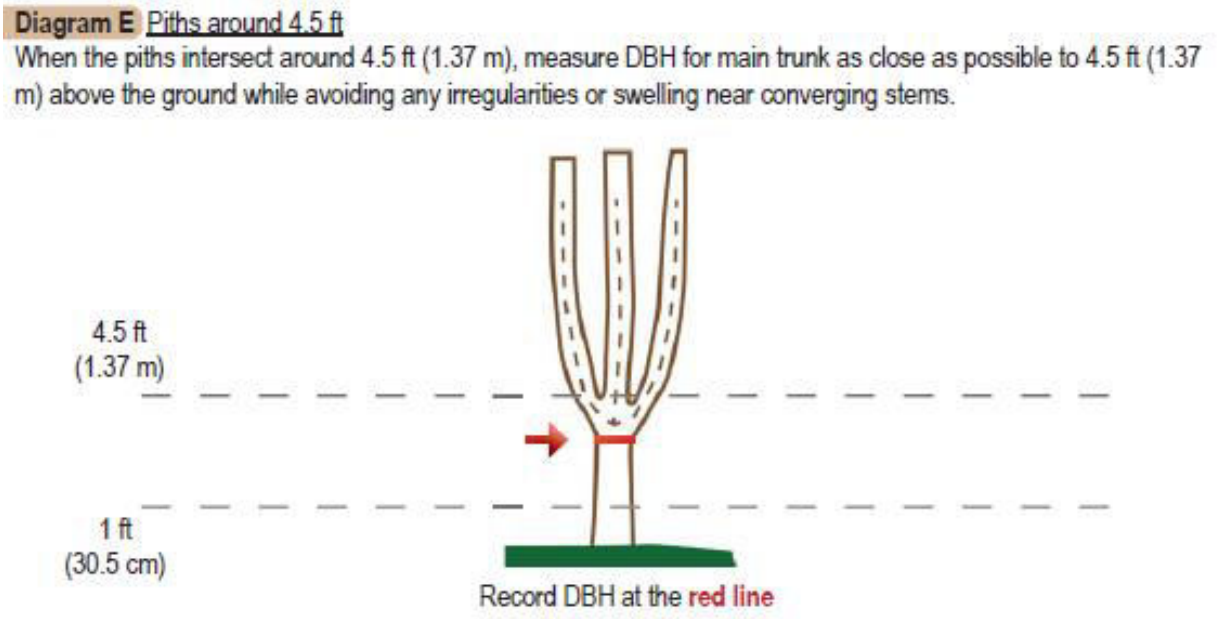


Figure 2 (cont'd).

D) Measuring distance from ground to tree top.

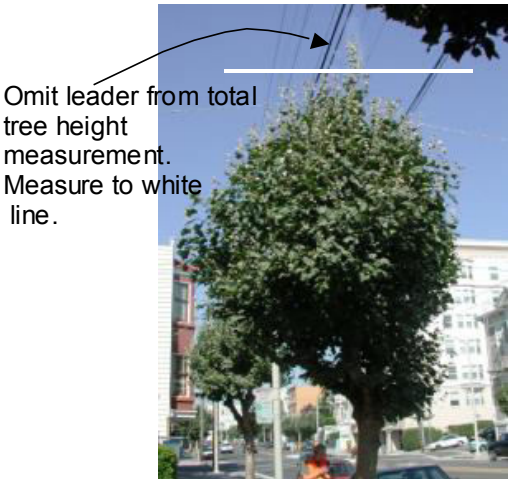


Figure 3. Erratic leader is omitted from measurement of distance from ground level to tree top.

E) Measuring distance across crown

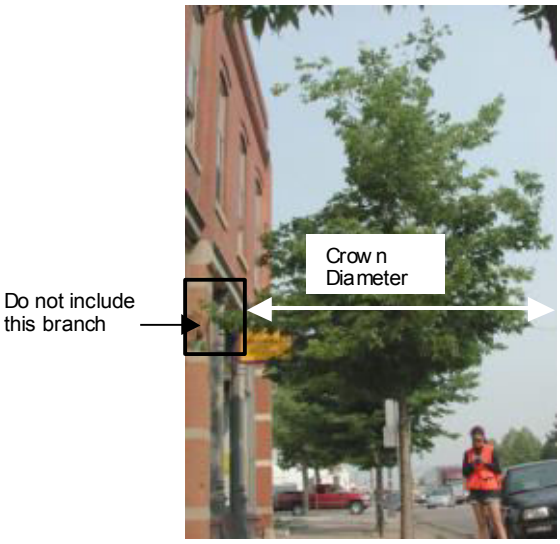


Figure 4. Erratic branch (in box at left) is omitted from crown diameter measurement. Distance measured is represented by white line.

F) Symptoms of pests and disease.

Figure 5. Examples of pest and disease symptoms (from urbantreegrowth.org)

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

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

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

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

Figure 5 (cont'd). Examples of pest and disease symptoms (from urbantreegrowth.org)

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

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

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

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

Fig. 5 (cont'd). Examples of pest and disease symptoms (from urbantreegrowth.org)

G) Symptoms of air pollution, boron toxicity, drought, excess water, frost/freeze damage, girdling, insects, mechanical damage, parasitic disease, salinity, sunburn/sunscald, vandalism, wind

Air pollution

The effects of pollution on plants include mottled foliage, "burning" at leaf tips or margins, twig dieback, stunted growth, premature leaf drop, delayed maturity, abortion or early drop of blossoms, and reduced yield or quality (Figure G1). In general, the visible injury to plants is of three types: (1) collapse of leaf tissue with the development of necrotic patterns, (2) yellowing or other color changes, and (3) alterations in growth or premature loss of foliage.

The exposure of succulent, broad-leaved plants to **sulfur dioxide** (SO2) and its by-product sulfuric acid usually results in dry, papery blotches that are generally white, tan, or straw-colored and marginal or interveinal (Figure G2). Uninjured tissue next to the veins remains green. On some species, chronic injury causes brown to reddish brown or black blotches (Figure G3). Both the upper and lower leaf surfaces are affected. The leaf veins normally remain green. Chlorosis (yellowing) and a gradual bleaching of the surrounding tissues is fairly common. **Pan** (peroxyacetyl nitrate) exposure symptoms include patchy silvering or light tan glazing of lower leaf surfaces. Affected leaf may exhibit spots or patches of papery thin almost transparent tissues. **Nitrous oxide** causes yellowing of leaf margins and interveinal chlorosis.

Figure G1. Yellowish mottle and marginal chlorosis on sweetgum leaf exposed to flourides.

Figure G2. Marginal and interveinal necrosis on American beech leaves exposed to sulfur dioxide.

Figure G3. Dark, reddish pigmentation on dogwood leaves exposed to sulfur dioxide.

Figure G4. Flecking as a result of ozone.

Acute symptoms of **ozone** vary from stippling, flecking (Figure G4), bleaching or dead areas. Chronic injury develops more slowly over days or weeks. Upper surfaces of broadleaf plants may have tan, red, brown, purple or black coloration (Figure G5). Yellowing usually occurs when plants are exposed to low doses of ozone and tip burn appears from exposure to high doses (Figure G6). This tip browning results from necrotic banding of medium aged tissue along the middle of needles, which is the most sensitive. Tip burn symptoms affect all of the needles equally on a branch. These dead needle tips may also break off over time giving the appearance of shorter than normal needles.

	
Figure G5. Ozone damage symptoms include upper surfaces of broadleaf plants having tan, red, brown, purple or black coloration.	Figure G6. Molting and yellowing of needs on a pine.
	Sources: https://extension.umd.edu/hgic/air-pollution-damage-trees-and-shrubs http://www.aces.edu/pubs/docs/A/ANR-0913/ANR-0913.pdf
Figure G7. Dark pigmented stipple on upper surface of yellow poplar leaves exposed to ozone.	

Boron toxicity

Symptoms of boron toxicity occur on older leaves of plants, and look much like symptoms of high salinity, or of iron or manganese deficiencies. Early stages of boron toxicity show up as chlorosis (yellowing) of leaf tips, and are followed by necrosis (death) of leaf margins and of the tissues in between leaf veins (Figure G8). In particular, later stages of boron toxicity exhibit as blackened areas or irregularly shaped black spots along leaf margins or between leaf veins, depending on the plant species affected. Conifer needles die from the tip downward, with the most extensive damage occurring on older needles. It must be emphasized that nutrient deficiencies or specific ion toxicities cannot be accurately diagnosed by observing symptoms. Soil, water and/or tissue samples should be tested where a definitive diagnosis is required. Source: http://www.unce.unr.edu/publications/files/ho/2012/sp1204.pdf

Figure G8. Boron toxicity symptoms on bur oak present as browning at the tips of the foliage.

Drought

Common symptoms of drought include:

- wilting or drooping leaves that do not return to normal by evening,
- curled or yellow leaves that may fold or drop,
- foliage that becomes grayish and loses its green luster, or is already brown,
- new leaves that are smaller or stem sections that are closer together than normal.

Excess water

Plants exposed to excess moisture often show similar symptoms as plants under drought stress. The primary symptom of excess moisture is yellowing of lower and inner needles. If excess water continues, plants may wilt, followed by scorch, needle drop, dieback or death. Excess moisture can result if soil is poorly drained, naturally wet, or over watered.

Frost/freeze damage

Sometimes frost damage is apparent almost immediately following freezing. However, this is not always the case and with some plants, particularly woody ones, the damage may take several months to appear. Symptoms include:

- Tender young growth may be damaged by spring frosts, causing scorching and pale brown patches to appear between the leaf veins. This tends to be on the exposed and top edges of the plant e.g. acer and carpenteria

- Hard frost in winter can cause the leaves of hardy evergreen plants to be scorched and turn brown, and may eventually lead to the death of the plant, e.g. bay and pittosporum
- Spring frosts can damage blossoms and young fruits. This may cause a corky layer to form at the flower end of the fruit i.e. apple and damage to blossom may lead to few or no fruits forming
- The foliage of certain plants exhibiting early symptoms of frost damage appears water-soaked and dark-green, turning black in time

Source: https://www.rhs.org.uk/advice/profile?pid=704#section-2

Girdling

Girdling roots grow in a circular or spiral pattern. If left unchecked they eventually cut off the sap flow from the stems and leaves (Figure G9). Girdling of the trunk may result from stake ties being left on too long (Figure G10).

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<tr><td>Figure G9.</td><td>Figure G10.</td></tr>
<tr><td>Source: http://extension.umd.edu/hgic/girdling-roots-trees-and-shrubs</td><td>Source: http://www.umass.edu/urbantree/factsheets/Images/stake_damage.jpg</td></tr>
</table>

Sunburn/ sunscald

Sunburn, or leaf scorch, is damage to foliage and other herbaceous plant parts caused by a combination of too much light and heat and insufficient moisture. A yellow or brown area develops on foliage, which then dies beginning in areas between the veins (Figure G11). **Sunscald** is damage to bark caused by excessive light or heat. Sunscald-damaged bark becomes cracked, sunken

Damage to tree trunks in most likely on the south and west sides of the tree where the sun is strongest. Occasionally growth cracks form in the tree trunk as a normal part of trunk

development. Growth cracks can be differentiated from frost cracks or cankers because there is no heartwood visible, and no decay or oozing from the crack.

	
Figure G11a. Sunburned branch	Figure G11b. Sunscalded leaves
Source: http://www.ipm.ucdavis.edu/PMG/GARDEN/ENVIRON/sunburn.html	

Insects

See section F for details.

Mechanical damage

Scattered dieback throughout a tree or shrub may be a result of mechanical damage (Figure G12-13). When equipment or machinery bangs into a tree or shrub it can crush the cambium layer or tear off bark and break branches (Figure G14). Repeated bumping of the trunk or stems, especially in young trees and shrubs, can severely damage or kill sections of the cambium layer just below the bark. Sap flow is interrupted between the roots and leaves, causing some twigs or branches to die. Mechanical damage also opens the tree or shrub to disease and insect organisms, which may further damage the plant. Lawn mowers, tractors and string trimmers are the primary cause of mechanical damage to plants. Trees and shrubs planted near parking lots, sidewalks, driveways or roads are also vulnerable to damage from cars or foot traffic bumping into them. Avoid mechanical injury by maintaining a mulched, weed free area around ornamentals.

Source: http://extension.umd.edu/hgic/mechanical-injury-trees-and-shrubs

<table>
<tr><td>  </td><td>  </td></tr>
<tr><td>Figure G12. Broken branches on juniper.</td><td>Figure G13. Dieback on shrub from compacted soil due to foot traffic.</td></tr>
<tr><td colspan="2">Source: http://extension.umd.edu/hgic/mechanical-injury-trees-and-shrubs</td></tr>
<tr><td>  </td><td></td></tr>
<tr><td>Figure G14. Tulip tree damaged by lawn mower or string trimmer (weed-eater).</td><td></td></tr>
<tr><td>Photo courtesy of Aron Namenwirth.</td><td></td></tr>
</table>

Parasitic disease

Armillaria is a genus of parasitic fungi that live on trees and woody shrubs. Armillaria spp. cause a white rot of wood. Symptoms include mycelial fans (white mats of fungal mycelium, between the inner bark and wood; Figure G15), rhizomorphs (attached to infected roots or to the surface

of uninfected roots; Figure G16), and mushrooms (caps are honey-brown, usually with small tufts of dark hairs, gills are whitish with notched attachment, spore prints are white, and stems are white to brown, usually with an irregular, mottled appearance; Figure G17). The mushrooms are generally in clusters near or on the base of trees.

Figure G15. Mycelial fans can be seen when the bark is cut or peeled back.

Photo by Steven Renquest

Figure G16. Rhizomorphs.

Figure G17. A cluster of mushrooms at the base of a western white pine with Armillaria root rot.

Phytophtora is a genus of plant-damaging oomycetes (water molds). Phytophtora spp. incite root and collar root disease on a range of hosts. Leaves will appear drought stressed, sometimes turning dull green, yellow, red, or purple as they wilt. Infected trees may survive a few years before the disease kills the whole plant. The bark around the soil-line may appear darkened. Cutting away some bark should reveal red-brown discoloration in the wood underneath it.

Disease symptoms are distinguishable from Armillaria root rot because mycelial mats do not develop in tissues infected with Phytophthora root rot. Source: http://www.missouribotanicalgarden.org

Salinity

Salt toxicity symptoms often starts with interveinal chlorosis (yellowing of the leaves between the veins with the veins remaining green). Burning on leaf surface or margins is also a symptom. As salts accumulate, the damage increases. Leaf burn becomes more severe until defoliation and twig dieback occurs. See Figures G18-23.

Sources:http://www.thebrittonfund.org/wpcontent/uploads/2012/06/BFsalinity2013.pdf and http://www.salinitymanagement.org/Salinity%20Management%20Guide/sp/sp_7a.html

Figure G18. Necrosis of tips and margins of older leaves; chlorosis of leaves.

Photo courtesy of Lin Wu.

Figure G19. Necrotic leaves on spray-irrigated ginkgo biloba.

Figure G20. Necrosis and defoliation of lower branches of the coast live oak (caused by wetting of the plant's leaves with saline rrigation water).

Photo courtesy of Lin Wu.

Figure G21. Severe burns on growing tips of spray-irrigated Escallonia.

Figure G22. Tips of needles exhibit reddish "burns".

Photo courtesy of Lin Wu.

Figure G23. Burned leaf margins on spray-irrigated California holly grape.

Vandalism

Source: ttps://savingourtrees.wordpress.com/2012/02/

Source: Wikimedia Commons

	
Vandals chopped tree with a sharp object. Photo courtesy of Brampton Guardian	

Wind

	
Branch failure.	Tree blown over.