The Urban Forest Effects (UFORE) Field Data Collection Procedures for the "Houston Green" Study

developed by

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1.0 Plot Establishment by Texas Forest Service

1) Locate property on the ground where plot center is located, based on evidence from map, DOQQ image, and/ or photograph provided.

2) Obtain permission from resident/owner to access property.
   - If owner/resident is available, present TFS credentials and letter explaining the purpose of the project. Try to obtain permission to enter all properties affected by the plot. If permission is denied for the property where plot center is located, entire plot is thrown out; if adjoining owner denies access, plot location is established and partial plot data is recorded.
   - If owner/resident is unavailable or unknown, find out any name or contact information from neighbors so that contact can eventually be made. If location is a business or residence, leave business card and letter explaining the project. Follow up later once contact is made with owner or resident.
   - If no owner information is available or obvious, collect sufficient tract information so that a courthouse records check is possible to locate the landowner.

3) Locate plot center *as shown on photo image* one of two ways:
   - Move as close as possible to the target location and fine-tune using the hand-held GPS device. Final location should match the photo as closely as possible. UTM coordinates provided are to two decimal places, but location can be established with a single decimal place match for both latitude and longitude.
   - Get as near to plot center as possible, while remaining in an area with landmarks that are visible on the photo image. Obtain a stable GPS reading for the landmark closest to plot center, then enter plot center coordinates into unit to obtain distance and direction readings. Proceed to plot center using tape and compass.

4) At plot center, establish reference to at least two permanent landmarks (direction and distance from object) and record actual GPS coordinates. On plot data sheet, identify location or other notes (e.g., address if available, front or back yard, etc.) and sketch plot center in reference to a few fixed objects (e.g., buildings, fences, etc). If plot is in the middle of the forest, write specific directions (distance and direction) to relocate plot center. Where feasible, a stake should be put into the ground to help identify plot center. Take two digital photographs to record the location of plot center, one facing the plot center and another from plot center facing one of the landmarks.

5) If plot center falls on a building or other surface (such as highways) where the center point cannot be accessed, the plot is not to be moved. Distance to plot center from all edges of the obstruction should be measured from the aerial photograph in combination with the GPS unit. Landmarks (such as building corners or highway signs) are to be recorded as if measured from the true plot center. Use the sketch map to indicate the geometry of the plot, showing the building or obstruction and rough plot boundaries (see Appendix 1).

1.1 Plot Data Recorded by TFS (See Appendix_2.PDF for data collection forms) Record this information only once per plot.

- **Plot ID** – Plot number from the aerial photograph.
- **Photo #** (two are required) – Record digital picture number from camera. One picture should be taken from plot center towards a visible landmark; the second photo should be taken of plot center, marked in some manner (stake, hardhat, flagging, etc.). Photos should be re-labeled in the office with the plot number, followed by A and B.
- **Plot address** – Additional notes will be useful if plot is not located in area where there are no street numbers (vacant land, parks, industrial areas, etc.).
- **Plot Contact Info** – If available, record contact person's name and phone number. For residential land uses, do not ask for this information. However, if name is on mailbox, record it. Owner/renter status is useful if it comes up in conversation.
- **GPS coor** – Coordinates of global positioning system at plot center (Lat./Long.).
- **No. of actual land use types** on plot.
- **Plot Center Staked** (Y/N) – Was stake used to identify plot center?
- **Landmarks** (at least two are required) – Plot center must be identified so that it can be located for future remeasurements of the plot. Identify at least 2 landmarks visible when standing at plot center. Try to use objects that are likely to be present 5 to 15 years from now, e.g. stop signs, telephone poles, structures, sidewalks/driveways.
- **Measured object** – Identify/describe the object (minimum of two fixed objects must be recorded with distance and direction).
- **Distance to object**
- **Direction to object**

2.0 Contractor Plot-Level Data Collection Procedures (Methods given are based on a 1/6-acre, circular, permanent plot, and its associated 1/75-acre microplot.)

1) Re-locate plot center (advance contact with owner/resident should have been made) and determine plot boundaries. Plot radius is 48.1 ft from true plot center on flat ground. Mark the rough boundaries at this distance with flagging and use this area to document ground cover and shrub information.

   If plot center is located on a building, the boundary of the plot should be determined on the ground in the plot area that is not obstructed (see Appendix 1). All distances and directions to trees are to be measured and recorded from a building corner or other fixed point. Make notation of "plot measurement point" on sketch map and data sheet.

2) For plots located on slopes greater than 5%, the determination of which trees to include for measurement will be made according to the measured slope to each tree, as detailed in Section 3.0.

3) Locate the center of the microplot 24.0 ft from plot center at 90^{o}. Microplot radius is 13.6 ft. If all or part of the microplot is obstructed, microplot is not to be moved; measure those trees >= 1 in within the unobstructed portion (see Section 3.0).

2.1 Measurement Units

All measured variables to be recorded in English (ft/in) units.

2.2 Tree vs. Shrub vs. Seedling

Tree species (see Appendix 3) with a stem diameter of 1-in or greater are considered TREES and are recorded according to the procedures in Section 3.1. Tree species (Appendix 3) with a stem diameter <1-in and a height > 1-ft are defined as SEEDLINGS and are recorded as shrub data according to the procedures in Section 2.6. SHRUB species (Appendix 3) are never classified or recorded as a tree, no matter how large the stem diameter. Woody vegetation < 1-in diameter and < 1-ft in height is considered herbaceous vegetation, and will be recorded according to the procedures in Section 2.5.

2.3 Plot Location Data (add new data to original data sheet; record only once per plot)

- **Date**
- **Crew** – List first and last initials of each crewmember.
- **Slope through plot center** – Slope is determined by sighting the clinometer along a line parallel to the average incline (or decline) through the center of each plot, in the direction of the plot's aspect. To measure slope, Observer 1 should stand at the uphill edge of the plot and sight Observer 2, who stands at the downhill edge of the plot. Sight Observer 2 at the same height as the eye-level of Observer 1. Read the slope directly from the percent scale of the clinometer. If slope changes gradually across the plot, record an average slope. If slope changes across the plot but the slope is predominantly of one direction, code the predominant slope percentage rather than the average. *Record to nearest 1%, for slopes >5%; for slopes <5%, record as 0%.*
- **Aspect** – Measure aspect with a hand-held compass along the same direction used to determine slope. *Record to nearest 1 degree. Values: 0 = no aspect (slope < 5 percent); 1 = 1 degree; 2 = 2 degrees; … 360 = 360 degrees, due north.*

2.4 Land Use Data (recorded for each land use in a plot)

- **Actual land use** – Actual human use of the land, as determined by the crew on the ground. This does not represent the ownership of the land, nor the cover type that occurs on the land, but rather how the land is being used. *Use the following codes:*
  - R – Single-family Residential (includes duplexes)
  - M – Multi-family Residential (four-plexes, apartments, condos, townhomes)
  - C – Commercial/Industrial
  - P – Park
  - G – Golf course
  - E – Cemetery
  - A – Agriculture (includes wooded land with evidence of management activity, such as recent timber harvesting)
  - V – Vacant or no apparent use

- I – Institutional (Gov't., schools, hospitals, etc.)
- T – Transportation/Utility
- W – Water/Wetland (use, not cover)

o **Percent in** – Proportion of the plot that is in the land use as determined by the field crew. For most plots, this number will be 100%. However, some plots will fall on a border between two or more land uses. (There must be a clear change in the *human use* of the land, not its cover or ownership.) For example, 40% of the plot area might be residential and 60% vacant. In this case, the plot is split into two separate plots (one for the residential area and one for the vacant area) and all data are recorded on the data sheets for each land use (i.e., collect all data for the 40% residential area; then collect all data for the 60% vacant area). When working on the residential area, "Percent in" would equal 40%; when working on the vacant area, "Percent in" would equal 60%. However, each side of the plot is considered to be independent, such that there are now 2 separate plots that are each less than 1/6 acre. No data collection procedures change except the crew is working in a smaller area and data are recorded for two plots. Plot ID should be given a suffix .1, .2, .3…. for each plot with more than one land use. So, if plot number 14 is split, one plot would be noted as 14.1 and the other 14.2.

o **Plot Tree Cover (%)** – The proportion of the sky above the plot obscured by tree crowns. (Use the definition of TREES and SHRUBS from Section 2.2.) When looking upward from within the plot, one will either see tree canopies or open sky areas between the canopies. *Record to nearest 5% (<2.5% = 0; 2.5-<7.5% = 5; 7.5-<12.5% = 10; etc….)*

o **Plot Shrub/Seedling Cover (%)** – The proportion of the sky above the plot covered by shrub and tree seedling canopies (see Section 2.2 for definitions of TREES, SHRUBS, and SEEDLINGS). *Record to nearest 5% (<2.5% = 0; 2.5-<7.5% = 5; 7.5-<12.5% = 10; etc….)*

o **Plantable Space** – Percent of the plot area that is plantable for trees, i.e. amount of plantable soil that is not filled with tree canopies above (or other overhead restrictions) and where tree planting/establishment would not be prohibited due to land use (e.g., footpath, baseball field, etc.). Gardens and other areas (such as the space underneath tall trees) that contain non-woody vegetation are considered plantable space. *Record to nearest 5% (<2.5% = 0; 2.5-<7.5% = 5; 7.5-<12.5% = 10; etc….)*

2.5 Ground Cover Data

Within the plot, various materials will cover the ground (trees and shrubs are considered separately; tree stems as a ground cover are ignored). The crew should estimate to the nearest 5% (roughly equal to two parking lot spaces) what proportion of the plot ground area is covered by the materials listed below. The sum of all proportions recorded must add to 100%. *Record to nearest 5% (<2.5% = 0; 2.5-<7.5% = 5; 7.5-<12.5% = 10; etc….).*

- Buildings (%BLDG)
- Cement (%CMNT)
- Tar/blacktop/asphalt (%TAR)

- Other impervious (OTHIMP) - could include exposed surface roots or "knees"
- Soil (%SOIL)
- Permeable rock (%PERM ROCK) – permeable rock surfaces such as gravel. Large solid rock outcrops would be listed as “other impervious.”
- Duff/mulch (%DUFF/MULCH)
- Mown, maintained grass (%MAIN.GRASS)
- Wild, unmaintained grass (%UNMAIN.GRASS)
- Agricultural crops (%AG CROPS)
- Herbaceous (%HERB/IVY) - low herbaceous ground cover, exclusive of grass, but including woody plants <1-ft in height
- Water - including pools (%H2O)
- Other pervious surfaces (%OTHER PERV)

2.6 Shrub/Seedling Data

Shrubs and/or tree seedlings may occupy a certain proportion of the plot (see Section 2.4). If shrubs or tree seedlings are present, focus on the area covered by these plants and record data for this portion of the plot only. The following data are recorded for the each shrub/seedling genus group of similar height (i.e., many shrubs or tree seedlings of the same genus and height can be combined for this estimate):

- **Shrub/Seedling Genus** – (see Appendix 3). If genus (or species) not known, note deciduous (DESH1, 2, etc.), or conifer (EVSH1, 2, etc.). A tree species with a stem diameter less than 1-in is considered a seedling and is recorded with the shrub data.
- **Height** – Height (ft) of the mass of shrubs/seedlings for the genus.
- **Percent Area** – Of the total ground area of all shrubs/seedlings on the plot (from Section 2.4), record the percent of this ground area that is occupied by this genus/height combination (0-100%). Total of all percent area values recorded on the plot **may exceed 100%** if there are two or more shrub/seedling height layers of on the plot. *Record to nearest 5% (<2.5% = no record; 2.5-<7.5% = 5; 7.5-<12.5% = 10; etc….)*
- **Percent occupied** – Of the cylindrical volume of the shrub/seedling mass for this genus/height combination (visualize the height of mass x ground area covered), record the percent of this volume occupied by leaves. Allow for natural arrangement or spacing of leaves, but be sure to account for gaps between branches and other voids in the crown area. This measure allows field crew to account for voids in vegetation and inaccuracies of simple height x area estimates (e.g., height of mass might not be uniform). Intent of this variable is to adjust height and area measurements to reveal actual volume of leaves. *Record to nearest 5% (<2.5% = no record; 2.5-<7.5% = 5; 7.5-<12.5% = 10; etc….)*

3.0 Tree Data

Within each 1/6-acre plot, all tree species with stem diameters >= 5-in will be measured (see Section 3.1 for diameter measurement instructions). After these trees are measured and recorded, a 1/75-acre microplot (13.6 ft radius) should be installed according to the instructions

in Section 2.0. All tree species >= 1-in diameter and < 5-in diameter are measured, with distance and azimuth readings for each tree taken from the center of the microplot.

Data collection (within the plot or microplot) for trees starts with the tree to the north and then proceeds in a clockwise direction. (Note: flagging or chalking each tree as it is measured will help keep track of trees once they are measured and prevent missing or double-entering a tree*. No permanent marks, such as paint or scribe marks are allowed.*)

For plots with slopes <5%, trees are determined to be within the plot boundary if the distance from plot center to the center of the trunk at or near the ground line is 48.1 ft or less. For plots with slopes >=5%, the ground distance and actual slope to each tree should be measured. Trees will be recorded and measured if more than ½ of its stem meets the limiting distance according to the following table:

Slope %	**5**	**10**	**12**	**15**	**17**	**20**	**22**	**25**	**27**	**30**
Slope Angle	2.9°	5.7°	6.8°	8.5°	9.7°	11.3°	12.4°	14.0°	15.1°	16.7°
Limiting Distance	48.2’	48.3’	48.4’	48.6’	48.8’	49.1’	49.3’	49.6’	49.8’	50.2’

If laser rangefinder is used, shoot parallel to the ground line to measure slope distance, then use limiting distance table above based on ground slope. Actual distance values recorded are for horizontal distance and may not exceed 48.1 ft. Actual slope distance and slope percent can be recorded in the Remarks section.

3.1 Basic Tree Measurements

For each tree within the plot with greater than ½ of its stem in the plot (or microplot) and stem diameter >= 5-in (or >=1-in and <5-in for the microplot) -- *including dead trees* -- the following data are recorded:

- **MP** – Check this box if the measured tree is within a 1/75-acre microplot. (**NOTE:** This box should only be checked if the tree is >= 1-in and < 5-in stem diameter.)
- **DR** – Azimuth direction from plot center to the tree in degrees. *Record to nearest 1 degree. Values: 1 = 1 degree; 2 = 2 degrees; … 360 = 360 degrees, due north.*
- **DS** – Horizontal distance from plot center to the pith of the tree at its base, measured in ft. Rangefinder values to front of tree are acceptable, except for trees at the edge of the plot radius; these trees must conform to the limiting distance table in Section 3.0. *Record to nearest 0.1 ft. Values may not exceed 48.1 ft for main plot, nor 13.6 ft for trees in the microplot.*
- **SPECIES** – *Species must be recorded for all trees, including dead trees*. Sometimes the species of a dead tree can be determined; other times it may be recorded using the species code UNKN. If species is not known, take sample and record in notebook as SAMPLE_1, etc. Each unknown tree with a number is unique to a specific species, so every time that same unknown is encountered it will be recorded as SAMPLE_1. Sequentially number unknowns in notebook, identify later, and correct data to proper species code. If identification of individual species is difficult (e.g., due to hybridization) or individual species is not known, then record genera if possible. *Record using codes given in Appendix 3.*

- **DIAMETER –** In general, measure stem diameter at 4.5 ft above the ground line (DBH) on the uphill side of the tree. For forked or multi-stemmed trees, determine the point at which the pith of the stems converge: if pith union is below the ground line, each fork or stem is treated as a separate tree; if pith union is above ground, measure stem diameter at the narrowest point below the fork. For trees that fork close to the ground, included bark down to the ground line is a good indicator that the pith union is below ground. If tree forks above DBH, measure diameter at the narrowest point between DBH and the ground. See Appendix 4 for other special circumstances. *Record values to the next lowest 0.1-in (e.g. -- a reading of 3.68 inches is recorded as 3.6 inches).*
- **HEIGHT TO DIAMETER** – Distance along the stem from the ground line on the uphill side to the point where diameter was measured. *Record to the nearest 0.1-in.*
- **TOT HEIGHT** – Height to top of tree, measured in ft. For downed living trees or severely leaning trees, height is considered the distance along the main stem from ground to treetop. *Record to the nearest 1-ft.*
- **HEIGHT TO CROWN BASE** – Height to base of live crown, in ft (see Appendix 9). *Record to the nearest 1-ft; dead trees = 0.*
- **% IMP** – Percent of land area beneath entire tree canopy that is impervious. If tree crown crosses out of plot boundary, entire area beneath tree is still estimated. *Record to nearest 5% (<2.5% = 0; 2.5-<7.5% = 5; 7.5-<12.5% = 10; etc….)*
- **% SHRUB** – Percent of land area beneath canopy that is occupied by shrubs/seedlings. If tree crown crosses out of plot boundary, entire area beneath tree is still estimated. *Record to nearest 5% (<2.5% = 0; 2.5-<7.5% = 5; 7.5-<12.5% = 10; etc….)*
- **S** – Tree is a street tree, defined as growing within 10 ft of the surface of the road or in a boulevard median. *Record Y if a street tree, N if not a street tree.*

3.2 Tree Crown Measurements

- **CROWN WIDTH** – Crown width measured in ft. Crown width is recorded by two measurements: widest and then at a right angle to the first measurement. If tree is downed or leaning, take width measurements perpendicular to the tree bole. *Record to the nearest 1-ft; dead trees = 0.*
- **FOLIAGE ABSENT** – Within the "typical crown outline," estimate the percent foliage missing due to pruning, dieback, defoliation, uneven crown, or dwarf or sparse leaves. The typical crown outline is defined as a symmetrical silhouette created by the live crown width, height, and height to base of live crown measurements (see Appendix 5). It is assumed to be symmetrical around the center point of the measured width of the tree and filled with leaves as if it were a healthy tree in excellent condition. This measure estimates the percent of leaf mass that is missing from the outline as compared to a healthy tree with a full symmetrical crown. Take into account the natural crown shape for the particular species. Two perpendicular measures of missing leaf mass are made and the average result is recorded. *Record to nearest 5% (<2.5% = 0; 2.5-<7.5% = 5; 7.5-<12.5% = 10; etc.; record dead trees as 99).*
- **DB (DIEBACK)** – Percent crown dieback in live crown area. This dieback does not include natural branch dieback due to crown competition/shading in the lower portion of the crown. However, branch dieback on side(s) of crown area due to shading from a

building or another tree would be included. *Record to nearest 5% (<2.5% = 0; 2.5-<7.5% = 5; 7.5-<12.5% = 10; etc.; record dead trees as 99). See Appendix 6.*

- **TR (TRANSPARENCY)** – Amount of skylight visible through the live foliated portion of the crown. If there are variations in different sections of the crown, come up with an average. Use foliage transparency scale (see Appendix 7). Look at branches or clumps of foliage to come up with the value. Don't include skylight that is present between branches. Evaluate without standing directly beneath the tree and avoid having branches from the same tree or others behind it influence the light passing through. *Record to nearest 5% (<2.5% = 0; 2.5-<7.5% = 5; 7.5-<12.5% = 10; etc.; record dead trees as 99).*
- **CLE** – Crown Light Exposure: Number of sides of the tree receiving sunlight from above. Top of tree is counted as one side. Divide the crown vertically into four equal sides. Count the number of sides that would receive direct light if the sun were directly above the tree. Add one if the tree receives any direct light from the top. **Note: One-third of the live crown must be receiving full light in order for a side to qualify. A sliver of a side receiving light does not qualify.** *Record values from 0 – 5.*

Crown Light Exposure Codes.

Code	Definition
0	The tree receives no full light because it is shaded by buildings, trees, vines, or other vegetation. (Suppressed)
1	The tree receives full light from the top or 1 side. (Suppressed or intermediate)
2	The tree receives full light from the top and 1 side (or 2 sides without the top). (Intermediate)
3	The tree receives full light from the top and 2 sides (or 3 sides without the top). (Intermediate or Co-dominant)
4	The tree receives full light from the top and 3 sides. (Co-dominant or Dominant)
5	The tree receives full light from the top and 4 sides. (Dominant)

3.3 Proximity to Buildings

For trees with total heights >=20-ft located within 60 feet of space-conditioned buildings (powered for heating and/or cooling) that are 3 stories (2 stories + attic) or less in height, record distance class and direction as instructed below. This measure is used to calculate *residential* energy savings due to shading from trees, so exclude consideration of large commercial or institutional structures. **Note: affected buildings do not have to be on the plot. For trees within 60 feet of more than one building, add data to D2 and S2 for second building, D3 / S3 for third building, etc.**

- **D#** – Direction from the tree **to** the closest part of the building, in degrees.
- **S#** – Distance class corresponding to the shortest distance to the building, such as closest wall or to corner of building (for tree planted on corner). *Values: 1 = 20-ft or less; 2 = 21 to 40-ft; 3 = 41 to 60-ft.*

3.4 Tree Condition

A visual examination of each tree will be made in order to assess its general condition. Five factors contribute to the overall assessment: roots, trunk, branches, twigs, and foliage. Each portion of the tree is assessed independently and assigned a value from the table below:

Tree Condition Scoring Values.

Score	Definition
1	Extreme problems
2	Major problems
3	Minor problems
4	No apparent problems

Each factor has several criteria that require inspection, as listed below. For more information, review the *Guide for Plant Appraisal – 9th Edition*, published by International Society of Arboriculture. **Note: the scoring value selected for each factor should be based on both the number and severity of the problems found.**

- **ROOTS** – Inspect the structural and health criteria associated with the tree roots and root collar. These include *root anchorage*, *root collar/flare soundness*, *mechanical injury*, *girdling roots*, *compacted or waterlogged roots*, *insects or disease*, and *presence of mushrooms*. *Record value from 1-4.* **Note: absence of a visible root flare is evidence of at least a minor problem.**
- **TRUNK** – Inspect the structural and health criteria associated with the tree trunk. These include *sound bark and wood*, *cavities*, *mechanical or fire injury*, *cracks*, *swollen or sunken areas*, *insects or disease*, and *presence of conks.* *Record value from 1-4.*
- **BRANCHES** – Inspect the structural and health criteria associated with the scaffold branches. These include *strong attachments*, *diameter smaller than trunk*, *vertical branch distribution*, *included bark*, *decay and cavities*, *well-pruned*, *well-proportioned or tapered*, *wound closure*, *deadwood or fire injury*, and *insects or disease*. *Record value from 1-4.*
- **TWIGS** – Inspect the structural and health criteria associated with the tree's small branches and twigs. These include *vigor of current shoots*, *distribution through the canopy*, *appearance of buds*, *presence of insects or disease*, *presence of weak or dead twigs*. *Record value from 1-4.*
- **LEAVES** – Inspect the structural and health criteria associated with the tree foliage and/or buds. These include *size of foliage/buds*, *coloration of foliage*, *wilted or dead leaves*, *herbicide/chemical/pollution injury*, *dry buds*, and *presence of insects or disease*. *Record value from 1-4.*
- **UTILITY** – Record Y if there is an obvious utility conflict (overhead wires, underground utilities) within 5 ft of the tree; N if no conflict is evident.
- **REMARKS** -- Make any notations here that help clarify recorded measurements for this tree.

4. Equipment

The following are field equipment that are needed for UFORE plot measurements:

- Aerial photographs and street map to locate plot
- Clinometer, or other tree height measuring device
- Diameter tape
- Clipboard; data sheets, pens/pencils (or digital recorders-PDA)
- 50/100 ft tape measure (or electronic measuring device)
- Species ID guide
- Notebook, clippers, and tape (to store unknown samples)
- First Aid Kit
- Calculator
- Compass (Suunto or other "see-through" brand)
- Binoculars (for estimating crown dieback)
- Dazer (to ward off dogs)
- Digital Camera
- Chalk/Flagging (to mark trees that have been measured)
- Electronic rangefinder (optional)

5. Safety

Safety is a critical component of any field operation. In cities, differing neighborhood condition can cause potential safety hazards. Be aware of the surrounding environments and use caution at all times. Discuss with local project managers specific conditions that may be encountered within the city. Also contact local police for more information, if necessary, and to let the police know that the field operation is occurring. Leave daily itineraries with the project manager regarding the area of the city to be sampled. See Tallent-Halsell, N.G. (ed.) 1994. Forest Health Monitoring 1994 Field Methods Guide. EPA/620/R-94/027. U.S. Environmental Protection Agency, Washington, DC for more information on safety procedures.

Appendices

Appendix 1 – Plot Center on Building

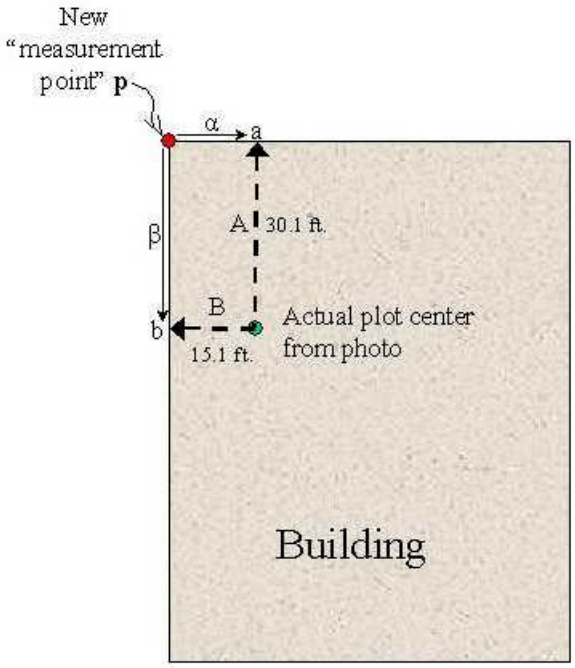

Figure 1-1. Plot center located as per TFS sketch map

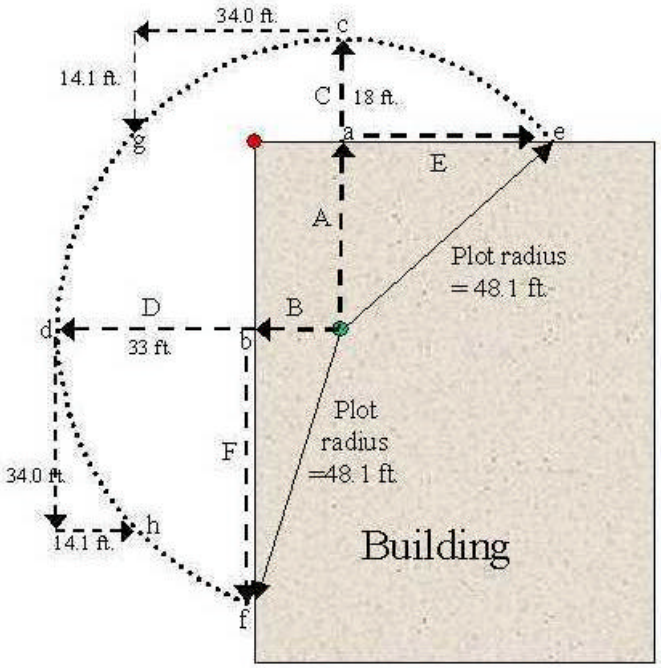

Figure 1-2. Establishing points along plot perimeter.

Step 1: Measure azimuths **a** and **ß** along building walls using compass. Ex. -- Point **a** is 15.1 ft. from corner; point **b** is 30.1 ft. from corner.

Step 2: Find points **c**, **d**, **e,** and **f** on plot perimeter: Example --
Distance **C** = (plot radius - A) = (48.1-30.1) = 18 ft.; direction = **ß** + 180º.
Distance **D** = (plot radius - B) = (48.1-15.1) = 33 ft.; direction = **a** + 180º.
Distance **E** = $(\text{radius}^2\text{-A}^2)^{-1}$ = $(2313.6\text{-}906.0)^{-1}$ = 37.5 ft.
Distance **F** = $(\text{radius}^2\text{-B}^2)^{-1}$ = $(2313.6\text{-}228.0)^{-1}$ = 45.7 ft.

Step 3: Find points **g** and **h** on plot perimeter: Example --
From point **c**, go 34.0 ft. on azimuth **a** + 180º, then 14.1 ft. on azimuth **ß** to point **g**.
From point **d**, go 34.0 ft. on azimuth **ß**, then 14.1 ft. on azimuth **a** to point **h**.

Appendix 2. – Field Data Sheets

Sheets are available as Appendix_2.PDF

Appendix 3. – Species Codes

Species codes are available as Appendix_3.PDF

Appendix 4. DBH Measurement

From: Forest Inventory and Analysis National Core Field Guide. Volume 1: Field Data Collection Procedures for Phase 2 Plots. Version 1.4

Special DBH situations:

1. Tree with butt-swell or bottleneck: Measure these trees 1.5 ft above the end of the swell or bottleneck if the swell or bottleneck extends 3.0 ft or more above the ground (Figure 4-1).

2. Forked tree: If the tree forks, determine the point at which the pith of each fork meets. If that point is below the ground line (included bark at the ground line is evidence of separation), treat each fork as a separate tree (Figure 4-3); if the pith intersection is above the ground line, measure diameter at the narrowest point between 4.5 ft and the ground (Figure 4-2).

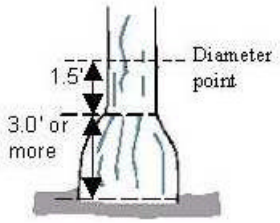

Figure 4-1: Tree with swelled butt (1)

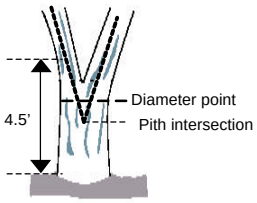

Figure 4-2: One tree (2)

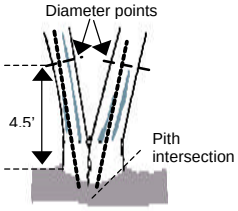

Figure 4-3: Two trees (2)

3. Tree with irregularities at DBH: On trees with swellings (Figure 4-4), bumps, depressions, branches (Figure 4-5), etc. at DBH, diameter will be measured immediately above the irregularity at the place it ceases to affect normal stem form.

4. Tree on slope: Measure diameter at 4.5 ft from the ground along the bole on the uphill side of the tree (Figure 4-6).

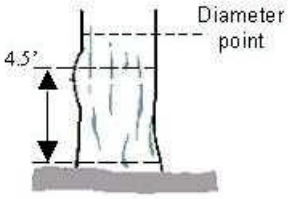

Figure 4-4: Tree with swelling (3)

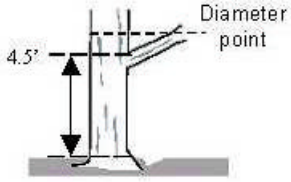

Figure 4-5: Tree with branch (3)

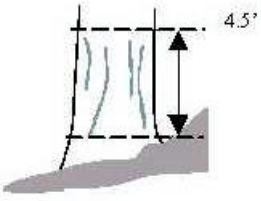

Figure 4-6: Tree on a slope (4)

5. Leaning tree: Measure diameter at 4.5 ft from the ground along the bole. The 4.5 ft distance is measured along the underside face of the bole (Figure 4-7).

6. Independent trees that grow together: Continue to treat them as two trees.

7. Diameter on trees missing a portion of bark or bole at the point of diameter measurement is measured and recorded to the nearest 0.1 in as the tree actually exists (e.g., do not "reconstruct" the bole) (Figure 4-8).

8. Live windthrown tree: Measure from the top of the root collar along the length to 4.5 ft (Figure 4-9).

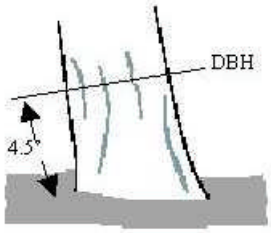

Figure 4-7: Leaning tree (5)

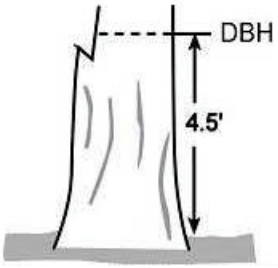

Figure 4-8: Tree with broken stem (7)

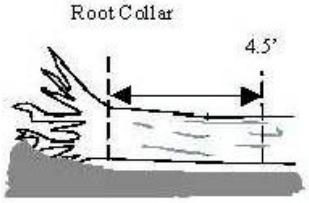

Figure 4-9: Tree on the ground (8)

Appendix 5. Foliage Absent

Foliage absent is the percent of the typical crown outline (for the measured tree's height and width) that is missing compared to the actual crown outline. The typical crown outline is defined as a symmetrical silhouette created by the crown width, height, and height to base of live crown measurements. It is assumed to be symmetrical around the center point of the measured width of the tree and filled with leaves as if it were a healthy tree in excellent condition. See illustrations in the upper right corner of Figures 5-1 and 5-2. The actual crown outline, which is used for foliage transparency (Appendix 7) is illustrated in lower right corner of Figures 5-1 and 5-2.

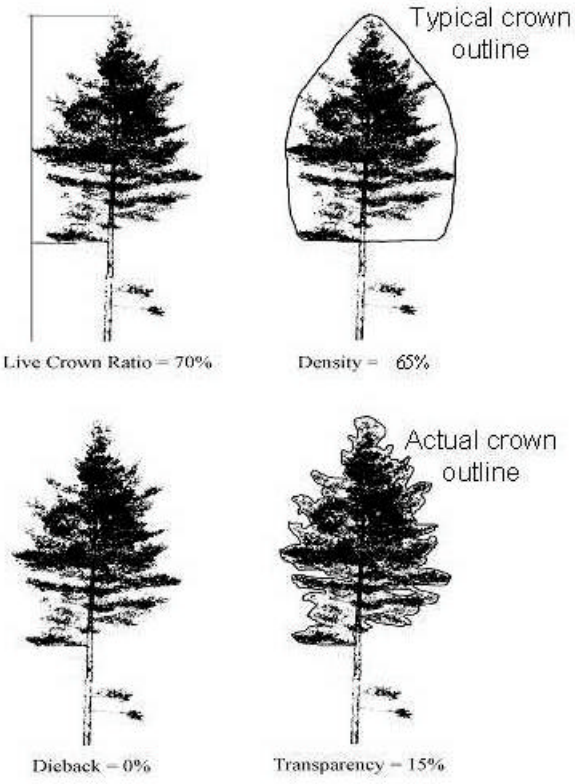

Figure 5-1. Examples of a conifer with crown measurement outlines.

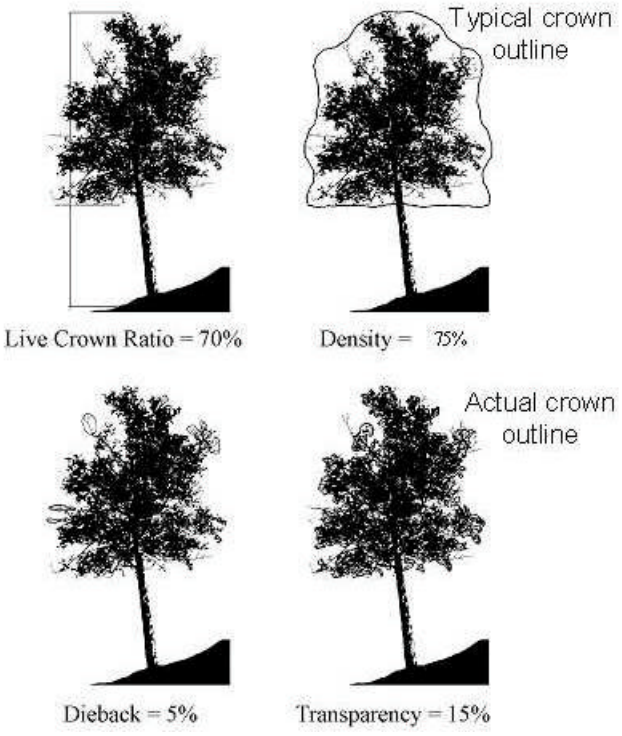

Figure 5-2. Examples of a deciduous tree with crown measurement outlines.

Foliage absent assumes the actual crown outline is totally filled and no light passes through. Light passing through the actual crown outline will be assessed using foliage transparency.

Foliage absent is measured by two people standing perpendicular angles to the tree (Figure 5-3). Typical and actual crown shape is determined by the measurements made for crown width, tree height, and height to base of live crown.

When two individuals disagree with their estimates, follow the guidelines listed in Appendix 10. The estimate is placed into one of 21 percentage classes.

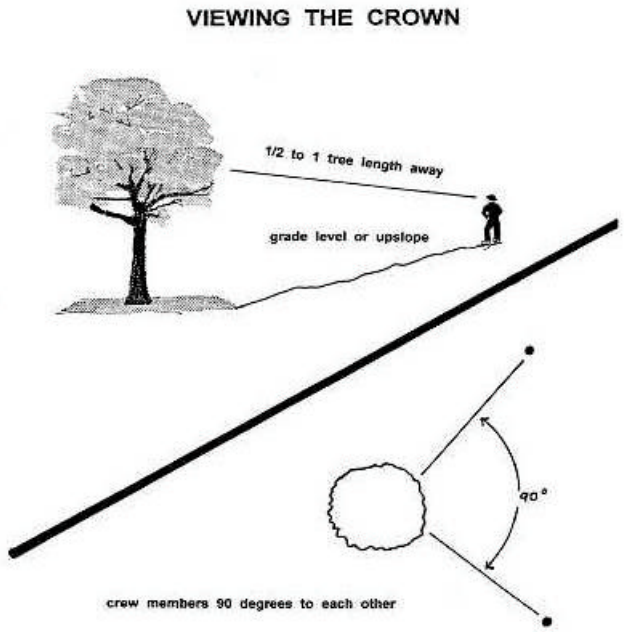

Figure 5-3. Crew positions for viewing crowns.

Appendix 6. Crown Dieback

From: Forest Inventory and Analysis National Core Field Guide. Volume 1: Field Data Collection Procedures for Phase 2 Plots. Version 1.4

Crown dieback is defined as recent mortality of branches with fine twigs, which begins at the terminal portion of a branch and proceeds toward the trunk. Dieback should occur from the top of the crown down and from the outside in toward the main stem. Dieback is only considered when it occurs in the upper and outer portions of the tree. When whole branches are dead in the upper crown, without obvious signs of damage such as breaks or animal injury, assume that the branches died from the terminal portion of the branch. Dead branches in the lower portion of the live crown are assumed to have died from competition and shading. Dead branches in the lower live crown are not considered as part of crown dieback, unless there is continuous dieback from the upper and outer crown down to those branches.

Crown dieback estimates reflect the severity of recent stresses on a tree. Estimate crown dieback as a percentage of the live crown area, including the dieback area. The crown base should be the same as that used for the live crown ratio estimate. Assume the perimeter of the crown is a two-dimensional outline from branch-tip to branch-tip, excluding snag branches and large holes or gaps in the crown (Figure 6-1).

Crown dieback is obtained by two people (Figure 5-3). Binoculars should be used to assist in the data collection. Observers should be conscious of lighting conditions and how light affects the day's observations. Under limited-light conditions, observers should take extra time. Poor lighting can make the measurement more difficult.

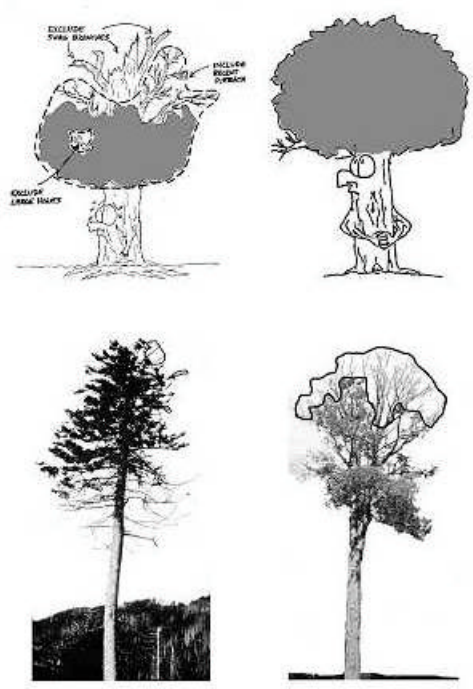

Figure 6-1. Dieback rating examples

Each individual should mentally draw a two-dimensional crown outline, block in the dieback and estimate the dieback area.

When two individuals disagree with their estimates, follow the guidelines listed in Appendix 10. The estimate is placed into one of 21 percentage classes.

Training for crown variables (crown dieback, foliage transparency) can be aided by using the Forest Health Monitoring – Crown Indicator 2000 CD by Mike Schomaker of the USDA Forest Service.

Appendix 7. Foliage Transparency

From: Forest Inventory and Analysis National Core Field Guide. Volume 1: Field Data Collection Procedures for Phase 2 Plots. Version 1.4

Foliage transparency is the amount of skylight visible through the live, normally foliated portion (where you would expect to see foliage if the tree was not or had not been impacted by a stressing agent during the current evaluation year) of the crown. Make sure to evaluate the live portions of the crown that are temporarily defoliated, but exclude dead branches from the estimate. A recently defoliated tree except for one or two live leaves should have a transparency rating of 99 not 0!! Check with binoculars to assess which branches are alive and should have foliage.

Different tree species have a normal range of foliage transparency, which may be more or less than that of other species. Changes in foliage transparency can also occur as a result of current damage, frequently referred to as defoliation, or from reduced foliage resulting from stresses during preceding years.

Estimate foliage transparency using the crown density - foliage transparency card (Figure 7-1). Exclude vine foliage from the transparency estimate as best you can. Dead branches in the lower live crown, snag branches, crown dieback and missing branches or areas where foliage is expected to be missing are deleted from the estimate (Figure 7-2).

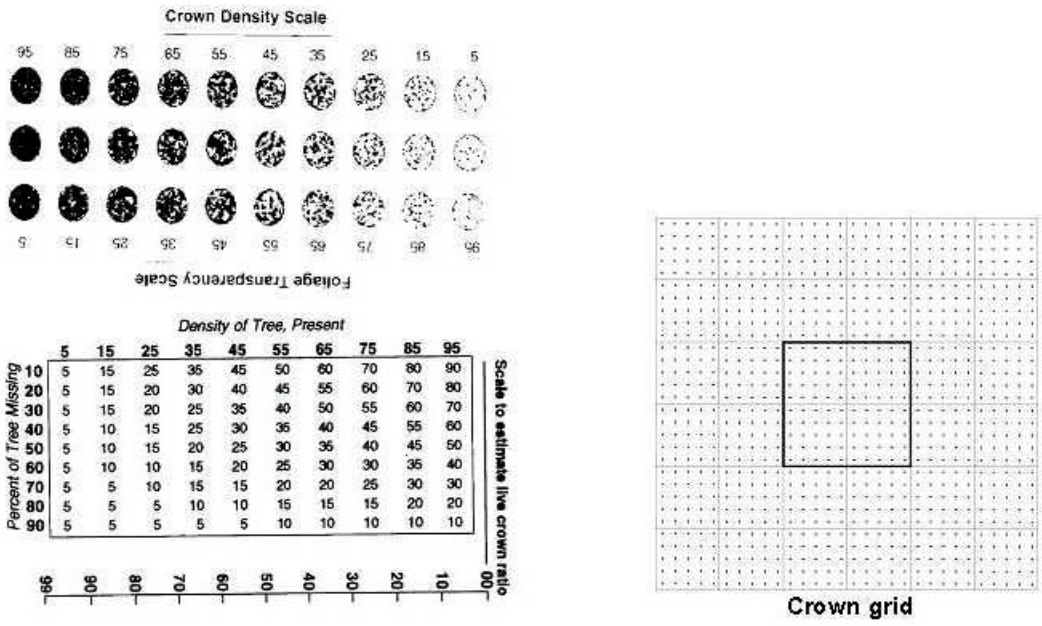

Figure 7-1. Crown density - foliage transparency card and crown grid.

Large uniform crowns are rated as if the whole crown should be foliated. When defoliation is severe, branches alone will screen the light, but you should exclude the branches from the foliage outline and rate the area as if the light was penetrating those branches. For example, an almost completely defoliated dense spruce may have less than 20 percent skylight coming through the crown, but it will be rated as highly transparent because of the missing foliage. Old trees and some hardwood species, have crowns with densely foliated branches that are spaced far apart. These spaces between branches should not be included in the foliage transparency rating. When foliage transparency in one part of the crown differs from another part, the average foliage transparency is estimated.

Foliage transparency should be rated by two people (Figure 5-3). First, each individual will mentally draw a two-dimensional crown outline. Second, the foliated area will be blocked into the crown outline. Third, estimate the transparency of the foliated area.

When two individuals disagree with their estimates, follow the guidelines listed in Appendix 10. The estimate is placed into one of 21 percentage classes.

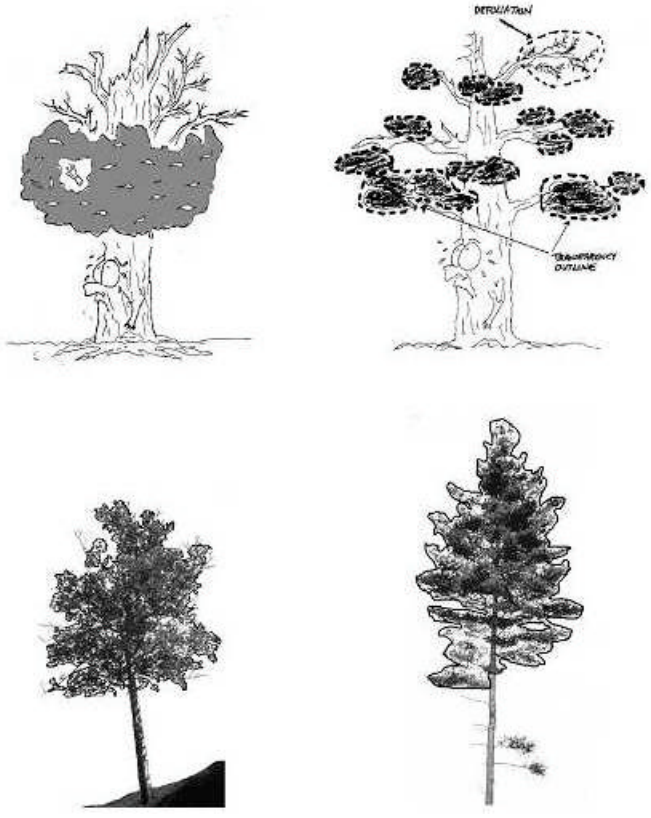

Figure 7-2. Transparency rating examples.

Appendix 9. Base of Live Crown

From: Forest Inventory and Analysis National Core Field Guide. Volume 1: Field Data Collection Procedures for Phase 2 Plots. Version 1.4

Live crown length is determined from the last live foliage at the crown top (dieback in the upper portion of the crown is not part of the live crown) to the “base of live crown”. Many times there are additional live branches below the “base of live crown”. These branches are only included if they have a basal diameter greater than 1 in and are within 5 ft of the base of the obvious live crown. The live crown base becomes that point on the main bole perpendicular to the lowest live foliage on the last branch that is included in the live crown. The live crown base is determined by the live foliage and not by the point where a branch intersects with the main bole.

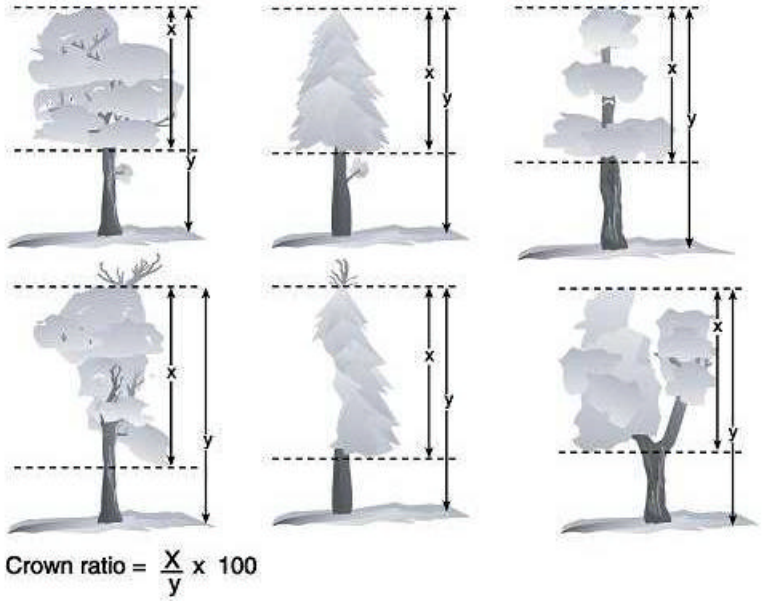

Figure 9-1 Example of base of live crown.

Appendix 10. Crown Rating Precautions

From: Forest Inventory and Analysis National Core Field Guide. Volume 1: Field Data Collection Procedures for Phase 2 Plots. Version 1.4

Crews must be especially careful when making evaluations under certain conditions and follow these procedures:

Distance from the tree

Crews must attempt to stay at least 1/2 to 1 tree length from the tree being evaluated. Some ratings change with proximity to the tree. In some situations, it is impossible to satisfy this step, but the crew should do the best it can in each case. All evaluations are made at grade (same elevation as base of the tree) or up slope from the tree. This may not be possible in all cases but never get in the habit of evaluating trees from the down slope side.

View of the crown

Crewmembers should evaluate trees when standing at an angle to each other, striving to obtain the best view of the crown. The ideal positions are at 90 degrees to each other on flat terrain (Figure 10-1). If possible, never evaluate the tree from the same position or at 180 degrees. In a forest, getting a good perspective of the crown becomes difficult. Overlapping branches, background trees and lack of a good viewing area can cause problems when rating some trees. Crews need to move laterally to search for a good view. Take special care when rating such trees.

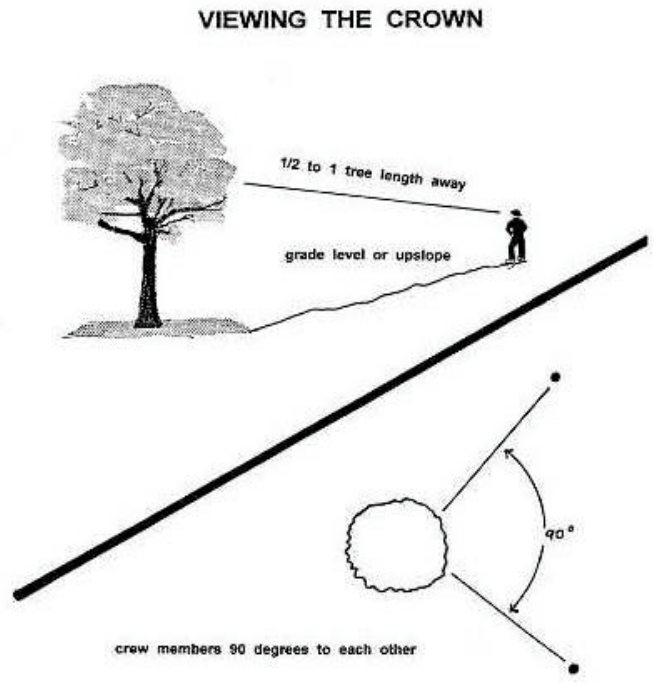

Figure 10-1. Crew positions for viewing crowns.

Climatic conditions

Cloudy or overcast skies, fog, rain and poor sun angles may affect estimates. Live crown ratio and crown diameters may be affected but to a lesser degree than other crown indicators. Crown density tends to be overestimated or underestimated because light does not project well through the foliage or, in some cases, the light may be too bright for a good estimate. Crown dieback may be underestimated, because it is difficult to see dead twigs and/or to differentiate defoliated twigs from dead twigs. Foliage transparency estimates could be affected in either direction, because it is hard to separate foliage from branches. The data quality expectation standard helps, because crews can normally be within ?10 percent, even in poor weather conditions. However, crews need to be especially careful during poor lighting conditions. Crews should move around a tree to get another view, even if the view appears adequate at a specific location.

Heavy defoliation

During heavy defoliation, crown dieback may be overestimated and foliage transparency may be underestimated due to the difficulty in differentiating dead twigs from defoliated twigs. The use of binoculars may help in separating dead twigs from defoliated twigs.

Trees with no crown after application of definitions (epicormics or sprigs only)

After a sudden release or damage, a tree may have very dense foliage, but no crown. These situations are coded as follows: live crown ratio - 00, crown light exposure - 0, crown position - 3, crown density - 00, crown dieback - 99, foliage transparency - 99.

Epicormics remain epicormics until they regain the size of previous branches for trees with no branches 1 in or larger in diameter at the base above the swelling. For trees that had 1 in or larger branches when the epicormics formed, epicormics become branches once they reach 1 inch in diameter.

Measurement differences resolution

If the numbers for a crown measurement estimate by two crewmembers do not match, arrive at the final value by:

- Taking an average, if the numbers differ by 10% (2 classes) or less.
- Changing positions, if the numbers differ by 15 % or more and attempt to narrow the range to 10% or less.
- Averaging the two estimates for those trees that actually have different ratings from the two viewing areas (ratings of 30 and 70 would be recorded as 50)

Appendix 11. Quality Control Standards & Procedures

The accuracy and precision of the data collected through this study is critical to the validity of any statistical measures or conclusions concerning tree cover. Therefore the following procedures will be used to validate the data collected through this study:

Weekly Plot Check System

A point system for evaluating the quality of data collected has been established (see **Table 1** below). For each crew involved in UFORE data collection, 10% of their plots will be checked by the Quality Assurance (QA) team each week, with a minimum of one plot checked per week. For instance, if a crew turns in data for nine plots on a given Friday, the QA team will randomly select one of these plots for remeasurement during the following week. Deductions will be assessed against each plot or tree variable according to the schedule in Table 1. Corrective actions on the part of the contractor will be required when the score for a crew exceeds 10 total points on a given plot, as shown below:

Score	Corrective Action
0-20	None required
21-50	Crew must return to the plot for re-training
>50	Crew must return to plot for additional training ***AND*** data for all plots collected the same week must be re-collected at contractor's expense

Table 1. -- Tolerances and deductions for UFORE field variables.

VARIABLE	TOLERANCE	DEDUCTION
PLOT LOCATION		
Plot Number	None	2
Date	None	1
Crew ID	None	1
Aspect	+/- 5 degrees	1
Slope	+/- 1 percent	1
PLOT COVER / LAND USE DATA		
Number of actual land uses	None	5
Actual land use	None	2
Percent of plot in each use	+/- 5 percent	1
Plot tree cover %	+/- 10 percent	1
Plot shrub cover %	+/- 10 percent	1
Plantable space %	+/- 10 percent	1
Ground cover % (each cover type)	+/- 10 percent	1
No. of shrub-genus layers	+/- 1 layer	1
Shrub layer height (each genus)	+/- 2 feet	1
Shrub layer % of area (each genus)	+/- 10 percent	1
Shrub layer % leaves (each genus)	+/- 20 percent	1

continued…

VARIABLE	TOLERANCE	DEDUCTION
TREE DATA VARIABLES		
Tree missed or added	None	5
MP box checked	None	1
Azimuth	+/- 3 degrees	2
Distance	+/- 1 foot	2
Species	Within genus	5
Diameter	+/- 0.2 inch	5
Total height	+/- 10 feet	5
Height to crown base	+/- 5 feet	5
Percent impervious surface	+/- 10 percent	1
Percent shrub cover under tree	+/- 10 percent	1
Street tree	None	1
Crown width (wide)	+/- 5 feet	2
Crown width (perpendicular)	+/- 5 feet	2
Foliage absent	+/- 10 percent	2
Dieback	+/- 10 percent	2
Transparency	+/- 10 percent	2
Crown light exposure	None	1
Building direction	+/- 3 degrees	2
Building distance	+/- 5 feet	2
Roots condition	+/- 1 point	1
Trunk condition	+/- 1 point	1
Branches condition	+/- 1 point	1
Twigs condition	+/- 1 point	1
Leaves condition	+/- 1 point	1
Utility conflict	None	1