MICHIGAN ASH MONITORING PLOT SYSTEM

FIELD METHODS PROTOCOL HANBOOK

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HANDBOOK VERSION 1.0
May 2004

Handbook Adapted from :

U.S. Department of Agriculture, Forest Service. 2004a. Forest inventory and analysis national core field guide, volume 1: field data collection procedures for phase 2 plots, version 2.0. U.S. Department of Agriculture, Forest Service, Washington Office. Internal report. On file with: U.S. Department of Agriculture, Forest Service, Forest Inventory and Analysis, 201 14th St., Washington, D.C., 20250

And

Thompson E.M. and J.A. Witter. 2002. Michigan beech bark disease monitoring and impact analysis system: field methods protocol handbook. Handbook 02-1. Univ. Mich., Sch. Nat. Res. Environ., Ann Arbor, MI. 45p.

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Ash Monitoring Plot System
Type 1 Plot Field Methods Protocol Handbook ver. 1.0
May 2004

A. Introduction

Biological invasions, the arrival, establishment and spread of nonindigenous organisms that have detrimental effects on native species, have become an increasing problem affecting the health of forests worldwide. In the past two years, a new biological invasion has been causing major concern in the United States and Canada. In July 2002, beetles collected from ash trees in southeastern Michigan and Windsor, Ontario were identified as *Agrilus planipennis* Fairmaire (Emerald Ash Borer (EAB)). Following the initial discovery of this wood-boring beetle, the pest has spread and established in 13 counties in Michigan and isolated outbreaks have occurred in Ohio, Maryland, Virginia and Indiana. EAB has been found infesting the three major ash species in Michigan (green ash (*Fraxinus pennsylvanica*), white ash (*Fraxinus americana*), and black ash (*Fraxinus nigra*)) as well as horticultural varieties. Since its invasion, EAB has caused economic losses in Michigan estimated at $11.6 million and potential losses are estimated at $1.7 billion for timber trees alone (USDA-APHIS 2003). With the current known geographic range of EAB, the opportunity exists to establish baseline data on the health of the ash resource in Michigan before the perhaps inevitable spread of the pest. During the summers of 2004 and 2005 a network of permanent monitoring and research plots will be established throughout the state. This ash monitoring plot system will allow documentation of the present state of the ash resource, changes in the ash resource over time, and determination of the abiotic and biotic factors that are affecting the health of these trees. In addition we aim to determine the distribution and spread of EAB in Michigan and factors associated with its presence or absence. A website containing a project description, maps, and educational materials is under development at www.michiganash.org. This handbook provides the field protocols that are to be used in the establishment of plots throughout Michigan.

B. Objectives

The general objectives of the ash monitoring plot system are to:

- Examine state parks and campgrounds in northern Lower Michigan in order to detect EAB occurrence; these sites are at high risk to have received infested firewood over the last few years
- Monitor conditions of ash and levels of EAB infestation for trees in 400 forest stands in Michigan. Planted street trees will not be included as they are the focus of other programs. This monitoring will provide baseline data on current conditions of ash trees and stands containing ash, and also will serve as a database of stands to re-sample for future comparisons
- Re-sample all study plots three years after establishment and initial sampling
- Plots found to be infested with EAB will be re-sampled yearly to document changes
- Eighty intensive plots will be selected for detailed research studies and will be re-sampled yearly to document changes

- Identify areas at high risk, develop a risk model/health evaluation index, and prioritize research needs
- For areas with the highest risk and poorest levels of ash health, we will perform detailed comparisons of site factors and assemble a team of experts who will evaluate a range of abiotic and biotic components in order to determine most likely causes of poor tree health.

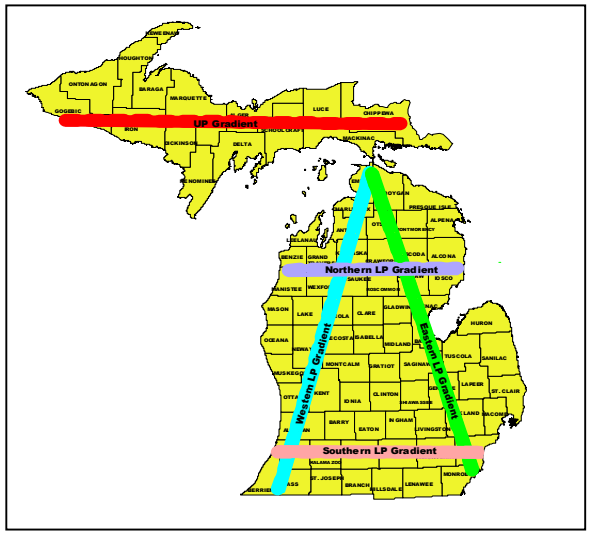
The specific objectives of this ash monitoring system are:

- Develop a sampling protocol handbook that documents the methodology used in this study
- Determine differences in stands with and without high levels of ash decline based on stand, plot and tree-level variables
- Develop maps of ash occurrence patterns, severity of ash decline, and risk for the rural forests of Michigan
- Determine impacts of ash decline on ash trees and hardwood stands containing ash in Michigan.

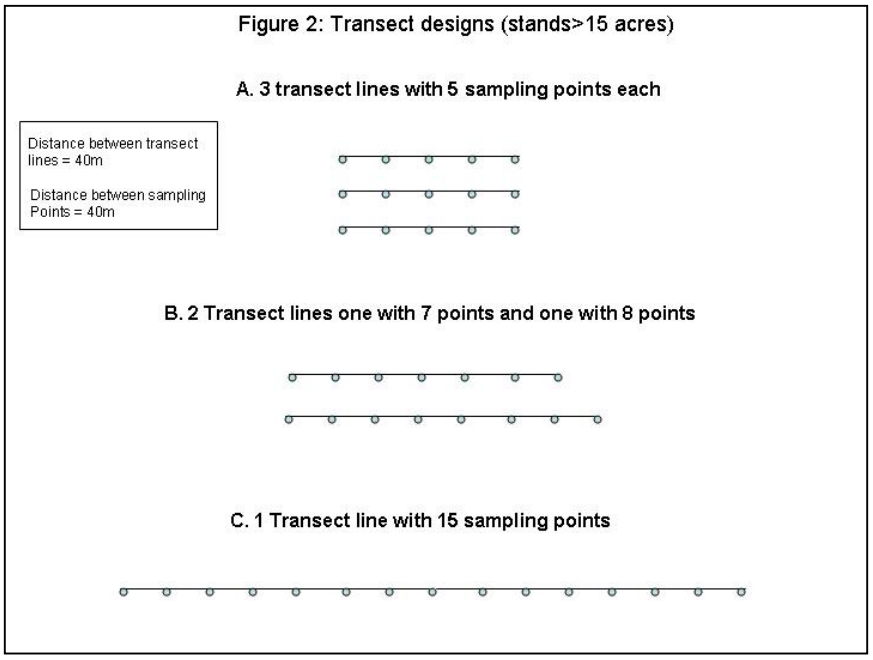
C. Study Area

Four hundred plots are to be established throughout the state of Michigan. Researchers from Michigan Technological University are responsible for establishment and data collection of plots in the Upper Peninsula and the northern Lower Peninsula. Researchers from the University of Michigan are responsible for establishment of plots and data collection in the southern Lower Peninsula. The plots are proportionately distributed between upland well-drained sites containing white ash and bottomland/wet sites containing green and/or black ash to reflect the natural distribution of ash in the state. Plots are selected based on the presence of ash. Two hundred and fifty of the plots are located along one of five transects: Southern Lower Peninsula (East/West), Northern Lower Peninsula (East/West), Diagonal Lower Peninsula (North/South), Western Lower Peninsula (North/South), and Upper Peninsula (East/West) (Figure 1). Fifty plots are located in each gradient. These gradients cover the main travel routes in Michigan and represent the natural distribution of ash in the state as determined by USFS data. The remaining 150 plots are located in areas with ash that are not covered by these five gradients. Plots are located on both public and private lands.

Figure 1: Five Sampling gradients in Michigan

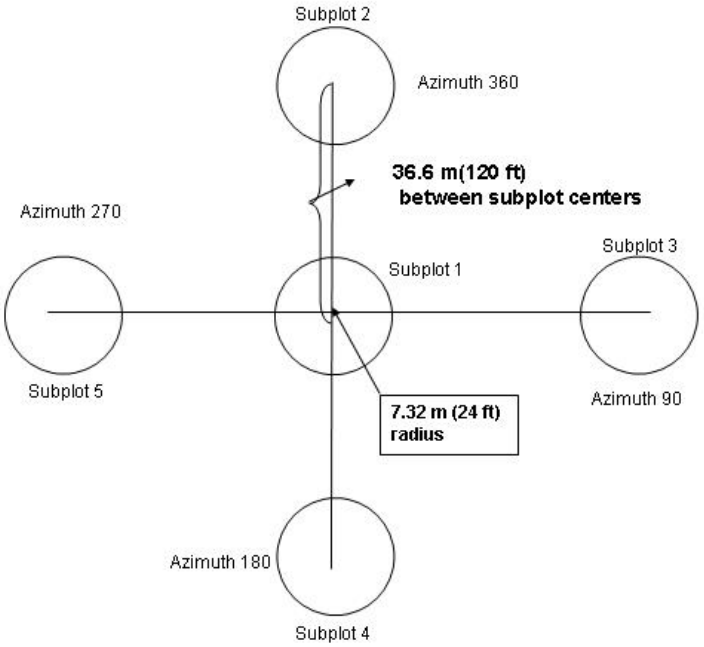


D. Plot Design



Within each plot there are four possible sampling protocols depending on the size and shape of the stand. Stands which are greater than 6 hectares are sampled at fifteen points in one of three variations (Figure 2). Stands less than 6 hectares are sampled at 5 points along one transect line. After the establishment of the plot system in the first year, $1/5^{th}$ (80) of the four hundred plots will be chosen as intensive research plots. In addition to the standard sampling along the gradients, subplots will be established at these sites in the summer of 2005 to be used for repeated sampling. There will be five circular subplots (36.6 m apart) one central and four radiating out in the cardinal directions (Figure 3). These intensive plots will be sampled annually.

Figure 3: Circular Subplot Design



Locating the plots

To facilitate finding the locations of plots, a witness tree on the nearest road is painted with a single blue band and the plot number is painted on the backside of the tree in blue. In areas where painting of the trees is prohibited, alternate marking methods or existing landmarks will be used to distinguish the reference points. Any deviation from the standard marking protocol should be recorded. The distance and azimuth to the first prism point from the reference point is recorded. GPS readings are taken at both points. For each site a data sheet is created that includes a detailed description of the site and a map for locating the stand and first prism point (Appendix 2).

E. Field Measurements

The parameters selected for measuring forest health were based on those developed by the USFS for Forest Inventory and Analysis (FIA) plots (comprehensive repeated surveys of forests throughout the country) (U.S. Department of Agriculture, Forest Service 2004a,b). A similar protocol has been used effectively in Michigan in a study of American beech and the impacts of beech bark disease in the state (Thompson and Witter 2002). This handbook has been developed largely from these two resources.

Field measurements will be taken at the stand, plot, and tree level.

I. Stand Level Measurements

1. **ID Name and Number-** Each stand is sequentially assigned a unique descriptive name and number. Plots established by MTU begin with 300 and those established by U of M begin with 001. The plot number is painted on the back of the witness tree in blue.

2. **Stand size**- Recorded as greater than 6 ha or less than 6 ha

3. **Date Established** – The date on which the plot was established

4. **Date Sampled** – The date on which the plot was sampled

5. **County-** Each county is assigned a two digit code (Appendix 1, Table 1) Appendix 3 contains maps of the counties and major highways in Michigan.

6. **Ownership-** Ownership is recoded as one of twelve types (Appendix 1, Table 2)

7. **Township, Range, and Section Number** – Recorded as T- two digits and direction; R- two digits and direction; and section number. This parameter is not entered in the field.

8. **Compartment and Stand Number**-When applicable, the DNR compartment and stand numbers are recorded in the field

9. **Global Positioning System (GPS) location**- The location of each plot is recorded using the Trimble GeoXT unit. The location of the witness tree and the first prism point are recorded.

10. **Forest Cover Type**- Determined from the prism point data in the plots. It is based on the most common dominant overstory species in the stand. It is recorded as one of thirteen categories (Appendix 1, Table 3)

11. **Forest Habitat Type**- Completed for lower northern MI by Burger and Kotar 1999. This parameter is not entered in the field.

12. **Land Type Association**- Based on Albert's (1994) regional landscape ecosystem classification (Appendix 3). This parameter is not entered in the field

13. **Bailey's Ecoregion**- Based on Bailey's (1995) ecoregion classification system. This parameter is not entered in the field

14. **Landform** – Based on Albert et al. (1994). This parameter is not entered in the field

15. **Ash Stand Age**- To measure ash stand age, core two dominant or codominant ash trees located anywhere in the plot that are not tagged trees. Reject trees that are visibly damaged, have ring patterns that exhibit signs of suppression, or have rotten cores. For each core, record diameter at breast height (DBH), direction the core is taken, height of core, and tree height. Place tree cores in trays for transport to the laboratory. In the lab, tree rings are counted from the outside edge of the core to the pith. Tree age is based on the total number of rings at 1.37 m above ground and is not corrected for early growth years.

16. **Site Index**-Measured using the two trees selected for stand age as well as two additional borings from two dominant/codominant non-ash trees. Site trees are a measure of productivity and expressed by the height to age relationship of the dominant and codominant trees. This parameter is not entered in the field

17. **Recent Cutting History**-Based on information from MDNR, USFS or private records with emphasis on the last 20 years. This parameter is not entered in the field

II. Plot Level Measurements

1. **Slope position**- Slope position is the position of the plot in relation to the surrounding topography (Figure 4). It recorded as one of seven FIA categories (Appendix 1, Table 4)

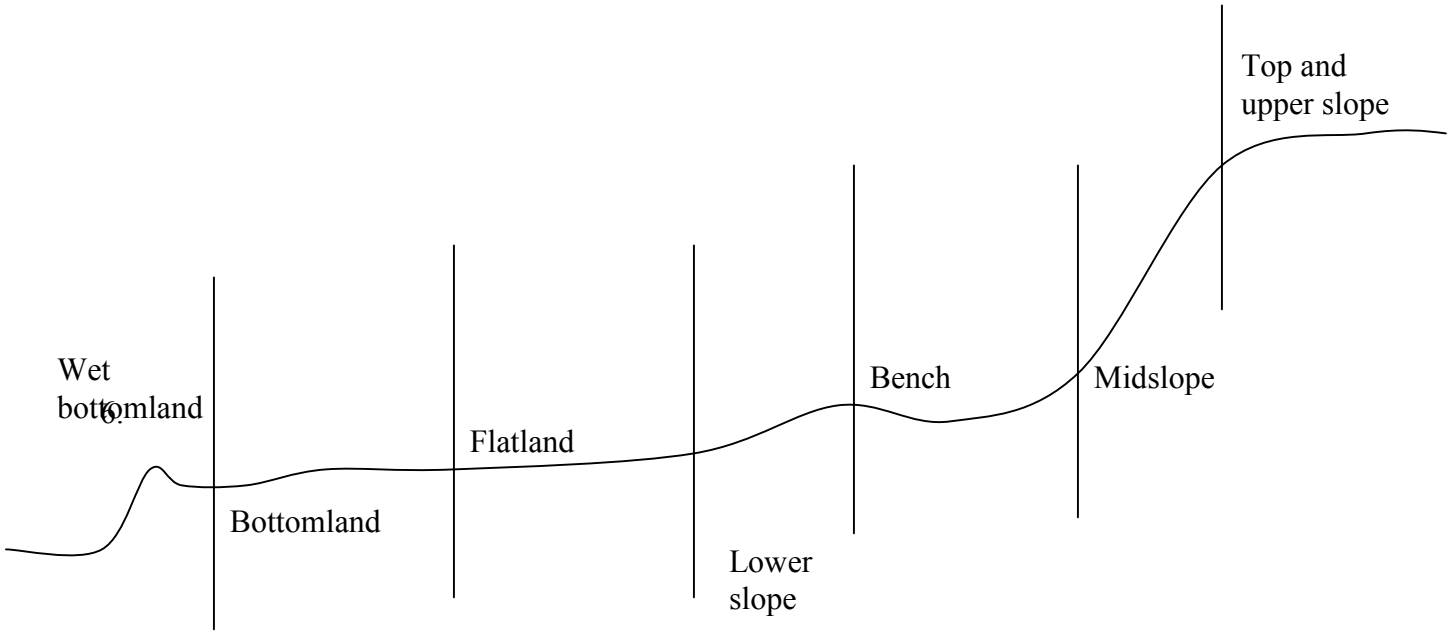
2. **Elevation**- Elevation is determined using the GPS readings from the Trimble GeoXT and USGS 7.5min topographical maps

3. **Basal area**- Total live and dead basal area for each individual tree species and all species together is measured using a basal area factor (BAF) 10 prism at each sampling point. Common Michigan tree species are listed in Appendix 5.

4. **Percent of stems that are live ash or dead ash- Determined from basal area (see #5).**

5. **Soil Samples**- Five soil samples are taken from the upper 30 cm of soil (excluding leaf litter) in auger holes near prism points 1, 4, 8, 12 and 15 in plots greater than 15 acres and at points 1, 3, and 5 for the smaller plots. The samples are homogenized in a 38 L bucket and one 1 kg composite sample is drawn from the whole. The samples are stored in labeled 3.8 L zip-top plastic bags. Bags are placed in a warm dry room and left open for air-drying. The sample is then be analyzed for soil texture (% sand, silt and clay)..

Figure 4. Slope position diagram



III. Tree Level Measurements

In addition to the stand and plot measurements, data is taken at the tree level at each sampling (prism) point. Data is collected from the nearest live ash tree (>12.5 cm diameter at breast height (DBH)) to the prism point. For smaller plots (<6 ha) the **three** nearest live ash trees will be evaluated at each prism point.

1. **Tree ID and location**- The azimuth and distance from the prism point to the nearest live ash tree is recorded. Each ash tree measured in the plot is given a sequential ID number. A numbered aluminum tag is placed at the base of each sampled tree and each tree is painted with a blue band. Any deviations from this protocol are recorded.

2. **Tree Species/origin-**The species of ash is recorded for each sampled tree as one of four categories (Appendix 1, Table 5). The origin of the ash is recorded as either natural or planted (Appendix 1, Table 6). Appendix 6 contains detailed information for ash identification.

3. **Diameter at Breast Height (DBH)-**DBH is measured to the nearest 0.1 cm using a metric diameter tape at 1.37 m from ground level on the uphill side of the tree. Methods for DBH in unusual situations will follow FIA guidelines (Appendix 7). A blue band is painted at 1.37 m from the ground to indicate the point at which DBH was measured

4. **Tree Height**- Tree height is measured using either a Vertex Laser® hypsometer or a Suunto® clinometer. It is recorded to the nearest foot and then converted to meters.

5. **Percent slope**-% slope is measured at each prism point along the transect. All % slope measurements will be determined using a fraction of 1:20 m scale and a baseline of 20 m.

6. **Crown Measurements** (U.S. Department of Agriculture, Forest Service 2004b)

Two persons make all crown measurements. When estimates made by two individuals disagree, they should discuss the reasons for their ratings until an agreement is reached, or use the methods below to resolve the situation.

If the numbers for a crown measurement estimated by two crew members do not match, arrive at the final value by: (1) taking an average, if the numbers differ by 10 percent (2 classes) or less; (2) changing positions, if the numbers differ by 15 percent or more and attempting to narrow the range to 10 percent or less if crew members cannot agree; or (3) 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).

Distance and slope 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 evaluating trees from the down slope side should be avoided.

View of the crown

Crew members 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 5). If possible, never evaluate the tree from the same position or at 180 degrees. In a thick canopy 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.

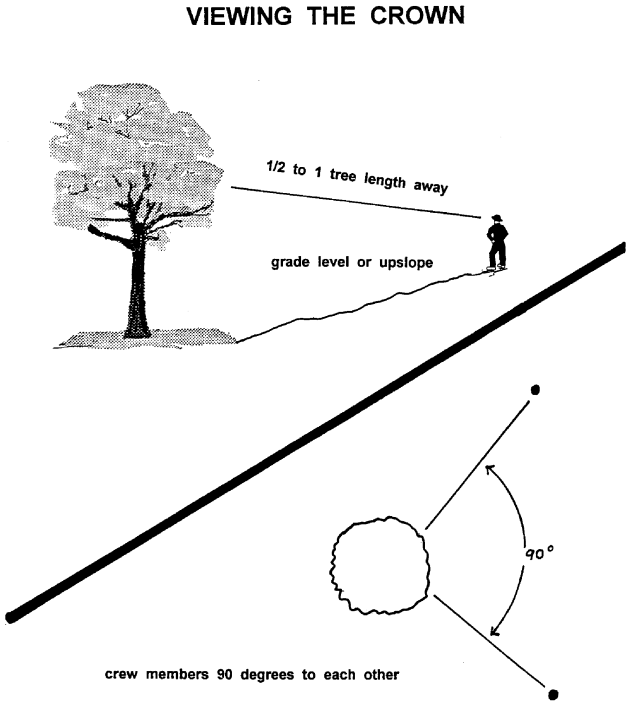


Figure 5. Crew positions for viewing crowns.

Climatic conditions

Cloudy or overcast skies, fog, rain and poor sun angles may affect the accuracy of crown estimates. Crews need to be especially careful during poor lighting conditions to obtain the best possible view of the crown for the given climate conditions.

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.

Leaning trees

Leaning trees cause a major problem in estimating crown variables. Record crown variables as accurately as possible for the tree as it actually occurs rather than as it might appear if standing upright and also record in the PDR tree note field that it is leaning. This will allow for better data interpretation.

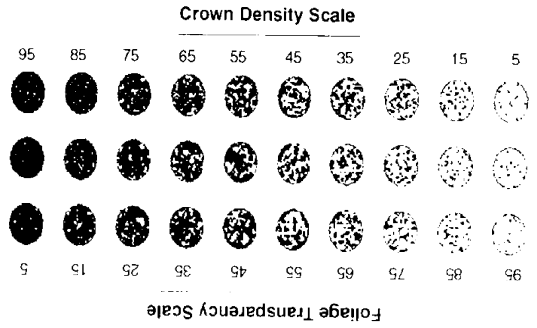
Trees with no "crown" by definition (epicormics or sprigs only)

After a sudden release or damage, a tree may have very dense foliage, but no crown. These situations are coded as follows: UNCOMPACTED LIVE CROWN RATIO = 00, CROWN LIGHT EXPOSURE = 0, CROWN POSITION = 3, CROWN DENSITY = 00, CROWN DIEBACK = 99, FOLIAGE TRANSPARENCY = 99. This combination of codes is a flag for trees with no crowns.

Crown density-foliage transparency card

The crown density - foliage transparency card (Figure 6) should be used as a training aid until personnel are comfortable with all ratings. White areas of the card represent skylight visible through the crown area and black areas represent a portion of the tree that is blocking skylight. After training, use the card to calibrate your eyes at the start of each day and rate those trees that do not fit into an obvious class. For crown density, hold the card so that "Crown Density" is right-side up ("Foliage Transparency" should be upside down). Use the numbers that are right-side up. Conversely, for foliage transparency, make sure that "Foliage Transparency" is right-side up. Refer to specific crown density or foliage transparency sections for a definition of aspects that are included in the crown rating.

The back of the crown density - foliage transparency card has two uses: for crown density when a portion of the crown is missing and a general scale for estimating uncompacted live crown ratio. Refer to the crown density and uncompacted live crown ratio sections for the use of this side of the card.



Front

Back

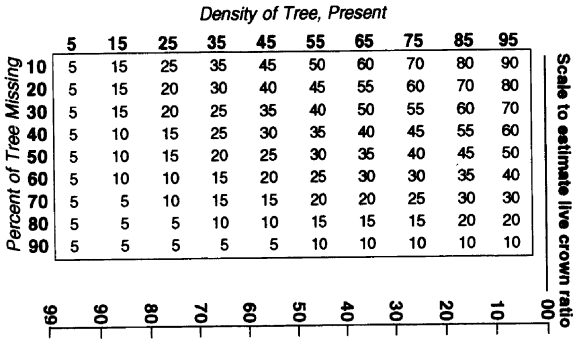


Figure 6. Density-Transparency card

5.1 Uncompacted Live Crown Ratio (ULCR)- ULCR is recorded as a percentage determined by dividing the live crown length by the total height of the tree (Figure 7). High live crown ratios are generally considered healthier and faster growing than low crown ratios. Live crown height is the distance from the live crown top (dieback in the upper portion of the crown is not part of the live crown) to the "obvious live crown" base (Figure 8). Many times there are additional live branches below the "obvious live crown". These branches are only included if they have a basal diameter greater than 1.0 inch and are within 5.0 feet of the base of the obvious live crown (Figure 9). 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. Occasionally, small trees or certain species may not have 1.0-inch diameter branches. If this occurs, use the 5.0-foot rule, and apply it to branches that you feel contribute significantly to tree growth.

An individual can use the uncompacted live crown ratio scale on the back of the crown density - foliage transparency card to help estimate ratios. Hold the card in one hand, parallel to the trunk of the tree being evaluated and move the card closer or farther from your eye until the 0 is at the live crown top and the 99 is at the base of the tree where it meets the ground. Then place your finger at the live crown base. The number on the scale provides the uncompacted live crown ratio. Interpolate to the nearest 5 percent if the point is between two values on the scale. A clinometer can also be used to verify the uncompacted live crown ratio by determining the values of both heights and determining the ratio of the two values.. The estimate of UCLR is placed in one of 22 percentage categories (Appendix 1, Table 7).

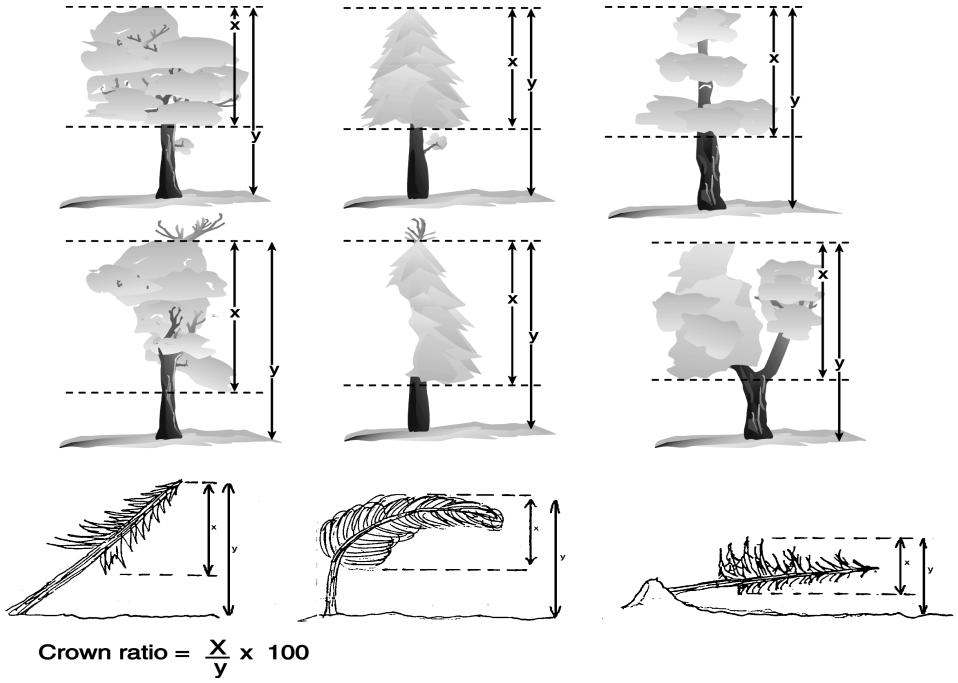


Figure 7. UNCOMPACTED LIVE CROWN RATIO examples.

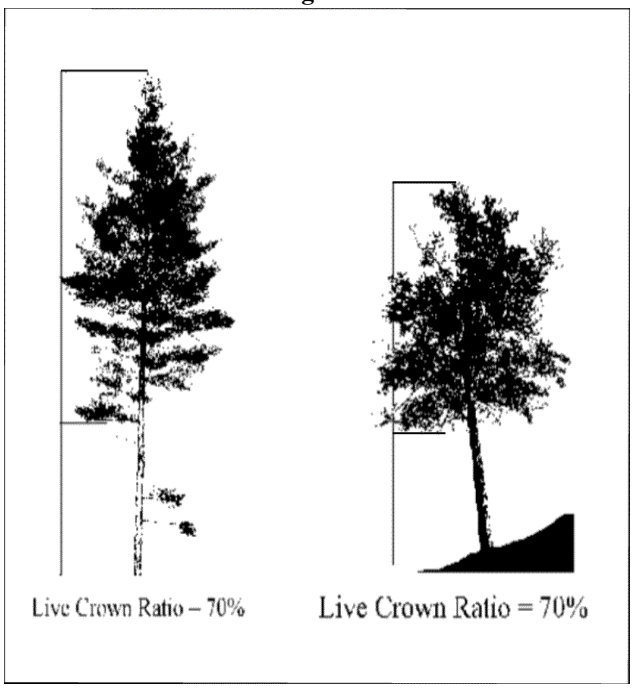


Figure 8. Uncompacted live crown ratio outline and rating examples

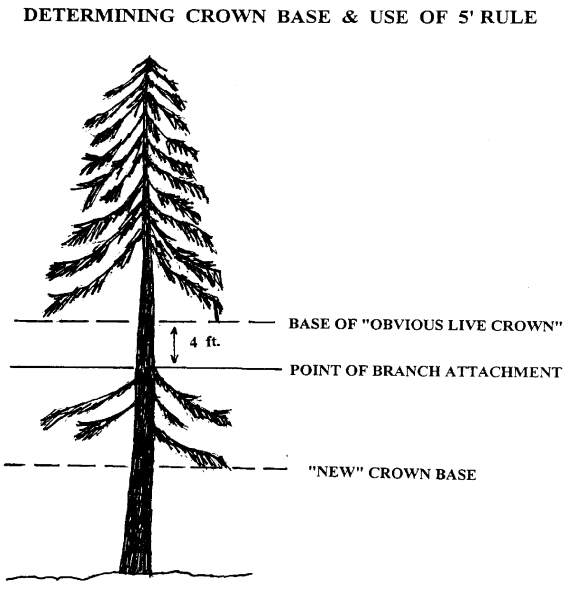


Figure 9. Determining the base of the live crown.

5.2 Crown Density- Crown density is the percent of total light that is blocked from shining through the crown by leaves, branches and fruit. It is measured as the percent of total light blocked by the tree material. It takes into account both the live and dead parts of the crown and is affected by the tree's shape and growing conditions. Low crown density indicates a thin crown, missing sections of the crown or poor foliage amounts. High crown density indicates that the tree has a large amount of leaf material available for photosynthesis and has growing conditions that enable full and symmetrical growth.

To determine the crown shape, select the crown base on the stem used for uncompacted live crown ratio. Project a full "mirror image" crown based on that tree's shape. Include missing or dead tops. Project half-sided trees as full crowns by using the "mirror image" of the existing half of the crown. Foliage below the crown base is not included (Figure 9). Include crown dieback and open areas in this outline (Figures 10).

After determining the crown shape, each person should use the crown density - foliage transparency card (Figure 6). Along the line of sight, estimate what percentage of the outlined area is blocking sunlight. In cases where portions of the tree may be missing, i.e., half-sided trees, it may be easier to determine the percent of the crown shape missing and the actual density of the tree's remaining portion. Then use the table on the back of the crown density - foliage transparency card to arrive at the final crown density. The estimate is placed into one of 22 percentage classes (Appendix 1, Table 7).

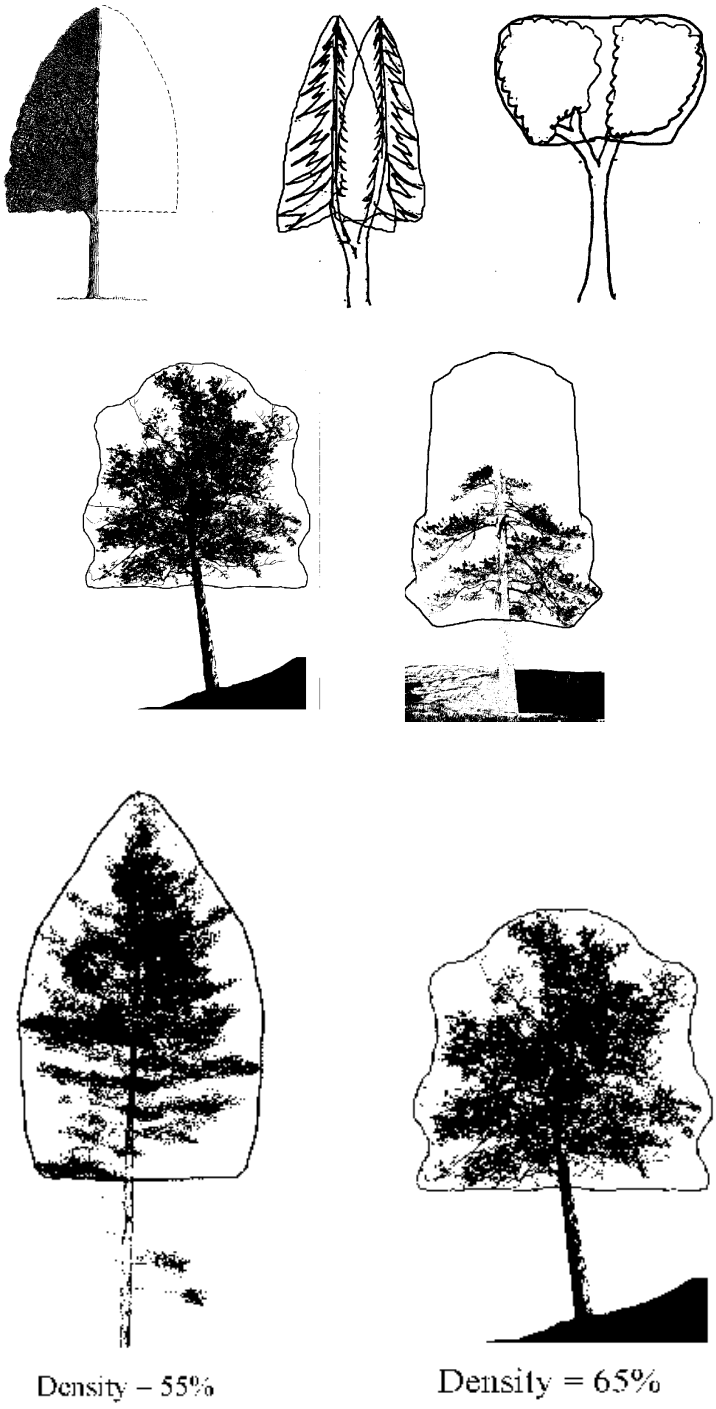


Figure 10. Crown density outline and rating examples

5.3 Crown Dieback- Crown dieback is indicated by the percent of dead branch tips found in the upper portion and outer edges of the live crown. Trees with high dieback values have a reduced leaf area index. A large amount of dieback is a sign the tree is under stress. The crown base should be the same as that used for the UNCOMPACTED 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 (Figures 11). Project a two-dimensional crown outline, block in the dieback and estimate the dieback area. The estimate is placed into one of 22 percentage classes (Appendix 1, Table 7).

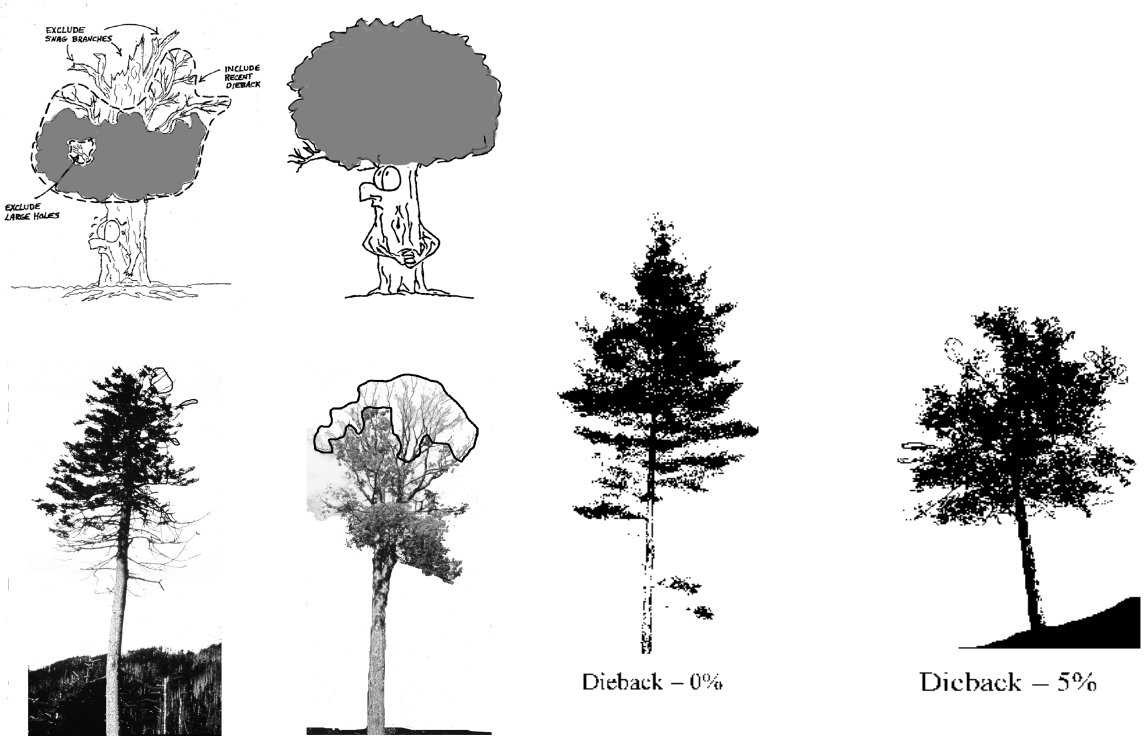


Figure 11. Crown dieback rating outline examples.

5.4 Foliage Transparency- Foliage transparency is a measure of the amount of skylight that shines through the live portion of a tree's crown as a percent of total light that would be visible if the light was not blocked. Light comes through the crown where leaves are missing, damaged, smaller, or less numerous than normal. Transparency values differ among tree species and are affected by the tree's shape and growing conditions. Higher than normal transparency values for a species indicate that the tree has less leaf area to catch sunlight for photosynthesis. High transparency values may result from insects feeding on tree leaves and damaging them, diseases causing leaves to fall or become damaged, or other stresses such as drought or frost that can affect leaves.

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. Project a two-dimensional crown outline. Determine the foliated area within the crown outline and estimate the transparency of the normally foliated area Estimate foliage transparency using the crown density - foliage transparency card (Figure 6). 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 12). The estimate is placed into one of 22 percentage classes (Appendix 1, Table 7).

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 widely spaced. 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.

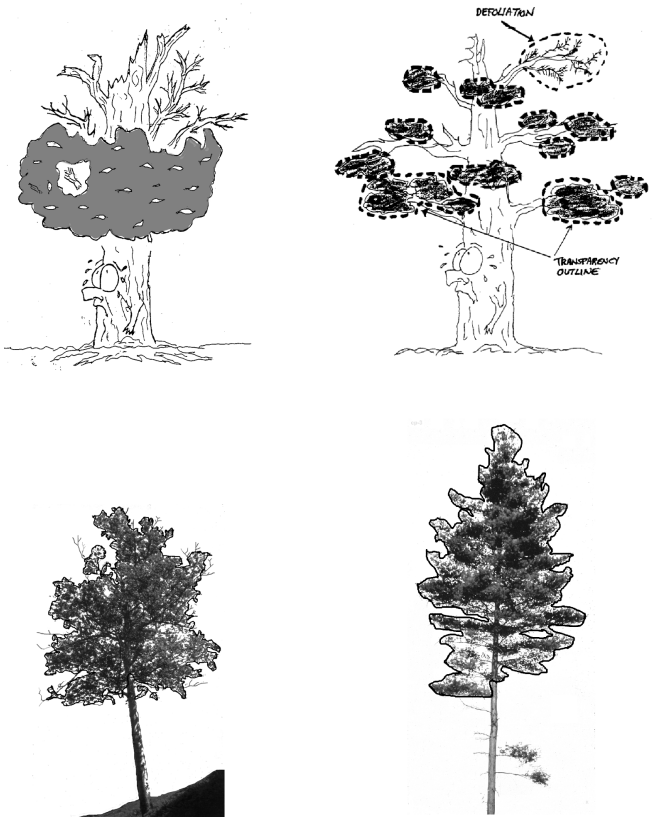


Figure 12. Foliage transparency rating outline examples.

5.5 Crown Light Exposure- Crown light exposure estimates the number of sides of the tree that would receive direct sunlight if the sun were directly above the tree. To determine this, the crown is visually divided vertically into four equal sides. At least 1/3 of a single side must be exposed to direct sunlight for the side to qualify as directly lit, therefore, sides with less than a 33% live crown ratio are not counted. Additionally, for a side to qualify, a continuous portion of live crown 35 percent or more in length must be completely exposed to direct light. For this measurement, a tree cannot shade itself (e.g., leaning trees or umbrella shaped trees). Try to divide the crown in such a way that as many sides as possible receive full light. Count the number of sides that would receive direct light if the sun were directly above the tree. Add one if the tree receives direct light from the top (Figure 13). The values for crown light exposure are recorded as a value from 0-5 indicating the total number of sides receiving direct light. (Appendix 1, Table 8). The entire side (25 percent of the crown circumference) must be receiving full light to qualify. A sliver of a side receiving light does not qualify. Trees with all sides having less than a 35 percent uncompacted live crown ratio can have a maximum crown exposure of one. Individual sides with less than 35 percent uncompacted live crown ratio should not be counted (Figure 14).

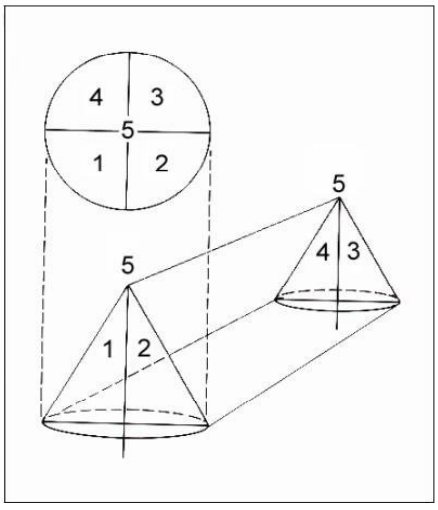


Figure 13. Dividing the crown.

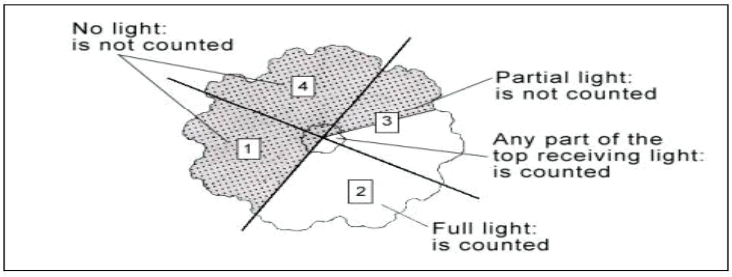


Figure 14. Crown light exposure.

5.6 Tree Vigor/Condition - Each of the sampled ash trees are assigned a tree crown condition rating from 1 to 8 based on the amount of dead wood in the crown after the initial visit (Appendix 1, Table 9). Any sampling after the initial visit also will include classes 9 through 12 (Appendix 1, Table 9). A ranking of 1 indicates a normal crown, a ranking of 5 indicates a crown more than half dead, a ranking of 6 through 10 indicates various stages of a standing dead tree, and rankings of 11 and 12 indicate stages of a blown down tree. Dead trees are recorded only if the standing tree bole is taller than 1.37 m above ground. This tree vigor/condition classification system is a modification of that used in MIMS (Stoyenoff et al. 2000) and will give us more information on how long dead trees are available for wildlife species. The condition of each tree is recorded at the time of plot establishment and every time the plot is re-sampled.

5.7 Crown Class/Position- Crown class/position is recorded for each tree. It is a composite of light exposure and tree height that rates tree crowns in relation to the sunlight received and proximity to neighboring trees (Figure15). The assessment is based on the position of the crown at the time of observation. Example: a formerly overtopped tree which is now dominant due to tree removal is classified as dominant. Crown class/position is recorded as one of five categories (Appendix 1, Table 10).

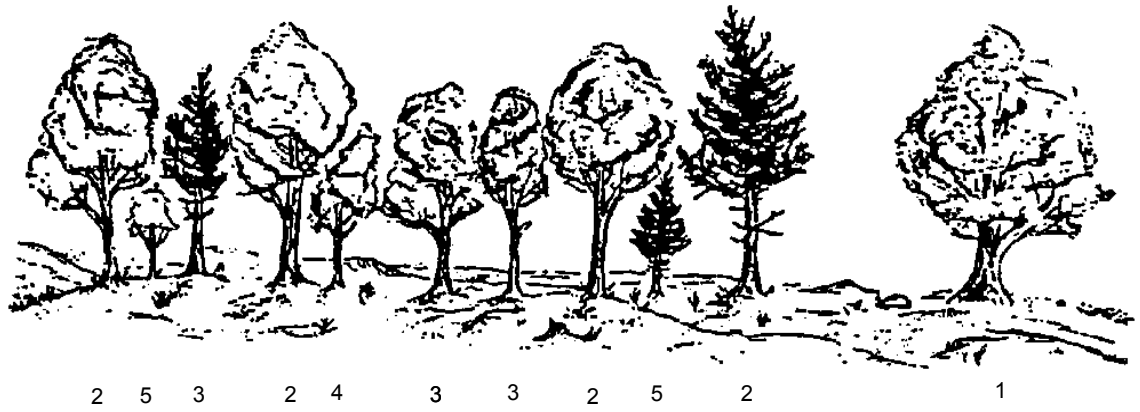


Figure 15. Examples of crown class code definitions (numbers are the crown class codes).

6. Tree Damage

Damage signs and symptoms are only recorded if the damage could kill or affect the long-term survival of the tree. Cause of damage is not recorded because damage often involves complex interactions of biotic and abiotic agents resulting in variability in the individuals rating the trees to determine the specific cause of damage. Damage is recorded up to three different damages per tree. Damage is characterized according to three attributes: location of damage, type of damage, and severity of damage. Damages must meet severity thresholds in order to be recorded. Appendix 8 contains examples of

damage coding from the FIA protocols (U.S. Department of Agriculture, Forest Service 2004a).

6.1 Damage Location

The tree is observed from all sides starting at the roots (Figure 16). Damage signs and symptoms are prioritized and recorded based on location in the following order: roots, roots and lower bole, lower bole, lower and upper bole, upper bole, crownstem, and branches. The location of the damage is recorded as one of ten categories (Appendix 1, Table 11).

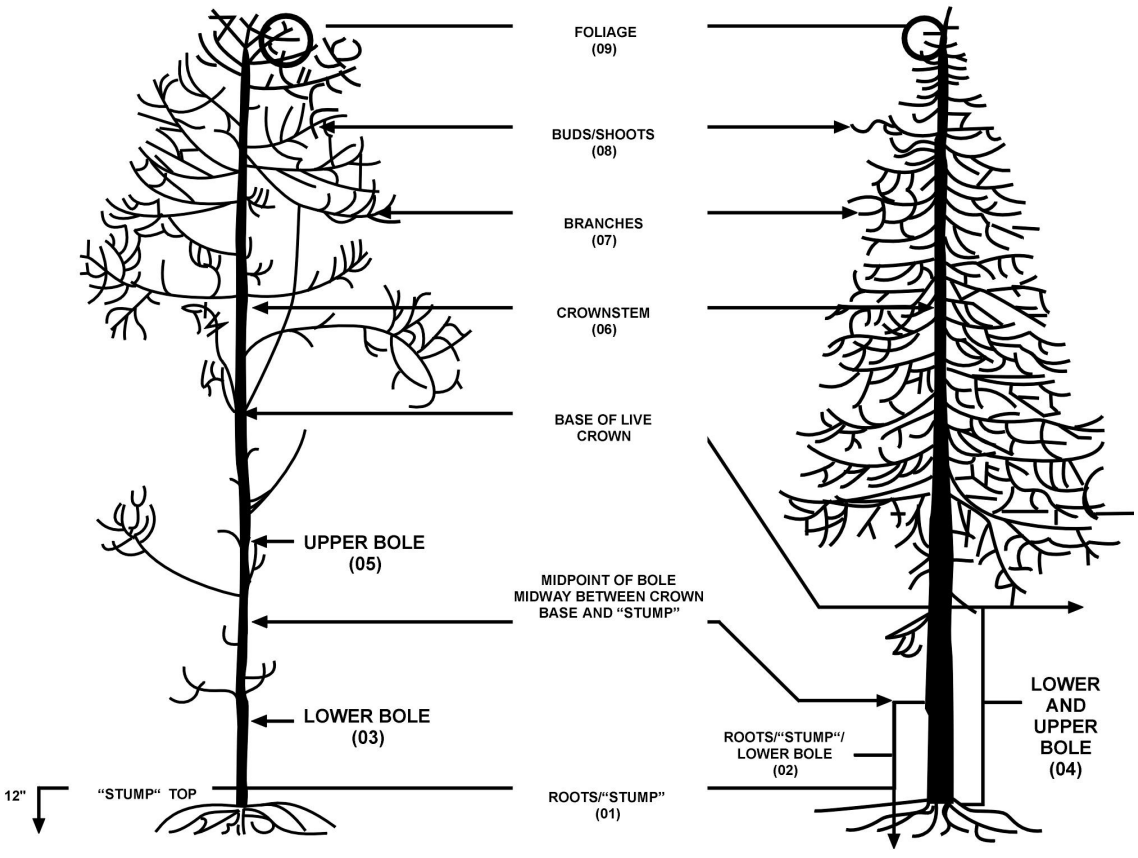


Figure 16. Location codes for damage

6.2 Damage Type

The first three damage types observed that meet the damage severity threshold definition in the lowest location are recorded. Damage categories are recorded based on the numeric order that denotes decreasing significance from damage 01 – 31 (Appendix 1, Table 12) (i.e., Damage type 01 is more significant than Damage type 25. A maximum of three damages are recorded for each tree. If a tree has more than three damages that meet the threshold levels, the first three that are observed starting at the roots are recorded. When multiple damages occur in the same place, the most damaging is recorded. For example, if a canker, Damage type 02, meets the threshold and has a conk growing in it, record only the canker. Another example: if an open wound meets threshold and also has resinosis, record only the open wound). Appendix 7 contains detailed definitions of damage types.

6.3 Damage Severity

When a damage symptom is recorded, a code is also recorded to indicate the severity of the damage. These codes vary depending on the type of damage (Appendix 1, Table 12).

7. Presence or absence of Emerald Ash Borer

The presence or absence of EAB is recorded as **one or more** of six categories (Appendix 1, Table 13). Record all signs and symptoms present. Appendix 9 has photos of EAB and the damage it causes.

F. References

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APPENDICES

APPENDIX 1: DATA TABLES

Table 1: Michigan County Codes

NAME	CNTY_FIPS	FIPS
Alcona	001	26001
Alger	003	26003
Allegan	005	26005
Alpena	007	26007
Antrim	009	26009
Arenac	011	26011
Baraga	013	26013
Barry	015	26015
Bay	017	26017
Benzie	019	26019
Berrien	021	26021
Branch	023	26023
Calhoun	025	26025
Cass	027	26027
Charlevoix	029	26029
Cheboygan	031	26031
Chippewa	033	26033
Clare	035	26035
Clinton	037	26037
Crawford	039	26039
Delta	041	26041
Dickinson	043	26043
Eaton	045	26045
Emmet	047	26047
Genesee	049	26049
Gladwin	051	26051
Gogebic	053	26053
Grand Traverse	055	26055
Gratiot	057	26057
Hillsdale	059	26059
Houghton	061	26061
Huron	063	26063
Ingham	065	26065
Ionia	067	26067
Iosco	069	26069
Iron	071	26071
Isabella	073	26073
Jackson	075	26075
Kalamazoo	077	26077
Kalkaska	079	26079
Kent	081	26081
Keweenaw	083	26083
Lake	085	26085
Lapeer	087	26087
Leelanau	089	26089
Lenawee	091	26091
Livingston	093	26093
Luce	095	26095
Mackinac	097	26097
Macomb	099	26099
Manistee	101	26101
Marquette	103	26103
Mason	105	26105
Mecosta	107	26107
Menominee	109	26109
Midland	111	26111
Missaukee	113	26113
Monroe	115	26115
Montcalm	117	26117
Montmorency	119	26119
Muskegon	121	26121
Newaygo	123	26123
Oakland	125	26125
Oceana	127	26127
Ogemaw	129	26129
Ontonagon	131	26131
Osceola	133	26133
Oscoda	135	26135
Otsego	137	26137
Ottawa	139	26139
Presque Isle	141	26141
Roscommon	143	26143
Saginaw	145	26145
Sanilac	151	26151
Schoolcraft	153	26153
Shiawassee	155	26155
St. Clair	147	26147
St. Joseph	149	26149
Tuscola	157	26157
Van Buren	159	26159
Washtenaw	161	26161
Wayne	163	26163
Wexford	165	26165

Table 2: Stand Ownership Codes

Code	Ownership
1	Federal:USFS
2	Federal:Dept. of Interior
3	State:MDNR Forestry
4	State:MDNR Parks and Recreation Areas
5	County
6	Township
7	University owned
8	Private non-profit
9	MDNR game areas
10	Private industry
11	Private individual
12	Other (specify)

Table 3: Forest Cover Type Codes

Code	Definition
1	Maple-Ash (upland) (%maple>%ash)
2	Ash-Maple (upland) (%ash>%maple)
3	Ash-Beech (%ash>%beech)
4	Beech-Ash (%beech>%ash)
5	Lowland Ash (Green/Black Ash)
6	Stream-edge (Green/Black Ash)
7	Oak-White Pine
8	Planted Ash –campground
9	Planted Ash-non-campground
10	Black Ash swamp
11	Other (specify)

Table 4: Slope Position Codes

Code	Definition
1	Top and upper slope— convex region on the upper part of the slope profile; may be either xeric or mesic depending on aspect
2	Midslope— uniform, fairly straight region of the middle part of the slope profile; may be either xeric or mesic depending on aspect
3	Bench— area of level terrain, with midslope above and lower slope below
4	Lower slope— concave region on the lower part of the slope profile
5	Flatland— level or near-level terrain not part of or related to major elevational change; may have minimal elevational change (e.g., rolling uplands, flatwoods, and deep sands)
6	Bottomland— level terrain; normally well-drained but subject to occasional flooding (e.g., floodplains of rivers and streams)
7	Wet bottomland— level terrain, generally having year-round abundance or over-abundance of water (e.g., swamps, small drains, bays, and wet pocosins)

Table 5: Ash Species Codes

Code	Ash Species
1	Green Ash (*Fraxinus pennsylvanica*)
2	White Ash (*Fraxinus americana*)
3	Black Ash (*Fraxinus nigra*)
4	Blue Ash (*Fraxinus quadrangulata)*
5	Pumpkin Ash (*Fraxinus profunda*)

Table 7: Live Crown Ratio, Crown Density, Crown Dieback, and Foliage Transparency Codes.

Code	Definition
00	0%
01	1%
05	2-5%
10	6-10%
15	11-15%
20	16-20%
25	21-25%
30	26-30%
35	31-35%
40	36-40%
45	41-45%
50	46-50%
55	51-55%
60	56-60%
65	61-65%
70	66-70%
75	71-75%
80	76-80%
85	81-85%
90	86-90%
95	91-95%
99	96-100%

Table 8: Crown Light Exposure Codes and Definitions

Category	Definition
0	The tree receives no full light because it is shaded by trees, vines, or other vegetation; the tree has no crown by definition.
1	The tree receives full light from the top or 1 side.
2	The tree receives full light from the top and 1 side (or 2 sides without the top).
3	The tree receives full light from the top and 2 sides (or 3 sides without the top).
4	The tree receives full light from the top and 3 sides
5	The tree receives full light from the top and 4 sides.

Table 9: Tree Vigor/Condition Codes and Criteria

Code	Criteria
1	Crown with relatively few dead twigs; foliage density and color normal; occasional small dead branches in upper crown; occasional large branch stubs on upper bole
2	Crown with occasional large dead branch in upper portion; foliage density below normal; some small dead twigs at top of crown; occasional large branch stubs on upper bole
3	Crown with moderate dieback; several large dead branches in upper crown; bare twigs beginning to show; several branch stubs on upper and mid bole
4	Approximately half of crown dead
5	Over half of crown dead
6	Tree dead; not cut, standing with fine twigs (less than 2.54 cm (1 in) in diameter) attached to branches
7	Tree dead (natural death); not cut; standing without fine twigs but still has some branches attached to bole of tree
8	Tree dead; standing but bole only, no branches attached to bole
9	Tree cut, dead when cut; only used after plots were established*
10	Tree cut, not known if live or dead when cut; only used after plots were established*
11	Blow down; tree laying on ground and dead with attached branches
12	Blow down; tree laying on ground and dead without any attached branches

Table 10 : Crown Class/Position Codes and Definitions

Code	Definition
1	Open grown trees- trees with crowns that received full light from above and from all sides throughout most of their life, particularly during their early developmental period.
2	Dominant – trees with crown extending above the general level of the crown canopy and receiving full light from above and partly from the sides. These trees are taller than the average trees in the stand and their crowns are well developed, but they could be somewhat crowded on the sides. Also, trees whose crowns have received full light from above and from all sides during early development and most of their life. Their crown form or shape appears to be free of influence from neighboring trees.
3	Co-dominant – trees with crowns at the general level of the crown canopy. Crowns receive full light from above but little direct sunlight penetrates their sides. Usually they have medium-sized crowns and are somewhat crowded from the sides. In stagnated stands, co-dominant trees have small-sized crowns and are crowded on the sides.
4	Intermediate – trees that are shorter than dominants and co-dominant, but their crowns extend into the canopy of co-dominant and dominant trees. They receive little direct light from above and none from the sides. As a result, intermediate trees usually have small crowns and are very crowded from the sides.
5	Overtopped – trees with crowns entirely below the general level of the crown canopy that receive no direct sunlight either from above or the sides.

Table 11: Damage Location Codes

Code	Definition
0	No damage
1	Roots (exposed) and “stump” (30cm in height from ground)
2	Roots and lower bole
3	Lower bole (lower half of trunk between the “stump” and the base of the live crown)
4	Lower and upper bole
5	Upper bole (upper half of trunk between the “stump” and the base of the live crown)
6	Crownstem (main stem within live crown area, above the base of the live crown)
7	Branches (>2.5 cm at the point of attachment to the main or crownstem within the live crown area)
8	Buds and shoots (the most recent years growth)
9	Foliage

Table 12: Damage Type and Severity Codes and Definitions

Damage Type Code	Definition	Threshold	Damage Severity Code	Severity class
01	Canker, gall	20%	2	20-29%
			3	30-39%
			4	40-49%
			5	50-59%
			6	60-69%
			7	70-79%
			8	80-89%
			9	90-99%
02	Conks, fruiting bodies, and signs of advanced decay	none	0	None (except roots > 0.91 m from bole or branches is 20%)
03	Open wounds	20%	2	20-29%
			3	30-39%
			4	40-49%
			5	50-59%
			6	60-69%
			7	70-79%
			8	80-89%
			9	90-99%
04	Resinosis or gummosis	20%	2	20-29%
			3	30-39%
			4	40-49%
			5	50-59%
			6	60-69%
			7	70-79%
			8	80-89%
			9	90-99%
05	Cracks and seams (>1.52 m in length)	none	0	None (except roots > 0.91 m from bole or branches is 20%)
11	Broken bole or roots less than 3 feet from bole	none	0	None
12	Brooms on roots or bole	none	0	None

13	Broken or dead roots	20%	2	20-29%
			3	30-39%
			4	40-49%
			5	50-59%
			6	60-69%
			7	70-79%
			8	80-89%
			9	90-99%
20	Vines in crown	20%	2	20-29%
			3	30-39%
			4	40-49%
			5	50-59%
			6	60-69%
			7	70-79%
			8	80-89%
			9	90-99%
21	Loss of apical dominance, dead terminal	1%	0	01-09%
			1	10-19%
			2	20-29%
			3	30-39%
			4	40-49%
			5	50-59%
			6	60-69%
			7	70-79%
			8	80-89%
			9	90-99%
22	Broken or dead branches	20%	2	20-29%
			3	30-39%
			4	40-49%
			5	50-59%
			6	60-69%
			7	70-79%
			8	80-89%
			9	90-99%
23	Excessive branching or brooms	20%	2	20-29%
			3	30-39%
			4	40-49%
			5	50-59%
			6	60-69%
			7	70-79%
			8	80-89%
			9	90-99%

24	Damaged buds, shoots or foliage	30% are more than 50% affected	3	30-39%
			4	40-49%
			5	50-59%
			6	60-69%
			7	70-79%
			8	80-89%
			9	90-99%
25	Discoloration of foliage	30% is more than 50% affected	3	30-39%
			4	40-49%
			5	50-59%
			6	60-69%
			7	70-79%
			8	80-89%
			9	90-99%
31	Other	none	0	None, describe condition in notes

Table 13: Emerald Ash Borer Presence or Absence Codes

Code	Definition
0	No signs/symptoms of EAB
1	Presence of larvae, pupae or adults
2	Larval galleries under splitting bark
3	Woodpecker damage
4	D-shaped exit holes
5	Epicormic sprouts

APPENDIX 2: SAMPLE DATA SHEETS

Ash Monitoring Plot System

2004 Site Establishment Data Form

Surveyor _____ Date | | | | | | |

Site# | | | | Full name of site _____

Stand Parameters (Not entered in field)

Township, range, section number	
Land type association	
Bailey's ecoregion	
Age of ash in stand	
Site index	
Recent cutting history	
Elevation	
Percent of stems live/dead ash	**Live=** **Dead=**

Stand Parameters

Stand size (1<=6 ha, 2>=6 ha)	
County	
Ownership	
Forest type	
GPS witness tree	
GPS First Prism point, first transect	
GPS First Prism point, second transect	
GPS First Prism point, third transect	

Plot Parameters

Transect type	
Transect aspect	
Distance and Azimuth from witness tree to first prism point	
Slope position	

Tree Parameters

Prism Point	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Tree ID															
Species															
Distance from prism point															
Diameter at breast height (cm)															
Tree Height (cm)															
Uncompacted live crown ratio															
Crown density															
Crown dieback															
Foliage transparency															
Crown light exposure															
Tree vigor/condition															
Crown class/position															
Presence/absence of EAB															
Soil Sample															
Percent slope															

Tree Damage (record a maximum of three damages per tree)

Prism Point	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Tree ID															
Location															
Type															
Severity															

Cored Tree Measurements

	Site Number	Species	DBH	Direction of Core	Core Height	Tree Height
1 Ash						
2 Ash						
3 non-Ash						
4 non-Ash						

Weather Description (% cloud cover, temperature, ppt., etc.)

_____

_____

_____

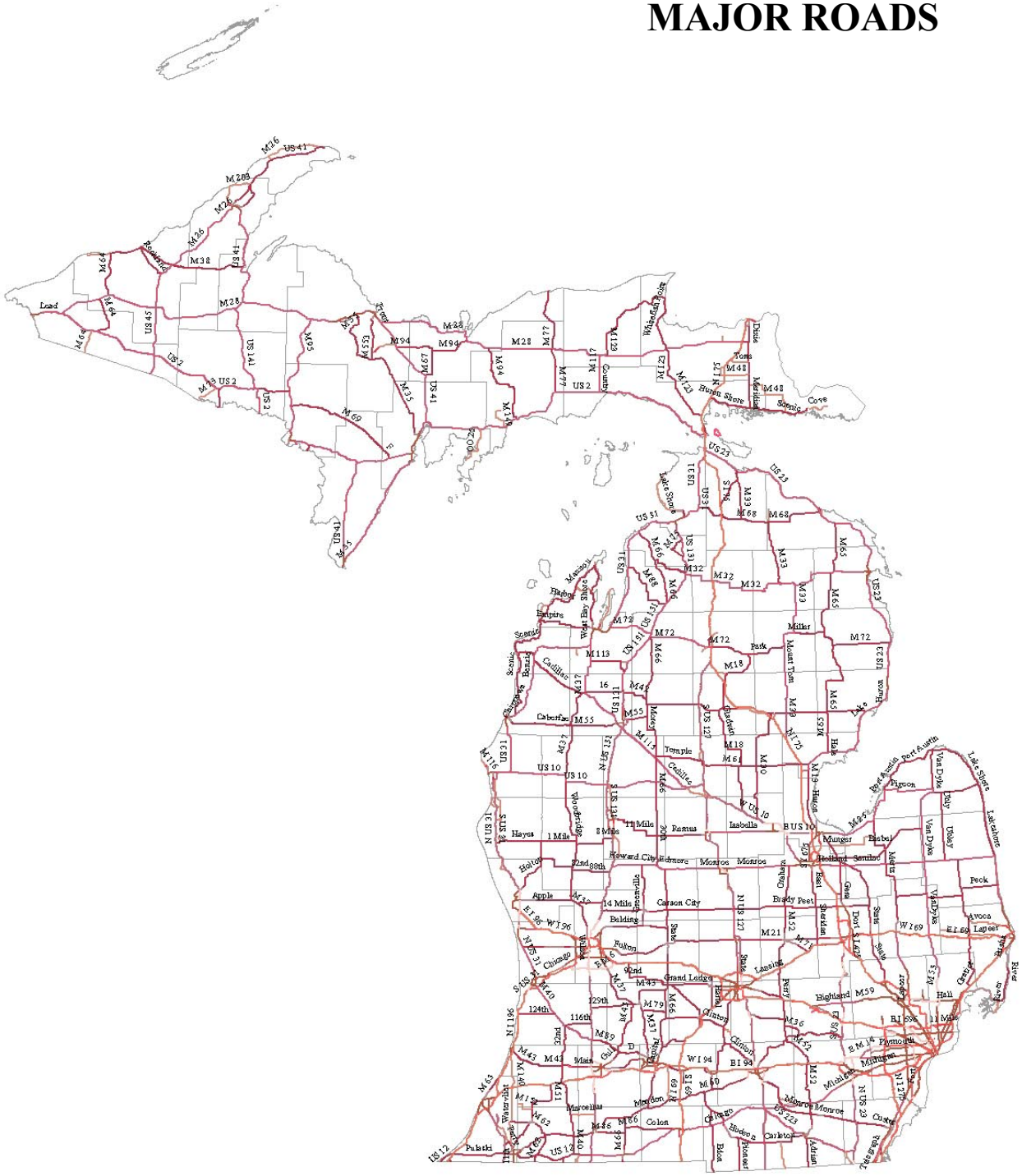
Site Map

Site and Direction Comments:

APPENDIX 3: MAPS- MICHIGAN COUNTIES AND STATE ROADS

MICHIGAN COUNTIES

MICHIGAN
MAJOR ROADS



APPENDIX 4: LAND TYPE ASSOCIATIONS

Land Type Association (Albert 1994) (see associated maps below)

Code	**Land Type Association**
01	VI.1.1 Southern Lower Michigan/Washtenaw/Maumee Lake Plain
02	VI.1.2 Southern Lower Michigan/Washtenaw/Ann Arbor Moraines
03	VI.1.3 Southern Lower Michigan/Washtenaw/Jackson Interlobate
04	VI.2.1 Southern Lower Michigan/Kalamazoo Interlobate/Battle Creek Outwash Plain
05	VI.2.1 Southern Lower Michigan/Kalamazoo Interlobate/Cassopolis Ice-Contact Ridges
06	VI.3.1 Southern Lower Michigan/Allegan/Berrien Springs
07	VI.3.2 Southern Lower Michigan/Allegan/Southern Lake Michigan Lake Plain
08	VI.3.3 Southern Lower Michigan/Allegan/Jamestown
09	VI.4.1 Southern Lower Michigan/Ionia/Lansing
10	VI.4.2 Southern Lower Michigan/Ionia/Greenville
11	VI.5.1 Southern Lower Michigan/Huron/Sandusky Lake Plain
12	VI.5.2 Southern Lower Michigan/Huron/Lum Interlobate
13	VI.6 Southern Lower Michigan/Saginaw Bay Lake Plain
14	VII.1.1 Northern Lacustrine-Influenced Lower Michigan/Arenac/Standish
15	VII.1.2 Northern Lacustrine-Influenced Lower Michigan/Arenac/Wiggins Lake
16	VII.2.1 Northern Lacustrine-Influenced Lower Michigan/Highplains/Cadillac
17	VII.2.2 Northern Lacustrine-Influenced Lower Michigan/Highplains/Grayling Outwash Plain
18	VII.2.3 Northern Lacustrine-Influenced Lower Michigan/Highplains/Vanderbilt Moraines
19	VII.3 Northern Lacustrine-Influenced Lower Michigan/Newaygo Outwash Plain
20	VII.4 Northern Lacustrine-Influenced Lower Michigan/Manistee
21	VII.5.1 Northern Lacustrine-Influenced Lower Michigan/Leelanau and Grand Traverse Peninsula/Williamsburg
22	VII.5.2 Northern Lacustrine-Influenced Lower Michigan/Leelanau and Grand Traverse Peninsula/Traverse City
23	VII.6.1 Northern Lacustrine-Influenced Lower Michigan/Presque Isle/Onaway
24	VII.6.2 Northern Lacustrine-Influenced Lower Michigan/Presque Isle/Stutsmanville
25	VII.6.3 Northern Lacustrine-Influenced Lower Michigan/Presque Isle/Cheboygan
26	VIII.1.1 Northern Lacustrine-Influenced Upper Michigan and Wisconsin/Niagaran Escarpment and Lake Plain/St. Ignace
27	VIII.1.2 Northern Lacustrine-Influenced Upper Michigan and Wisconsin/Niagaran Escarpment and Lake Plain/Rudyard
28	VIII.1.3 Northern Lacustrine-Influenced Upper Michigan and Wisconsin/Niagaran Escarpment and Lake Plain/Ecanaba/Door Peninsula

29	VIII.2.1 Northern Lacustrine-Influenced Upper Michigan and Wisconsin/Luce/Seney Sand Lake Plain
30	VIII.2.2 Northern Lacustrine-Influenced Upper Michigan and Wisconsin/Luce/Grand Marais Sandy End Moraine and Outwash
31	VIII.3.1Northern Lacustrine-Influenced Upper Michigan and Wisconsin/Dickinson/Northern Lake Michigan (Hermanville) Till Plain
32	VIII.3.2 Northern Lacustrine-Influenced Upper Michigan and Wisconsin/Dickinson/Gwinn
33	VIII.3.3 Northern Lacustrine-Influenced Upper Michigan and Wisconsin/Dickinson/Deerton
34	IX.1 Northern Continental Michigan, Wisconsin and Minnesota/Spread Eagle-Dunbar Barrens
35	IX.1 Northern Continental Michigan, Wisconsin and Minnesota/Michigamme Highland
36	IX.3.1 Northern Continental Michigan, Wisconsin and Minnesota/Upper Wisconsin Michigan Moraines/Brule and Paint Rivers
37	IX.3.2 Northern Continental Michigan, Wisconsin and Minnesota/Upper Wisconsin, Michigan Moraines/Winegar Moraine
38	IX.5 Northern Continental Michigan, Wisconsin and Minnesota/Lac Veaux Desert Outwash Plain
39	IX.6.1 Northern Continental Michigan, Wisconsin and Minnesota/Bergland/Gogebic-Penokee Iron Range
40	IX.6.2 Northern Continental Michigan, Wisconsin and Minnesota/Bergland/Ewen
41	IX.6.3 Northern Continental Michigan, Wisconsin and Minnesota/Bergland/Baraga
42	IX.7.1 Northern Continental Michigan, Wisconsin and Minnesota/Keweenaw/Gay
43	IX.7.2 Northern Continental Michigan, Wisconsin and Minnesota/Keweenaw/Calumet
44	IX.7.3 Northern Continental Michigan, Wisconsin and Minnesota/Keweenaw/Isle Royale
45	IX.8 Northern Continental Michigan, Wisconsin and Minnesota/Lake Superior Lake Plain

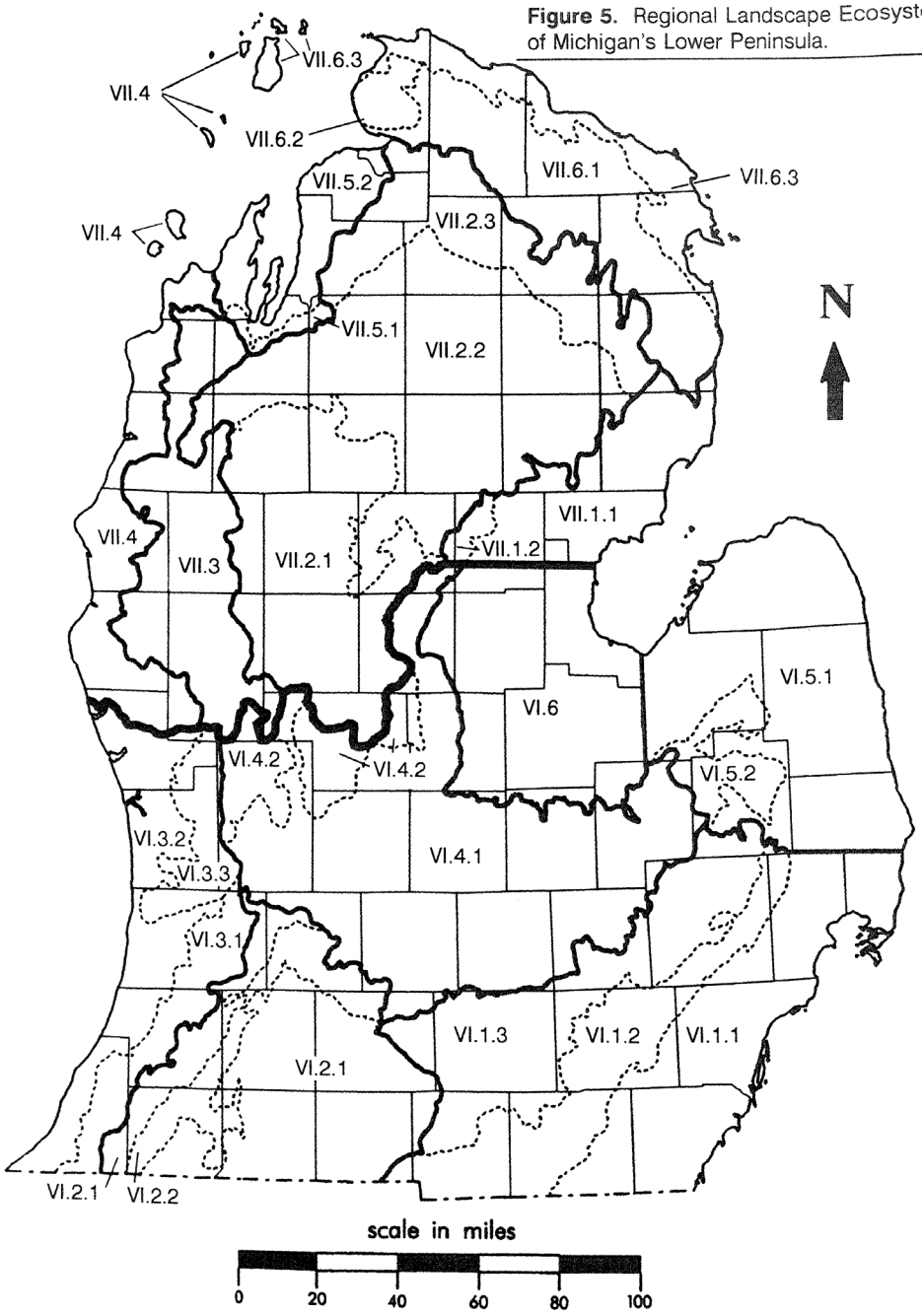


Figure 5. Regional Landscape Ecosystems of Michigan's Lower Peninsula.

Scale 1 : 2,000,000

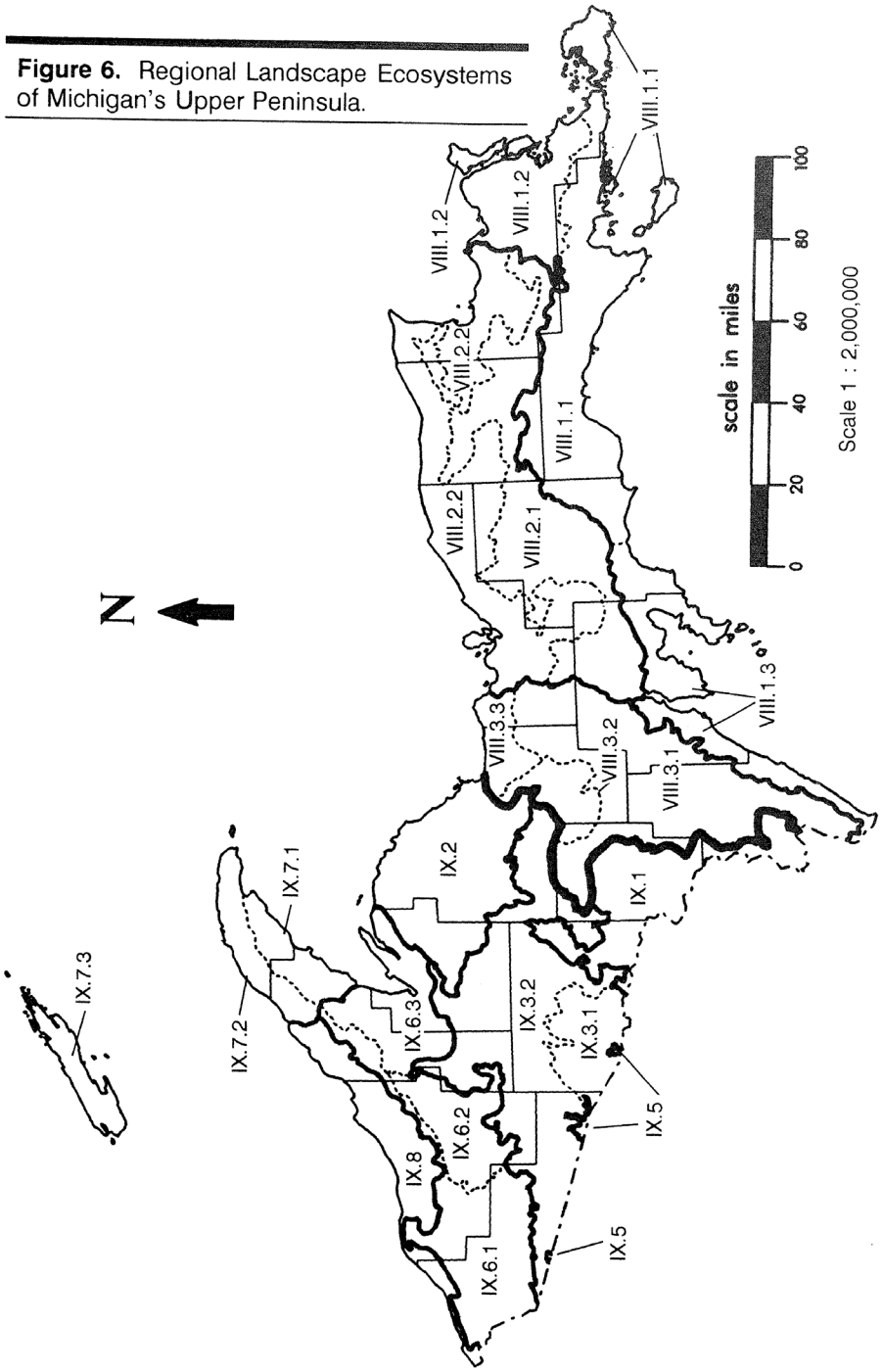


Figure 6. Regional Landscape Ecosystems of Michigan's Upper Peninsula.

APPENDIX 5: COMMON TREE SPECIES IN MICHIGAN

Code	Common Name	*Genus species*
012	balsam fir	*Abies balsamea*
071	Tamarack	*Larix laricina*
094	white spruce	*Picea glauca*
105	jack pine	*Pinus banksiana*
125	red pine	*Pinus resinosa*
129	white pine	*Pinus strobus*
130	scotch pine	*Pinus sylvestris*
241	northern white-cedar	*Thuja occidentalis*
261	eastern hemlock	*Tsuga canadensis*
313	boxelder	*Acer negundo*
314	black maple	*Acer nigrum*
315	striped maple	*Acer pensylvanicum*
316	red maple	*Acer rubrum*
317	silver maple	*Acer saccharinum*
318	sugar maple	*Acer saccharum*
319	Norway maple	*Acer platanoides*
356	serviceberry	*Amelanchier* spp.
371	yellow birch	*Betula alleghaniensis*
375	paper birch	*Betula papyrifera*
391	American hornbeam	*Carpinus caroliniana*
402	bitternut hickory	*Carya cordiformis*
403	pignut hickory	*Carya glabra*
407	shagbark hickory	*Carya ovata*
491	flowering dogwood	*Cornus florida*
500	hawthorn	*Crataegus* spp.
531	American beech	*Fagus grandifolia*
541	white ash	*Fraxinus americana*
542	black ash	*Fraxinus nigra*
544	red ash/green ash	*Fraxinus pennsylvanica*
660	apple spp.	*Malus spp.*
693	blackgum	*Nyssa sylvatica*
701	hop-hornbeam	*Ostrya virginiana*
741	balsam poplar	*Populus balsamifera*
742	eastern cottonwood	*Populus deltoides*
743	bigtooth aspen	*Populus grandidentata*
746	trembling aspen	*Populus tremuloides*
762	black cherry	*Prunus serotina*
802	white oak	*Quercus alba*
804	swamp white oak	*Quercus bicolor*
809	northern pin oak	*Quercus ellipsoidalis*
823	bur oak	*Quercus macrocarpa*
833	northern red oak	*Quercus rubra*
837	black oak	*Quercus velutina*
931	sassafras	*Sassafras albidum*
951	American basswood	*Tilia americana*
972	American elm	*Ulmus americana*
975	slippery elm	*Ulmus rubra*

APPENDIX 6 :ASH IDENTIFICATION GUIDE

(from : Barnes, B.V. and W.H. Wagner. 2004. Michigan Trees. The University of Michigan Press. Ann Arbor, MI. 447pp.)

APPENDIX 7 : DBH PROCEDURES IN SPECIAL SITUATIONS

Special DBH situations (USDA Forest Service 2004)

1. **Forked tree**: 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. Forks originate at the point on the bole where the piths intersect. Forked trees are handled differently depending on whether the fork originates below 1.0 foot, between 1.0 and 4.5 feet, or above 4.5 feet.

• Trees forked below 1.0 foot. Trees forked in this region are treated as distinctly separate trees (Figure 21). Distances and azimuths are measured individually to the center of each stem where it splits from the stump (Figure 24 A-C). DBH is measured for each stem at 4.5 feet above the ground. When stems originate from pith intersections below 1 foot, it is possible for some stems to be within the limiting distance of the microplot or subplot, and others to be beyond the limiting distance. If stems originating from forks that occur below 1.0 foot fork again between 1.0 and 4.5 feet (Figure 24-E), the rules in the next paragraph apply.

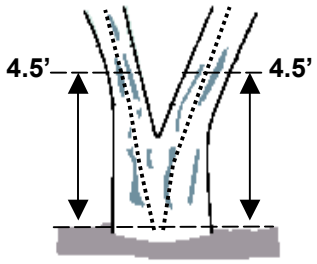


Figure 21. Forked below 1.0 ft.

• Trees forked between 1.0 foot and 4.5 feet. Trees forked in this region are also counted as separate trees (Figure 22), but only one distance and azimuth (to the central stump) is used for all (Figure 24 D-F). Although a single azimuth and distance applies to all, multiple stems should be recorded as they occur in clockwise order (from front to back when one stem is directly in front of another). The DBH of each fork is measured at a point 3.5 feet above the pith intersection. When forks originate from pith intersections between 1.0 and 4.5 feet, the limiting distance is the same for all forks--they are either all on, or all off the plot.

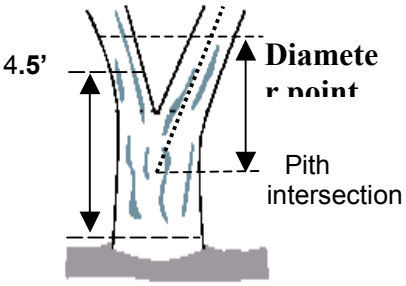
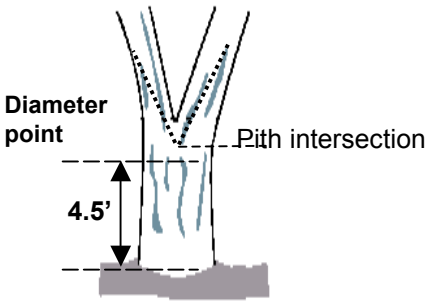


Figure 22. Forked between 1.0-4.5 ft.

Multiple forks are possible if they all originate from approximately the same point on the main stem. In such cases, measure DBH on all stems at 3.5 feet above the common pith intersection (Figure 24-F).

Once a stem is tallied as a fork that originated from a pith intersection between 1.0 and 4.5 feet, 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 24-E (i.e., do not move the point of diameter the entire 3.5 feet above the first fork).



• Trees forked at or above 4.5 feet. Trees forked in this region count as one single tree (Figure 23). If a fork occurs at or immediately above 4.5 feet, measure diameter below the fork just beneath any swelling that would inflate DBH

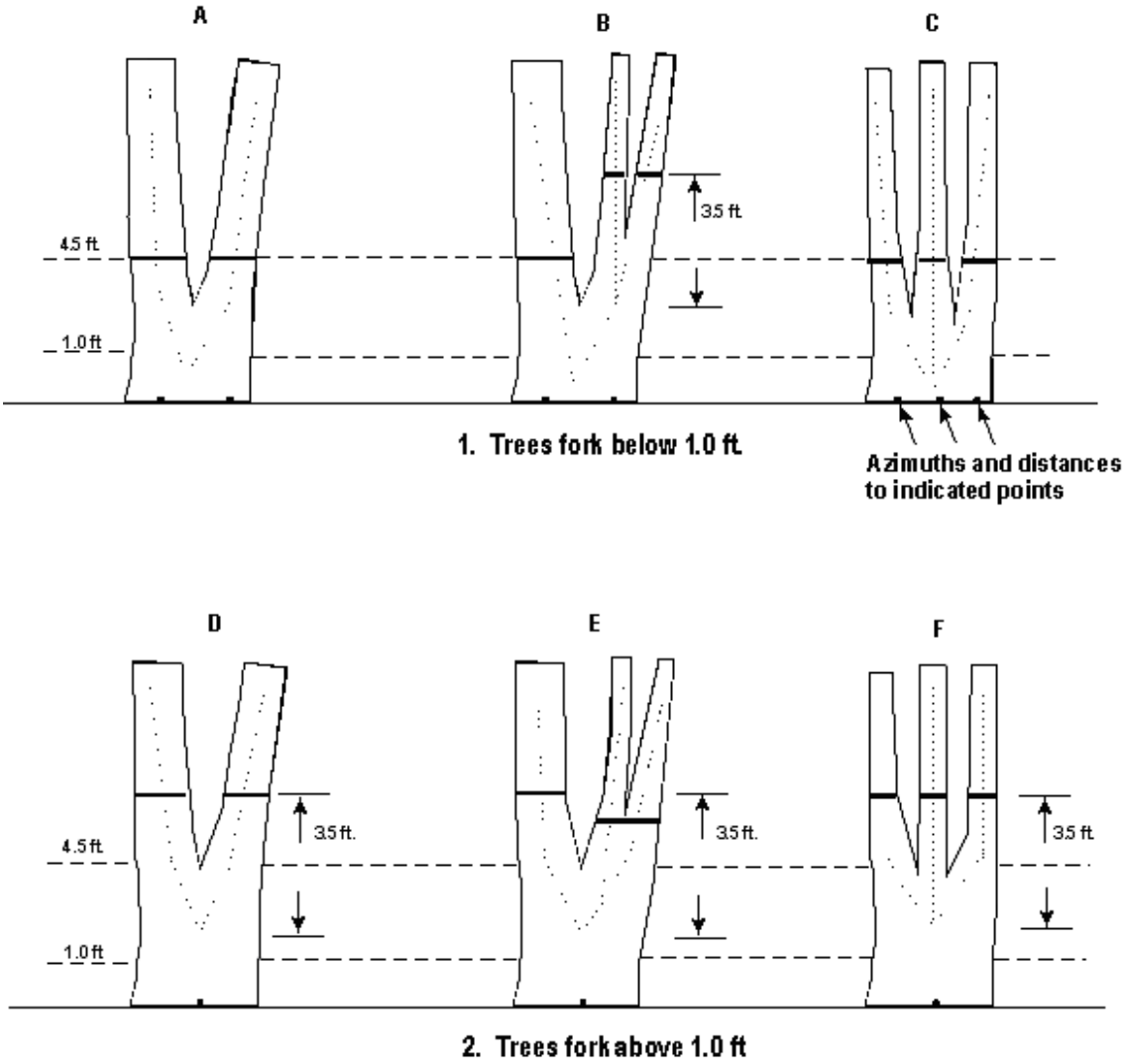


Figure 24. Summary of where to measure DBH, distance, and azimuth on forked trees.

2. Stump Sprouts. Stump sprouts originate between ground level and 4.5 feet on the boles of trees that have died or been cut. Stump 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 bole. Stump sprouts originating below 1.0 foot are measured at 4.5 feet from ground line. Stump sprouts originating between 1.0 foot and 4.5 feet are measured at 3.5 feet above their point of occurrence. As with forks, rules for measuring distance and azimuth depend on whether the sprouts originate above or below 1.0 foot. For multi-stemmed woodland species, treat all new sprouts as part of the same new tree.

3. Tree with butt-swell or bottleneck: Measure these trees 1.5 feet above the end of the swell or bottleneck if the swell or bottleneck extends 3.0 feet or more above the ground (Figure 25).

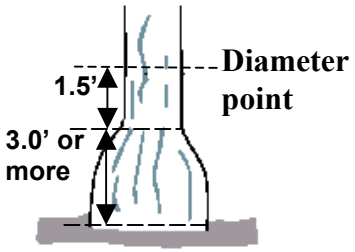


Figure 25. Bottleneck tree.

4. Tree with irregularities at DBH: On trees with swellings (Figure 26), bumps, depressions, and branches (Figure 27) at DBH, diameter will be measured immediately above the irregularity at the place it ceases to affect normal stem form.

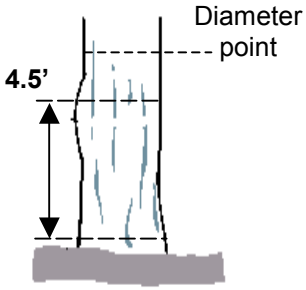


Figure 26. Tree with swelling.

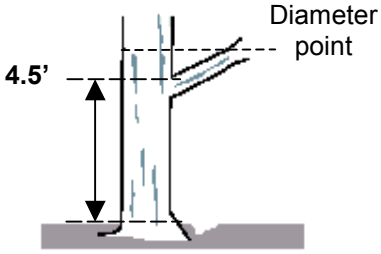


Figure 27. Tree with branch.

5. Tree on slope: Measure diameter at 4.5 feet from the ground along the bole on the uphill side of the tree (Figure 28).

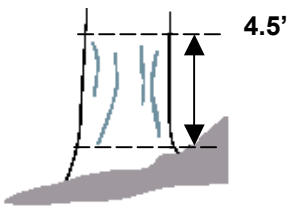


Figure 28. Tree on a slope.

6. Leaning tree: Measure diameter at 4.5 feet from the ground along the bole. The 4.5-foot distance is measured along the underside face of the bole (Figure 29).

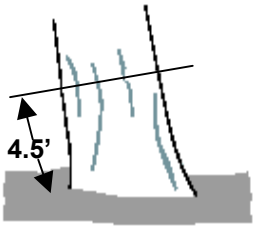


Figure 29. Leaning tree.

7. Turpentine tree: On trees with turpentine face extending above 4.5 feet, estimate the diameter at 10.0 feet above the ground and multiply by 1.1 to estimate DBH outside bark.

8. Independent trees that grow together: If two or more independent stems have grown together at or above the point of DBH, continue to treat them as separate trees. Estimate the diameter of each, and explain the situation in the notes.

9. Missing wood or bark. Do not reconstruct the DBH of a tree that is missing wood or bark or at the point of measurement. Record the diameter, to the nearest 0.1 inch, of the wood and bark that is still attached to the tree (Figure 30). If a tree has a localized abnormality (gouge, depression, etc.) at the point of point of DBH, apply the procedure described for trees with irregularities at DBH (Figure 26 and 27).

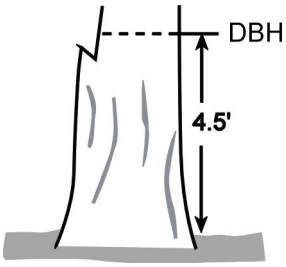


Figure 30. Tree with broken stem.

10. Live windthrown tree: Measure from the top of the root collar along the length to 4.5 feet (Figure 31).

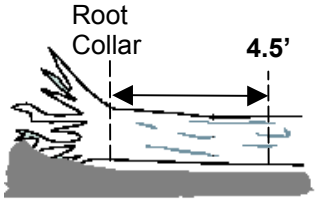


Figure 31. Tree on the ground.

11. Down live tree with tree-form branches growing vertical from main bole. When a down live tree, touching the ground, has vertical (less than 45 degrees from vertical) tree-like branches coming off the main bole, first determine whether or not the pith of the main bole (averaged along the first log of the tree) is above or below the duff layer.

• If the pith of the main bole is above the duff layer, use the same forking rules specified for a forked tree, and take all measurements accordingly (Figure 32).

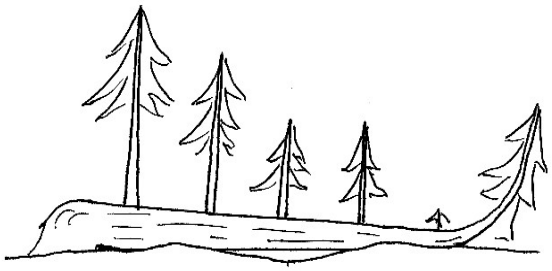


Figure 32. Down tree above duff.

• If the pith intersection of the main down bole and vertical tree-like branch occurs below 4.5 feet from the stump along the main bole, treat that branch as a separate tree, and measure DBH 3.5 feet above the pith intersection for both the main bole and the tree-like branch.

• If the intersection between the main down bole and the tree-like branch occurs beyond the 4.5 feet point from the stump along the main bole, treat that branch as part of the main down bole.

• If the pith of main tree bole is below the duff layer, ignore the main bole, and treat each tree-like branch as a separate tree; take DBH and length measurements from the ground, not necessarily from the top of the down bole (Figure 33). However, if the top of the main tree bole curves out of the ground towards a vertical angle, treat that portion of that top as an individual tree originating where the pith leaves the duff layer.

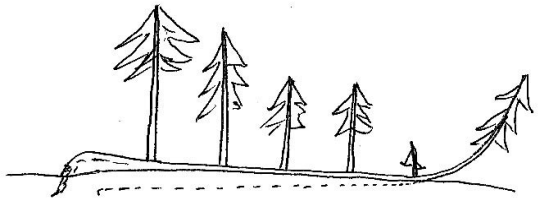


Figure 33. Down tree below duff.

12. Tree with curved bole (pistol butt tree): Measure along the bole on the uphill side (upper surface) of the tree (Figure 34).

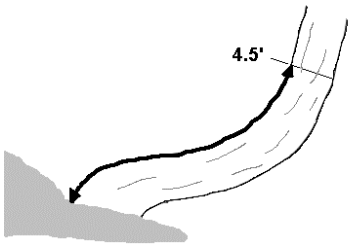


Figure 34. Tree with curved bole (pistol butt tree).

APPENDIX 8 : DAMAGE TYPE DESCRIPTIONS

1 Canker, gall: Cankers may be caused by various agents but are most often caused by fungi. The bark and cambium are killed, and this is followed by death of the underlying wood, although the causal agent may or may not penetrate the wood. This results in areas of dead tissue that become deeper and wider, or galling (including galls caused by rusts), on roots, bole, or branches. Due to the difficulty in distinguishing some abnormal swellings (e.g., burls) from classic galls and cankers, all are recorded as damage 01. A canker may be:

Annual (enlarges only once and does so within an interval briefer than the growth cycle of the tree, usually less than one year),

Diffuse (enlarges without characteristic shape or noticeable callus formation at margins), or
Perennial (enlarges during more than one year - often has a target appearance).

2 Conks, fruiting bodies, and signs of advanced decay: Fruiting bodies on the main bole, crownstem, and at the point of the branch attachment are signs of decay. "Punky wood" is a sign of decay and is evidenced by soft, often moist, and degraded tissue.

Cavities into the main bole that are oriented in such a way that they act as catchment basins for water are signs of decay. Bird cavities are signs of decay.

*Rotten branches or branches with conks **are not indicators of decay unless** the threshold is met (>20% of branches are affected).*

Rotting stumps associated with coppice regeneration (e.g., northern pin oak, maple) are excluded from coding.

3 Open wounds: An opening or series of openings where bark has been removed or the inner wood has been exposed and no signs of advanced decay are present. Improper pruning wounds that cut into the wood of the main stem are coded as open wounds, if they meet the threshold; those which leave the main stemwood intact are excluded.

4 Resinosis or gummosis: The origin of areas of resin or gum (sap) exudation on branches and trunks.

5 Cracks and seams: Cracks in trees are separations along the radial plane greater than or equal to 5 feet. When they break out to the surface they often are called frost cracks. These cracks are not caused by frost or freezing temperature, though frost can be a major factor in their continued development. Cracks are most often caused by basal wounds or sprout stubs, and expand when temperatures drop rapidly. Seams develop as the tree attempts to seal the crack, although trees have no mechanism to compartmentalize this injury.

Lightning strikes are recorded as cracks when they do not meet the threshold for open wounds.

11 Broken bole or roots (less than 3 feet from bole): Broken roots within 3 feet from bole either from excavation or rootsprung for any reason. For example, those which have been excavated in a road cut or by animals.

Stem broken in the bole area (below the base of the live crown) and tree is still alive.

12 Brooms on roots or bole: Clustering of foliage about a common point on the trunk. Examples include ash yellows witches' brooms on white and green ash and eastern and western conifers infected with dwarf mistletoes.

13 Broken or dead roots (beyond 3 feet): Roots beyond 3 feet from bole that are broken or dead.

20 Vines in the crown: Kudzu, grapevine, ivy, dodder, etc. smothers tree crowns. Vines are rated as a percentage of tree crown affected.

21 Loss of apical dominance, dead terminal: Mortality of the terminal of the crownstem caused by frost, insect, pathogen, or other causes.

22 Broken or dead: Branches that are broken or dead. Branches with no twigs are ignored and not coded as dead. Dead or broken branches attached to the bole or crownstem outside the live crown area are not coded. 20% of the main, first order portion of a branch must be broken for a branch to be coded as such. For woodland species only: Since dead branches often originate below the 12 in stump height and must be measured for DRC, there is no requirement that damage to branches can only occur to branches that originate within the live crown area.

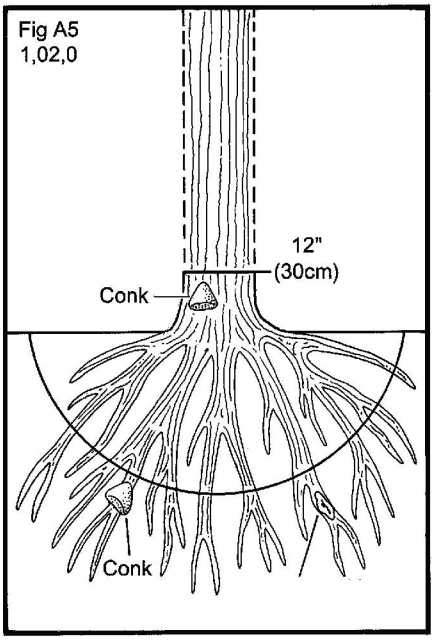
23 Excessive branching or brooms within the live crown area: Brooms are a dense clustering of twigs or branches arising from a common point that occur within the live crown area. Includes abnormal clustering of vegetative structures and organs. This includes witches' brooms caused by ash yellows on green and white ash and those caused by dwarf mistletoes.

24 Damaged buds, foliage or shoots: Insect feeding, shredded or distorted foliage, buds or shoots >50% affected, on at least 30% of foliage, buds or shoots. Also includes herbicide or frost-damaged foliage, buds or shoots.

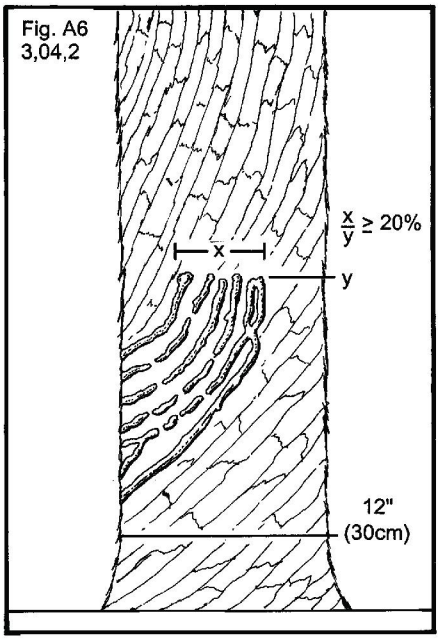
25 Discoloration of foliage: At least 30% of the foliage is more than 50% affected. Affected foliage must be more of some color other than green. If the observer is unsure if the color is green, it is considered green and not discolored.

31 Other: Use when no other explanation is appropriate, specify damage.

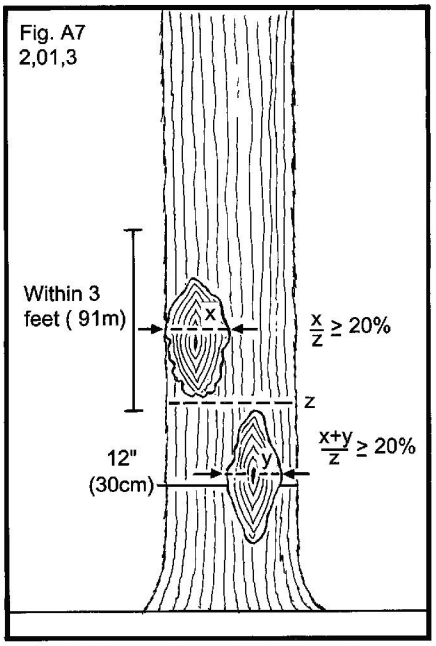
Examples of damage coding.



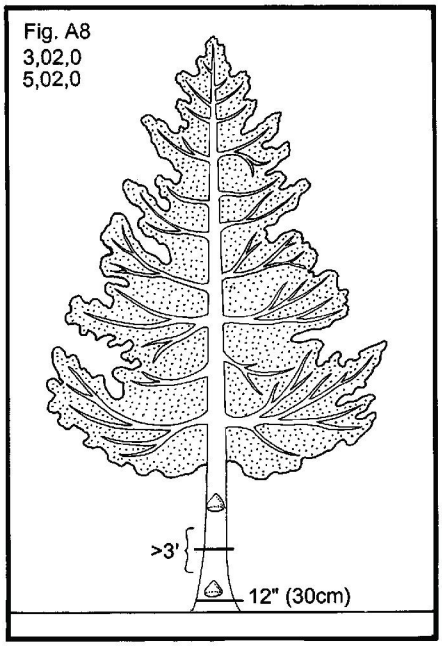
02 - Indicator of decay within 3' of bole. Beyond 3" of bole, indicators must affect ≥ 20% of roots (see fig. 12)



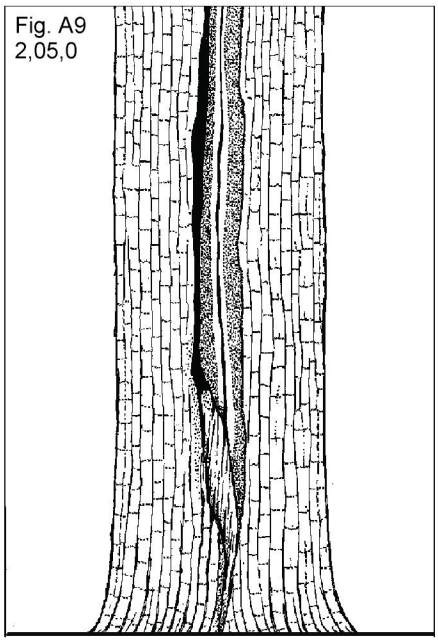
04 - Origin of resinosis in lower bole



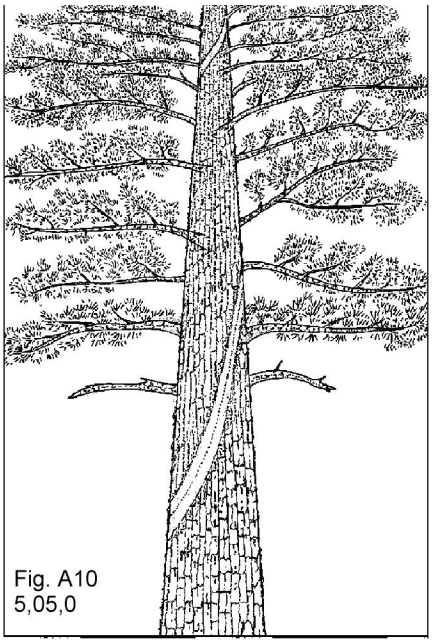
01 - Additive cankers within 3' in roots and lower bole



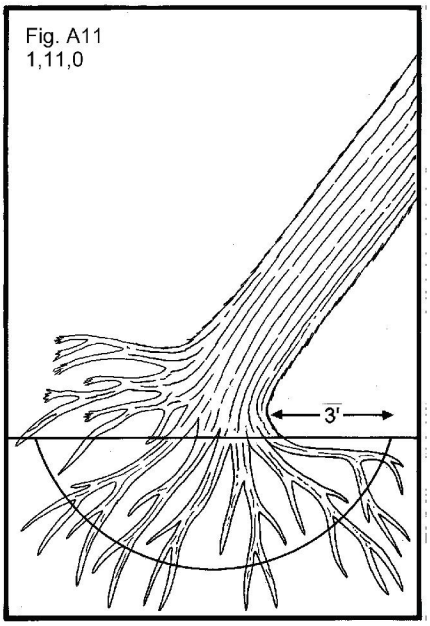
02 - Conks separated by >3'; 2 damages



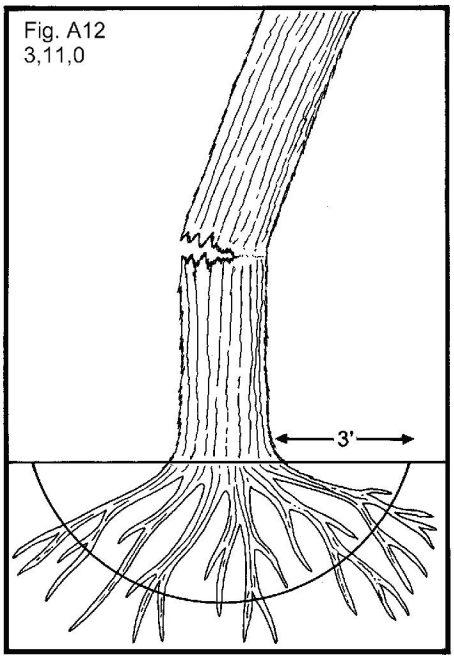
05- Cracks and seams



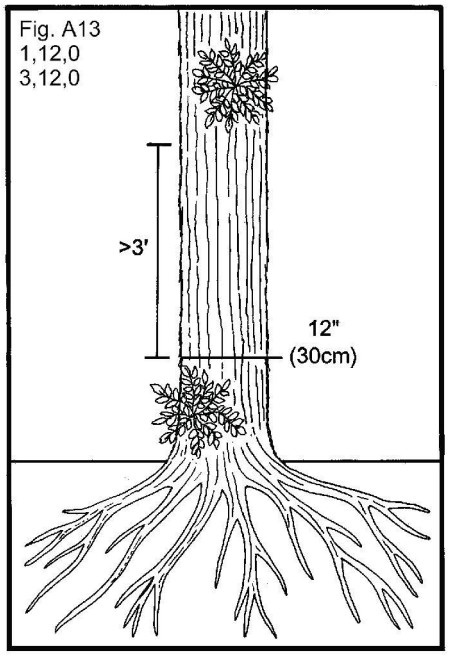
05 - Lightning strike



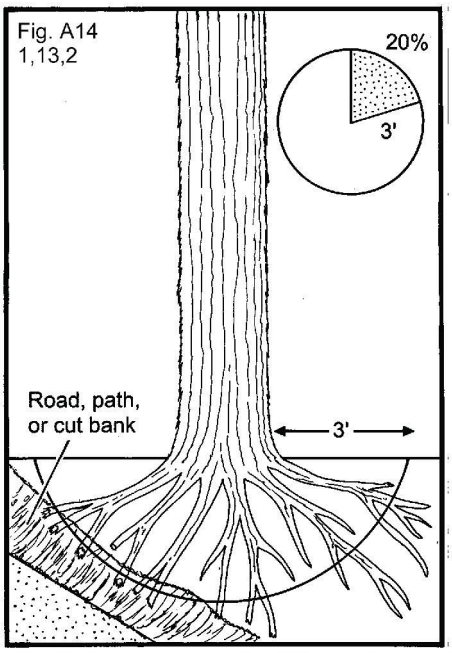
11 - Broken bole or roots <3' from bole, broken roots must be visible



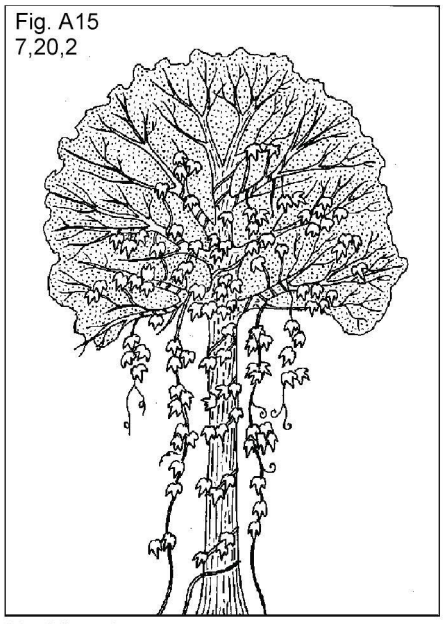
11 - Broken bole or roots <3' from bole



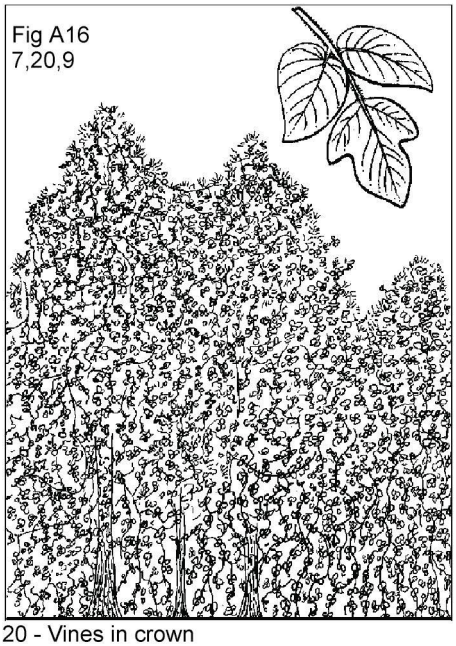
12 - Brooms on roots or bole



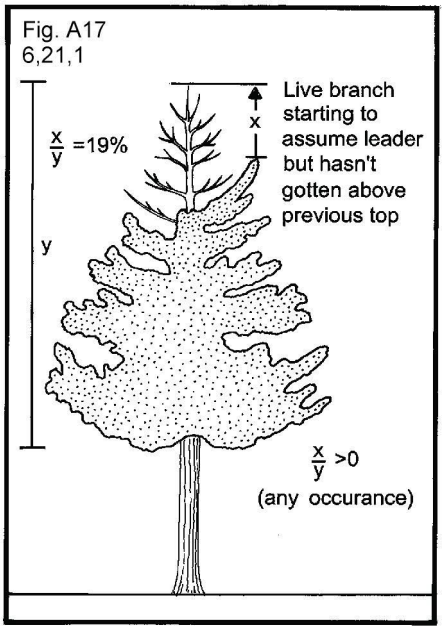
13 - Broken or dead roots >3' from bole



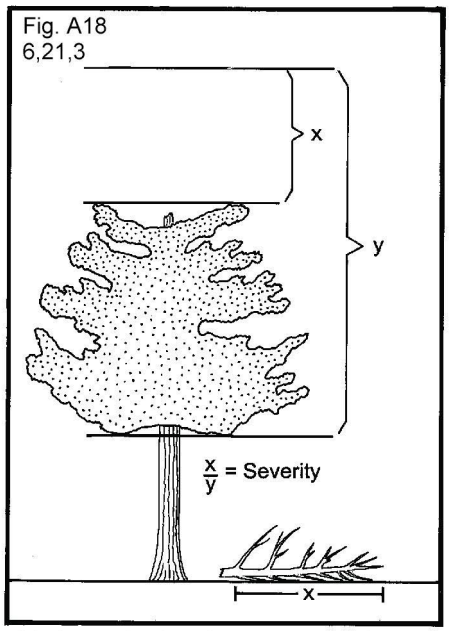
20 - Vines in crown



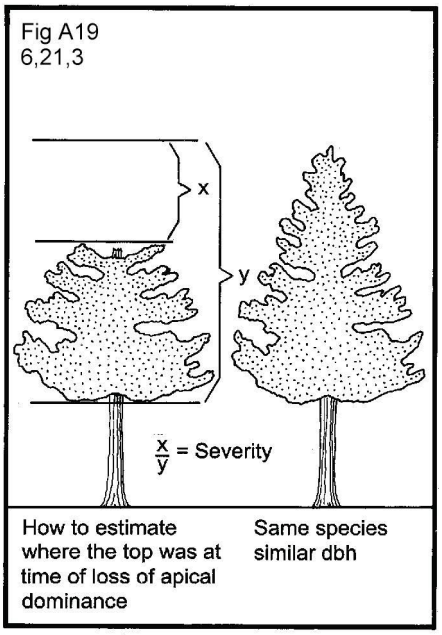
20 - Vines in crown



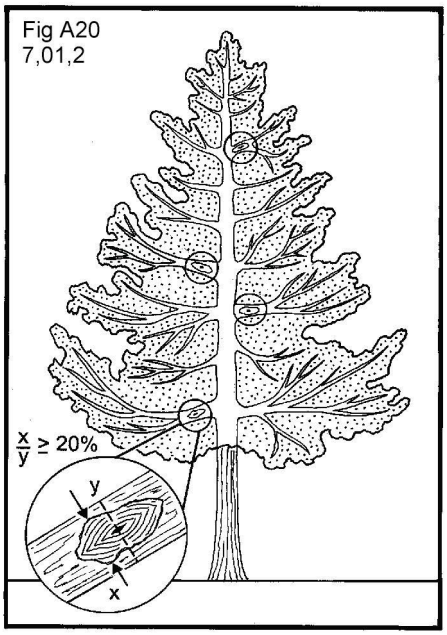
21 - Loss of apical dominance



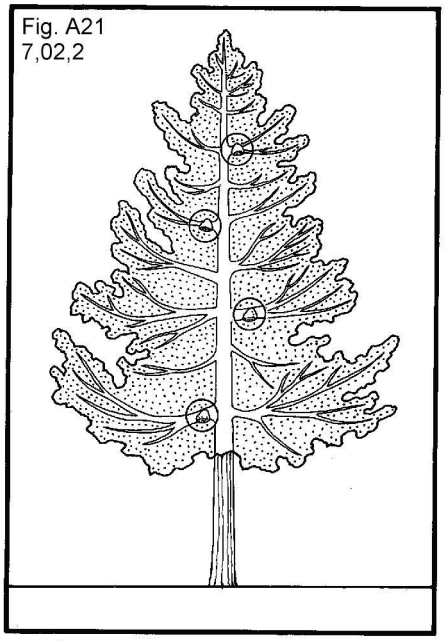
21 - Loss of apical dominance, look for old top to estimate the top of x and y



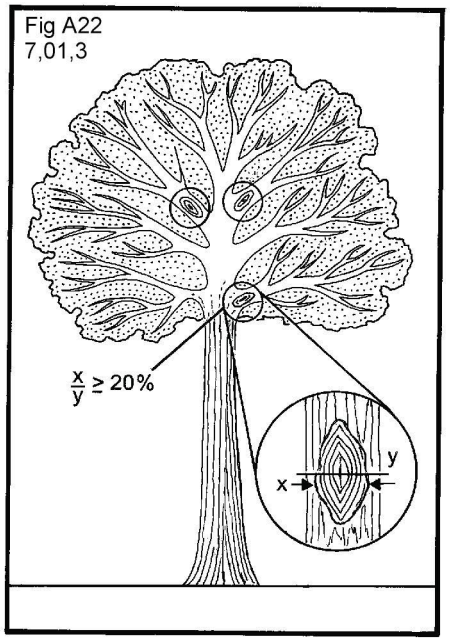
21 - Loss of apical dominance, look for same species of similar dbh



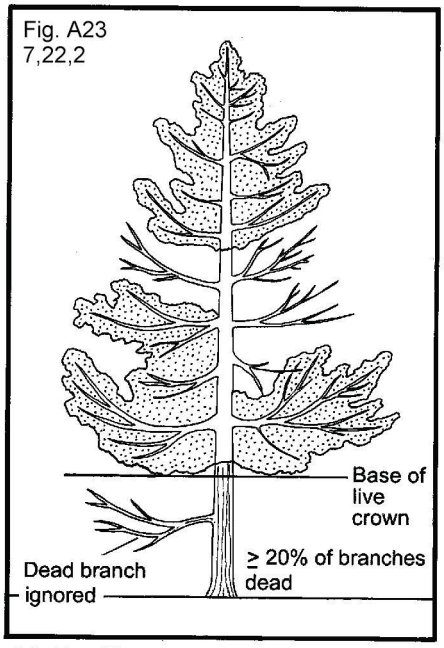
01 - Cankers above the threshold on ≥ 20% of branches



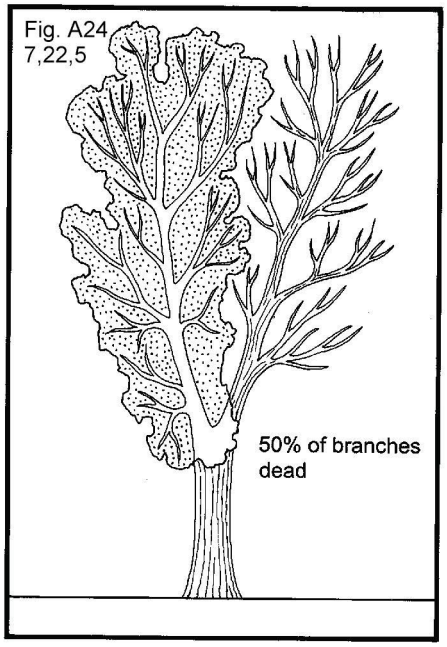
02 - Conks on ≥ 20% of branches



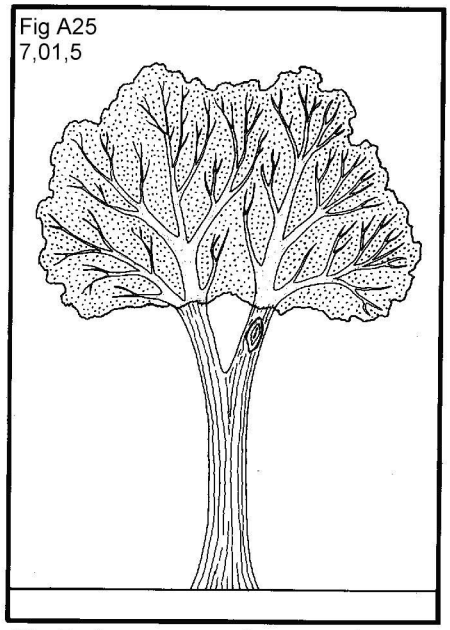
01 - Cankers above threshold on ≥ 20% of branches



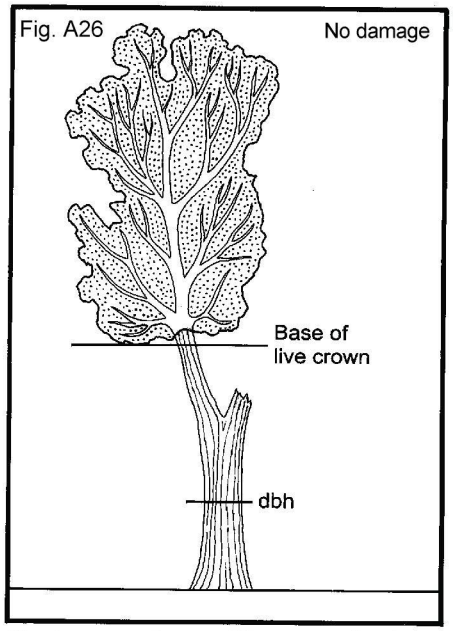
22 - Dead branches within the live crown area. If branches cannot easily be counted, estimate % area of live crown affected



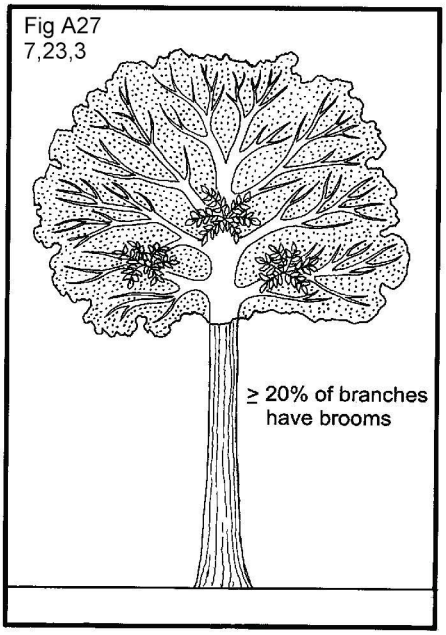
22 - Dead branches; only 2 branches present within live crown area, fines present and ≥20% of branch dead



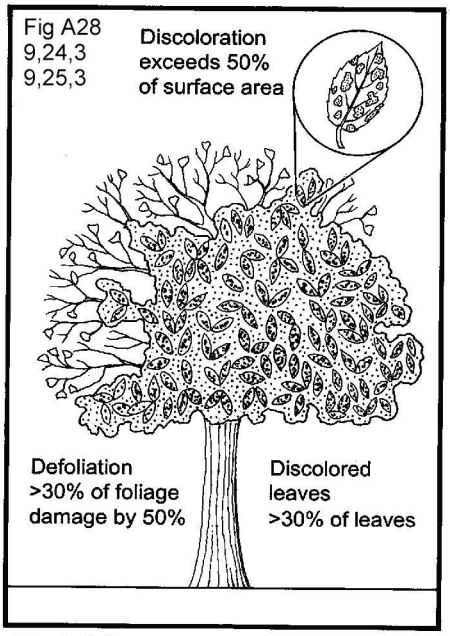
01 - Canker; no crown stem and only 2 branches present



No damage - base of live crown is above old fork, stub is a snag branch



23 - Excessive branching or brooms in crown



24 - Defoliation, 25 - Discoloration

APPENDIX 9: EMERALD ASH BORER PICTURES

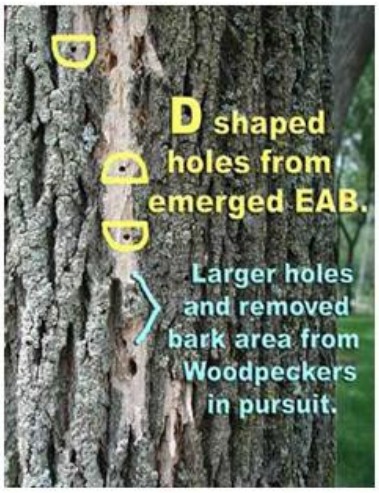
EAB larvae

EAB eggs

EAB adults

EAB pupae

EAB Serpentine Galleries



EAB
D-shaped Exit Holes

EAB damage to ash trees