INTERIOR WEST FOREST INVENTORY & ANALYSIS

FOREST SURVEY P3
FIELD PROCEDURES

March, 2005 (V2.01)

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CHAPTER 1
CROWNS

1.1 OVERVIEW (Core 12.1)

Crown indicators are designed to be used together. Each indicator comprises a piece of information that can be used individually or as a factor in combination with other indicators. Each variable, alone or in combination with others, adds to the overall rating given each tree. It is important to realize that models are designed to rate trees on how they look, from thriving to almost dead and to help predict future conditions of trees and forest ecosystems.

VIGOR CLASS, UNCOMPACTED LIVE CROWN RATIO, CROWN LIGHT EXPOSURE and CROWN POSITION are determined for each sapling. Foliage below the point used for UNCOMPACTED LIVE CROWN RATIO is not considered in VIGOR CLASS determination. All sapling measurements are done during plot establishment and whenever plot remeasurement occurs.

Crown evaluations, including UNCOMPACTED LIVE CROWN RATIO, LIGHT EXPOSURE, POSITION, DENSITY, DIEBACK, and TRANSPARENCY are made on all trees with DBH/DRC (DRC in the West) 5.0 inches or larger. Trees with high scores for UNCOMPACTED LIVE CROWN RATIO and DENSITY, and low scores for DIEBACK and FOLIAGE TRANSPARENCY have increased potential for carbon fixation, nutrient storage and increased potential for survival and reproduction. Crown evaluations allow for the quantitative assessment of current tree conditions and provide an integrated measure of site conditions, stand density and influence of external stresses. All crown measurements are taken during plot establishment and whenever plot remeasurement occurs.

Two persons make all crown measurements. Individuals should be ½ to 1 tree length from the base of the tree to obtain a good view of the crown. Move away from each other at least 10 feet to take these measurements. A position of 90 degrees to each other from the tree base is ideal (Figure 3). 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).

1.2 CROWN DEFINITIONS (Core 12.2)

Crown Shape

Crown shape is the silhouette of a tree, drawn from branch tip to branch tip, which contains all of a tree's foliage as it grows in a stand. Exclude abnormally long branches beyond the edge of the crown for this silhouette. Normally, silhouettes are derived from vigorous, open grown trees and tend to be species-specific. For Phase 3 purposes, silhouettes vary with age and spacing. Tree crowns tend to flatten out with age and be more slender when growing in crowded conditions. Crown shape is important when measuring CROWN DENSITY and is used to estimate crown biomass. Crown shape is used as an outline for the sides of the tree.

Crown Top

The crown top is the highest point of a standing tree. Young trees usually have more conical-shaped crowns and the main terminal is the top. Older trees and many hardwoods have globose and flat-topped crowns, where a lateral branch is the highest point. For some measurements the highest live foliage is considered the live crown top. Other measurements include a dead top. Some crown measurements assess how much of the expected crown is present and include broken or missing tops.

Dieback

This is recent mortality of branches with fine twigs, which begins at the terminal portion of a branch and proceeds toward the trunk. 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.

Epicormic

Shoot growth, from latent or suppressed buds, that arises from old branches, from the trunk or near large branch wounds or breaks. Epicormics remain epicormics until they regain the size of previous branches for trees with no branches 1.0 inch or larger in diameter at the base above the swelling. For trees that had 1.0 inch or larger branches when the epicormics formed, epicormics become branches once they reach 1.0 inch in diameter.

Live Branch
A live branch is any woody lateral growth supporting foliage, and is 1.0 inch or larger in diameter at the base above the swelling where it joins a main stem or larger branch. Small trees or certain tree species greater than 5.0 inches DBH/DRC may have only live twigs which have not yet reached 1.0 inch or larger at the point of attachment. If the death of larger branches is not the cause of these twigs, the twigs are considered branches for these smaller branched trees until the tree matures to a point where twigs have attained 1.0 inch or larger in diameter at the base above the swelling where it joins a main stem or larger branch.

Live Crown Base
The live crown base is an imaginary horizontal line drawn across the trunk from the bottom of the lowest live foliage of the "obvious live crown" for trees and from the lowest live foliage of the lowest twig for saplings. The "obvious live crown" is described as the point on the tree where most live branches/twigs above that point are continuous and typical for a tree species (and/or tree size) on a particular site. Include most crown branches/twigs, but exclude epicormic twigs/sprigs and straggler branches that usually do not contribute much to the tree's growth. The base of the live branch/twig bearing the lowest foliage may be above or below this line.

For trees 5.0 inches DBH/DRC or greater, if any live branch is within 5 feet below this "obvious live crown" line, a new horizontal line is established. Create the new line at the base of live foliage on that branch. Continue this evaluation process until no live branches are found within 5 feet of the foliage of the lowest qualifying branch (Figure 1).

Occasionally, all original major crown branches/twigs are dead or broken and many new twigs/sprigs develop. These situations are likely to occur in areas of heavy thinning, commercial clearcuts and severe weather damage:

- Trees that had an "obvious live crown" with live branches now have no crown to measure until the new live twigs become live branches. When these new live branches appear, draw the new live crown base to the live foliage of the lowest live branch that now meets the 5-foot rule.

- Saplings and small trees that had only live twigs should establish the crown base at the base of the live foliage on the new lowest live twig. If no live twigs are present, there is no crown to measure.

DETERMINING CROWN BASE & USE OF 5' RULE

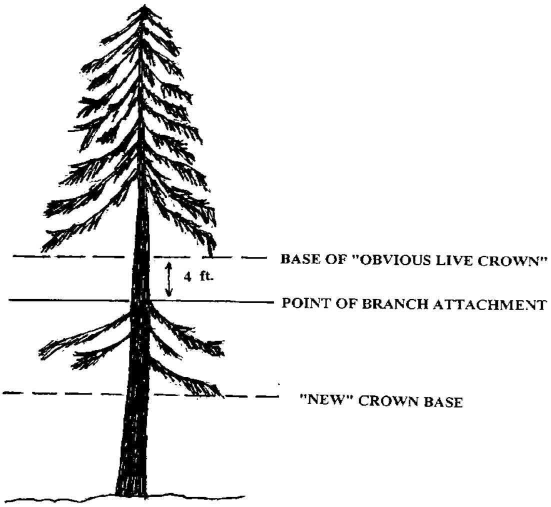


Figure 1. Determining the base of the live crown. (12-1)

Overstory Canopy Zone
The area delineated by the average live crown height determined from the UNCOMPACTED LIVE CROWN RATIO of overstory trees. The bottom of the overstory canopy zone is the average height of the live crown bases. The top of the zone is the average height for the live crown tops.

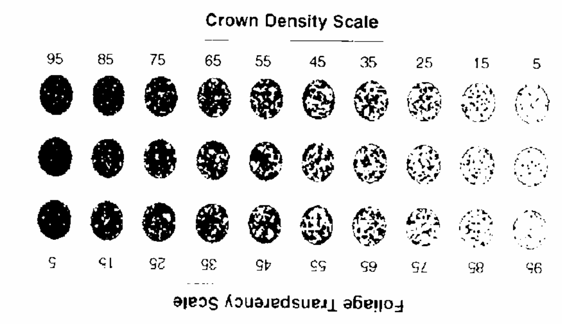
Snag Branch
A dead upper crown branch without twigs or sprigs attached to it. A lower branch on woodland trees such as juniper is not considered a snag branch unless the branch reaches into the upper crown, or reached into the upper crown when the branch was alive. A branch that died due to shading in any crown is not a snag branch.

Sprig
Any woody or non-woody lateral growth, without secondary branching, less than 1.0 inch in diameter at the base above the swelling at the point of attachment to a branch or crown stem.

Twig
Any woody lateral growth, with secondary branching, less than 1.0 inch in diameter at the base above the swelling at the point of attachment to a branch or crown stem.

1.3 CROWN DENSITY-FOLIAGE TRANSPARENCY CARD (Core 12.3)

Front



Back

Density of Tree, Present

Percent of Tree Missing	5	15	25	35	45	55	65	75	85	95
10	5	15	25	35	45	50	60	70	80	90
20	5	15	20	30	40	45	55	60	70	80
30	5	15	20	25	35	40	50	55	60	70
40	5	10	15	25	30	35	40	45	55	60
50	5	10	15	20	25	30	35	40	45	50
60	5	10	10	15	20	25	30	30	35	40
70	5	5	10	15	15	20	20	25	30	30
80	5	5	5	10	10	15	15	15	20	20
90	5	5	5	5	5	10	10	10	10	10

Scale to estimate live crown ratio: 99 90 80 70 60 50 40 30 20 10 00

Figure 2. Density-Transparency card (12-2)

The crown density - foliage transparency card (Figure 2) should be used as a training aid until crew 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. Crews should 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. Crews should refer to the CROWN DENSITY and UNCOMPACTED LIVE CROWN RATIO sections for the use of this side of the card.

1.4 CROWN RATING PRECAUTIONS (Core 12.4)

Crews must be especially careful when making evaluations, and pay special attention to certain factors that may affect measurements in the field. These factors include:

- Distance and slope from the tree
- View of the crown
- Climatic conditions
- Heavy defoliation
- Leaning trees
- Trees with no “crown” by definition

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 3). 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.

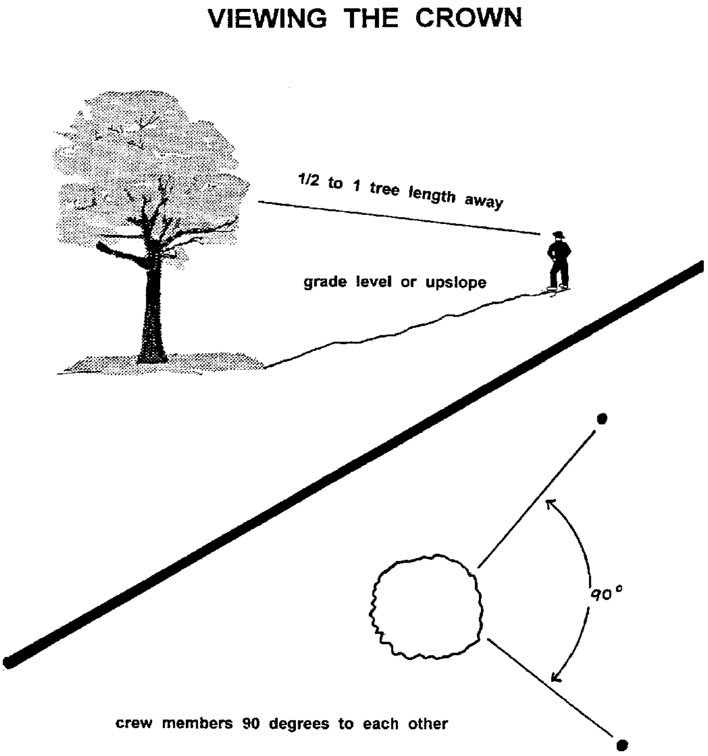


Figure 3. Crew positions for viewing crowns. (12-3)

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 (Figure 5). 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.

After a sudden release or damage, a sapling may have very dense foliage, but no crown as it only has sprigs. These situations are coded as follows: UNCOMPACTED LIVE CROWN RATIO = 00, CROWN LIGHT EXPOSURE = 0, CROWN POSITION = 3, sapling VIGOR = 3. This combination of codes is a flag for saplings with no crowns.

1.5 UNCOMPACTED LIVE CROWN RATIO (Core 12.5)

UNCOMPACTED LIVE CROWN RATIO is a percentage determined by dividing the live crown height by the total live tree height (Figure 5).

Saplings

Determine sapling UNCOMPACTED LIVE CROWN RATIO by dividing the live crown height by total tree height to the live crown top, then enter the appropriate code into the PDR. Live crown height is the distance between the top live foliage (dieback and dead branches are not included) and the lowest live foliage on the lowest live twig for saplings. Be sure to eliminate vine foliage as best you can when determining the live crown. The live crown base for saplings is different from trees 5.0 inches DBH/DRC and larger. The 5-foot/1-inch rule does not apply in this case. Do not include sprigs or leaves on the main stem below the lowest live twig (Figure 4).

When the two estimates do not agree, follow the guidelines listed at the end of section 1.1 *Overview*. The estimate is placed into one of 21 percentage classes.

Measure leaning saplings as they are (Figure 5).

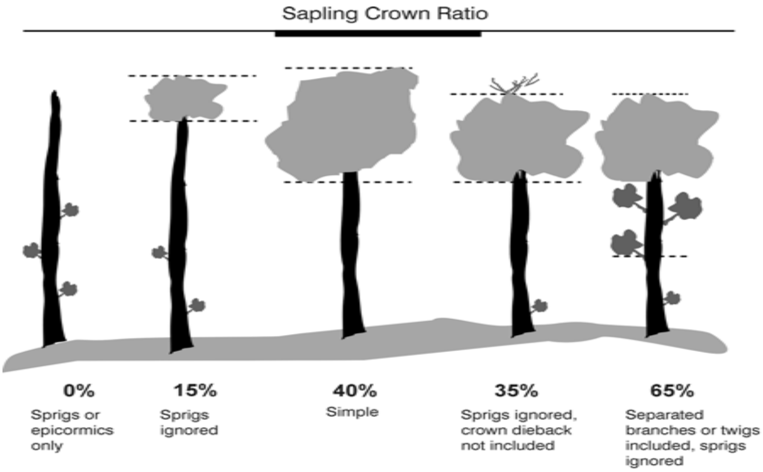


Figure 4. Sapling UNCOMPACTED LIVE CROWN RATIO determination examples. (12-4)

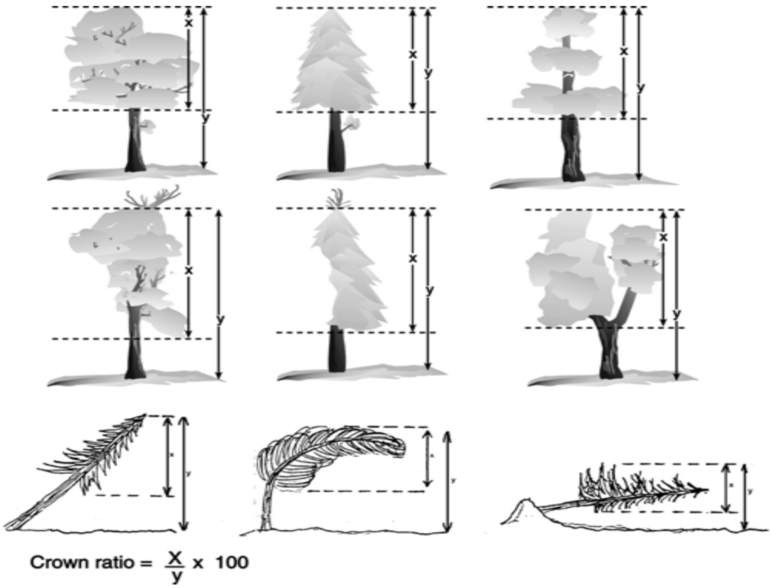


Figure 5. UNCOMPACTED LIVE CROWN RATIO

Trees

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 6). 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 1). 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 (Figure 2). 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.

When estimates between crew members do not agree, follow the guidelines listed at the end of section 1.1 *Overview*. The estimate is placed into one of 21 percentage classes.

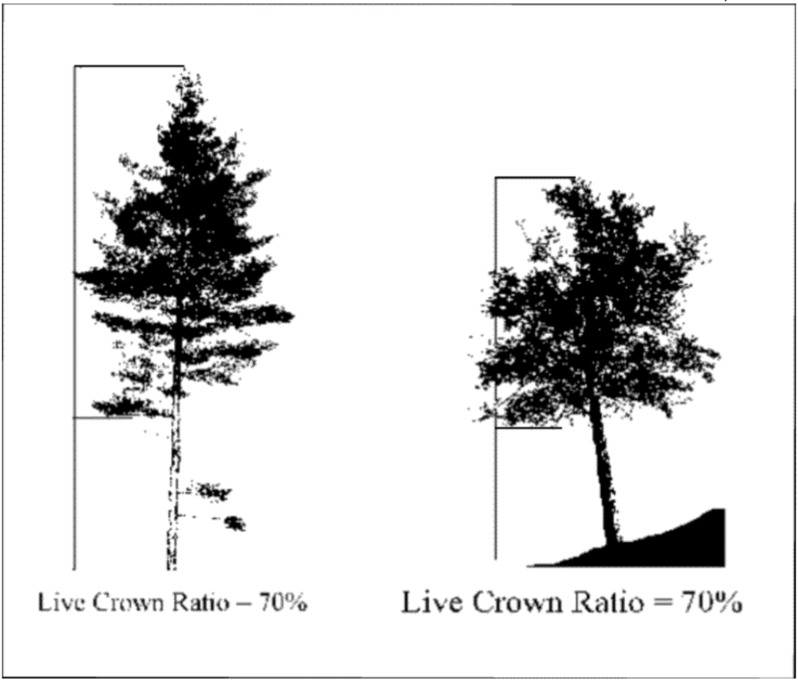


Figure 6. UNCOMPACTED LIVE CROWN RATIO outline and rating examples (12-6)

When collected: All live trees ≥ 1.0 in DBH/DRC
Field width: 2 digits
Tolerance: +/- 10% (2 classes)
MQO: At least 90% of the time
Values:

Code	Definition	Code	Definition	Code	Definition
00	No crown	35	31-35%	70	66-70%
05	1-5%	40	36-40%	75	71-75%
10	6-10%	45	41-45%	80	76-80%
15	11-15%	50	46-50%	85	81-85%
20	16-20%	55	51-55%	90	86-90%
25	21-25%	60	56-60%	95	91-95%
30	26-30%	65	61-65%	99	96-100%

Note: Class code is the percentage of the upper limits of the class, i.e., Code 10 is 6% to 10%, etc.

1.6 CROWN LIGHT EXPOSURE (Core 12.6)

Rate the UNCOMPACTED LIVE CROWN RATIO for each side of the tree separately using the criteria for estimating total UNCOMPACTED LIVE CROWN RATIO. Visually divide the crown vertically into four equal sides. In order for a side to qualify for tally, the side must have an uncompacted live crown ratio of at least 35 percent. 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 7).

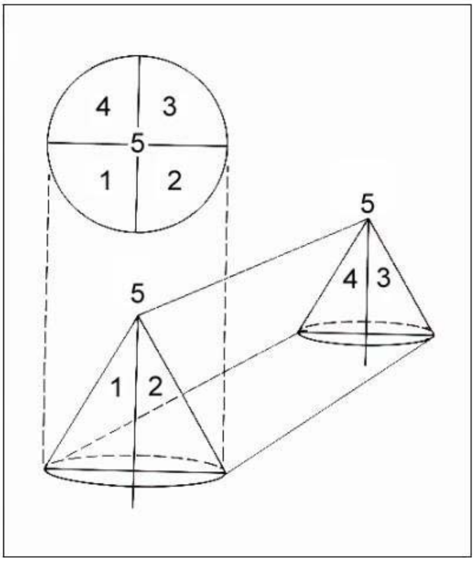


Figure 7. Dividing the crown. (12-7)

Note: 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 8).

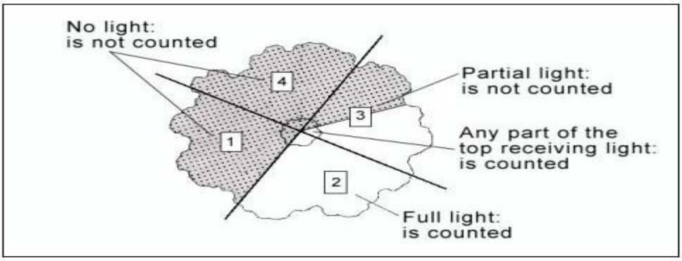


Figure 8. CROWN LIGHT EXPOSURE. (12-8)

When collected: All live trees ≥ 1.0 in DBH/DRC
Field width: 1 digit
Tolerance: within 1 if > 0
MQO: At least 85% of the time
Values:

Code	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.

1.7 CROWN POSITION (Core 12.7)

Determine the relative position of each tree in relation to the overstory canopy zone (Figure 9). Codes 1-3 should be used in stands where the tree crown cover is closed (>50 percent cover). If the tree crowns are not closed (<50 percent cover) and the area is greater than 1 acre in size, then assign code 4. When code 4 is used, it is assigned to all trees in the stand except trees with no crown by definition. Code 4 is typically used in the following cases:

- Trees and saplings in stands, over 1 acre in size, where crown cover is less than 50 percent.
- Trees and saplings in clumps less than 1 acre in size (i.e., not a condition class) when the overall forest (the condition class), over 1 acre in size, is a patchwork of open areas and clumps of trees.

Code 1 is not used for saplings.

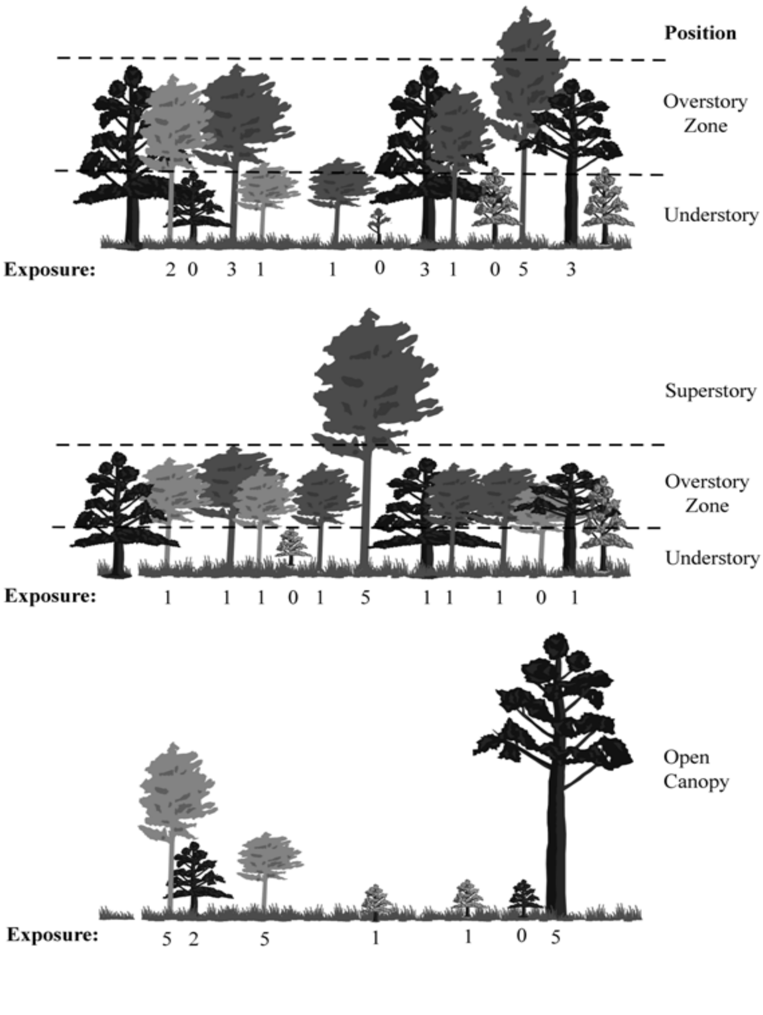


Figure 9. CROWN LIGHT EXPOSURE and CROWN POSITION. (12-9)

When collected: All live trees ≥ 1.0 in DBH/DRC

Code	Definition
1	Superstory. The live crown top must be two times the height of the top of the overstory canopy zone. The tree is open grown because most of the crown is above the overstory canopy zone (pioneers, seed trees, whips, remnants from previous stands, etc.). NOT USED FOR SAPLINGS.
2	Overstory. The live crown top is above the middle of the overstory canopy zone.
3	Understory. The live crown top is at or below the middle of the overstory canopy zone, or tree has no crown by definition.
4	Open Canopy. An overstory canopy zone is not evident because the tree crowns in this condition are not fully closed (<50% cover). Most of the trees in this stand are not competing with each other for light.

Field width: 1 digit
Tolerance: No errors
MQO: At least 85% of the time
Values:

1.8 CROWN VIGOR CLASS (Core 12.8)

See Figure 10 for a visual description of the sapling CROWN VIGOR classes.

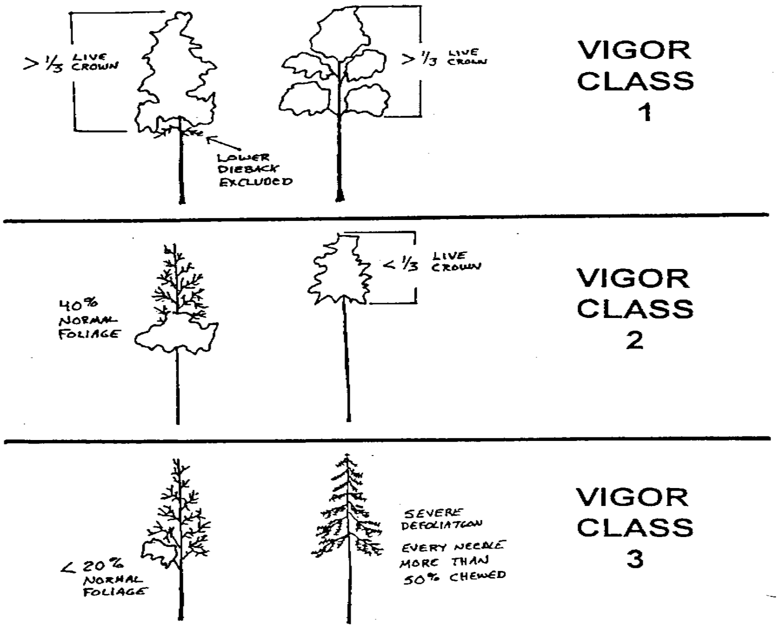


Figure 10. Sapling CROWN VIGOR classes. (12-10)

When collected: All live trees ≥ 1.0 in DBH/DRC and < 5.0 in DBH/DRC
Field width: 1 digit
Tolerance: No errors
MQO: At least 90% of the time

Values:

Class/Code	Definition
1	Saplings must have an UNCOMPACTED LIVE CROWN RATIO of 35 or higher, have less than 5 percent DIEBACK (deer/rabbit browse is not considered as dieback but is considered missing foliage) and 80 percent or more of the foliage present is normal or at least 50 percent of each leaf is not damaged or missing. Twigs and branches that are dead because of normal shading are not included.
2	Saplings do not meet Class 1 or 3 criteria. They may have any UNCOMPACTED LIVE CROWN RATIO, may or may not have DIEBACK and may have between 21 and 100 percent of the foliage classified as normal.
3	Saplings may have any UNCOMPACTED LIVE CROWN RATIO and have 1 to 20 percent normal foliage or the percent of foliage missing combined with the percent of leaves that are over 50 percent damaged or missing should equal 80 percent or more of the live crown. Twigs and branches that are dead because of normal shading are not included. Code is also used for saplings that have no crown by definition.

1.9 CROWN DENSITY (Core 12.9)

CROWN DENSITY estimates crown condition in relation to a typical tree for the site where it is found. CROWN DENSITY also serves as an indicator of expected growth in the near future. CROWN DENSITY is the amount of crown branches, foliage and reproductive structures that blocks light visibility through the crown. Each tree species has a normal crown that varies with the site, genetics, tree damage, etc.

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 1). Include CROWN DIEBACK and open areas in this outline (Figures 1 and 12).

After determining the crown shape, each person should use the crown density - foliage transparency card (Figure 2). 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. When two individuals disagree with their estimates, follow the guidelines listed at the end of section 2.1 *Overview*. The estimate is placed into one of 21 percentage classes.

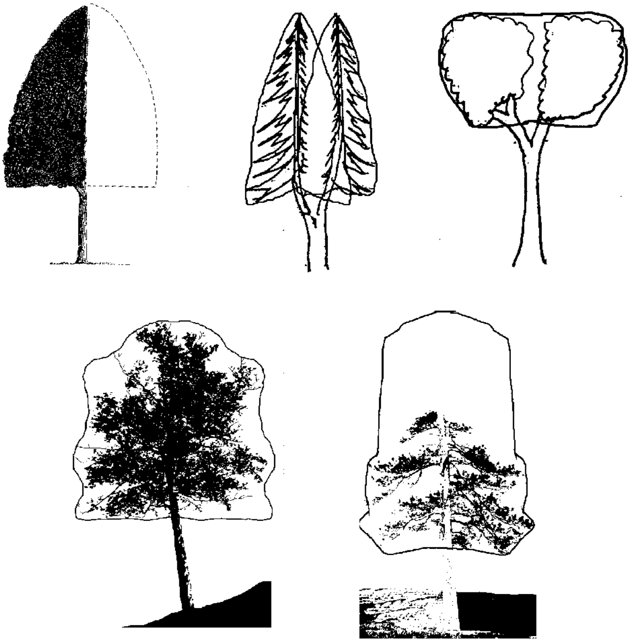


Figure 11. CROWN DENSITY rating outline examples. (12-11)

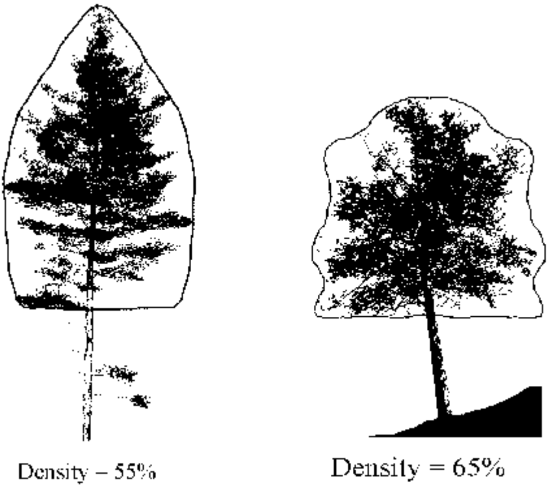


Figure 12. Crown density outline and rating examples (12-12)

When collected: All live trees ≥ 5.0 in DBH/DRC
Field width: 2 digits
Tolerance: +/- 10% (2 classes)
MQO: At least 90% of the time
Values:

Code	Definition	Code	Definition	Code	Definition
00	No crown	35	31-35%	70	66-70%
05	1-5%	40	36-40%	75	71-75%
10	6-10%	45	41-45%	80	76-80%
15	11-15%	50	46-50%	85	81-85%
20	16-20%	55	51-55%	90	86-90%
25	21-25%	60	56-60%	95	91-95%
30	26-30%	65	61-65%	99	96-100%

Note: Class code is the percentage of the upper limits of the class, i.e., Code 10 is 6% to 10%, etc

1.10 CROWN DIEBACK (Core 12.10)

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 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 13 and 14).

Project 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 at the end of section 1.1 *Overview*. The estimate is placed into one of 21 percentage classes.

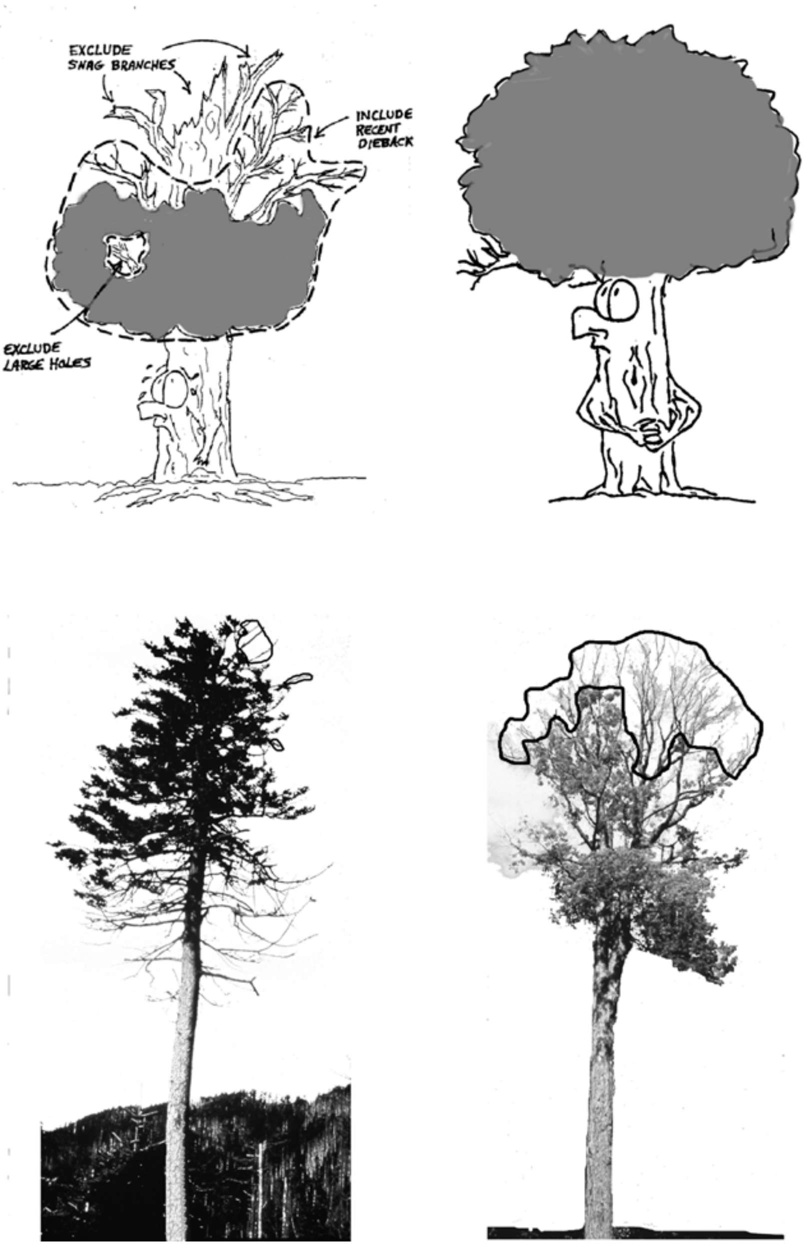


Figure 13. CROWN DIEBACK rating outline examples. (12-13)

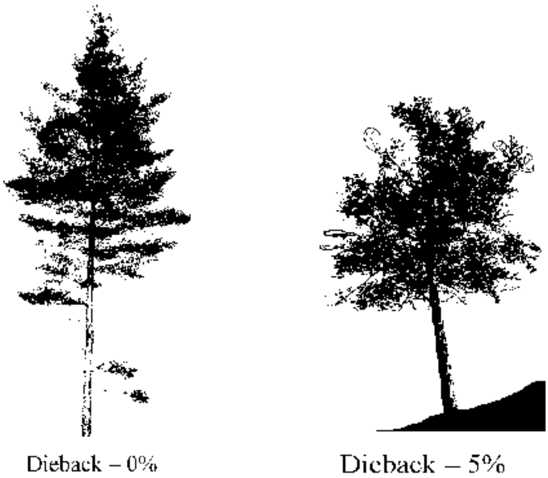


Figure 14. Dieback outline and rating examples. (12-14)

When collected: All live trees ≥ 5.0 in DBH/DRC
Field width: 2 digits
Tolerance: +/- 10% (2 classes)
MQO: At least 90% of the time
Values:

Code	Definition	Code	Definition	Code	Definition
00	0%	35	31-35%	70	66-70%
05	1-5%	40	36-40%	75	71-75%
10	6-10%	45	41-45%	80	76-80%
15	11-15%	50	46-50%	85	81-85%
20	16-20%	55	51-55%	90	86-90%
25	21-25%	60	56-60%	95	91-95%
30	26-30%	65	61-65%	99	No crown

Note: Class code is the percentage of the upper limits of the class, i.e., Code 10 is 6% to 10%, etc.

1.11 FOLIAGE TRANSPARENCY (Core 12.11)

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

Estimate FOLIAGE TRANSPARENCY using the crown density - foliage transparency card (Figure 2). 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 15).

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.

Project a two-dimensional crown outline. Determine the foliated area within the crown outline and estimate the transparency of the normally foliated area.

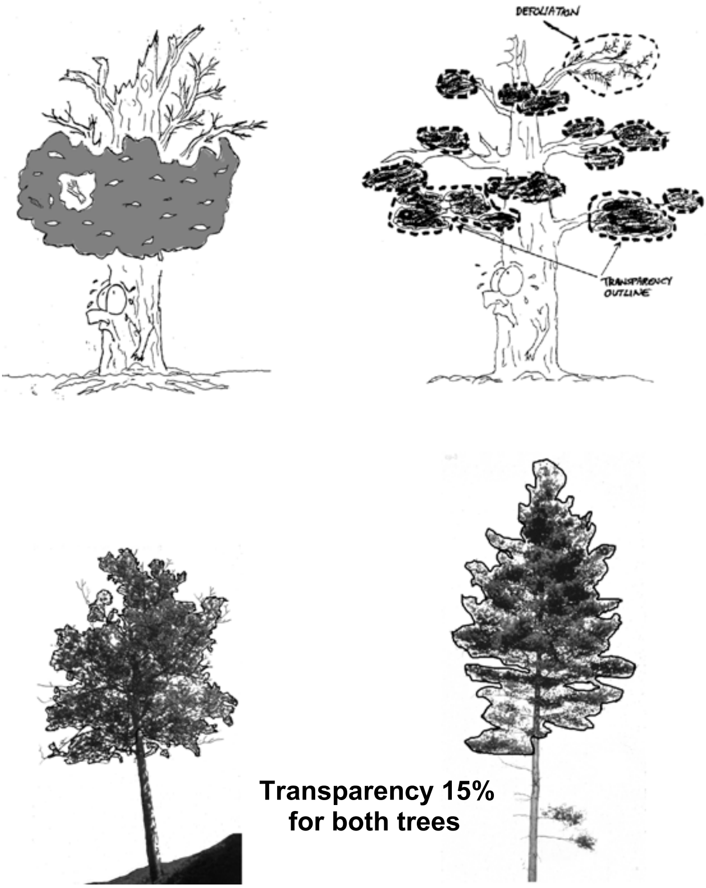


Figure 15. FOLIAGE TRANSPARENCY rating outline examples. (12-15)

When collected: All live trees ≥ 5.0 in DBH/DRC
Field width: 2 digits
Tolerance: +/- 10% (2 classes)
MQO: At least 90% of the time
Values:

Code	Definition	Code	Definition	Code	Definition
00	0%	35	31-35%	70	66-70%
05	1-5%	40	36-40%	75	71-75%
10	6-10%	45	41-45%	80	76-80%
15	11-15%	50	46-50%	85	81-85%
20	16-20%	55	51-55%	90	86-90%
25	21-25%	60	56-60%	95	91-95%
30	26-30%	65	61-65%	99	No crown

Note: Class code is the percentage of the upper limits of the class, i.e., Code 10 is 6% to 10%, etc.

1.12 ACKNOWLEDGEMENTS (Core 12.12)

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CHAPTER 2
DOWN WOODY MATERIAL

2.0 INTRODUCTION (CORE 14.0)

Down woody materials (DWM) are an important component of forest ecosystems across the country. DWM is dead material on the ground in various stages of decay. Wildlife biologists, ecologists, mycologists, foresters, and fuels specialists are some of the people interested in DWM because it helps describe the:

- Quality and status of wildlife habitats.
- Structural diversity within a forest.
- Fuel loading and fire behavior.
- Carbon sequestration – the amount of carbon tied up in dead wood.
- Storage and cycling of nutrients and water – important for site productivity.

Down woody components and fuels estimated by the FIA program are: coarse woody, fine woody, litter, herb/shrubs, slash, duff, and fuelbed depth. Any crew member can learn to collect down woody materials data. If untrained members of the crew are available to help, they can locate, measure, and flag transect lines and record the condition class information for the transect segments.

DWM is only sampled in accessible forest conditions intersected by the transect. If a transect crosses a nonforest condition, the boundaries of the condition are recorded (see section 2.3) but no DWM or fuels measurements are taken along this portion of the transect. The majority of DWM in the inventory is sampled using the line intersect sampling method (also called planar intercept method). In this method, transects are established, and individual pieces of CWD or FWD are tallied if the central axis of the piece is intersected by the plane of the transect. In addition, each piece must meet specified dimensions and other criteria before being selected for tally. Special procedures apply when a CWD piece lays across a condition class boundary (section 2.2). Transects will always be used to sample FWD. Transects will be used to sample CWD when crews are able to see and measure individual pieces.

The line intersect method is not practical for sampling CWD when it is part of machine-piled windrows or slash piles, or part of log "jumbles" at the bottom of steep-sided ravines. In these situations, individual pieces are impractical to tally separately and are labeled as “residue piles”. A different sampling method is used to tally and measure CWD residue piles (see section 2.8, Sampling Residue Piles).

2.1 DEFINITION OF DOWN WOODY MATERIALS (CORE 14.1)

CWD – In this inventory, CWD includes downed, dead tree and shrub boles, large limbs, and other woody pieces that are severed from their original source of growth and on the ground. CWD also includes dead trees (either self-supported by roots, severed from roots, or uprooted) that are leaning > 45 degrees from vertical. Also included are non-machine processed round wood such as fence posts and cabin logs. For multi-stemmed woodland trees such as juniper, only tally stems that are dead, detached, and on the ground; or dead and leaning > 45 degrees from vertical.

CWD does not include:

1. Woody pieces < 3.0 inches in diameter at the point of intersection with the transect.
2. Dead trees leaning 0 to 45 degrees from vertical.
3. Dead shrubs, self-supported by their roots.
4. Trees showing any sign of life.
5. Stumps that are rooted in the ground (i.e., not uprooted).
6. Dead foliage, bark or other non-woody pieces that are not an integral part of a bole or limb. (Bark attached to a portion of a piece is an integral part).
7. Roots or main bole below the root collar.

FWD – In this inventory, FWD includes downed, dead branches, twigs, and small tree or shrub boles that are not attached to a living or standing dead source. FWD can be connected to a larger branch, as long as this branch is on the ground and not connected to a standing dead or live tree. Only the woody branches, twigs, and fragments that intersect the transect are counted. FWD can be connected to a down, dead tree bole or down, dead shrub. FWD can be twigs from shrubs and vines. FWD must be no higher than 6 feet above the ground to be counted.

FWD does not include:

1) Woody pieces ≥ 3.0 inches in diameter at the point of intersection with the transect.
2) Dead branches connected to a live tree or shrub; or to a standing dead tree or dead shrub.
3) Dead foliage (i.e., pine or fir needles, or leaf petioles).
4) Bark fragments or other non-woody pieces that are not an integral part of a branch, twig, or small bole.
5) Small pieces of decomposed wood (i.e., chunks of cubical rot)

2.2 LOCATING AND ESTABLISHING LINE TRANSECTS (CORE 14.2)

Transects are established on each subplot if the subplot center is accessible (i.e., not census water, access denied, or hazardous), and there is at least one forest land condition class mapped within the 24.0-foot radius subplot (CONDITION CLASS STATUS = 1). Transects begin at the subplot center and extend 24.0 feet to the edge of the subplot. The location of condition class boundaries are recorded along the transect. It is extremely important to lay out the transect in a straight line to avoid biasing the selection of pieces and to allow the remeasurement of transect lines and tally pieces for future change detection.

Transect lines should be marked with a pin or small piece of flagging at the end of the line (24.0 feet, horizontal distance) to help the QA staff identify the path of the transect during the check-plot procedure. Because the tolerance for the transect azimuth is +/- 2 degrees, the line might have been laid down in a slightly different direction from the check-plot crew. This could affect the location of diameter measurements for CWD pieces as well as identifying whether a CWD piece is a valid tally piece. It is also helpful to mark the point where the FWD transect begins (14 feet, slope distance).

2.2.1 CWD transects (Core 14.2.1)

Three transects are established that originate at the subplot center and extend out 24.0 feet horizontal distance (the radius of the subplot) at azimuths of 30, 150, 270 degrees (Figure 16). This transect configuration was chosen to avoid sampling bias on sloped land, where it is possible that CWD may be oriented in one direction. This configuration of transects should pick up CWD logs that are lying parallel to the slope, perpendicular to the slope, and across slope.

2.2.2 FWD transects (Core 14.2.2)

One transect is established on each subplot, along the 150 degree azimuth. FWD is tallied within 3 size classes. Because FWD is generally present in higher densities, a shorter transect will pick up an acceptable amount of tally. The transect begins at 14 feet (slope distance) from the subplot center and extends out either 6 or 10 feet (slope distance) depending on the FWD size class, as follows:

Category of FWD	Size Class	Diameter range	Transect length (slope distance)	Transect location (slope distance)
Small FWD	1	0 in to 0.24 in	6 feet	14 to 20 feet
Medium FWD	2	0.25 in to 0.9 in	6 feet	14 to 20 feet
Large FWD	3	1.0 in to 2.9 in	10 feet	14 to 24 feet

Note that the FWD transects are slope distance not horizontal distance. The formulas used to estimate biomass from the data contain an adjustment for slope. It is helpful to have a size gauge available until your eye is 'trained' to recognize the 3 size classes. Examples include a plastic or cardboard card with 3 notches cut for each size class, or a set of 3 dowels representing each size class.

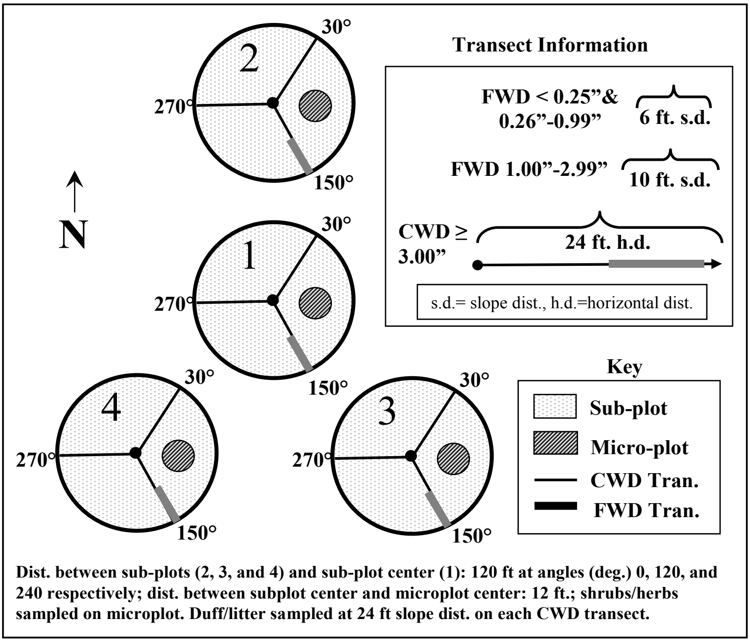

Figure 16. Plot layout for sampling CWD, FWD, and fuels. (14-1)

2.3 TRANSECT LINE SEGMENTING (Core 14.3)

Transect lines are segmented to determine the length of transect that occurs within each mapped condition class intersecting the line. A segment is a length of transect that is in one condition. Segments are identified by recording the BEGINNING DISTANCE and ENDING DISTANCE of the slope from subplot center out to the end of the subplot. In the office, the segmenting data will be combined with CWD distances to determine which condition class each piece falls in (condition classes are not assigned to CWD pieces in the field). If more than one condition is found on the FWD transects, the segmenting information recorded here will provide the length of transect in each condition.

Starting at the subplot center and working towards the fixed radius plot boundary, each segment of transect line in a different condition class is delineated and recorded as a separate record. On each record, the BEGINNING DISTANCE and ENDING DISTANCE of the slope are recorded for each condition class encountered. The first record for each transect will have a BEGINNING DISTANCE of 0 feet. If only one condition class occurs on the transect line, only one segment is recorded. The transect must extend a total of 24.0 feet horizontal distance. If the entire 24.0-foot subplot is nonforest, enter codes for SUBPLOT NUMBER, TRANSECT, CONDITION CLASS NUMBER, followed by zeros in the remaining fields.

On subplots where a transect intersects a boundary between condition classes, the transect continues across the boundary into the adjacent class (Figure 17). Although DWM is only sampled in accessible forest conditions, all CONDITION CLASS BOUNDARIES (BEGINNING DISTANCE and ENDING DISTANCE) are recorded on each transect.

Individual pieces of DWM intersected by a transect are tallied or counted if they meet the tally rules for CWD or FWD specified in the sections that follow. It is expected that the majority of FWD transects will be in one condition, but if the condition class changes along the transect, a count is recorded for each condition. Again, the segmenting data recorded here will identify which condition class is associated with each count.

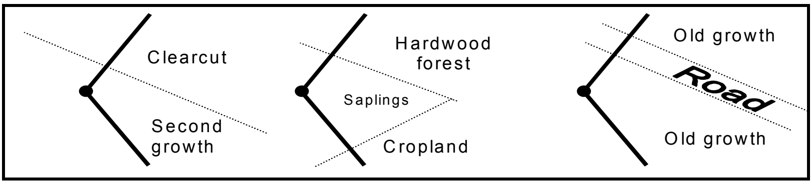

Figure 17. Transects are installed across condition class boundaries. (14-2)

2.3.1 SUBPLOT NUMBER (Core 14.3.1)

Record the code indicating the subplot center from which the transect originates.

When collected: All tally segments
Field width: 1 digit
Tolerance: No errors
MQO: At least 99% of the time
Values: 1 to 4

1	Center subplot
2	North subplot
3	Southeast subplot
4	Southwest subplot

2.3.2 TRANSECT (Core 14.3.2)

Record the code indicating the transect on which a condition class is being delineated. The three transects used are 30 degrees, 150 degrees, and 270 degrees. These transects, when being installed, have a tolerance of +/- 2 degrees.

When Collected: All tally segments
Field width: 3 digits
Tolerance: No errors
MQO: At least 99% of the time
Values:

030	Transect extends 30 degrees from subplot center
150	Transect extends 150 degrees from subplot center
270	Transect extends 270 degrees from subplot center

2.3.3 CONDITION CLASS NUMBER (Core 14.3.3)

Record the code indicating the number of the condition class for the transect segment. Use the same code assigned to the condition class on the subplot or elsewhere on the plot. The first segment recorded for each transect will have the same CONDITION CLASS NUMBER as assigned to the subplot center.

When collected: All tally segments
Field width: 1 digit
Tolerance: No errors
MQO: At least 99% of the time
Values: 1 to 9

2.3.4 BEGINNING DISTANCE (Core 14.3.4)

Record the location (using slope distance) on the transect line where the transect intersects the boundary with the adjacent condition class nearer to the subplot center. The first record for each transect will have a BEGINNING DISTANCE of 00.0 ft. Each subsequent record will have a BEGINNING DISTANCE equal to the ENDING DISTANCE of the previous record. Measure to the nearest 0.1 ft.

When collected: All tally segments
Field width: 3 digits
Tolerance: +/- 1.0 ft
MQO: At least 95% of the time
Values: 00.0 to 99.9

2.3.5 SLOPE PERCENT (Core 14.3.5)

Record the code indicating the average slope percent along the transect within the condition class being segmented. When only one condition class is present on a transect, slope percent is the average slope percent along the entire transect. Measure to the nearest 5%.

When collected: All tally segments
Field width: 3 digits
Tolerance: +/- 10%
MQO: At least 90% of the time
Values: 005 to 155

2.3.6 ENDING DISTANCE (Core 14.3.6)

Record the location (using slope distance) on the transect line where the transect exits the condition class being delineated and intersects the boundary with a different condition class further away from the subplot center. If no other condition classes are encountered, record the location (using slope distance) of the end of the transect line. Measure to the nearest 0.1 foot.

When collected: All tally segments
Field width: 3 digits
Tolerance: +/- 1.0 ft
MQO: At least 95% of the time
Values: 00.1 to 99.9

2.4 SAMPLING METHODS FOR COARSE WOODY DEBRIS (CWD) (CORE 14.4)

2.4.1 Tally Rules for Coarse Woody Debris (CWD) (Core 14.4.1)

1. Coarse woody debris (CWD) is sampled in accessible forest land conditions only.
   Tally a piece if its central longitudinal axis intersects the transect, and the condition class is accessible forest land at the point of intersection (Figure 18). The entire piece is assigned to this condition.

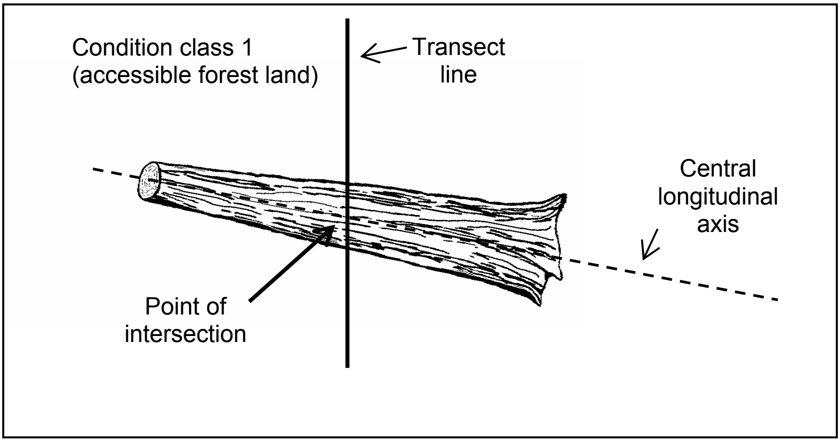

Figure 18. Tally rules for CWD. (14-3)

2. Tally dead trees and tall stumps that are leaning > 45 degrees from vertical. Do not tally live trees or standing dead trees and stumps that are still upright and leaning < 45 degrees from vertical. Follow the same rules for down trees as outlined in section 5.0 'Tree and Sapling Data' from the P2 field guide. Most CWD will be laying on the ground.

3. The minimum length of any tally piece is 3.0 feet. When CWD pieces are close to 3 feet, measure the length to the nearest 0.1 f00t to determine if it is ≥3.0 feet.

4. Decay class of the piece determines whether or not the piece is tallied (see section 2.4.3.4).

   <u>For decay classes 1 to 4</u>: tally a piece if it is ≥ 3.0 inches in diameter at the point of intersection with the transect. The piece must be ≥ 3.0 feet in

length and $\geq$ 3.0 inches or more in diameter along that length. If the intersect diameter is close to 3.0 inches, measure the diameter to the nearest 0.1 inch to determine if the piece qualifies (Figure 19).

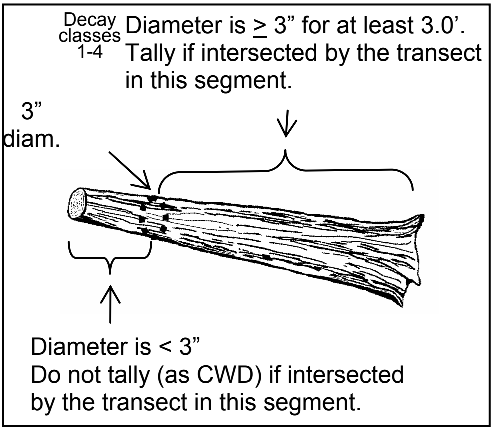

Figure 19. CWD tally rules for decay classes 1-4. (14-4)

For decay class 5: tally a piece if it is $\geq$ 5.0 inches in diameter at the point of intersection and $\geq$ 5.0 inches high from the ground. The piece must be $\geq$ 3.0 feet in length and $\geq$ 5.0 inches or more in diameter along that length. The reason for treating decay class 5 pieces differently is because they are difficult to identify, especially when heavily decomposed. Only pieces that still have some shape and log form are tallied—humps of decomposed wood that are becoming part of the duff layer are not tallied.

5. Tally pieces created by natural causes (examples: natural breakage or uprooting) or by human activities such as cutting only if not systematically machine-piled. Do not record pieces that are part of machine-piled slash piles or windrows, or that are part of a log "jumble" at the bottom of a steep-sided ravine in which individual pieces are impractical to tally separately. Instead, sample these piles according to instructions in section 3.8 'Sampling Residue Piles'. A slash pile or windrow consists of broken logs, limbs, and other vegetative debris.

6. Tally a piece only if the point of intersection occurs above the ground. If one end of a piece is buried in the litter, duff, or mineral soil, the piece ends at the point where it is no longer visible. Measure the diameter and length at this point.

7. If the central longitudinal axis of a piece is intersected more than once on a transect line or if it is intersected by two transect lines, tally the piece each time it is intersected (uncommon situation, see Figure 20).

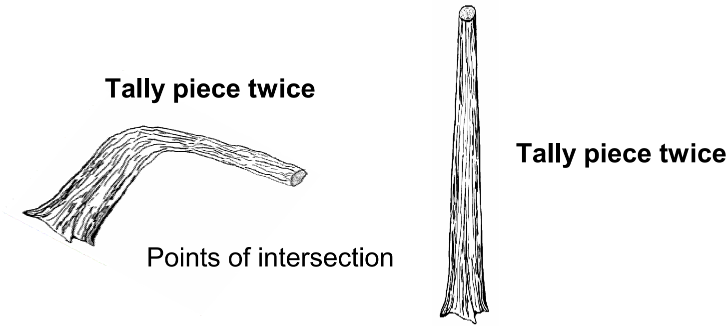

Figure 20. CWD tally rules: intersections. (14-5)

8. Tally a piece only once if the subplot center falls directly on the central longitudinal axis of the piece. Tally the piece on the 30 degree transect and record the CWD Distance as 001.

9. If a piece is fractured across its diameter or length, and would pull apart at the fracture if pulled from either end or sides, treat it as two separate pieces. If judged that it would not pull apart, tally as one piece. Tally only the pieceintersected by the transect line.

10. Do not tally a piece if it intersects the transect on the root side of the root collar. Do not tally roots.

11. When the transect crosses a forked down tree bole or large branch connected to a down tree, tally each qualifying piece separately. To be tallied, each individual piece must meet the minimum diameter and length requirements.

12. In the case of forked trees, consider the "main bole" to be the piece with the largest diameter at the fork. Variables for this fork such as TOTAL LENGTH and DECAY CLASS should pertain to the entire main bole. For smaller forks or branches connected to a main bole (even if the main bole is not a tally piece), variables pertain only to that portion of the piece up to the point where it attaches to the main bole (see Figure 21).

13. If a transect intersects a nonforest condition (e.g., a road), no CWD is tallied.

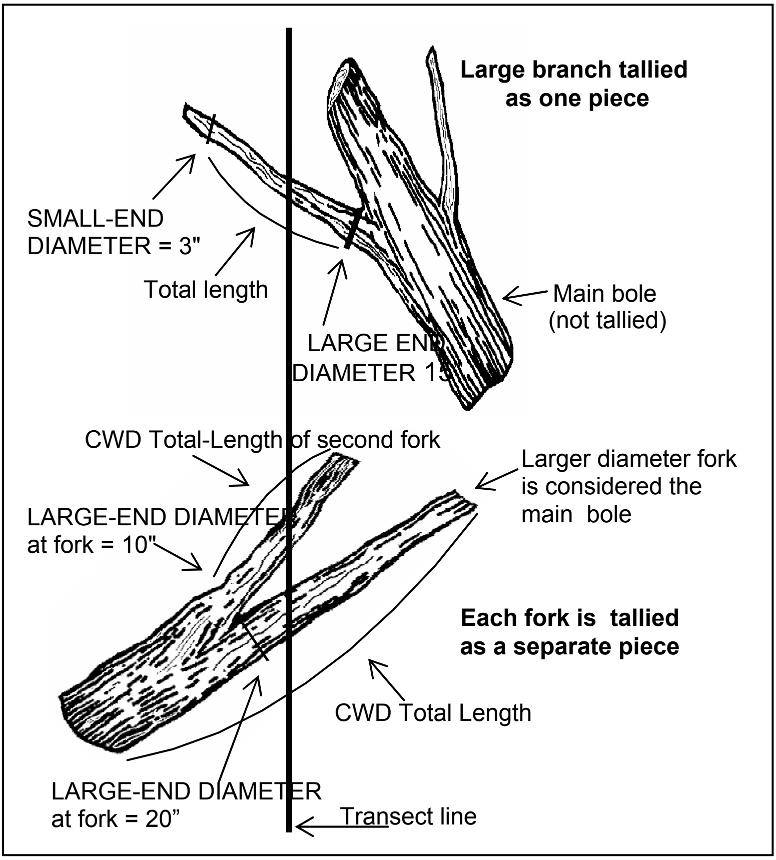

Figure 21. CWD tally rules for forked trees. (14-6)

2.4.2 Marking CWD (Core 14.4.2)

Marking CWD is optional. Marked CWD is an aid to future crews returning to the plot for a QA check or to remeasure the plot at the next remeasurement period. Nails can be used to mark the location of the point of intersection, if the piece is in decay class 1, 2, or 3. Position the nail on top of the piece, and if possible, drive the nail into the piece so that about 1 inch of the nail is left exposed. Stop driving the nail if the next blow means breaking the piece or seriously disturbing the location of the piece. Please see section 2.3 Transect Line Segmenting, for information on the required marking of the transect line.

2.4.3 Recording Procedures for CWD (Core 14.4.3)

The tolerance for the total number of pieces (≥ 3 inches, transect diameter) tallied across all transects on the plot is : +/- 2 piece or +/- 5%, whichever is greater for the plot. Note: always round up to a whole piece count when using the 5% option.

2.4.3.1 SUBPLOT NUMBER (Core 14.4.3.1)

Record the code indicating the number of the subplot center from which the transect originates.

When collected: All tally pieces
Field width: 1 digit
Tolerance: No errors
MQO: At least 99% of the time
Values: 1 to 4

1	Center subplot
2	North subplot
3	Southeast subplot
4	Southwest subplot

2.4.3.2 TRANSECT (Core 14.4.3.2)

Record the code indicating the azimuth of the transect on which the piece is sampled.

When Collected: All tally pieces
Field width: 3 digits
Tolerance: No errors
MQO: At least 99% of the time
Values:

030	Transect extends 30 degrees from subplot center
150	Transect extends 150 degrees from subplot center
270	Transect extends 270 degrees from subplot center

2.4.3.3 CWD SLOPE DISTANCE (Core 14.4.3.3)

Record the code indicating the slope distance from the subplot center to the point where the transect intersects the longitudinal center of the piece. If two or more pieces have the same slope distances, record the top piece first. Measure and record to the nearest 0.1 feet. CWD SLOPE DISTANCE is an important item because it will be used to assign the CWD piece to a condition class by comparing the recorded distance to the piece with the recorded BEGINNING DISTANCE and ENDING DISTANCE to the condition class boundary. CWD SLOPE DISTANCE is also used to locate the piece for QA and remeasurement in future inventories.

When Collected: All tally pieces
Field width: 3 digits
Tolerance: +/- 1.0 ft
MQO: At least 90% of the time
Values: 00.1 to 99.9

2.4.3.4 CWD DECAY CLASS (Core 14.4.3.4)

Record a 1-digit code indicating the decay class of the piece. Code the decay class which predominates along the recorded CWD TOTAL LENGTH (3.4.3.7) of the piece. Use the guide below to determine CWD DECAY CLASS.

When Collected: All tally pieces
Field width: 1 digit
Tolerance: +/- 1 class
MQO: At least 90% of the time
Values:

Decay Class	Structural Integrity	Texture of Rotten Portions	Color of Wood	Invading Roots	Branches and Twigs
1	Sound, freshly fallen, intact logs	Intact, no rot; conks of stem decay absent	Original color	Absent	If branches are present, fine twigs are still attached and have tight bark
2	Sound	Mostly intact; sapwood partly soft (starting to decay) but can't be pulled apart by hand	Original color	Absent	If branches are present, many fine twigs are gone and remaining fine twigs have peeling bark
3	Heartwood sound; piece supports its own weight	Hard, large pieces; sapwood can be pulled apart by hand or sapwood absent	Reddish-brown or original color	Sapwood only	Branch stubs will not pull out
4	Heartwood rotten; piece does not support its own weight, but maintains its shape	Soft, small blocky pieces; a metal pin can be pushed into heartwood	Reddish or light brown	Through-out	Branch stubs pull out
5	None, piece no longer maintains its shape, it spreads out on ground	Soft; powdery when dry	Red-brown to dark brown	Through-out	Branch stubs and pitch pockets have usually rotted down

Note: CWD DECAY CLASS 5 pieces can be difficult to identify because they often blend into the duff and litter layers. They must still resemble a log, therefore, the first tally rule is that they must be > 5.0 inches in diameter, > 5.0

inches from the surface of the ground, and at least 3.0 feet long. Decomposed logs that are slightly elevated 'humps' on the ground are not tallied.

CWD DECAY CLASS: The chart above was developed primarily for Douglas-fir in the Pacific Northwest. At the present time, there are no other charts available to use to describe decay classes for other species or locations. Concentrate on the structural integrity and texture when estimating a decay class for CWD logs.

If a log is case hardened (hard, intact outer sapwood shell) but the heartwood is rotten, code this log as a CWD DECAY CLASS 2 with a HOLLOW PIECE code of 1. CWD DECAY CLASS 1 should be reserved for 'freshly fallen' logs that are completely intact (i.e., recent windfalls, or harvest).

2.4.3.5 SPECIES (Core 14.4.3.5)

Record the code indicating the species of the piece. Species codes are the same as those used in P2 (see TREE SPECIES list of the P2 field guide). Because CWD includes the tally of large shrub boles and woody vines, enter a code of '0001' for SPECIES if the tally piece is a shrub or vine.

Species identification may be uncertain for some pieces. The piece's bark (either attached or sloughed and laying beside the piece), branching pattern (if the branches are still present), or heartwood smell (particularly if cedars, Douglas-fir, or western hemlock) may provide clues. On remeasurement plots, see what tree species were tallied in past inventories. One way to distinguish hardwoods from softwoods is by the type of decay present. Hardwoods usually have a white or grayish stringy rot, while softwoods usually have a reddish-brown blocky rot. If it is not possible to identify the species, attempt to estimate if it is softwood or hardwood. Enter code 0299 for unknown conifer or 0998 for unknown hardwood. If all else fails, enter the unknown SPECIES code (0999).

When Collected: CWD DECAY CLASS = 1 to 4
Field width: 4 digits
Tolerance: No errors
MQO: At least 80% of the time
Values: See species codes in Appendix 3 of the P2 field guide.

2.4.3.6 Diameters (Core 14.4.3.6)

The diameter is most commonly measured by holding a tape above the log, at a position perpendicular to the length (Figure 22). It is useful to carry a steel carpenters retracting tape to measure diameters. Other methods include wrapping a tape around the bole if possible, holding a straight-edge ruler above the piece, or using calipers.

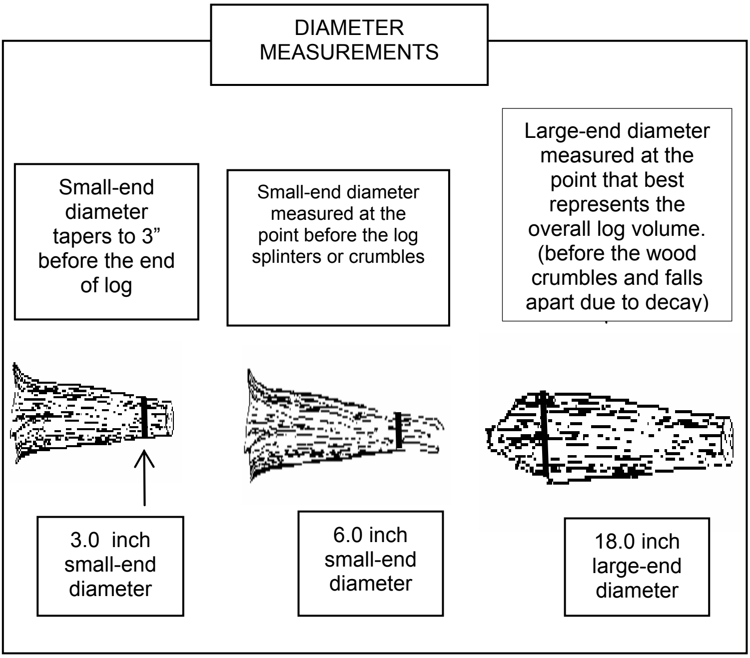

Figure 22. Diameter measurements (14-7)

For pieces that are not round in cross-section because of missing chunks of wood or "settling" due to decay, measure the diameter in two directions and take an average. Estimate the longest and shortest axis of the cross-section ("A" and "B" in Figure 23), and enter the average in the diameter field. This technique applies to intersect, small-end, and large-end diameters.

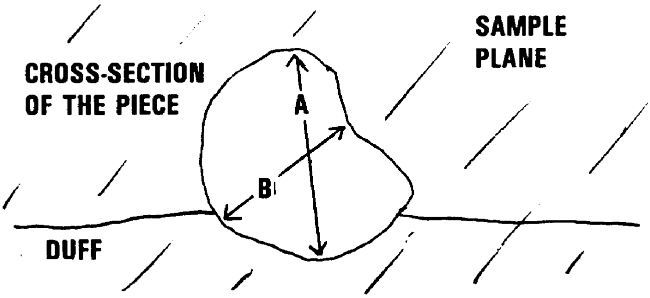

Figure 23. Estimating the diameter of pieces that are not round in cross-section. (14-8)

If the transect intersects the log at the decayed or splintered end (Figure 24) (i.e., the portion where we do not consider it part of the log because it is falling apart), record the diameter at this location as the intersect diameter, but record the large end and small end diameter according to our established rules (i.e., at the points where they best represent the log volume). If the splintered end appears to be two separate pieces (i.e., a major split located just at the end) – in this situation treat it as one log and take a diameter around the end (take two measurements if it is odd shaped). Length would be measured between the large and small end diameters.

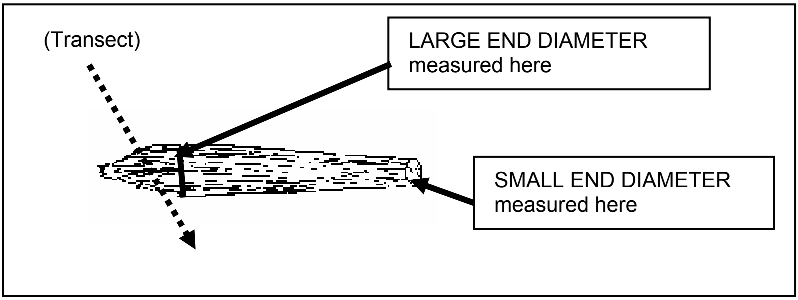

Figure 24. Example of decayed end intersecting the transect (14-9)

2.4.3.6.1 DIAMETER AT POINT OF INTERSECTION (Core 14.4.3.6.1)

Record the code indicating the piece's diameter at the point where the transect intersects the longitudinal center of the piece. If the diameter is close to 3 inches, measure the diameter to the nearest 0.1 inch to determine if the piece is actually ≥3.0 inches and a valid tally piece. The diameter is recorded to the nearest inch.

When Collected: All tally pieces
Field width: 3 digits
Tolerance: Pieces < 20.0 in diameter: +/- 3 in
Pieces ≥ 20.0 in diameter: +/- 20%
MQO: At least 90% of the time
Values: 003 to 200

2.4.3.6.2 DIAMETER AT THE SMALL END (Core 14.4.3.6.2)

Record the code indicating the diameter at the piece's small end. The diameter is recorded to the nearest inch. The DIAMETER AT THE SMALL END occurs either at (1) the actual end of the piece, if the end has a diameter ≥ 3.0 inches, or (2) at the point where the piece tapers down to 3.0 inches in diameter. If the end is splintered or decomposing (sloughing off), measure the diameter at the point where it best represents the overall log volume. Use the same measuring procedures described in 2.4.3.6.1 (see Figure 22).

When Collected: CWD DECAY CLASS = 1 to 4
Field width: 3 digits
Tolerance Pieces < 20.0 in diameter: +/- 2 in
Pieces ≥ 20.0 in diameter: +/- 10%
MQO: At least 90% of the time
Values: 003 to 200

2.4.3.6.3 DIAMETER AT THE LARGE END (Core 14.4.3.6.3)

Record the code indicating the diameter at the piece's large end. The diameter is recorded to the nearest inch. The large end will occur either at a broken or sawn end, at a fracture, or at the root collar. If the end is splintered or decomposing (sloughing off), measure the diameter at the point where it best represents the overall log volume. Use the same measuring procedures used for 2.4.3.6.1.

When Collected: CWD DECAY CLASS = 1 to 4
Field width: 3 digits
Tolerance: Pieces < 20.0 in diameter: +/- 2 in
Pieces ≥ 20.0 in diameter: +/- 15%

MQO: At least 90% of the time
Values: 003 to 200

2.4.3.7 CWD TOTAL LENGTH (Core 14.4.3.7)

Record the code indicating the total length of the piece. CWD TOTAL LENGTH is the length of the piece that lies between the piece's recorded DIAMETER AT THE SMALL END AND DIAMETER AT THE LARGE END (2.4.3.6.2 & 2.4.3.6.3). For DECAY CLASS = 5, DIAMETER AT THE SMALL END AND DIAMETER AT THE LARGE END are not recorded for a log, therefore the length is measured between the two physical ends of the log. For curved logs, measure along the curve. The minimum log length is 3.0 feet before it is a valid tally log. When the length is close to 3.0 feet, measure the length to determine if the piece is actually ≥3.0 feet. CWD TOTAL LENGTH is recorded to the nearest foot.

When Collected: All tally pieces
Field width: 3 digits
Tolerance: + / - 20%
MQO: At least 90% of the time
Values: 003 to 250

2.4.3.8 IS THE PIECE HOLLOW? (Core 14.4.3.8)

Record the code indicating whether or not the piece is hollow (see Figure 25).

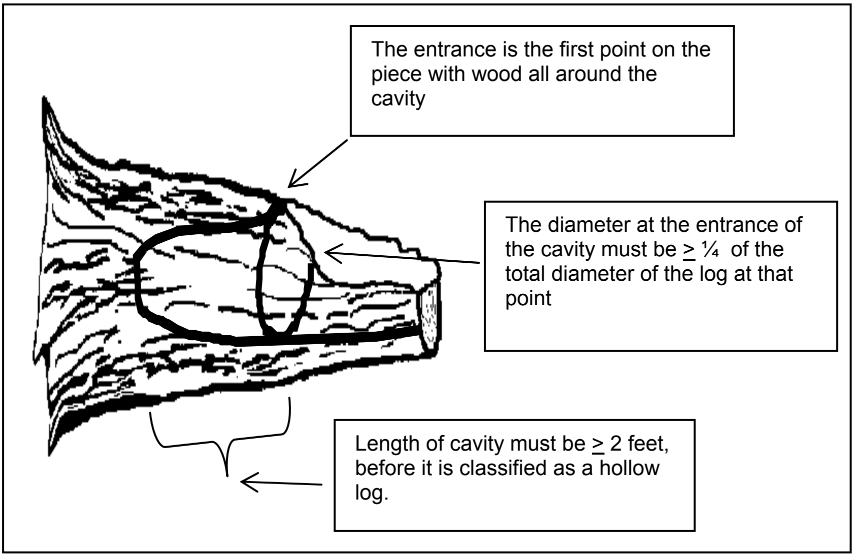

Figure 25. Determining if the piece is hollow. (14-10)

When Collected: CWD DECAY CLASS = 1 to 4
Field width: 1 digit
Tolerance: No errors
MQO: At least 90% of the time

Values:

- Y A piece is considered hollow if a cavity extends at least 2 feet along the central longitudinal axis of the piece, and the diameter of the entrance to the cavity is at least 1/4 of the diameter of the piece where the entrance occurs. The entrance occurs at the point where the circumference of the cavity is whole -- the point where wood is present completely around the circumference of the cavity. The length of the cavity begins at this point.
- N Does not meet criteria for being a hollow log

2.4.3.9 CWD HISTORY (Core 14.4.3.9)

Record the code that indicates whether or not the piece of CWD is on the ground as a result of harvesting operations or as a result of natural circumstances. One objective of this item is to identify those pieces that are considered logging residue. If the piece appears to have fallen to the ground as a result of natural causes such as decomposition or windfall, enter a code of 1. This category would include blown out tops, snapped off boles, wind-fallen trees on clearcut edges, and trees that basically collapsed and fell over due to decomposition.

If the piece is on the ground as a result of recent (since last annual remeasurement; if the plot is new, the time between the panel remeasurements) harvesting activity, either because the tree was cut down with a chainsaw (or other device) or pushed over by harvesting equipment (bulldozer), enter a code of 2. A code of 2 would be considered logging residue (usually you are in the middle of a recent clearcut).

If the piece is on the ground as a result of older (more than 15 years) harvesting activity, enter a code of 3. This would be a situation where you tally an old decomposing log that has a sawn end – if it appears that the log was cut and left on site, then enter a code of "3".

If a piece is on the ground as a result of incidental harvest (such as a standing tree was cut for firewood or small clearing), enter a code of "4". Incidental harvest involves a few trees and is not a part of a major organized harvesting operation.

If the crew cannot decide the history of the CWD log, classify it as "unknown", and give it a code of "5".

When Collected: CWD DECAY CLASS = 1 to 4
Field width: 1 digit
Tolerance: No errors
MQO: At least 90% of the time
Values:

1	CWD piece is on the ground as a result of natural causes
2	CWD piece is on the ground as a result of major recent harvest activity (<= 15 yrs old)
3	CWD piece is on the ground as a result of older harvest activity (> 15 yrs old)
4	CWD piece is on the ground as a result of an incidental harvest (such as firewood cutting)
5	Exact Reason Unknown

2.5 SAMPLING METHODS FOR FINE WOODY DEBRIS (FWD) (CORE 14.5)

1. Fine Woody Debris (FWD) is sampled in accessible forest land conditions. The length of FWD transects are measured in slope distance--no correction is applied to obtain a horizontal distance. The FWD transects start at 14.0 feet slope distance and extend for 6.0 or 10.0 feet slope distance. Estimates of FWD biomass calculated in the office, will include a slope correction factor obtained from the transect segmenting data on the subplot.

2. Only sample FWD that intersects a plane from the ground to a height of 6 feet.

3. FWD is sampled in three size classes, on the 150 degree azimuth transect. Two of the FWD size classes (0.01 to 0.24 inches and 0.25 to 0.9 inches) are counted on a 6-foot transect, from 14 to 20 feet. Pieces in the third size class (1.0 to 2.9 inches) are counted on a 10-foot transect, from 14 to 24 feet (see section 14.2 for details on transects). These transects overlap. Note: individual diameters are not recorded for FWD.

4. Count a piece of FWD if it intersects the transect, and the condition class is accessible forest land at the point of intersection. Only count a piece if the twig, branch, wood fragment, or shrub/tree bole are woody. Do not count pine or fir needles or non-woody parts of a tree or shrub.

5. Accumulate the number of pieces counted within each size class and enter the total count on one record for the subplot (unless there are >1 condition classes). If there is no tally on a transect, enter zeros for the count.

6. Accurate counts of FWD can be conducted efficiently up to about 50 pieces for small and medium size classes, and up to 20 pieces for the large size class. After that, crews can begin estimating counts in a systematic fashion. Transects that fall on very dense FWD where counting is nearly impossible, can be subsampled and calculated. For example, an accurate count can be conducted on a 2.0-foot section of the transect and then multiplied by 3 to provide an estimate for the 6 foot transect, as long as the crew feels that the remaining transect has a similar density of FWD pieces.

7. If a transect intersects a large pile of material such as a wood rat's nest or a recently fallen tree (with many attached fine branches), crews should estimate a count based on #6 above, but also enter a code indicating that this is an unusual situation (see section 2.5.6).

8. If rocks, logs, or other obstructions are present along the transect (14- to 24-foot section) include any FWD that is present on top of these obstructions in the respective FWD counts. If the obstructions are so large (huge boulder) that the top surface cannot be seen, assume the count is zero in this area, and continue counting if there is transect line beyond the boulder.

9. If a residue pile intersects the FWD transect at any point along the 14- to 24-foot section, do not measure FWD on this transect. It is too subjective determining exact boundaries of the pile, and how they relate to the exact point on the transect line. To identify this situation, code 1 in RESIDUE PILE ON TRANSECT which indicates that a residue pile has intersected the transect line.

10. If a transect crosses a condition class boundary, record the CONDITION CLASS NUMBER and enter a count for each condition on separate records. Transect lengths within each condition class will be obtained from the transect segmenting data entered for the subplot.

2.5.1 SUBPLOT NUMBER (Core 14.5.1)

Record the code indicating the subplot center from which the transect originates.

When collected: All tally segments
Field width: 1 digit
Tolerance: No errors
MQO: At least 99% of the time

Values: 1 to 4

1	Center subplot
2	North subplot
3	Southeast subplot
4	Southwest subplot

2.5.2 CONDITION CLASS NUMBER (Core 14.5.2)

Record the code indicating the number of the condition class that pertains to the FWD count.

When collected: All tally segments
Field width: 1 digit
Tolerance: No errors
MQO: At least 99% of the time
Values: 1 to 9

2.5.3 SMALL FWD COUNT (14.5.3)

Record the number of pieces counted in this size class (0.01 to 0.24-inch diameter) along the transect segment. An accurate count should be conducted up to 50 pieces. If the count exceeds 50, the transect can be subsampled to estimate a total count for the transect segment (see 2.5, #6)

When collected: On the 150 degree transect in CONDITION CLASS STATUS = 1
Field width: 3 digits
Tolerance:0 to 50 = +/- 20% of the total count for the transect
51 to 100 = +/- 25% of the total count for the transect
100 + = +/- 50% of the total count for the transect
MQO: At least 90% of the time
Values: 000 to 999

2.5.4 MEDIUM FWD COUNT (Core 14.5.4)

Record the number of pieces counted in this size class (0.25 to 0.9-inch diameter) along the transect segment. An accurate count should be conducted up to 50 pieces. If the count exceeds 50, the transect can be subsampled to estimate a total count for the transect segment (see 2.5, #6)

When collected: On the 150 degree transect in CONDITION CLASS STATUS = 1
Field width: 3 digits
Tolerance: +/- 20% of the total count for the transect
MQO: At least 90% of the time
Values: 000 to 999

2.5.5 LARGE FWD COUNT (Core 14.5.5)

Record the number of pieces counted in this size class (1.0 to 2.9 inch diameter) along the transect segment. An accurate count should be conducted up to 20 pieces. If the count exceeds 20, the transect can be subsampled to estimate a total count for the transect segment (see section 2.5, #6).

When collected: On the 150 degree transect in CONDITION CLASS STATUS = 1
Field width: 3 digits
Tolerance: +/- 20% of the total count for the transect
MQO: At least 90% of the time
Values: 000 to 500

3.5.6 HIGH COUNT REASON (Core 14.5.6)

Enter a code that applies to the situation encountered on the transect. Enter a code if any of the counts on a transect are greater than 100 pieces.

When Collected: When any count on the transect $\geq$100
Field width: 1 digit
Tolerance: No errors
MQO: At least 90% of the time
Values:

0 FWD is not unusually high

1 High count is due to an overall high density of FWD across the transect

2 Wood Rat's nest located on transect

3 Tree or shrub laying across transect

4 Other reason

2.5.7 RESIDUE PILE ON TRANSECT (Core 14.5.7)

Enter a code that indicates whether a residue pile intersects the FWD transect segment. The default is always 0; crews will enter a 1 if the situation is encountered on the transect.

When Collected: On all FWD transects (between 14 and 24 ft)
Field width: 1 digit
Tolerance: No errors
MQO: At least 90% of the time
Values:

0 No
1 Yes

2.6 DUFF, LITTER, AND FUELBED DEPTH MEASUREMENTS (CORE 14.6)

Depth measurements are sampled in accessible forest land conditions. The depth of the duff layer, litter layer, and overall fuelbed are important components of fire models used to estimate fire behavior, fire spread, fire effects, and smoke production. These measurements are taken at the 24-foot location on each transect. An average depth will be calculated in the office and stored with other information about the condition class on the plot. If a residue pile, log, rock, or other obstruction intersects the transect at the 24-ft location, do not measure the duff or litter depth. But, do measure the fuelbed depth if the obstruction is a log or residue pile.

2.6.1 Definitions (Core 14.6.1)

1. Litter is the layer of freshly fallen leaves, needles, twigs (< 0.25 inch in diameter), cones, detached bark chunks, dead moss, dead lichens, detached small chunks of rotted wood, dead herbaceous stems, and flower parts (detached and not upright). Litter is the loose plant material found on the top surface of the forest floor. Little decomposition has begun in this layer.

Litter is flash fuel – so think about it as the loose material that is exposed to the air, capable of igniting quickly and carrying a fire across the surface of the forest floor.

Litter does not include bark that is still attached to a down log, or rotten chunks of wood that are still inside a decaying log or log end (i.e., if a decayed log end has a lot of rotten cubes or pieces laying on a log surface and exposed to air, they are considered part of the log and not litter – fire would burn differently if it hit a pile of rotten punky wood chips, cradled by the unrotted sapwood shell). If these rotten chunks have spilled out to the ground and are actually on the ground surface, then they would be included in the litter layer.

Litter does not include animal manure.

Microplot estimates: As you look down on the microplot, litter is the material that you see covering the surface area of the 6.8-foot radius plot.

2. Duff is the layer just below litter. It consists of decomposing leaves and other organic material. You should see no recognizable plant parts, the duff layer is usually dark decomposed organic matter. When moss is present, the top of the duff layer is just below the green portion of the moss. The bottom of this layer is the point where mineral soil (A horizon) begins.

3. The fuelbed is the accumulated mass of dead, woody material on the surface of the forest floor. It begins at the top of the duff layer, and includes litter, FWD, CWD, and dead woody shrubs. In this definition, the fuelbed does not include dead hanging branches from standing trees.

2.6.2 Overview of Measurements (Core 14.6.2)

Depth measurements will be taken at the 24-foot (slope distance) location on each transect. If a log, rock or other obstruction occurs at the sample location, do not measure duff or litter depth, regardless of what is on top of the obstruction. However, if the obstruction is a log, proceed with the fuelbed depth estimate.

The DUFF, LITTER, AND FUELBED SAMPLE variable has three options for indicating if duff, litter, and/or fuelbed were measured at each sample location. The default value for this variable is 1, indicating that all three variables were measured (duff, litter, and fuelbed). A value of 0 is entered if duff and litter were not sampled (obstruction), but fuelbed was sampled. A value of 2 is entered if none of the three (duff, litter, and the fuelbed) were sampled (i.e., submerged part of plot).

2.6.2.1 Duff and Litter (Core 14.6.2.1)

The duff layer is the organic material layer between the A-horizon (or uppermost soil mineral horizon) and the litter layer. The duff is a soil layer dominated by organic material derived from the decomposition of plant and animal litter (pine straw, leaves, twigs, etc) and deposited on either an organic or a mineral surface. This layer is distinguished from the litter layer in that the original organic material has undergone sufficient decomposition that the source of this material (e.g., individual plant parts) can no longer be identified. Litter is defined as undecomposed or only partially decomposed organic material that can be readily identified (e.g., plant leaves, twigs, etc.). As a general rule, duff depth should rarely exceed a few inches. Crews should be absolutely sure they are measuring deep duff depths, instead of mineral soil layers or parts of the litter layer. Duff can easily weigh more than 6 times that of litter. If unsure of the bottom of the duff layer, crews should feel the texture of the suspect material in their hand. Rub the soil between your fingers. Does it crumble (duff) or feel more like modeling clay (mineral).

Carefully expose a shallow profile of the forest floor by digging out an area at the sample point using a knife, hatchet, or other tool. Estimate the depth of each layer with a ruler to the nearest 0.1 inch. If there is a log, rock, or other obstruction on the surface at the sample point, do not measure the litter or duff depth (record DUFF, LITTER, AND FUELBED SAMPLE = 0 or 2, depending if fuelbed can be sampled) ; a value of 99.9 will be entered by the TALLY program for each depth.

As you dig the hole for this measurement, if you encounter a rock, root, or buried log – stop the depth measurement at this point.

The height of the litter should be measured at the top of the loose material located at the sample point on the transect. Try to preserve the conditions of this location by walking around this point, so the QA staff will measure the same height as the original crew.

2.6.2.2 Fuelbed (Core 14.6.2.2)

Measure the height of the fuelbed from the top of the duff layer (just below the litter) to the highest piece of woody debris found at the transect point. Round to the nearest 0.1 foot. If a rock or other obstruction (other than a log) occurs at the 24.0-foot sample location, do not measure fuelbed depth.

2.6.3 SUBPLOT NUMBER (Core 14.6.3)

Record the code indicating the number of the subplot center from which the transect originates.

When collected: All tally segments
Field width: 1 digit
Tolerance: No errors
MQO: At least 99% of the time
Values: 1 to 4

1	Center subplot
2	North subplot
3	Southeast subplot
4	Southwest subplot

2.6.4 TRANSECT (Core 14.6.4)

Record the code indicating the azimuth of the transect.

When collected: All tally segments
Field width: 3 digits
Tolerance: No errors
MQO: At least 99% of the time
Values:

030	Transect extends 30 degrees from subplot center
150	Transect extends 150 degrees from subplot center
270	Transect extends 270 degrees from subplot center

2.6.5 DUFF, LITTER, AND FUELBED SAMPLE (Core 14.6.5)

Record the code indicating if the depth of the duff and litter layer was measured.

When collected: At 24.0 ft on each transect
Field width: 1 digit
Tolerance: No errors
MQO: At least 99% of the time
Values:

0	Duff and litter depth not sampled; Fuelbed is sampled
1	All sampled: Duff, litter, and fuelbed
2	Nothing sampled; Duff, litter, fuelbed are not sampled

2.6.6 DUFF DEPTH (Core 14.6.6)

Record the code indicating the depth of the duff layer to the nearest 0.1 inch.

When collected: At 24.0 ft on each transect
Field width: 3 digits
Tolerance: +/- 0.5 inch
MQO: At least 90% of the time
Values: 00.0 to 99.9

2.6.7 LITTER DEPTH (Core 14.6.7)

Record the code indicating the depth of the litter layer to the nearest 0.1 inch.

When collected: At 24.0 ft on each transect
Field width: 3 digits
Tolerance: +/- 0.5 inch
MQO: At least 90% of the time
Values: 00.0 to 99.9

2.6.8 FUELBED DEPTH (Core 14.6.8)

Record the code indicating the depth of the fuelbed layer, to the nearest 0.1 foot. If the fuelbed depth is >0 and ≤ 0.1 foot enter 0.1foot. In this situation finer depth resolution will be obtained from the duff and litter measurements.

When collected: At 24.0 ft on each transect
Field width: 3 digits
Tolerance: +/- 20%
MQO: At least 90% of the time
Values: 00.0 to 99.9

2.7 FUEL LOADING ON THE MICROPLOT (CORE 14.7)

Another component of the total fuel loading on a plot is the biomass of live and dead understory material. The 6.8-foot radius microplot will be used to estimate the percent cover and height of live and dead shrubs, live and dead herbs (includes grasses) and litter. Fuel loading is estimated in accessible forest land conditions on the microplot. Enter one value for all forested conditions combined.

Shrubs are plants with woody stems, including woody vines. Herbs are non-woody herbaceous plants, but also include ferns, mosses, lichens, sedges, and grasses. Although many forbs and grasses will die by the end of the growing season, an estimate of live and dead biomass on a given date will help fire modelers predict the phenology of herbaceous material during the year, allowing them to estimate fire danger patterns across the landscape.

Percent cover is estimated for each of the five fuel categories (live shrubs, dead shrubs, live herbs, dead herbs, and litter) in 10-percent classes for the accessible forested conditions of the microplot. For live fuels, estimate the percent of the microplot area that is covered by live plant material. Include whole plants that are entirely green (or alive) and the live branches on plants that are a mixture of live and dead plant parts. Include live branches or leaves that extend into the microplot area from a plant that is actually rooted outside of the microplot. Do not include herbaceous material above 6 feet (i.e., moss, ferns, lichens, epiphytes that are growing in tree branches above 6 feet).

For dead fuels, estimate the percent cover using the same procedures as live fuels, but include plants that are entirely dead and branches or leaves that are dead but still attached to a live plant. Dead plant material must be clearly visible. Do not include dead material that has fallen to the ground. Cover estimates are made by visualizing an outline around the dead material (with all 'air' space included) and accumulating this across the forested microplot area.

An estimate of the total height of the shrub and herbaceous layers is also needed to calculate biomass and fuel loadings. Record a height estimate for each fuel category, except litter. Height is estimated for the tallest shrub on the microplot.

Microplot Cover Estimation Guide (Hint: 8.5" x 11" = about 0.5% coverage)

%	area (sq ft)	radius (ft)	square (ft)
1	1.45	0.68	1.20
10	14.52	2.15	3.81
20	29.04	3.04	5.39
30	43.56	3.72	6.60
40	58.08	4.30	7.62
50	72.60	4.81	8.52
60	87.12	5.27	9.33

70	101.64	5.69	10.08
80	116.16	6.08	10.78
90	130.68	6.45	11.43
100	145.2	6.80	12.05

2.7.1 SUBPLOT NUMBER (Core 14.7.1)

Record the code indicating the number of the subplot center from which the transect originates.

When collected: All microplots with at least one CONDITION CLASS STATUS = 1
Field width: 1 digit
Tolerance: No errors
MQO: At least 99% of the time
Values: 1 to 4

1	Center subplot
2	North subplot
3	Southeast subplot
4	Southwest subplot

2.7.2 LIVE SHRUB PERCENT COVER (Core 14.7.2)

Record the code for the cover class that indicates the percent cover of the forested microplot area covered with live shrubs.

When collected: All microplots with at least one CONDITION CLASS STATUS = 1
Field width: 2 digits
Tolerance: +/- 1 class
MQO: At least 85% of the time
Values:

00	Absent
01	Trace (< 1% cover)
10	1 – 10%
20	11-20%
30	21-30%
….	
90	81-90%
99	91-100%

2.7.3 LIVE SHRUB HEIGHT (Core 14.7.3)

Record the code indicating the height of the tallest shrub to the nearest 0.1 foot. Measure heights < 6 feet and estimate heights ≥ 6 feet.

When collected: All microplots with at least one CONDITION CLASS STATUS = 1
Field width: 3 digits
Tolerance: +/- 0.5 ft
MQO: At least 90% of the time
Values: 00.0 to 99.9

2.7.4 DEAD SHRUBS PERCENT COVER (Core 14.7.4)

Record the code for the cover class that indicates the percent cover of the forested microplot area covered with dead shrubs and dead branches attached to live shrubs if visible from above.

When collected: All microplots with at least one CONDITION CLASS STATUS = 1
Field width: 2 digits
Tolerance: +/- 1 class
MQO: At least 85% of the time
Values:

00	Absent
01	Trace (< 1% cover)
10	1 – 10%
20	11-20%
30	21-30%
….	
90	81-90%
99	91-100%

2.7.5 DEAD SHRUB HEIGHT (Core 14.7.5)

Record the code indicating the height of the tallest dead shrub to the nearest 0.1 foot. Measure heights < 6 feet and estimate heights ≥ 6 feet.

When collected: All microplots with at least one CONDITION CLASS STATUS = 1
Field width: 3 digits
Tolerance: +/- 0.5 ft
MQO: At least 90% of the time
Values: 00.0 to 99.9

2.7.6 LIVE HERBS PERCENT COVER (Core 14.7.6)

Record the code for the cover class that indicates the percent cover of the forested microplot area covered with live herbaceous plants.

When collected: All microplots with at least one CONDITION CLASS STATUS = 1
Field width: 2 digits
Tolerance: +/- 1 class
MQO: At least 85% of the time
Values:

00	Absent
01	Trace (< 1% cover)
10	1 – 10%
20	11-20%
30	21-30%
….	
90	81-90%
99	91-100%

2.7.7 LIVE HERBS HEIGHT (Core 14.7.7)

Record the code indicating the height (at the tallest point) of the live herbaceous layer to the nearest 0.1 foot. Maximum height is 6 feet.

When collected: All microplots with at least one CONDITION CLASS STATUS = 1
Field width: 2 digits
Tolerance: +/- 0.2 ft
MQO: At least 90% of the time
Values: 0.0 to 6.0

2.7.8 DEAD HERBS PERCENT COVER (Core 14.7.8)

Record the code for the cover class that indicates the percent cover of the forested microplot area covered with dead herbaceous plants and dead leaves attached to live plants if visible from above.

When collected: All microplots with at least one CONDITION CLASS STATUS = 1
Field width: 2 digits
Tolerance: +/- 1 class
MQO: At least 85% of the time

Values:

00	Absent
01	Trace (< 1% cover)
10	1 – 10%
20	11-20%
30	21-30%
….	
90	81-90%
99	91-100%

2.7.9 DEAD HERBS HEIGHT (Core 14.7.9)

Record the code indicating the height (at the tallest point) of the dead herbaceous layer to the nearest 0.1 foot. Maximum height is 6 feet.

When collected: All microplots with at least one CONDITION CLASS STATUS = 1
Field width: 2 digits
Tolerance: +/- 0.2 ft
MQO: At least 90% of the time
Values: 0.0 to 6.0

2.7.10 LITTER PERCENT COVER (Core 14.7.10)

Record the code for the cover class that indicates the percent cover of the forested microplot area covered with litter. Litter is the layer of freshly fallen leaves, twigs, dead moss, dead lichens, and other fine particles of organic matter found on the surface of the forest floor. Decomposition is minimal.

When collected: All microplots with at least one CONDITION CLASS STATUS = 1
Field width: 2 digits
Tolerance: +/- 1 class
MQO: At least 85% of the time

Values:

00	Absent
01	Trace (< 1% cover)
10	1 – 10%
20	11-20%
30	21-30%
….	
90	81-90%
99	91-100%

2.8 SAMPLING RESIDUE PILES (CORE 14.8)

The line transect method is not practical when sampling CWD within piles and windrows. Piles and windrows will be located and sampled on the subplot plot, regardless of whether they intersect a transect.

Piles and windrows created directly by human activity and log piles at the bottom of steep-sided ravines in which individual pieces are impossible to tally separately, are more efficiently sampled by using the following instructions. However, loose CWD in piles created by wind throw, landslides, fires, and other natural causes should be tallied using line transects unless it is physically impossible to measure the pieces in the natural pile.

For a pile to be tallied on a subplot that contains forest land, all of the following criteria must be met (Figure 26):

- The pile's center must be within 24.0 horizontal feet of subplot center,
- The pile's center must be in an accessible forest land condition class, and
- The pile contains pieces of CWD $\geq$ 3 inches diameter that would be impossible to tally separately.

Use the PILE DENSITY variable to estimate the percent of the pile that contains woody material $\geq$ 3 inches.
The pile is assigned to the condition class in which the pile center lies.

Apply the following steps to determine the center of a pile or windrow:

1. Determine the longest axis of a pile.
2. Determine the midpoint of this axis.
3. Project a line through this midpoint that is perpendicular to the axis determined in step 1.
4. Determine the midpoint of the segment of this projected line that crosses the pile.
5. This is the center of the pile.

Piles that cross the 24.0-foot fixed-radius subplot boundary: If the center of a pile is within 24.0 horizontal feet of subplot center, tally the pile, recording the dimensions of the entire pile even if part of the pile is beyond 24.0 feet. If the center of a pile is more than 24.0 horizontal feet of subplot center, do not tally the pile or any portion of the pile.

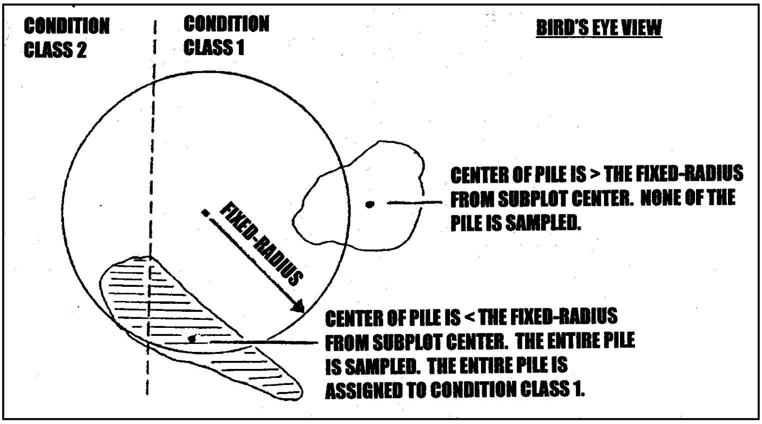

Figure 26. Residue pile selection examples. (14-11)

2.8.1 SUBPLOT NUMBER (Core 14.8.1)

Record the code indicating the subplot number.

When collected: Record for all sampled residue piles
Field width: 1 digit
Tolerance: No errors
MQO: At least 99% of the time
Values: 1 to 4

1	Center subplot
2	North subplot
3	Southeast subplot
4	Southwest subplot

2.8.2 CONDITION CLASS (Core 14.8.2)

Record the code indicating the number of the condition class to which the pile is assigned.

When collected: Record for all sampled residue piles
Field Width: 1 digit
Tolerance: No errors
MQO: At least 99% of the time
Values: 1 to 9

2.8.3 PILE AZIMUTH (Core 14.8.3)

Record the code indicating the azimuth from the subplot center to the pile. This azimuth centers on the pile so that it can be relocated. Use 360 for north.

When collected: All sampled residue piles
Field width: 3 digits
Tolerance: +/- 10
MQO: At least 90% of the time
Values: 001 to 360

2.8.4 PILE SHAPE (Core 14.8.4)

Record the code indicating the shape of the pile. Determine which of the four shapes diagrammed in Figure 27 most resembles the pile and record the dimensions. Pile dimensions should be ocularly smoothed out when making estimates. Average the unevenness of protruding pieces.

When collected: All sampled residue piles
Field width: 1 digit
Tolerance: No errors
MQO: At least 90% of the time
Values: 1 to 4

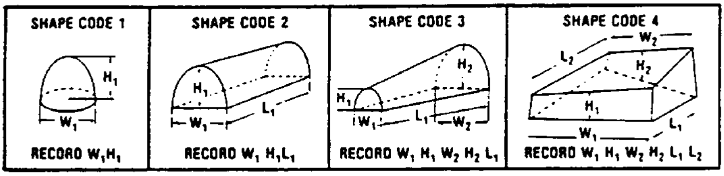

Figure 27. PILE SHAPE codes. (14-12)

2.8.5 PILE LENGTH 1 (Core 14.8.5)

Record the code indicating the length of the sides of the pile. Estimate to the nearest foot. PILE LENGTH 1 may often equal PILE LENGTH 2.

When collected: All sampled residue piles and PILE SHAPE = 2, 3, 4
Field width: 2 digits
Tolerance: +/- 10%
MQO: At least 90% of the time
Values: 01 to 99

2.8.6 PILE LENGTH 2 (Core 14.8.6)

Record the code indicating the length of the sides of the pile. Estimate to the nearest foot. PILE LENGTH 1 may often equal PILE LENGTH 2.

When collected: All sampled residue piles and PILE SHAPE = 4
Field width: 2 digits
Tolerance: +/- 10%
MQO: At least 90% of the time
Values: 01 to 99

2.8.7 PILE WIDTH 1 (Core 14.8.7)

Record the code indicating the width of the sides of the pile. Estimate to the nearest foot. PILE WIDTH 1 may often equal PILE WIDTH 2.

When collected: All sampled residue piles, and PILE SHAPE = 1, 2, 3, 4
Field width: 2 digits
Tolerance: +/- 10%
MQO: At least 90% of the time
Values: 01 to 99

2.8.8 PILE WIDTH 2 (Core 14.8.8)

Record the code indicating the width of the sides of the pile. Estimate to the nearest foot. PILE WIDTH 1 may often equal PILE WIDTH 2.

When collected: All sampled residue piles, and PILE SHAPE = 3, 4
Field width: 2 digits
Tolerance: +/- 10%
MQO: At least 90% of the time
Values: 01 to 99

2.8.9 PILE HEIGHT 1 (Core 14.8.9)

Record the code indicating the height of either end of the pile. Estimate to the nearest foot. PILE HEIGHT 1 may often equal PILE HEIGHT 2.

When collected: All sampled residue piles, and PILE SHAPE = 1, 2, 3, 4
Field width: 2 digits
Tolerance: +/- 10%
MQO: At least 90% of the time
Values: 01 to 99

2.8.10 PILE HEIGHT 2 (Core 14.8.10)

Record the code indicating the height of either end of the pile. Estimate to the nearest foot. PILE HEIGHT 1 may often equal PILE HEIGHT 2.

When collected: All sampled residue piles, and PILE SHAPE = 3, 4
Field width: 2 digits
Tolerance: +/- 10%
MQO: At least 90% of the time
Values: 01 to 99

2.8.11 PILE DENSITY (Core 14.8.11)

Record the code estimating the percent of the pile that consists of wood. Air, soil, rock, plants, etc, should be factored out of the estimate. Estimate to the nearest 10 percent.

When collected: All sampled residue piles
Field width: 2 digits
Tolerance: +/- 20%
MQO: At least 75% of the time
Values:

00	Absent
01	Trace (< 1% cover)
10	1 – 10%
20	11-20%
30	21-30%
….	
90	81-90%
99	91-100%

2.9 ACKNOWLEDGEMENTS (CORE 14.9)

Contact information for the National Advisor for this indicator is: Chris Woodall, USDA Forest Service, North Central Research Station, 1992 Folwell Ave, St. Paul, MN 55108, cwoodall@fs.fed.us, http:\\ncrs2.fs.fed.us\4801\DWM .

APPENDIX. DATA SHEETS

DWM Data Sheet **POINT 1** State ___ Co _____ P2# _____

Transect 30 Az - SEGMENTS

SDist1	Slope%	SDist2	Hdist	Cond
00.0 ft				

Transect 30 Az - Coarse Woody Debris - (Transect diameter >3" and > 3 ft length)

Sdist	Decay	Species	Tr Dia	SmDia	LgDia	Length	Hollow?	CWDHist
							Y - N	
							Y - N	
							Y - N	

Transect 30 Az - Duff / Litter / Fuelbed Depth (at 24' Slope)

Sampled _____ Duff (XX.X in) _____ Litter (XX.X in) _____ Fuelbed (XX.X ft) _____

Transect 150 Az - SEGMENTS

SDist1	Slope%	SDist2	Hdist	Cond
00.0 ft				

Transect 150 Az - Coarse Woody Debris - (Transect diameter >3" and > 3 ft length)

Sdist	Decay	Species	Tr Dia	SmDia	LgDia	Length	Hollow?	CWDHist
							Y - N	
							Y - N	
							Y - N	

Transect 150 Az - Fine Woody Debris - S (0.01-0.24") M (0.25"-0.9") L (1.0-2.9")

Piles?___ S _____ M _____ L _____ Reason ____________________ Res Pile? Y - N

Transect 150 Az - Duff / Litter / Fuelbed Depth (at 24' Slope)

Sampled _____ Duff (XX.X in) _____ Litter (XX.X in) _____ Fuelbed (XX.X ft) _____

Transect 270 Az - SEGMENTS

SDist1	Slope%	SDist2	Hdist	Cond
00.0 ft				

Transect 270 Az - Coarse Woody Debris - (Transect diameter >3" and > 3 ft length)

Sdist	Decay Class	Species	Tr Dia	SmDia	LgDia	Length	Hollow?	CWDHist
							Y - N	
							Y - N	
							Y - N	

Transect 270 Az - Duff / Litter / Fuelbed Depth (at 24' Slope)

Sampled _____ Duff (XX.X in) _____ Litter (XX.X in) _____ Fuelbed (XX.X ft) _____

Microplot Fuel Loading **Residual Piles**

	Live %	Live Ht	Dead %	Dead Ht
Shrub				
Herb				

% Litter _____

Condition	
Azimuth	
Shape	
L1 =	L2 =
W1 =	W2 =
Ht1 =	Ht2 =
Pile Density	

DWM Data Sheet **POINT 2** State ___ Co _____ P2# _____

Transcect 30 Az - SEGMENTS

SDist1	Slope%	SDist2	Hdist	Cond
00.0 ft				

Transect 30 Az - Coarse Woody Debris - (Transect diameter >3" and > 3 ft length)

Sdist	Decay	Species	Tr Dia	SmDia	LgDia	Length	Hollow?	CWDHist
							Y - N	
							Y - N	
							Y - N	

Transect 30 Az - Duff / Litter / Fuelbed Depth (at 24' Slope)

Sampled _____ Duff (XX.X in) _____ Litter (XX.X in) _____ Fuelbed (XX.X ft) _____

Transect 150 Az - SEGMENTS

SDist1	Slope%	SDist2	Hdist	Cond
00.0 ft				

Transect 150 Az - Coarse Woody Debris - (Transect diameter >3" and > 3 ft length)

Sdist	Decay	Species	Tr Dia	SmDia	LgDia	Length	Hollow?	CWDHist
							Y - N	
							Y - N	
							Y - N	

Transect 150 Az - Fine Woody Debris - S (0.01-0.24") M (0.25"-0.9") L (1.0-2.9")

Piles?___ S _____ M _____ L _____ Reason ___________________ Res Pile? Y - N

Transect 150 Az - Duff / Litter / Fuelbed Depth (at 24' Slope)

Sampled _____ Duff (XX.X in) _____ Litter (XX.X in) _____ Fuelbed (XX.X ft) _____

Transect 270 Az - SEGMENTS

SDist1	Slope%	SDist2	Hdist	Cond
00.0 ft				

Transect 270 Az - Coarse Woody Debris - (Transect diameter >3" and > 3 ft length)

Sdist	Decay Class	Species	Tr Dia	SmDia	LgDia	Length	Hollow?	CWDHist
							Y - N	
							Y - N	

							Y - N	

Transect 270 Az - Duff / Litter / Fuelbed Depth (at 24' Slope)

Sampled _____ Duff (XX.X in) _____ Litter (XX.X in) _____ Fuelbed (XX.X ft) _____

Microplot Fuel Loading

	Live %	Live Ht	Dead %	Dead Ht
Shrub				
Herb				

% Litter _____

Residual Piles	
Condition	
Azimuth	
Shape	
L1 =	L2 =
W1 =	W2 =
Ht1 =	Ht2 =
Pile Density	

DWM Data Sheet **POINT 3** State ___ Co _____ P2# _____

Transect 30 Az - SEGMENTS

SDist1	Slope%	SDist2	Hdist	Cond
00.0 ft				

Transect 30 Az - Coarse Woody Debris - (Transect diameter ≥3" and ≥ 3 ft length)

Sdist	Decay	Species	Tr Dia	SmDia	LgDia	Length	Hollow?	CWDHist
							Y - N	
							Y - N	
							Y - N	

Transect 30 Az - Duff / Litter / Fuelbed Depth (at 24' Slope)

Sampled _____ Duff (XX.X in) _____ Litter (XX.X in) _____ Fuelbed (XX.X ft) _____

Transect 150 Az - SEGMENTS

SDist1	Slope%	SDist2	Hdist	Cond
00.0 ft				

Transect 150 Az - Coarse Woody Debris - (Transect diameter ≥3" and ≥ 3 ft length)

Sdist	Decay	Species	Tr Dia	SmDia	LgDia	Length	Hollow?	CWDHist
							Y - N	
							Y - N	
							Y - N	

Transect 150 Az - Fine Woody Debris - S (0.01-0.24") M (0.25"-0.9") L (1.0-2.9")

Piles?___ S _____ M _____ L _____ Reason ____________________ Res Pile? Y - N

Transect 150 Az - Duff / Litter / Fuelbed Depth (at 24' Slope)

Sampled _____ Duff (XX.X in) _____ Litter (XX.X in) _____ Fuelbed (XX.X ft) _____

Transect 270 Az - SEGMENTS

SDist1 Slope% SDist2 Hdist Cond

00.0 ft				

Transect 270 Az - Coarse Woody Debris - (Transect diameter >3" and > 3 ft length)

Sdist	Decay Class	Species	Tr Dia	SmDia	LgDia	Length	Hollow?	CWDHist
							Y - N	
							Y - N	
							Y - N	

Transect 270 Az - Duff / Litter / Fuelbed Depth (at 24' Slope)

Sampled _____ Duff (XX.X in) _____ Litter (XX.X in) _____ Fuelbed (XX.X ft) _____

Microplot Fuel Loading

	Live %	Live Ht	Dead %	Dead Ht
Shrub				
Herb				

% Litter _____

Residual Piles

Condition	
Azimuth	
Shape	
L1 =	L2 =
W1 =	W2 =
Ht1 =	Ht2 =
Pile Density	

DWM Data Sheet **POINT 4** State ___ Co _____ P2# _____

Transect 30 Az - SEGMENTS

SDist1	Slope%	SDist2	Hdist	Cond
00.0 ft				

Transect 30 Az - SEGMENTS

Transect 30 Az - Coarse Woody Debris - (Transect diameter >3" and > 3 ft length)

Sdist	Decay	Species	Tr Dia	SmDia	LgDia	Length	Hollow?	CWDHist
							Y - N	
							Y - N	
							Y - N	

Transect 30 Az - Duff / Litter / Fuelbed Depth (at 24' Slope)

Sampled _____ Duff (XX.X in) _____ Litter (XX.X in) _____ Fuelbed (XX.X ft) _____

Transect 150 Az - SEGMENTS

SDist1	Slope%	SDist2	Hdist	Cond
00.0 ft				

Transect 150 Az - Coarse Woody Debris - (Transect diameter >3" and > 3 ft length)

Sdist	Decay	Species	Tr Dia	SmDia	LgDia	Length	Hollow?	CWDHist
							Y - N	
							Y - N	
							Y - N	

Transect 150 Az - Fine Woody Debris - S (0.01-0.24") M (0.25"-0.9") L (1.0-2.9")

Piles?___ S _____ M _____ L _____ Reason ___________________ Res Pile? Y - N

Transect 150 Az - Duff / Litter / Fuelbed Depth (at 24' Slope)

Sampled _____ Duff (XX.X in) _____ Litter (XX.X in) _____ Fuelbed (XX.X ft) _____

Transect 270 Az - SEGMENTS

SDist1	Slope%	SDist2	Hdist	Cond
00.0 ft				

Transect 270 Az - Coarse Woody Debris - (Transect diameter ≥3" and ≥ 3 ft length)

Sdist	Decay Class	Species	Tr Dia	SmDia	LgDia	Length	Hollow?	CWDHist
							Y - N	
							Y - N	
							Y - N	

Transect 270 Az - Duff / Litter / Fuelbed Depth (at 24' Slope)

Sampled _____ Duff (XX.X in) _____ Litter (XX.X in) _____ Fuelbed (XX.X ft) _____

Microplot Fuel Loading

	Live %	Live Ht	Dead %	Dead Ht
Shrub				
Herb				

% Litter _____

Residual Piles	
Condition	
Azimuth	
Shape	
L1 =	L2 =
W1 =	W2 =
Ht1 =	Ht2 =
Pile Density	

CHAPTER 3
SOILS

3.0 INTRODUCTION (Core 11.0)

The objective of the Phase 3 (P3) Soils Indicator is to assess forest ecosystem health in terms of the physical and chemical properties of the soils. The soil resource is a primary component of all terrestrial ecosystems, and any environmental stressor that alters the natural function of the soil has the potential to influence the vitality, species composition, and hydrology of forest ecosystems.

Specifically, soils data are collected on P3 plots to assess (Santiago Declaration 1995):

- the potential for erosion of nutrient-rich top soils and forest floors.
- factors relating to the storage and cycling of nutrients and water.
- the availability of nutrients and water to plants (dependent upon soil structure and texture).
- carbon sequestration (the amount of carbon tied up in soil organic matter).
- deposition of toxic metals from pollution.
- acidification of the soil from deposition of pollutants.

Chemical properties of the soil are analyzed in order to develop indices for plant nutrient status, soil organic matter, and acidification. Together, these three factors largely determine the fertility and potential productivity of forest stands. Soil nutrient status refers to the concentration of plant nutrients (e.g., potassium, calcium, magnesium, and sodium) and is a key indicator of site fertility and species composition. The amount of organic matter in the soil largely determines water retention, carbon storage, and the composition of soil biota. Loss of soil organic matter as a result of management practices can alter the vitality of forest ecosystems through diminished regeneration capacity of trees, lower growth rates, and changes in species composition. Finally, increased soil acidity resulting from deposition of atmospheric pollutants has the capacity to reduce nutrient availability, decrease rates of decomposition, promote the release of toxic elements into the soil solution (e.g., aluminum), and alter patterns and rates of microbial transformations.

Nutrient and water availability to forest vegetation is also dependent on the physical capacity of roots to grow and access nutrients, water, and oxygen from the soil. In addition to playing an important role in plant nutrition, the physical properties of the soil largely determine forest hydrology, particularly with regards to surface and ground water flow. Human activities that result in the destruction of soil aggregates, loss of pore space (compaction), and erosion may increase rates of surface runoff and alter historic patterns of stream flow. In some areas, these changes may result in flooding and/or dewatered streams and can reflect on both the health of aquatic ecosystems and the management and conservation of associated forest and agricultural areas.

3.1 SUMMARY OF METHOD (Core 11.1)

The soil measurement and sampling procedures are divided into three parts: soil erosion, soil compaction, and soil chemistry. Data collection for soil erosion assessment consists of estimating the percent of bare soil in each subplot. These measurements are combined with data from other sources and used to parameterize established models for erosion potential (RUSLE – Revised Universal Soil Loss Equation , WEPP – Water Erosion Prediction Project). Soil compaction measurements consist of an estimate of the percentage of soil compaction on each subplot along with a description of the type of compaction. Data are recorded using a handheld computer (PDR) with a preloaded data input program.

The chemical and physical properties of the soil are assessed through the collection of soil samples, which are then submitted to a regional laboratory for analysis. Soil samples are collected from the forest floor (subplots 2, 3, and 4) and underlying mineral soil layers (subplot 2). The entire forest floor layer is sampled from a known area after measuring the thickness of the duff (humus) and litter layers at four locations in a sampling frame of known area. Once the forest floor has been removed, mineral or organic soils are sampled volumetrically by collecting cores from two depths: 0 to 4 inches and 4 to 8 inches. The texture of each layer is estimated in the field and characterized as organic, loamy, clayey, sandy, or coarse sandy. Following soil sampling, the depth to any restrictive horizon within the top 20 inches is estimated using a soil probe. In the case of organic soils (e.g., wetland soils), samples are collected from the litter layer and the 0-4 inch and 4-8 inch organic layers.

Physical and chemical properties of the soil are determined in the laboratory. Analyses of forest floor samples include bulk density, water content, total carbon, and total nitrogen. Analyses of mineral soil samples include bulk density, water content, coarse fragment content, total organic and inorganic carbon, total nitrogen, plant available (extractable) phosphorus and sulfur, exchangeable cations (calcium, magnesium, sodium, potassium, and aluminum), pH, and trace metals such as manganese. These data are used to provide indexes of nutrient status, acidification, and carbon sequestration.

3.2 DEFINITIONS (Core 11.2)

Cryptobiotic crusts	A layer of symbiotic lichens and algae on the soil surface (common in arid regions)
Duff (Humus)	A soil layer dominated by organic material derived from the decomposition of plant and animal litter and deposited on either an organic or a mineral surface. This layer is distinguished from the litter layer in that the original organic material has undergone sufficient decomposition that the source of this material (e.g., individual plant parts) can no longer be identified.
Forest floor	The entire thickness of organic material overlying the mineral soil, consisting of the litter and the duff (humus).
Litter	Undecomposed or only partially decomposed organic material that can be readily identified (e.g., plant leaves, twigs, etc.)
Loam	The textural class name for a soil having a moderate amount of sand, silt, and clay.
Mineral soil	A soil consisting predominantly of products derived from the weathering of rocks (e.g., sands, silts, and clays).
Organic soil	For the purposes of FIA, an organic soil is defined as any soil in which the organic horizon is greater than 8 inches in thickness. These soils are prevalent in wetland areas such as bogs and marshes and may be frequently encountered in certain regions of the country (e.g., Maine, northern Minnesota, coastal regions)

Restrictive layer	Any soil condition which increases soil density to the extent that it may limit root growth. This limitation may be physical (hard rock) or chemical (acid layer) or both.
Sampling frame	A frame used to collect forest floor samples from a known area. A bicycle tire 12 inches in diameter has been selected as the national standard.
Soil erosion	The wearing away of the land surface by running water, wind, ice or other geological agents.
Texture	The relative proportion of sand, silt, and clay in a soil.

3.3 EQUIPMENT AND SUPPLIES (Core 11.3)

Minimum required equipment is listed below. Field personnel may add equipment as needed to improve efficiency in some areas.

3.3.1 Field Gear Unique to the Soil Indicator (Core 11.3.1)

- Retractable measuring tape (inch intervals) for measuring soil layer depths.
- Frame for sampling known area of surface litter material. A small bicycle tire (16 x 2.125 in tire size with an internal diameter of 12 in) has been chosen as the standard size.
- Impact-driven soil core (2-in diameter x 8-in depth) sampler with two 2-in diameter by 4-in long stainless steel core liners for obtaining mineral soil samples.
- Additional bulk density sampling equipment: crescent wrench and universal slip wrench for disassembling bulk density sampler if stuck.
- Tile probe (42 in) for measuring depth to a restrictive layer.
- Garden trowel or hand shovel for sampling forest floor and excavating soil sample hole where soil core sampler cannot be used.
- Small knife with sharp blade for sampling the forest floor layers.
- Pruning shears (very useful in cutting through roots and litter).
- Plastic water bottle for use in hand-texturing soil.
- Small plastic tarp (1 yd x 1 yd) to use as a working surface.
- Indelible ink markers (black thin-line) for marking sample bags.

- Cleaning cloths or tissues.
- Soil sample bags (9 x 12 in or quart size) for mineral soil samples.
- Soil sample bags (10 x 18 in or gallon size) for forest floor samples.
- Soil sample labels.

3.3.2 Optional Soils Equipment (Core 11.3.2)

- Supplemental soil sampling equipment for organic soils: Dutch auger.
- Supplemental soil sampling equipment for saturated or wetland soils: mud auger or piston-type core sampler.
- Garden gloves.
- 1-in diameter soil tube probe to take soil samples for hand-texturing or where soil core sampler cannot be used.

3.3.3 Required Equipment not Unique to the Soil Indicator (Core 11.3.3):

- Compass for locating sampling points.
- Measuring tape -100 ft loggers tape for measuring distance to sampling locations.
- Flagging for marking soil sample points.
- Back pack for carrying sampling equipment to the field.
- Clear plastic shipping tape to cover labels after they have been filled out.

3.4 LABORATORY ANALYSES (Core 11.4)

Phase 3 forest floor samples are analyzed in the laboratory for:

- Bulk density.
- Water content.
- Total carbon.
- Total nitrogen.

Phase 3 mineral soil samples are analyzed for:

- Bulk density, water content, and coarse fragment [>0.08-in (>2-mm)] content.
- pH in water and in 0.01 M $CaCl_2$.
- Total carbon.
- Total organic carbon.
- Total inorganic carbon (carbonates) (pH>7.5 soils only).
- Total nitrogen.
- Exchangeable cations (Na, K, Mg, Ca, Al, Mn).
- Extractable sulfur and trace metals.
- Extractable phosphorus (Bray 1 method for pH < 6 soils, Olsen method for pH > 6 soils).

Methods for preparing and analyzing the collected soil samples are available in a separate document.

3.5 QUALITY ASSURANCE (QA) (Core 11.5)

The QA program for the soils indicator addresses both field and laboratory measurements. For field measurements, QA protocols are the same as those used for all other Phase 3 indicators. Measurement Quality Objectives (MQOs) have been established for each of the measurements. The MQOs are used during training, certification and auditing to assist with the control of data quality. Periodic re-measurements are undertaken to establish data quality attributes such as precision, bias and comparability.

This field guide only addresses aspects of QA related to the field portion of the program. Soil laboratories have another set of guidelines for ensuring data quality and are required to enroll in a national proficiency testing program. Details of the lab QA protocol may be obtained by contacting the regional lab directors.

3.5.1 Training And Certification (Core 11.5.1)

Field crews are trained to make field measurements as well as take soil samples. After training, all field crew members are tested and certified for soil indicator measurements. Each trained crew member must demonstrate the ability to conduct soil measurements within established MQOs.

3.5.2 Hot Checks, Cold Checks, and Blind Checks (Core 11.5.2)

QA/QC for the field portion of the soil indicator consists of three parts:

Hot Check – an inspection normally done as part of the training process. The inspector is present on the plot with the trainee and provides immediate feedback regarding data quality. Data errors are corrected. Hot checks can be done on training plots or production plots.

Cold Check – an inspection done either as part of the training process, or as part of the ongoing QC program. Normally the installation crew is not present at the time of inspection. The inspector has the completed data in-hand at the time of inspection. The inspection can include the whole plot or a subset of the plot. Data errors are corrected. Discrepancies between the two sets of data may be reconciled. Cold checks are done on production plots only.

Blind Check – a re-installation done by a qualified inspection crew without production crew data on hand; a full re-installation of the plot for the purpose of obtaining a measure of data quality. The two data sets are maintained separately. Discrepancies between the two sets of data are not reconciled. Blind checks are done on production plots only.

3.5.3 Reference Plots (Core 11.5.3)

Remeasurements of field observations by regional trainer crews occur on routine plots recently visited by a standard field crew (cold checks or hot checks) or on reference plots. All erosion and soil compaction remeasurements can be taken on the subplots as described in the soil measurement methods. Reference plots should be selected with areas of bare and compacted soil to allow for an evaluation of a crew's ability to make these measurements.

3.5.4 Debriefing (Core 11.5.4)

Feedback from the field crews is critical to identifying problems with the soil indicator measurements and improving the program for subsequent field seasons. Crew members conducting soil measurements should fill out a debriefing form and submit it to the regional field coordinator prior to the end of the field season. Crew members should consider it part of their responsibility to report any problems, inconsistencies, or errors in the field guide or the method.

3.6 SOIL EROSION AND COMPACTION (Core 11.6)

Erosion is defined as the wearing away of the land surface by running water, wind, or ice. Erosion is a natural process that occurs on all non-flat areas of the landscape. However, human activity (such as timber removal or road-building) can result in accelerated rates of erosion that degrade the soil and reduce the productivity of land. Extensive areas of soil erosion can have a major effect on the aquatic ecosystems associated with forests, recreational opportunities, potable water supplies and the life span of river infrastructure (e.g., dams, levees).

On average, the U. S. loses about 5 billion tons of soil annually to water and wind erosion. As this soil is removed from the landscape, it carries with it all of the nutrients and organic matter that took decades to centuries (or longer) to build up. On human time scales, fertile topsoil is not a renewable resource.

On FIA plots, soil erosion potential is estimated using published models, such as the Revised Universal Soil Loss Equation (RUSLE) and the Water Erosion Prediction Project (WEPP). These models are based on factors that represent how climate, soil, topography, and land use affect soil erosion and surface runoff. Generally, these models require the following factors for analysis: percent slope, slope length, precipitation factor, vegetation cover, and litter cover. Some of these factors are collected as part of the P2 mensuration data and other P3 indicators (percent slope and vegetation cover), one factor is obtained from outside sources (precipitation factor), and the remaining factors (% cover, which is given by 100 minus % BARE SOIL, and SOIL TEXTURE) are measured on each subplot as part of the soil indicator.

Estimates of bare soil are made on all four subplots. Soil texture is measured at the soil sampling site adjacent to subplot 2 during the collection of mineral and organic soil samples.

Compaction refers to a reduction in soil pore space and can be caused by heavy equipment or by repeated passes of light equipment that compress the soil and break down soil aggregates. This compression increases the bulk density and reduces the ability of air and water to move through the soil. These conditions also make it more difficult for plant roots to penetrate the soil and obtain necessary nutrients, oxygen, and water.

In general, compaction tends to be a greater problem on moist soils and on fine-textured soils (clays). These effects can persist for long periods of time and may result in stunted tree growth.

Information about compaction is collected on all subplots that are in a forested condition. Compaction data collected as part of the soil indicator include an estimate of the percent of each subplot affected by compaction and the type(s) of compaction present.

3.6.1 PERCENT COVER OF BARE SOIL (Core 11.6.1)

Record a two-digit code indicating the percentage of the subplot that is covered by bare soil (mineral or organic). Fine gravel [0.08-0.20 inch (2-5 mm)] should be considered part of the bare soil. However, do not include large rocks protruding through the soil (e.g., bedrock outcrops) in this category because these are not erodible surfaces. For the purposes of the soil indicator, cryptobiotic crusts are not considered bare soil.

If the subplot includes non-forested areas, multiply the % COVER OF BARE SOIL in the forested part of the subplot by the % of the subplot that is in forested area. For example, if 50% of the subplot is forested and the % COVER OF BARE SOIL of the forested part is 30%, then the % COVER OF BARE SOIL for the entire subplot is 15 %.

When Collected: When any portion of the subplot contains at least one accessible forested condition class
Field Width: 2 digits
Tolerance: +/- 10%
MQO: 75% of the time
Values:

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

3.6.2 PERCENT COMPACTED AREA ON THE SUBPLOT (Core 11.6.2)

Record a two-digit code indicating the percentage of the subplot that exhibits evidence of compaction. Soil compaction is assessed relative to the conditions of adjacent undisturbed soil. Do not include improved roads in your evaluation.

When Collected: When any portion of the subplot contains at least one accessible forested condition class
Field Width: 2 digits
Tolerance: +/- 15%
MQO: 75% of the time

Values:

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

3.6.3 TYPE OF COMPACTION - RUTTED TRAIL (Core 11.6.3)

Type of compaction is a rutted trail. Ruts must be at least 2 inches deep into mineral soil or 6 inches deep from the undisturbed forest litter surface. Record a “1” if this type of compaction is present; record a “0” if it is not present.

When Collected: When PERCENT COMPACTED AREA ON THE SUBPLOT > 00
Field Width: 1 digit
Tolerance: No errors
MQO: 75% of the time

Values:

1	Present
0	Not present

3.6.4 TYPE OF COMPACTION – COMPACTED TRAIL (Core 11.6.4)

Type of compaction is a compacted trail (usually the result of many passes of heavy machinery, vehicles, or large animals). Record a “1” if this type of compaction is present; record a “0” if it is not present.

When Collected: When PERCENT COMPACTED AREA ON THE SUBPLOT > 00
Field Width: 1 digit
Tolerance: No errors
MQO: 75% of the time
Values:

1	Present
0	Not present

3.6.5 TYPE OF COMPACTION – COMPACTED AREA (Core 11.6.5)

Type of compaction is a compacted area. Examples include the junction areas of skid trails, landing areas, work areas, animal bedding areas, heavily grazed areas, etc. Record a “1” if this type of compaction is present; record a “0” if it is not present.

When Collected: When PERCENT COMPACTED AREA ON THE SUBPLOT > 00
Field Width: 1 digit
Tolerance: No errors
MQO: 75% of the time
Values:

1	Present
0	Not present

3.6.6 TYPE OF COMPACTION – OTHER (Core 11.6.6.)

Type of compaction is some other form. Record a “1” if this type of compaction is present; record a “0” if it is not present. (An explanation must be entered in the plot notes).

When Collected: When PERCENT COMPACTED AREA ON THE SUBPLOT > 00
Field Width: 1 digit
Tolerance: No errors
MQO: 75% of the time
Values:

1	Present
0	Not present

3.7 SOIL SAMPLE COLLECTION (Core 11.7)

The chemical and physical properties of the soil are assessed through the collection of soil samples, which are then submitted to a regional laboratory for analysis. Soil samples are collected from the forest floor (subplots 2, 3, and 4) and underlying mineral soil layers (subplot 2). The entire forest floor layer is sampled from a known area after measuring the thickness at the north, south, east, and west edges of a sampling frame of known area. Once the forest floor has been removed, mineral and organic soils are sampled volumetrically by collecting cores from two depths: 0 to 4 inches and 4 to 8 inches. The texture of each layer is estimated in the field and characterized as organic, loamy, clayey, sandy, or coarse sandy. Following soil sampling, the depth to any restrictive horizon within the top 20 inches is estimated using a soil probe. In the case of organic soils, samples are collected from the litter layer and the 0 to 4 inch and 4 to 8 inch organic layers.

Soil samples are collected within the annular plot along soil sampling lines adjacent to subplots 2, 3, and 4 (Figure 28). During the first visit to a plot for soil sampling, soil samples will be collected at the point denoted as Soil Visit #1. On subsequent visits to a plot, soil sampling sites visit #2 or larger will be sampled. The soil sampling sites are spaced at 10-foot intervals alternating on opposite sides of soil sampling site number 1.

The initial sampling points (Soil Visit #1) are located:

- Subplot 2 soil measurement site: 30 feet due south (180^{o}) from the center of subplot 2.
- Subplot 3 soil measurement site: 30 feet northwest (300^{o}) from the center of subplot 3.
- Subplot 4 soil measurement site: 30 feet northeast (60^{o}) from the center of subplot 4.

If the soil cannot be sampled at the designated sampling point due to trampling or an obstruction (e.g., boulder, tree, standing water), the sampling point may be relocated to any location within a radius of 5 feet.

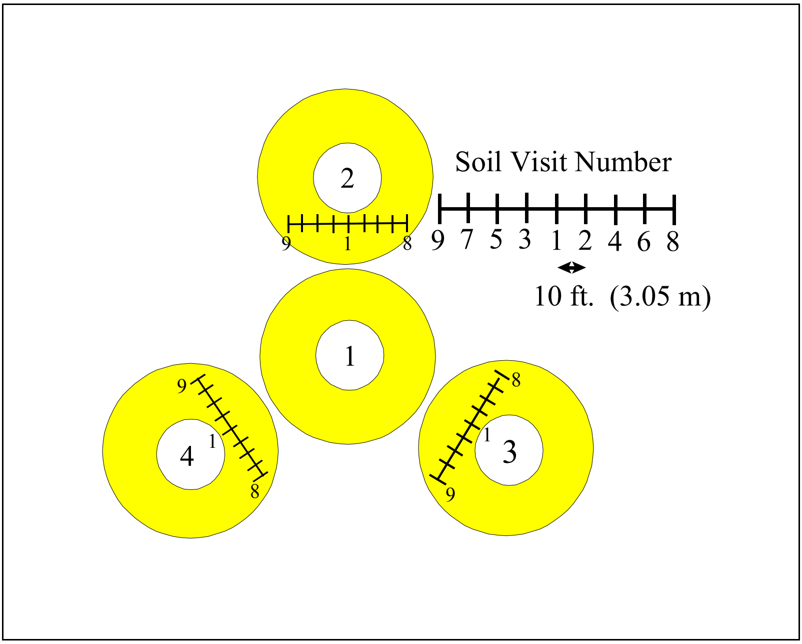

Figure 28. Location of soil sampling sites (11-1)

3.7.1 Forest Floor (Core 11.7.1)

Forest floor samples are collected from soil sampling sites adjacent to subplots 2, 3, and 4. Samples are collected if, and only if, the soil sampling sites are forested. The forest floor is sampled as a complete unit using a sampling frame (Figure 29).

1. Place the sampling frame over the sampling point taking care not to compact the litter layer.
   Locate the points due north, due east, due south and due west on the inside of the soil sampling frame and mark these with small vinyl stake flags. Carefully remove the sampling frame.

2. Measure the thickness of the entire forest floor to the nearest centimeter at the four flagged locations. At each sampling point, also measure the thickness of the litter layer.

3. Replace the soil sampling frame. Using a pair of clippers, carefully remove all live vegetation from the sample area. Living mosses should be clipped at the base of the green, photosynthetic material.

4. Using a sharp knife or a pair of clippers, carefully cut through the forest floor along the inner surface of the frame to separate it from the surrounding soil.

5. Using inward scooping motions, carefully remove the entire volume of the forest floor from within the confines of the sampling frame. Discard all woody debris (including pine cones, large pieces of bark, and decomposed wood) above 0.25 inches in diameter (approximately the diameter of a pencil). Discard any rocks or pebbles collected with the forest floor material.

6. Working over the tarp, place the entire forest floor layer sample into a pre-labeled gallon
   sample bag. In some areas more than one bag might be required to hold the sample. If so, label the bags with identical information, then add "1 of 2" and "2 of 2" respectively.

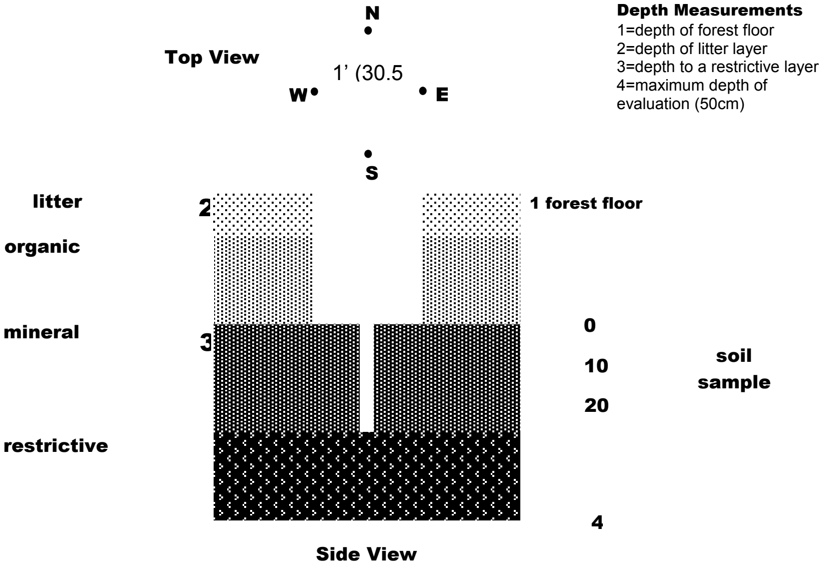

Figure 29. Cross-sectional views of sampling sites (top and side view).

3.7.2 Mineral Soil (Core 11.7.2)

Two mineral soil samples 0-4 inch and 4-8 inch are collected from the soil sampling site adjacent to **subplot 2 only**, and are collected if, and only if, the soil sampling site is forested (Figure 29).

1. Mineral soil samples are collected from within the area of the sampling frame after the forest floor has been removed.

2. Place the core sampler in a vertical position and drive the sampler into the soil until the top of the coring head is about 1 inch above the mineral soil surface. At this point, the soil should be even with the top of the liner.

3. With the handle of the slide hammer down, rotate the sampler in a circular motion. This motion breaks the soil loose at the bottom of the sampler and makes it easier to remove the core. Do not extend the sliding part of the slide hammer upwards to gain additional leverage as this may bend the attachment. Remove the core sampler from the ground by pulling the slide hammer upwards in a smooth vertical motion.

4. If a complete and intact core has been collected, unscrew the coring head from the top cap and carefully slide the core liners onto the tarp (see section 4.5. for techniques used in handling problem soils). If necessary, use the crescent and slip wrenches to separate the parts. Trim the top and bottom of the core even with the liner rims. Take care to avoid any loss of soil from the cores; if any material spills, you must resample.

5. Using a knife, slice through the soil core at the interface between the two liners (the 4-inch depth). Remove the soil from the 0-4 inch stainless steel liner and place it into a pre-labeled soil sample bag. Repeat for the 4-8 inch core. Be sure to place all of the material in the liner (including coarse fragments, roots, soil, etc.) into the sample bags.

6. For each plot, you should have a maximum of five samples:

   - Three labeled gallon bags containing the forest floor samples from the sampling sites adjacent to subplots 2, 3, and 4. Additional bags may be needed for deep soils.
   - One labeled quart bag containing the 0 - 4 inch mineral soil sample from the soil sampling site adjacent to subplot 2.
   - One labeled quart bag containing the 4 - 8 inch mineral soil sample from the soil sampling site adjacent to subplot 2.

7. Clean all soil sampling equipment thoroughly before sampling soil at the next plot.

3.7.3 Assembly and Operation of Impact Driven Soil Corer (Bulk Density Sampler)

(Core 11.7.3)

The impact driven core sampler (Figure 30) is used to collect a known volume of soil with a minimum of compaction and disturbance. The weight of this core is then used to determine bulk density (the mass of soil per unit volume), an important physical property of the soil. Although we usually think about the soil in terms of the mineral fraction, soils are actually a matrix of solids (mineral and organic), water, and air. The ratio between these fractions (pore space) determines the capacity of the soil to provide nutrients, air, and water to plant roots. In addition, bulk density is used to convert the chemical concentrations obtained in the lab to a volumetric basis, which is more meaningful in terms of plant nutrition.

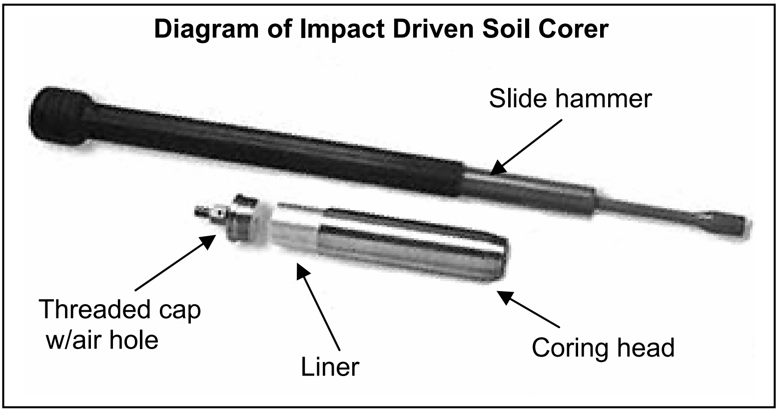

Figure 30. Diagram of Impact Driven Soil Corer (11-3)

Assembly

- Thread the top cap of the soil coring head onto the slide hammer attachment and tighten. This connection must be tight; if not, this connection may be sheared off during use.

- Insert two 2-in diameter x 4-in long stainless steel soil core liners into the soil coring head. It may be helpful to number the core liners with an indelible marker in order to tell them apart after the sample has been collected.

- Thread the soil coring head onto the top cap and slide hammer attachment until the top rim of the coring head just contacts the top cap. Make sure that the vent hole in the top cap is kept open, so that air displaced while the coring head is driven into the soil can escape from inside the coring head.

Maintenance

- Take care to clean and dry the inside and outside of the soil coring head after each sample. Moisture can cause rust build-up on the inside of the core head and make it difficult to insert and remove the liners.

- Use a brush and rag to clean both the inside and outside of the core liners as well. Grit on the outside of the liner can cause damage to the inside of the coring head and make it difficult to collect samples.

- Never twist, pull, or put pressure on the core sampler while the hammer attachment is extended. This can cause the attachment to break or bend.

3.7.4 Regulations Governing Sample Collection (National Historic Preservation Act) (Core 11.7.4)

The National Historic Preservation Act of 1966 (as amended) provides for the protection of historical and cultural artifacts. Due to the random placement of the Phase 3 monitoring design, a possibility exists that a Phase 3 plot may be located on a site of prehistoric or historical significance.

If cultural artifacts are encountered on a Phase 3 plot, do **not** take soil samples. Code the site as not sampled on the PDR and record a plot note explaining why soil samples were not taken.

If needed, archeologists or cultural resource specialists in these land management agencies will assist in obtaining permission to sample. Assistance is also available from State Historic Preservation Programs for state and private lands.

3.7.5 Alternate Sampling Methods for “Problem” Soils (Core 11.7.5)

In some cases, the soil coring procedure outlined above will not work. For example, in saturated organic soils, use of the core sampler may cause significant compaction of the sample. Very sandy soils or dry soils may tend to fall out of the liners, while in soils with a high rock content or a shallow depth to bedrock, it may not be possible to drive the core sampler into the ground. Approaches to handling these specific problems are addressed in section 3.7.6.

In general, make at least three attempts to collect a sample using the core sampler. If these attempts are unsuccessful, then use one of the following techniques to collect a sample.

1. Excavation method (hand shovel) – Dig a shallow hole whose width is at least 1.5 times the length of your knife. Starting at the top of the mineral soil, measure down 8 inches. Make a mark on the side of the

hole at 4 and 8 inches. Use your hand shovel to collect material from the 0-4 and 4-8 inch depth increments. Collect a sufficient volume of soil from the sides of the hole at each depth increment to approximately equal the volume of a soil core liner and place each depth increment sample in separate soil sample bags. Be sure to collect material from throughout the entire depth increment to avoid biasing the sample.

2. Tube probe – Remove the forest floor from an area and use the tube probe to collect samples from the 0-4 inch depth at a number of locations. Composite these samples until you have a sample volume approximately equal to that of the soil core liner. Repeat the sub-sampling and compositing for the 4-8 inch layer by returning to the points sampled previously and pushing the tube probe into the soil an additional 4 inches.

3. Dutch auger – Dutch augers can be very useful in wetland or saturated soils. In an area where the forest floor has been removed, drill into the soil with the auger and use a tape measure to help you collect material from the 0-4 and 4-8 inch depth increments.

For all of these methods, make sure to collect approximately the same amount of soil material [< 0.08 inch (< 2 mm)] that would have been needed to fill the core liner. Completion of the laboratory analyses requires at least 5 ounces (150 g) of mineral soil.

In soils with a large number of small rocks and pebbles, this means that you will need to collect a larger amount of sample so that the lab will have enough material to analyze once the rocks have been removed. In these soils, collect enough material to fill two core liners.

Be certain to circle “Other” on the label under sampler type.

3.7.6 Commonly Encountered Problems (Core 11.7.6)

It may not always be possible to obtain soil core samples using the soil core sampler. The following section provides some suggestions on how to overcome these problems.

1. Rocky soils

In soils containing a high percentage of rocks, it may not be possible to drive the core sampler in to the required 8 inches. If this occurs, remove any soil within the sampler, test for the presence of an obstruction using a plot stake pin or the tile probe, and make a second attempt either within the area where the forest floor has been removed or within the available soil sampling area (within a 5-foot radius of the original soil sampling location). Make a maximum of five attempts. If a complete sample from the 0-4 inch depth can be obtained, collect that sample. Otherwise, use the excavation or soil tube probe approaches outlined above (Section 4.7.5).

2. *Very sandy soils (or very dry soils) – sample falls out of the core*

If the soil will not stay in the core liner, use the shovel to dig around the soil coring head while it is still in place. Tilt the soil corer to one side and insert the blade of the shovel underneath the base of the core. Use the base of the shovel to hold the sample in place as you remove the corer from the soil. Depending on the soil type, this technique may require some practice and/or the use of a partner.

3. *Saturated or wetland soils.*

Attempt to collect a sample using the soil corer. If this is not possible, or if compaction occurs,
use one of the three alternate methods outlined in Section 4.7.5.

4. *Buried Soils*

In areas located adjacent to rivers or other bodies of water, sediment transport and periodic flooding may result in the formation of buried soils. Buried soils may be identified by alternating layers of mineral soil and forest floor material. To confirm the presence of a buried soil, excavate a small hole near the soil sampling site with a shovel and look for the presence of forest floor and litter materials buried between layers of mineral soil.

Collect only the litter and organic matter currently on the soil surface as a forest floor sample following the standard protocol. Attempt to collect 0-4 and 4-8 inch samples using the bulk density corer. If this is not possible, or if the cores do not fill completely, collect a sample using a shovel following the excavation method outlined in 4.7.5. Place a star on the upper right corner of the sampling label, circle “Other” for sampler type, and make a clear note on the shipping form to indicate that this sample represents a buried soil.

5. *Other situations in which a complete 8 inch core cannot be collected*

If a complete core cannot be obtained in one sample, but is cohesive enough to collect a second sample from the same hole, try the following. Collect a partial sample and measure the length of the collected core. Reinsert the sampler and drive it into the soil to an additional depth close to the length of the collected core. Remove the new core from the sampler. When placed together, the two cores should exceed 8 inches in length. With a knife, cut the cores at the 4-inch and 8-inch lengths. Replace the additional soil into the soil hole.

In some soil types, the 0-4 inch core may not fill completely, although the 4-8 inch core appears to be full. In this instance, attempt to collect a second core by driving the core deeper into the soil. In terms of the soil chemistry, it is better to *slightly* overcompact the sample than to under fill the core. Make three attempts to completely fill the core, driving the corer deeper each time. If you are still unable to obtain a complete 0-4 inch core, collect the 0-4 inch sample and mark "Other" under sampler type. An under filled core cannot be used a bulk density sample. If the 4-8 inch sample is full, it should be collected as a bulk density sample (mark "Bulk Density" under sampler type)

3.7.7 Organic soils (Core 11.7.7)

These soils are prevalent in certain regions of the country (e.g., Maine, northern Minnesota, coastal regions) and proper sampling requires modification of the above procedures.

- Due to the large thickness of the underlying organic soil, sampling is restricted to the litter layer. Measure the entire thickness of the forest floor to a maximum depth of 20 inches. However, only collect a sample of the litter layer (see section 3.7.1).

- Attempt to collect a soil sample using the impact driven corer. In many cases, this will not be possible without severe compaction of the sample. If compaction occurs, or if you have difficulty in obtaining a complete core, samples may be collected at the 0 - 4 inch and 4 - 8 inch depth increments using a Dutch auger or shovel (see section 3.7.5).

3.7.8 SUBPLOT NUMBER (Core 11.7.8)

Record the number of the subplot adjacent to the soil sampling site.

When Collected: All soil sample locations
Field Width: 1 digit
Tolerance: No errors
MQO: At least 99% of the time
Values: 2 to 4

3.7.9 CONDITION CLASS (Core 11.7.9)

Record the condition class for the soil sampling site. If the condition class for the soil sample is different from any recorded on the 4 subplots, enter “0".

When Collected: All soil sample locations
Field Width: 1 digit
Tolerance: No errors
MQO: At least 95% of the time
Values: 0 to 9

3.7.10 VISIT NUMBER (Core 11.7.10)

Record the number of the soil sampling location (Figure 28) at which the soil sample was collected.

When Collected: All soil sample locations
Field Width: 1 digit
Tolerance: No errors
MQO: At least 99% of the time
Values: 1 to 9

3.7.11 SOIL SAMPLE STATUS (Core 11.7.11)

Record whether or not a forest floor or mineral soil sample was collected at the soil sampling location. For both forest floor and mineral samples, it is the condition of the soil sampling sites in the annular plot that determines whether soil samples are collected. Samples are collected if, and only if, the soil sampling site is in a forested condition (regardless of the condition class of the subplot). For example, in cases where the subplot has at least one forested condition class and the soil sampling site is not in a forested condition class, soil samples are not collected. Similarly, in cases where the soil sampling site is in a forested condition class and the subplot does not have at least one forested condition class, soil samples are collected.

When Collected: Mineral soil on subplot 2 and forest floor on subplots 2, 3, and 4
Field Width: 1 digit
Tolerance: No errors
MQO: At least 99% of the time
Values:

1 Sampled
2 Not sampled: non-forest

The following are for forest conditions:

3 Not sampled: too rocky to sample
4 Not sampled: water or boggy
5 Not sampled: access denied
6 Not sampled: too dangerous to sample
7 Not sampled: obstruction in sampling area
8 Not sampled: broken or lost equipment
9 Not sampled: other - enter reason in plot notes

3.7.12 FOREST FLOOR THICKNESS – NORTH (Core 11.7.12)

Record the thickness (to the nearest 0.1inch) of the forest floor measured from the top of the litter layer to the boundary between the forest floor and mineral soil

Measure to a maximum depth of 20 inches. If the thickness of the forest floor is greater than 20 inches, then code "20." For locations where bare soil or bedrock material is exposed, enter "00" inches depth. On organic soils, measure the entire thickness of the forest floor (to 20 inches) even though you will only sample the litter layer.

When Collected: When SOIL SAMPLE STATUS = 1
Field Width: 2 digits
Tolerance: +/- 2 in
MQO: 90% of the time
Values: 00.0 to 20.0

3.7.13 FOREST FLOOR THICKNESS – EAST (Core 11.7.13)

Record the thickness (to the nearest 0.1 inch) of the forest floor measured from the top of the litter layer to the boundary between the forest floor and mineral soil.

Measure to a maximum depth of 20 inches. If the thickness of the forest floor is greater than 20 inches, then code "20." For locations where bare soil or bedrock material is exposed, enter "00" inches depth. On organic soils, measure the entire thickness of the forest floor (to 20 inches) even though you will only sample the litter layer.

When Collected: When SOIL SAMPLE STATUS = 1
Field Width: 2 digits
Tolerance: +/- 2 inches
MQO: 90% of the time
Values: 00.0 to 20.0

3.7.14 FOREST FLOOR THICKNESS – SOUTH (Core 11.7.14)

Record the thickness (to the nearest 0.1 inch) of the forest floor measured from the top of the litter layer to the boundary between the forest floor and mineral soil.

Measure to a maximum depth of 20 inches. If the thickness of the forest floor is greater than 20 inches, then code "20." For locations where bare soil or bedrock material is exposed, enter "00" inches depth. On organic soils, measure the entire thickness of the forest floor (to 20 inches) even though you will only sample the litter layer.

When Collected: When SOIL SAMPLE STATUS = 1
Field Width: 2 digits
Tolerance: +/- 2 in
MQO: 90% of the time
Values: 00.0 to 20.0

3.7.15 FOREST FLOOR THICKNESS – WEST (Core 11.7.15)

Record the thickness (to the nearest 0.1 inch) of the forest floor measured from the top of the litter layer to the boundary between the forest floor and mineral soil.

Measure to a maximum depth of 20 inches. If the thickness of the forest floor is greater than 20 inches, then code "20." For locations where bare soil or bedrock material is exposed, enter “00" inches depth. On organic soils, measure the entire thickness of the forest floor (to 20 inches) even though you will only sample the litter layer.

When Collected: SOIL SAMPLE STATUS = 1
Field Width: 2 digits
Tolerance: +/- 2 in
MQO: 90% of the time
Values: 00.0 to 20.0

3.7.16 THICKNESS OF THE LITTER LAYER - NORTH (Core 11.7.16)

Record the thickness of the litter layer (to the nearest 0.1 inch) at the north location within the sampling frame. The bottom of the litter layer can be distinguished as the boundary where plant parts (such as leaves or needles) are no longer recognizable as such because of decomposition. Another criterion is that the organic layer may contain plant roots, but the litter layer will probably not. At some locations, the depth of the forest floor and the litter layer may be the same. For locations where bare soil or bedrock material is exposed, enter “00" inches depth.

When Collected: SOIL SAMPLE STATUS = 1
Field Width: 2 digits
Tolerance: +/- 2 in
MQO: 90% of the time
Values: 00.0 to 20.0

3.7.17 THICKNESS OF THE LITTER LAYER – EAST (Core 11.7.17)

Record the thickness of the litter layer (to the nearest 0.1 inch) at the east location within the sampling frame. The bottom of the litter layer can be distinguished as the boundary where plant parts (such as leaves or needles) are no longer recognizable as such because of decomposition. Another criterion is that the organic layer may contain plant roots, but the litter layer will probably not. At some locations, the depth of the forest floor and the litter layer may be the same. For locations where bare soil or bedrock material is exposed, enter “00" inches depth.

When Collected: SOIL SAMPLE STATUS = 1
Field Width: 2 digits
Tolerance: +/- 2 in
MQO: 90% of the time
Values: 00.0 to 20.0

3.7.18 THICKNESS OF THE LITTER LAYER – SOUTH (Core 11.7.18)

Record the thickness of the litter layer (to the nearest 0.1 inch) at the south location within the sampling frame. The bottom of the litter layer can be distinguished as the boundary where plant parts (such as leaves or needles) are no longer recognizable as such because of decomposition. Another criterion is that the organic layer may contain plant roots, but the litter layer will probably not. At some locations, the depth of the forest floor and the litter layer may be the same. For locations where bare soil or bedrock material is exposed, enter “00" inches depth.

When Collected: SOIL SAMPLE STATUS = 1
Field Width: 2 digits
Tolerance: +/- 2 in
MQO: 90% of the time
Values: 00.0 to 20.0

3.7.19 THICKNESS OF THE LITTER LAYER – WEST (Core 11.7.19)

Record the thickness of the litter layer (to the nearest 0.1 inch) at the west location within the sampling frame. The bottom of the litter layer can be distinguished as the boundary where plant parts (such as leaves or needles) are no longer recognizable as such because of decomposition. Another criterion is that the organic layer may contain plant roots, but the litter layer will probably not. At some locations, the depth of the forest floor and the litter layer may be the same. For locations where bare soil or bedrock material is exposed, enter “00" inches depth.

When Collected: SOIL SAMPLE STATUS = 1
Field Width: 2 digits
Tolerance: +/- 2 in
MQO: 90% of the time
Values: 00.0 to 20.0

3.7.20 DEPTH TO RESTRICTIVE HORIZON (Core 11.7.20)

Insert the tile probe into five locations within the soil sampling area (center, north, east, south and west edges) to identify if a restrictive horizon exists. Record the median depth to a restrictive layer. The maximum depth for testing for a restrictive horizon is 20 inches. If a restrictive layer is encountered within the 20 inches, record the median depth (inches) to the restrictive horizon of the five locations probed. Record:

20 if a restrictive horizon is not encountered.
00 if superficial bedrock is present.
99 if too many rock fragments or cobbles prevent inserting soil probe.

When Collected: SOIL SAMPLE STATUS = 1
Field Width: 2 digits
Tolerance: +/- 6 in
MQO: 90% of the time
Values: 00 to 20, 99

3.7.21 SOIL TEXTURE IN THE 0-4 INCH LAYER (Core 11.7.21)

Record the code for the soil texture of the 0-4 inch layer. To estimate texture in the field, collect a sample of the soil from the appropriate horizon and moisten it with water to the consistency of modeling clay/wet newspaper; the sample should be wet enough that all of the particles are saturated but excess water does not freely flow from the sample when squeezed. Attempt to roll the sample into a ball. If the soil will not stay in a ball and has a grainy texture, the texture is either sandy or coarse sandy. If the soil does form a ball, squeeze the sample between your fingers and attempt to form a self-supporting ribbon. Samples which form both a ball and a ribbon should be coded as clayey; samples which form a ball but not a ribbon should be coded as loamy.

In some soils, telling the difference between the bottom of the forest floor and the top of an organic-rich mineral horizon can be difficult. If uncertain:

- Look for evidence of plant parts (e.g., leaves, needles). If you can see them decomposing in place, you're still in the forest floor.
- Rub the soil between your finger. Does it crumble (organic forest floor) or feel more like modeling clay (try pinching into a ribbon).
- Look for shiny flecks of mica or quartz (won't help in all soils).
- Look for a subtle change in color. Organic horizons tend to be black; a mineral horizon will tend to be more brownish.
- Wet a sample of the material and press it between your fingers. Note the color of the liquid that runs out. The blacker the color, the higher the organic content.
- Check for a change in density (mineral soils are denser).

When Collected: SOIL SAMPLE STATUS = 1 and SUBPLOT NUMBER = 2
Field Width: 1 digit
Tolerance: +/- 1 class
MQO: 80% of the time

Values:

0	Organic
1	Loamy
2	Clayey
3	Sandy
4	Coarse Sand

3.7.22 SOIL TEXTURE IN THE 4-8 INCH LAYER (Core 11.7.22)

Record the code for the soil texture of the 4-8 inch layer (see the directions for SOIL TEXTURE IN THE 0-4 INCH LAYER).

When Collected: SOIL SAMPLE STATUS = 1 and SUBPLOT NUMBER = 2
Field Width: 1 digit
Tolerance: +/- 1 class
MQO: 80% of the time
Values:

0	Organic
1	Loamy
2	Clayey
3	Sandy
4	Coarse Sand

3.8 SAMPLE LABELS (Core 11.8)

Pre-printed labels will be provided to each field crew. Completion of all items on the soil label is essential for proper processing of the sample by the laboratories. In past years, numerous samples have had to be discarded due to mistakes or inconsistencies on the labels. If you encounter a situation where you need to make additional notes on the sample (e.g., a sample which was particularly unusual or required significant deviation from the standard methods), place a star on the upper right corner of the label and make a note on the sample shipping form. An example label is presented in Figure 31.

Soil Sample Collected by Regular Field Crew	
State: «State»	County: «county»
P2 Plot: «FIAHex»	P3 Hex: «FHMHex»
P3 Plot #: _ Soil Visit #: _ Crew **#:** ___________	
Date: ____/____/____	Subplot#: 2 3 4
Layer: Forest Floor	0–4 in 4–8 in

Figure 31. Example soil label (11-4)

STATE

The 2-digit FIPS (Federal Information Processing Standard) code for the State (see Appendix 1 in the P2 field guide). This will be used by the soil analysis laboratory for batching of samples (should be pre-printed on labels).

COUNTY

The 3-digit FIPS (Federal Information Processing Standard) code identifying the county, parish, or borough (or unit in AK). See Appendix 1 in the P2 field guide. This will be used by the soil analysis laboratory for batching of samples (should be pre-printed on labels).

PLOT NUMBER

The P2 plot number (should be pre-printed on label)

P3 HEXAGON NUMBER

The seven digit P3 hexagon number for the plot. This must be the same as that entered on the PDR (should be pre-printed on label).

P3 PLOT NUMBER:

This number will usually be “1.” However, if more than one Phase 3 plot is located within a hexagon, then enter the number of the plot. Since most labels are preprinted, the number “1” may already be printed on the label. If incorrect, cross through this value and write the correct plot number above. If uncertain, check with your field supervisor.

SOIL VISIT NUMBER:

Record the soil visit number as described in Figure 39. For the first soil sample collected along a soil sampling line, this number will be "1". All subsequent visits to a plot will have higher numbers.

DATE SAMPLED:

Enter the date that soils were sampled on this plot.

CREW NUMBER

Enter your field crew identification number. If you have not been assigned a number, enter your last name.

LAYER TYPE:

Circle the type of sample collected and the depth increment of the sample.

SUBPLOT NUMBER:

Circle the subplot adjacent to the soil sampling site.

Subplot 2	Soil sample is from a soil sampling site adjacent to subplot 2
Subplot 3	Soil sample is from a soil sampling site adjacent to subplot 3
Subplot 4	Soil sample is from a soil sampling site adjacent to subplot 4

SAMPLER:

For mineral or organic soils, circle the method used to collect the sample

Bulk Density	Impact-driven soil core sampler
Other	Soil tube probe, excavation method, mud auger, or Dutch Auger

3.9 SAMPLE SHIPPING (Core 11.9)

After samples have been collected, changes in the oxygen and moisture content within the bag can cause significant alteration of sample chemistry. To prevent this from occurring, samples are to be shipped on a weekly basis to the regional soil lab designated for your state. Do not keep soil samples longer than a week unless they can be stored in a refrigerated area. Ship samples using the most economical rate. There is no need to ship soil samples using expensive overnight delivery rates.

3.9.1 Shipping Forms (Core 11.9.1)

All crews will be provided with shipping forms for forwarding soil samples to a regional laboratory that has been approved to receive soil samples from regulated areas. The addresses for the regional labs are listed at the bottom of the shipping form. An example shipping form is provided in Figure 32.

Forms may be submitted either in hard copy or electronically. Electronic versions are preferred by the lab since this greatly increases the efficiency of sample inventory.

The hard copy version of the shipping form consists of a triplicate copy. Prior to shipping samples, crews should completely fill out the shipping form and:

- Send the original with the soil samples to the laboratory.
- Mail one copy immediately to the laboratory in a separate envelope along with a copy of the shipping (tracking) information from the shipping service. The separate mailing of shipping forms will serve to notify the laboratory if a shipment of samples has been misplaced during transport.
- Send the third copy to the regional field supervisor for their records.

Electronic versions may be filled out on a computer and electronic copies sent to the lab and your regional field supervisor. Lab email addresses are provided at the bottom of the shipping form. Print out a hard copy of the form and enclose this in the box prior to shipping. The hard copy is required as a QA check on sample inventory.

A separate line must be completed for each sample collected. Information on the sample shipping form is used by the laboratory to create an inventory of samples, to assign lab numbers, and to help resolve inconsistencies on the sample label. A complete and accurate inventory of samples is critical to efficient and cost-effective processing of samples.

FIA Phase 3 Soil Samples Shipping Form

Name: ________________________ Shipped Via: ______________
Signature: ______________________ Tracking Number: ___________
Date: _________________________
Crew #: ______________ QA Status:__ Standard__ Audit__

State	County	P2 Plot Number	P3 Hexagon Number	Date Sampled	Layer Type (Forest Floor, 0-4 in, or 4-8 in)	Subplot Number (2, 3, or 4)	Bags/Sample (note if more than 1 such as for large forest floor samples)

Total Number of Bags Sent __________

Please provide all information and ship samples WEEKLY to the appropriate lab for the region in which the samples were collected.

Western States: Ship to: Soil and Water Analysis Phone (435) 755-3560
Forestry Sciences Lab
860 N 1200 E
Logan, UT 84321

Instructions:
1) Fill out form completely. Make certain all soil sample bag labels are correct and complete.
2) Send white copy with soil samples.
3) Mail yellow copy in separate envelope to lab.
4) Keep pink copy.
5) Regular field crews: Please check "Standard" box at top of form.
6) QA crews: Please use a separate form for QA audit samples and check "Audit" box above.

Figure 32. FIA Phase 3 soil samples shipping form. (11-5)

NAME:
Enter your name here.

SHIPPED VIA:
Enter the method used to ship the sample (e.g., UPS, Priority mail, regular mail).

SIGNATURE:
Sign your name here.

TRACKING NUMBER:
Enter the tracking number assigned to the shipment. This information is used by regional supervisors and the laboratories to locate lost or missing shipments.

STATE CODE:
Enter the two-digit FIPS code for the state in which the samples were collected.

DATE:
Enter the date on which samples were shipped.

CREW NUMBER:
If you have been assigned a crew number, enter it here.

QA STATUS:
Indicate whether this sample was collected as part of a standard plot or as part of an audit/QA plot. Unless you are conducting a hot, cold, or blind check, the option for "standard" should be checked.

P3 HEXAGON NUMBER:
Enter the seven digit P3 hexagon number for the plot. This must be the same as that entered on the PDR (should be pre-printed on sample label).

STATE
The 2-digit FIPS (Federal Information Processing Standard) code for the State (see Appendix 1 in the P2 field guide). This will be used by the soil analysis laboratory for batching of samples (should be pre-printed on labels).

COUNTY
The 3-digit FIPS (Federal Information Processing Standard) code identifying the county, parish, or borough (or unit in AK). See Appendix 1 in the P2 field guide. This will be used by the soil analysis laboratory for batching of samples (should be pre-printed on labels).

PLOT NUMBER

The P2 plot number (should be pre-printed on label).

DATE SAMPLED:

Enter the date that the soil sample was collected.

LAYER TYPE:

Indicate the soil layer from which this sample was collected. Choices are: forest floor, 0-4 inches, and 4-8 inches.

SUBPLOT NUMBER:

Enter the subplot adjacent to the soil sampling line from which this sample was collected.

BAGS/SAMPLE

Enter the number of bags associated with a sample. For some forest floor samples, more than 1 bag may be needed to collect all of the material. The lab uses this information to make certain that samples consisting of multiple bags are processed together.

TOTAL NUMBER OF BAGS SENT:

Enter the total number of bags contained in the shipment. The laboratory staff will compare the number on this shipping form to the number of bags that they receive in order to make sure that no samples are missing.

3.9.2 Government Regulations For Pest-Regulated States (Southern Region, NY, AZ, NM, CA, and HI)

In order to limit the movement of agricultural pests (e.g., fire ant, corn cyst nematode, golden nematode, witchweed, and Mexican fruit fly), the shipment of soil samples across state boundaries is strictly regulated by the USDA. States with these pests are primarily located in the southern United States and include AL, AR, FL, GA, LA, MD, MS, NC, OK, SC, TN, and TX); soil shipments are also regulated in AZ, NM, CA, HI, and NY. In order to receive a permit to accept soil samples from these areas, the soil labs have had to sign a compliance agreement with the Plant Protection and Quarantine program of the USDA Animal and Plant Health Inspection Service (APHIS) and pass an inspection.

The burden for meeting APHIS shipping regulations falls on the field crews. Crews must:

- Double bag or enclose all samples from a shipment within a larger plastic bag (i.e., trash bag).

- Attach a shipping label to the outside of the box .
- Attach a regulated soils label showing the regional lab's APHIS permit number to the box.

After analysis, all soil samples must be stored or disposed of in the prescribed manner.

3.10 TASKS THAT CAN BE PERFORMED BY OTHER CREW MEMBERS (Core 11.10)

In order to maximize efficiency on the plot, crew members not trained in the soil indicator may be asked to assist with certain tasks related to sample collection. These tasks include:

- Locating the sampling site (with instruction from trained crew member).
- Assembling the impact driven corer.
- Filling in bag labels and sample shipping forms (Note: these should be checked by trained crew member prior to leaving the plot to ensure completeness and accuracy).
- Cleaning the core liners and the coring head.
- Disassembling the impact driven corer.

3.11 REFERENCES (Core 11.11)

British Columbia Ministry of Forestry. 1997. Soil conservation surveys guidebook. http://www.for.gov.bc.ca/tasb/legsregs/fpc/fpcguide/SOILSURV/soil-toc.htm

Kern, J.S., M.L. Papp, J.J. Lee, and L.J. Blume. 1988. Soil Sampling Manual for the Direct/Delayed Response Project Mid-Appalachian Soil Survey. U.S. Environmental Protection Agency, Corvallis, OR.

NCASI. 1983. Field Study Program Elements to Assess the Sensitivity of Soils to Acidic Deposition Induced Alterations in Forest Productivity. Technical Bulletin No. 404. National Council of the Paper Industry for Air and Stream Improvement, Inc., New York.

Riitters, K., M. Papp, D. Cassell, and J. Hazard (eds.). 1991. Forest Health Monitoring Plot Design and Logistics Study. U.S. Environmental Protection Agency, Research Triangle Park, NC.

Santiago Declaration. 1995. Criteria and indicators for the conservation and sustainable management of temperate and boreal forests: The Montreal process.

Soil and Water Quality: An Agenda for Agriculture. 1993. Committee on Long-Range Soil and Water Conservation, Board of Agriculture, National Research Council. National Academy Press, Washington, DC.

United Nations Economic Commission For Europe, Convention on Long-range Transboundary Air Pollution. 1994. Manual on Methods and Criteria for Harmonized Sampling, Assessment, Monitoring and Analysis of the Effects of Air Pollution on Forests. 3rd ed.

USDA-Soil Conservation Service. 1992c. Soil Survey Manual. Title 430-V-SSM, U.S. Government Printing Office, Washington, DC.

3.12 ACKNOWLEDGEMENTS (Core 11.12)

The National Advisor for this indicator may be contacted at: Michael Amacher, USDA Forest Service, Rocky Mountain Research Station, 860 N. 1200 E, Logan UT 84321, via phone at (435) 755-3560 or via email at mamacher@fs.fed.us .

3.13 EXAMPLE DATA SHEETS (Core 11.13)

Soil Data Sheet 1
FIA Phase 3 Soil Sampling Site Measurements

State: ___ ___ County: ___ ___ ___ P2 Plot #: ___ ___ ___ ___

P3 Hexagon #: ___ ___ ___ ___ ___ ___ ___ Plot #: ___

Soil Visit #: ___

Date: ___/___/_____ Crew Member(s): ____

Soil Sampling Site Information

Soil Sampling

Site Adjacent To:	Condition Class	Code	Sampling Min 1	Sampler Min 2
Subplot 2:	______	______	____	____
Subplot 3:	______	______	____	____
Subplot 4:	______	______	____	____

Sampler

1= Bulk Density

2= Other

Sampling Codes

1 = Sampled
2 = Not sampled: non-forest
3 = Not sampled: too rocky
4 = Not sampled: water
5 = Not sampled: access denied
6 = Not sampled: too dangerous
7 = Not sampled: obstruction in sample area
8 = Not sampled: broken or lost equipment
9 = Not sampled: other (enter reason in plot notes)

Forest Floor Thickness (cm)

	N	E	S	W
Subplot 2 Soil Sampling Site:	_____	_____	_____	_____
Subplot 3 Soil Sampling Site:	_____	_____	____	_____
Subplot 4 Soil Sampling Site:	____	_____	_____	_____

Litter Layer Thickness (cm)

	N	E	S	W
Subplot 2 Soil Sampling Site:	_____	_____	_____	_____
Subplot 3 Soil Sampling Site:	_____	_____	_____	_____
Subplot 4 Soil Sampling Site:	_____	_____	_____	_____

Depth to Subsoil Restrictive Layer (cm)

Subplot 2 Soil Sampling Site: _____
Subplot 3 Soil Sampling Site: _____
Subplot 4 Soil Sampling Site: _____

Field Texture Determination

			Soil Texture Codes
Subplot 2 Soil Sampling Site:	Mineral 1 (0-4 in)	_____	0 = Organic
	Mineral 2 (4-8 in)	_____	1 = Loamy
Subplot 3 Soil Sampling Site:	Mineral 1 (0-4 in)	_____	2 = Clayey
	Mineral 2 (4-8 in)	_____	3 = Sandy
Subplot 4 Soil Sampling Site:	Mineral 1 (0-4 in)	_____	4 = Coarse sandy
	Mineral 2 (4-8 in)	_____	

Note to regular field crews: Collect mineral 1 and mineral 2 samples from forested sampling sites adjacent to subplot 2 only

Soil Data Sheet 2
FIA Phase 3 Soil Erosion and Compaction Measurements

State: ___ ___ County: ___ ___ ___ P2 Plot #: ___ ___ ___ ___

P3 Hexagon #: ___ ___ ___ ___ ___ ___ ___ Plot #: ___
Soil Visit #: ___

Date: ___/___/_____
Crew Member(s):
____

____

Soil Erosion Measurements:

Subplot	Bare Soil[a] (%)
1	
2	
3	
4	

[a] Percent area estimate for forested portion of subplot

Measurement	Subplot 1	Subplot 2	Subplot 3	Subplot 4
% Forested Area Compacted				
Type - Rutted Trail				
Type - Compacted Trail				
Type - Compacted Area				
Type - Other (Explain)*				

Soil Compaction Measurements:

*Explanations:
____
____

CHAPTER 4
LICHENS

4.1 OVERVIEW (Core 10.1)

4.1.1 Scope and Application (Core 10.1.1)

The purpose of the lichen community indicator is to use lichen species and communities as biomonitors of change in air quality, climate change, and/or change in the structure of the forest community. Lichen communities are excellent indicators of air quality, particularly long-term averages of sulfur dioxide concentrations (Hawksworth and Rose 1976; Smith and other 1993; van Dobben 1993).

Lichen communities provide information relevant to several key assessment questions, including those concerning the contamination of natural resources, biodiversity, and sustainability of timber production (Figure 33). Lichens not only indicate the health of our forests, but there is a clearly established linkage to environmental stressors, as described below.

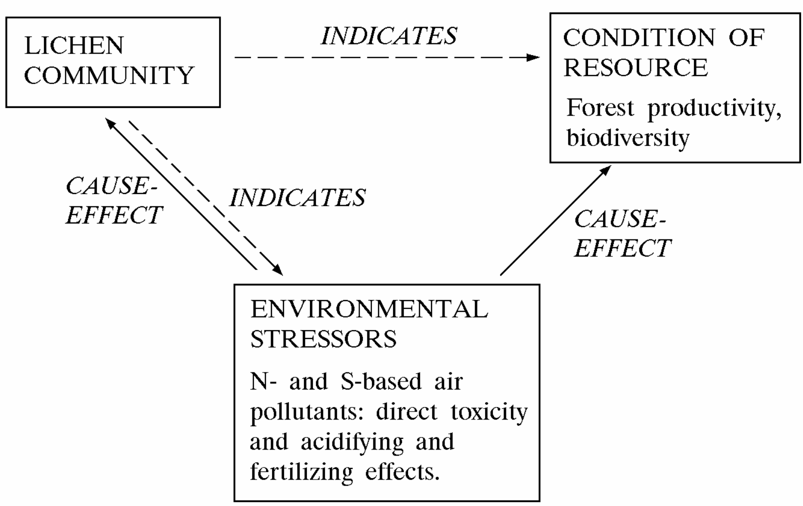

Figure 33. Conceptual model of the lichen community indicator. (10-1)

4.1.2 Summary of Method(Core 10.1.2)

The objectives of this task are to determine the presence and ABUNDANCE (section 4.3.9) of macrolichen species on woody plants in each plot and to collect samples to be mailed to lichen specialists. Note that the crew member responsible for this task is not required to accurately assign species names to the lichens (that is done later by a specialist) but must be able to make distinctions among species.

The field method has two parts that are performed at the same time:

1. Collect a specimen of each macrolichen species on the plot for identification by a specialist. The population being sampled consists of all macrolichens occurring on live or standing dead woody plants, excluding the 19.7 inch (0.5 m) basal portions of trees, snags, saplings, and shrubs. Include in your sampling recently fallen branches on which the canopy lichens still look healthy (usually down for no more than a few months). Branches and logs left from recent harvests are legal substrate. Older down woody debris and any sawed or human-treated wood surfaces are not legal substrates.

2. Estimate the ABUNDANCE (section 4.3.9) of each species. Possible species which you are not sure are different from those already collected should be collected as many times as needed with ABUNDANCE rated separately for each sample.

4.1.3 Equipment and Supplies (Core 10.1.3)

4.1.3.1 Consumable Supplies (Core 10.1.3.1)

- Specimen packets folded from 8.5" x 11" paper, averaging 30 per plot. Regions may differ in how packets are provided. It is convenient to type/print your name and State into a master template file, then print your customized template as a master to make copies. This file is available from your regional crew supervisor. Before you print the template, be sure the page margins in your word processing software are set so that the packet label prints on the bottom one-third of a 8.5 x 11- inch piece of paper. You can also type your name and State on a paper template (Figure 35) to use as a duplicating master. Take 30-50 #1 or #2 paper bags as backup “packets” on very wet days.
- Permanent ink pen for recording data on packets.
- Mailing forms (Figure 37).
- Large rubber bands to keep packets together. Medium size paper bags (#3 - #4) or similar size), one per plot as alternates, or a few for plots with many packets.

4.1.3.2 Equipment and Apparatus (Core 10.1.3.2)

- Backpack or similar bag to keep lichen packets and equipment together.
- Locking-blade or fixed-blade knife with sheath.
- 10X hand lens – Hastings triplet optics preferred to avoid headaches. String hand lens on a neck cord to avoid losing it.
- Hand pruners that are useful for collecting small branch segments.
- Wood chisel at least 0.75-inch wide that is useful for collecting samples from tough-barked hardwoods. Chisel should have a sheath.
- Timepiece.
- Convenient, optional equipment. 8-digit number stamp and date stamp plus ink pad for adding date and P3 HEXID to packets and Plot Data Card.

- Regional guides for lichen identification. Different guides will be needed for different areas:

  Northeast, Mid-Atlantic, and Southeast:
  - Hale, M.E. 1979. How to Know the Lichens. 2nd Ed. Wm. C. Brown, Dubuque, Iowa.
  - Flenniken, D. G. 1999. Macrolichens in West Virginia. 2727 Twp. Rd 421, Sugarcreek, OH: Carlisle Printing

  North Central
  - Hale, M.E. 1979. How to Know the Lichens. 2nd Ed. Wm. C. Brown, Dubuque, Iowa.

  Interior West
  - Bungartz, F.; Rosentreter, R.; Nash, III, T. H. 2002. Field guide to common epiphytic marolichens in Arizona. Arizona State University Lichen Herbarium. 91 p.
  - McCune, B.; Goward, T. 1995. Macrolichens of the Northern Rocky Mountains. Eureka, CA: Mad River Press, 208 pp.
  - St. Clair, L. L. A Color Guidebook to Common Rocky Mountain Lichens. Available from M. L. Bean Life Science Museum, 290 MLBM, Brigham Young University, Provo, UT 84602.
  - McCune, B.; Geiser, L. 1997. Macrolichens of the Pacific Northwest. Corvallis, OR: Oregon State University Press. 386 p.

  California
  - Hale, M. E.; Cole, M. 1988. Lichens of California. Berkeley: University of California Press.

- McCune, B.; Geiser, L. 1997. Macrolichens of the Pacific Northwest. Corvallis, OR: Oregon State University Press. 386 p.

Pacific Northwest:

- McCune, B.; Geiser, L. 1997. Macrolichens of the Pacific Northwest. Corvallis, OR: Oregon State University Press. 386 p.

4.1.4 Procedure (Core 10.1.4)

1. The area to be sampled (henceforth the "lichen plot") is a circular area with a 120-foot radius centered on subplot 1, but excluding the four subplots (see Figure 34). The area of the lichen plot is 40715 ft^2 = 3782 m^2 = 0.378 ha = 0.935 acres.

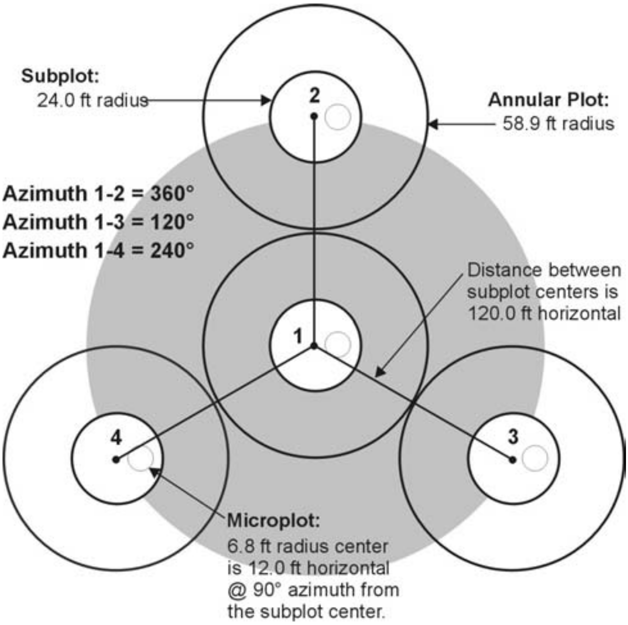

Figure 34. Lichen sampling area. The shaded area is the lichen plot. (10-2)

2. Record TIME LICHEN SAMPLING BEGAN and TIME LICHEN SAMPLING ENDED. Sampling continues for a maximum of two hours or until 10 minutes elapse with no additional species recorded. At least 45 minutes in the Northeast, North Central, South, and West Coast including Alaska, and 30 minutes in the Intermountain West, must be spent searching the plot, even if very few lichens are present.

3. Take a reconnaissance walk through the lichen plot, locating lichen epiphytes on woody plants and collecting lichen samples and assigning ABUNDANCE scores . The following method is suggested. Begin at approximately 100 ft due north from plot center, estimating to the limiting boundary of 120 feet, and continue to the right in a sinuous manner until reaching the perimeter of subplot 3. The same procedure is followed between subplots 3 & 4 and 4 & 2. The idea behind this approach is that the crew can scan the whole area but intensely scrutinize selected areas to best represent the diversity on the plot (see item 4 for more details). If time allows, make additional circuits of the plot, searching for substrates or spots that were not visited on the first pass. Collect on the entire lichen plot regardless of forest vs. nonforest condition. Do not collect from any portion of the lichen plot that is denied access or inaccessible. If only part of the plot is sampled for one of these reasons, note on the PDR under SAMPLING ISSUES OR PROBLEMS (section 10.3.24).

4. Lichen species with the following growth forms will be collected: fruticose and foliose (i.e., macrolichens).

   - Inspect woody plants (trees, saplings, and shrubs > 19.7 inches tall (0.5 m tall)) within the lichen plot for lichen species. This includes dead trees.
   - Be careful to inspect the full range of substrates and microhabitats available:
     - shaded and exposed
     - both live and standing dead trees,
     - conifers and hardwoods
     - branches and twigs on trees
     - recently fallen (judged to be from above 19.6 inches (0.5 m) healthy lichens plus branches and twigs on which the canopy lichens still look healthy (usually down for no more than a few months). Branches and logs left from recent harvests are legal substrates.
     - shrubs
     - trees in particular topographic positions (for example, check in a draw or ravine on an otherwise uniform slope, so long as it occurs within the lichen plot).

- Older down woody debris, decayed stumps, and any sawed or human-treated wood surfaces are not legal substrates.

5. Collect a large (ideally palm-sized) sample of each possible species and place it in a packet. Label the packet with the STATE, COUNTY, PLOT NUMBER, P3 HEXAGON NUMBER, and CURRENT DATE, packet number (sequentially as collected), and record relative ABUNDANCE code. Revise the ABUNDANCE rating as collection proceeds. Also record any comments on the outside of the packet. For more details about variables, see section 4.2, "DATA COLLECTION 1: SAMPLE PROCUREMENT". After completing the task, check each packet to be sure that each one has a STATE, COUNTY, PLOT NUMBER, P3 HEXAGON NUMBER, CURRENT DATE, and ABUNDANCE code.

6. The field crew may have uncertainties about the classification of an organism. The following rules for the field crew are designed to put the burden of the responsibility for classification on the specialist, not the field crew.

   - When in doubt, assume it is a lichen.
   - When the growth form is in doubt, assume it is a macrolichen.
   - When species distinctions are in doubt, assume that two different forms are different species.

   The purpose of these rules is to encourage the field crew to make as many distinctions in the field as possible. The specialist can later adjust the data by excluding specimens that are not macrolichens and by combining forms that were considered separate by the field crew but are actually the same species.

7. Be sure the electronic documentation and the Plot Data Card are complete and comparable where necessary.

8. Dry packets as needed, store them in a dry place, and mail them to the designated lichen specialist using package tracking.

4.1.5 Safety (Core 10.1.5)

Care should be used when removing lichens specimens with a knife or chisel. The knife must have a locking blade or fixed blade. Trees should not be climbed to procure specimens.

4.1.6 Assistance From Persons Not Certified For Lichens (Core 10.1.6)

A crew member not certified in lichens may assist by labeling lichen packets for the 'lichen' crew member as the latter collects. Crew members not certified in lichens should not collect specimens, nor should they help assign ABUNDANCE ratings for lichens.

4.2 DATA COLLECTION 1: SAMPLE PROCUREMENT (Core 10.2)

The set of lichen samples you collect, with the accompanying written information (See 4.3 DATA COLLECTION 2: PDR AND WRITTEN DATA) on the samples, are the primary data for the lichen indicator.

1. Optimally collect a sample of each macrolichen species that has at least 20 lobes or branches and has abundant morphological characters. For larger species this means collect a sample about 3-4 inches in diameter if possible. Macrolichens include all species that are three-dimensional (fruticose) or flat and lobed (foliose). Even minute fruticose and lobate forms should be included. Squamulose species and *Cladonia* squamules lacking fruit bodies or upright stalks should not be included.

2. Place each specimen in a separate packet and fill in the label (Figure 35) as follows:

   - Number packets sequentially as collected.
   - Record relative ABUNDANCE on the packet using the codes listed in section 4.3.9. (Revise this rating as collection proceeds.)

Code	Abundance
1	Rare (< 3 individuals in area)
2	Uncommon (4-10 individuals in area)
3	Common (> 10 individuals in area but less than half of the boles and branches have that species present)
4	Abundant (more than half of boles and branches have the subject species present) Note: this code is not frequently assigned, but is valid. Make sure that more than one out of every 2 boles, branches, and twigs host this species.

   - Often there will be more than one species on a given bark sample. If there is any chance of ambiguity about which species in the packet corresponds with the ABUNDANCE rating, write a descriptive clarifying phrase, such as "the white one" or "the sorediate one," on the packet in the REMARKS box.

- If you are not using a packet template with the CREW MEMBER NAME and STATE printed on it, fill out the CREW MEMBER NAME in the "collector" field and STATE in the label title.
- Fill in these additional fields on the packet label – P3 FHM HEXID, FIA PLOT NUMBER, COLLECTION NUMBER, ABUNDANCE NUMBER, REMARKS -- with an indelible marker, preferably a medium point rolling ball pen with permanent ink. Alternately, regular ballpoint pen (dry packets), waterproof alcohol markers (dry or damp packets), and very soft (#2 or softer) pencils (very damp packets) can be used. If you want to try naming the lichen in the "Scientific Name" box, leave enough room for the ID specialist to also write a name. Leave the "ID Notes" box blank for the ID specialist to use.
- Make sure to check packets for missing ABUNDANCE ratings before you leave the plot.

FOREST INVENTORY AND ANALYSIS PROGRAM - P3

LICHENS OF _______ *(STATE)*

P3 FHM Hexid No: **FIA Plot No:**	**Date:**	**Coll. No:**
Scientific Name:	ID Notes:	**Abundance:**
Collector:	Remarks:	

Figure 35. Lichen packet label. This label is printed centered at the very bottom of an 8.5 in x 11 inch sheet of paper. The sheet is triple-folded with the label on the outside flap; then the sides are folded in to make a packet with a flap. (10-3)

3. Avoid multi-species packets. Each species should be placed in a separate packet with its own ABUNDANCE rating. Multi-species packets typically result in missing ABUNDANCE ratings. Genera such as the tufted lichens *Usnea* and *Bryoria* are frequently found on the branch with several species clustered together. Separate these prior to packeting specimens if possible.

4. Label all of the packets from that day with STATE, COUNTY, P3 HEXAGON NUMBER, CURRENT DATE, PACKET NUMBER, and ABUNDANCE.

5. When also using the PDR, fill out only **bold** fields on the Plot Data Card, (Figure 36) Fill out this card also for a plot when **you have searched and found no lichens**.

6. Place all of the specimen packets from a given plot with the Plot Data Card. Either bundle with two crossed rubber bands, or place into a single or several paper bags **only if** there are too many samples for rubber bands. For paper bags, record P3 HEXAGON NUMBER, CREW MEMBER NAME, CURRENT DATE, and "Bag#___of___" (total # of bags for that plot). Fold the top of each paper bag closed and secure with a rubber band (no staples, please).

7. If specimens were damp or wet when collected, the individual packets should be spread out and dried as soon as possible. Never store or ship lichen specimens damp, and never in plastic bags. For more details, see 4.4 *SPECIMEN PRESERVATION, STORAGE, AND MAILING*.

8. Successful performance of the sample procurement procedure is the goal of all QA and the subject of all tests. For a successful procedure, a crew member finds at least 65% of the macrolichens found on the same plot by a lichen specialist, and correctly records all data for sample packets, the Lichen Data Card, and the mailing form. Correct selection and recording of data for the PDR are tested by correct recording of data on the Plot Data Card

Lichen Communities Indicator **PLOT DATA CARD**

This will be part of the permanent record for this plot. PLEASE COMPLETE IT FULLY!
If using the PDR, complete BOLD fields only. If not using the PDR, complete all fields.

P3 FHM Hexid #: _____________ FIA Plot # _____ **State:** _____ **County:** ________

Date: ____________ Lichen Project__________ **Crew Member's Name:** _________

Crew Type _______ **QA Status** ________ **LICHENS COLLECTED Y N**

Time lichen sampling began:_____ Time lichen sampling ended:_____**Elevation (ft):** ___

% Cover (on lichen plot): Conifers ___________ Hardwoods _________ Tall Shrubs ____

Dominant Tree/Shrub Species(w/% cover)

____

____

____

Important substrate species not on subplots __________________________________

____

% gap _______ Recent(<5 yr)? Y N w/ Tall Shrubs? Y N

Size class(es) of 3 largest trees (in DBH) <10 ____ 10-20 ____21-30 ____ 31-40 ___ >40 __

Features important for high/low lichen diversity (if any) ______________________________

____

Sampling issues/problems (weather, etc) ____

Other comments ____

REMEMBER:

- Record the abundance code on each packet!
- Remember to look for the common species.
- Try to put only one species in each packet.

Figure 36. Plot data card for lichen communities. Complete this form and bundle it with the packets for each plot. (10-4)

4.3 DATA COLLECTION 2: PDR AND WRITTEN DATA (Core 10.3)

4.3.1 OVERVIEW (Core 10.3.1)

Written data are entered for the Lichen Indicator in three locations: (1) the lichen sample Packet, (2) the lichen Plot Data Card, and (3) the lichen PDR screen. All locations for entry are listed for each variable below. If the PDR is working, fill out only **bold** fields on the Plot Data Card. If the PDR is not working, collect all variables by filling out all fields on the Plot Data Card.

Primary data for the Lichen Indicator consist of the set of lichen samples collected from the plots and the data recorded on the lichen packets; these are sent first to a lichen specialist for identification of samples and electronic data entry, then to the Lichen IA for confirmation, proofreading, and merging with other data for the state and region, then to regional and national IM for uploading to the FIA database. Written data on lichen packets link the sample to the proper plot and year during the sample identification process. Required fields on the Plot Data Card accompanying the samples help confirm sample location and provide habitat information about the plot that helps the lichen specialist (who never sees PDR entries) who identifies the samples.

Secondary data for the Lichen Indicator consist of the set of PDR entries on the lichen screen, with optional fields on the Plot Data Card to serve as paper backup when the PDR does not function properly. Duplicated sample location information on the lichen PDR screen and the lichen sample packets and data card are critical information used to correctly match primary lichen data from samples with both secondary data on the lichen PDR screen and data for P2 and other P3 indicators for the plot, in the FIA database.

4.3.2 P3 HEXAGON NUMBER (Core 10.3.2)

Record the unique code assigned to each Phase 3 (former FHM) hexagon on the Packet and the Plot Data card.

When collected: All Phase 3 plots
Field width: 7 digits
Tolerance: No errors
MQO: At least 99% of the time
Values: 7-digit number

4.3.3 FIA PLOT NUMBER (Core 10.3.3)

Record the unique code assigned to each FIA plot that, together with the state and county FIPS codes, identifies the location of the P3 plot. Record on the Packet and the Plot Data Card.

When collected: All Phase 3 plots
Field width: 4 digits
Tolerance: No errors
MQO: At least 99% of the time
Values: Up to a 4-digit number

4.3.4 STATE (Core 10.3.4)

Record the unique FIPS (Federal Information Processing Standard) code identifying the State where the plot center is located. Record on the Packet and the Plot Data Card, also noting the state letter abbreviation as well.

When collected: All Phase 3 plots
Field width: 2 digits
Tolerance: No errors
MQO: At least 99% of the time
Values: See Appendix 1 in the P2 field guide

4.3.5 COUNTY (Core 10.3.5)

Record the unique FIPS (Federal Information Processing Standard) code identifying the county, parish, or borough (or unit in AK) where the plot center is located. Record on the Packet and the Plot Data Card, noting the name as well.

When collected: All Phase 3 plots
Field width: 3 digits
Tolerance: No errors
MQO: At least 99% of the time
Values: See Appendix 1 in the P2 field guide

4.3.6 DATE (Core 10.3.6)

Record date on which plot was surveyed, not date of mailing. This is critically important in sorting out coding problems if any occur. Record on the Packet, the Plot Data Card, and the PDR.

When collected: All plots visited
Field width: NA
Tolerance: No errors
MQO: At least 99% of the time
Values: Full date in any format

4.3.7 LICHEN PROJECT (Core 10.3.7)

Record the type of lichen project for which these data are collected. Record on Packets, Plot Data Card, and PDR.

When collected; All Phase 3 plots
Field width: 1 digit
Tolerance: No errors
MQO At least 99% of the time

Values :

1	Standard production plot
2	Special Study
3	Gradient Study
4	Evaluation Monitoring

4.3.8 COLLECTION NUMBER (Core 10.3.8)

Record the consecutive COLLECTION NUMBER in the "Collection No." box on lichen Packets **only**.

When collected: Every lichen packet for every plot sampled for lichens
Field width: 3 digits
Tolerance: No errors
MQO: At least 99% of packets
Values: 1-999

4.3.9 ABUNDANCE (Core 10.3.9)

Record relative ABUNDANCE score on lichen Packets **only**.

When collected: Every lichen packet for every plot sampled for lichens
Field width: 1 digit
Tolerance: No errors
MQO: At least 99% of packets
Values:

Code	Abundance
1	Rare (< 3 individuals in area)
2	Uncommon (4-10 individuals in area)
3	Common (> 10 individuals in area but less than half of the boles and branches have that species present)
4	Abundant (more than half of boles and branches have the subject species present) Note: this code is not frequently assigned, but is valid. Make sure that more than one out of every 2 boles, branches, and twigs host this species.

4.3.10 CREW MEMBER NAME (Core 10.3.10)

Record the last name of the crew member who collected lichens on this plot on the Packet and the Plot Data Card.

When collected: All Phase 3 plots
Field width: Alphanumeric character field
Tolerance: N/A
MQO: N/A
Values: English language words, phrases, and numbers

4.3.11 CREW TYPE (Core 10.3.11)

Record the code to indicate the type of field crew using the following codes. Record on the Plot Data Card.

When collected: All lichen plots visited
Field width: NA
Tolerance: No errors
MQO: At least 99% of the time
Values:

1 Standard field crew
2 QA crew (any QA crew member present collecting data)

4.3.12 QA STATUS (Core 10.3.12)

Record the code to indicate the type of plot data collected, using the following codes. Record on the Plot Data Card.

When collected: All lichen plots visited
Field width: 1 digit
Tolerance: No errors
MQO: At least 99% of the time
Values:

1 Standard field production plot
2 Cold Check
3 Reference plot (off grid)
4 Training/Practice plot (off grid)
5 Botched Plot file (disregard during data processing)
6 Blind Check
7 Hot Check (production plot)

4.3.13 LICHENS COLLECTED (Core 10.3.13)

Record on the Plot Data Card and the PDR. When recording on the Plot Data Card, circle Y or N. If N is circled, add the reason to the "Other Comments" field using text from the Values listed below. When recording on the PDR, use the codes listed below.

When collected: All lichen plots visited (include all plots with any part designated as forest)
Field width: 1 digit
Tolerance: No errors
MQO: At least 99% of the time
Values:

1	Lichens collected
2	Plot searched, no lichens found
3	Not collected – no measurements taken, plot harvested
4	Not collected – no measurements taken – plot dangerous
5	Not collected – ran out of time
6	Not collected – rain/storm
7	Not collected – left plot for emergency
8	Lichens not scheduled for collection on the plot
9	Not collected for other reason

4.3.14 TIME LICHEN SAMPLING BEGAN (Core 10.3.14)

Enter TIME LICHEN SAMPLING BEGAN as HHMM, where HH is hour and MM is minutes. Use military time (e.g., 1:45 pm is 1345). Record on the Plot Data Card and the PDR.

When collected: All lichen plots visited
Field width: 4 digits
Tolerance:
MQO:
Values: Military time

4.3.15 TIME LICHEN SAMPLING ENDED (Core)

Enter TIME LICHEN SAMPLING ENDED as HHMM, where HH is hour and MM is minutes. Use military time (e.g., 1:45 pm is 1345). Record on the Plot Data Card and the PDR.

When collected: All lichen plots visited
Field width: 4 digits
Tolerance:
MQO:
Values: Military time

4.3.16 % COVER LICHEN PLOT CONIFERS (Core 10.3.16)

Percent canopy cover of overstory conifers (not of lichens). Total of % COVER LICHEN PLOT CONIFERS plus % COVER LICHEN PLOT HARDWOODS (10.3.17) plus % COVER LICHEN PLOT TALL SHRUBS (10.3.18) may be >100%. Total of % COVER LICHEN PLOT CONIFERS plus % COVER LICHEN PLOT HARDWOODS (10.3.17) should not be > 100%. Tall shrubs are those > 3.3 ft (1 m) tall. Record on the Plot Data Card and the PDR.

When collected: All lichen plots visited
Field width: 3 digits
Tolerance: +/- 10%
MQO: At least 99% of the time
Values: 1-100

4.3.17 % COVER LICHEN PLOT HARDWOODS (Core 10.3.17)

Percent canopy cover of overstory hardwoods (not of lichens). Total of % COVER LICHEN PLOT CONIFERS (4.3.16) plus % COVER LICHEN PLOT HARDWOODS plus % COVER LICHEN PLOT TALL SHRUBS (4.3.18) may be >100%. Total of % COVER LICHEN PLOT CONIFERS (4.3.16) plus % COVER LICHEN PLOT HARDWOODS should not be > 100%. Tall shrubs are those > 3.3 ft (1 m) tall. Record on the Plot Data Card and the PDR.

When collected: All lichen plots visited
Field width: 3 digits
Tolerance: +/- 10%
MQO: At least 99% of the time
Values: 1-100

4.3.18 % COVER LICHEN PLOT TALL SHRUBS (Core 10.3.18)

Percent canopy cover of tall shrubs (not of lichens). Total of % COVER LICHEN PLOT CONIFERS (4.3.16) plus % COVER LICHEN PLOT HARDWOODS (4.3.17) plus % COVER LICHEN PLOT TALL SHRUBS may be >100%. Total of % COVER LICHEN PLOT CONIFERS (10.3.16) plus % COVER LICHEN PLOT HARDWOODS (4.3.17)) should not be > 100%. Tall shrubs are those > 3.3 ft (1 m) tall. Record on the Plot Data Card and the PDR.

When collected: All lichen plots visited
Field width: 3 digits
Tolerance: +/- 10%
MQO: At least 99% of the time
Values: 1-100

4.3.19 MOST IMPORTANT TREE AND SHRUB SPECIES (Core 10.3.19)

Please record on the Plot Data Card only, full scientific names plus % cover for the most common trees and shrubs on the lichen plot. Only 1-3 tree species and 1-3 shrub species are needed here.

When collected: All lichen plots visited
Field width: Alphanumeric character field
Tolerance: N/A
MQO: N/A
Values: English language words, phrases, and numbers

4.3.20 IMPORTANT SUBSTRATE SPECIES NOT ON SUBPLOTS (Core 10.3.20)

Please record on the Plot Data Card only, the scientific name of any trees or shrubs that were not found on subplots and that hosted a significantly different or more abundant lichen flora from that on tree species also recorded on subplots.

When collected: Only when such a lichen host is found
Field width: Alphanumeric character field
Tolerance: N/A
MQO: N/A
Values: English language words, phrases, and numbers

4.3.21 Gap (Core 10.3.21)

The next three variables all relate to presence of gaps on the lichen plot.

4.3.21.1 % GAP (Core 10.3.21.1)

Record % GAP in 5 percent classes on the Plot Data Card and the PDR To be a gap, there must be:

- Markedly different terrestrial vegetation than on forest floor
- Lack of trees on at least 3-5% of plot. 3% of a plot is a circle with a 20-foot radius. 4.4% of a plot is the size of one subplot.
- Canopy opening whose length or width is at least one tree length.

Note: Gaps are caused by disturbance, not just low density of tree establishment.

When collected: All lichen plots visited
Field width: 2 digits
Tolerance: +/- 10%
MQO: At least 90% of the time
Values: 00-99

4.3.21.2 RECENT (Core 10.3.21.2)

Record on the Plot Data Card and the PDR. Did the gap appear to be less than 5 years old (e.g., caused by recent disturbance) or not.

When collected: All lichen plots visited
Field width: 1 digit
Tolerance: No errors
MQO: At least 90% of the time
Values:

0	≥ 5 yr old
1	< 5 yr old

4.3.21.3 TALL SHRUBS (Core 10.3.21.3)

Does the gap have > 40% cover of tall shrubs (i.e., > 3.3 ft (1 m) tall)? Broadleaf shrubs in gaps of conifer forest are often especially rich areas for lichen diversity.

When collected: All lichen plots visited
Field width: 1 digit
Tolerance: No errors
MQO: At least 90% of the time
Values:

0	No tall shrubs
1	Tall shrubs present

4.3.22 SIZE CLASS OF 3 LARGEST TREES ENCOUNTERED ON THE LICHEN PLOT (Core 10.3.22)

Record the size class of the three largest trees on the entire lichen plot. Record on the Plot Data Card and the PDR.

When collected: All lichen plots visited
Field width: 1 digit
Tolerance: No errors
MQO: At least 80% of the time
Values:

Code	Size class (DBH, inches)
1	< 10

2	10-20
3	21-30
4	31-40
5	> 40

4.3.23 FEATURES IMPORTANT FOR HIGH/LOW LICHEN DIVERSITY (Core 10.3.23)

Record the important substrate species or conditions that had the most impact on the plot (e.g., recently clearcut, riparian with large hardwoods, old growth). If the diversity is normal, record 00. Record on the Plot Data Card and the PDR.

When collected: All lichen plots visited
Field width: 2 digits
Tolerance: No errors
MQO: At least 90% of the time
Values:

00 No significant features

High Diversity:

01 Stand appears relatively old for its forest type
02 Old remnant trees in otherwise young stand
03 Riparian
04 Gap in forest
05 Moist areas on plot with open structure and high light
06 Abundance of tall shrubs hosting high lichen diversity
07 Hardwoods within conifer forest had high diversity and/or different species
08 Conifers within hardwood forest had high diversity and/or different species
09 Presence of exceptionally good lichen substrate species (differs by region)
10 Other

Low Diversity:

11 Very young forest or recently regenerating clearcut
12 Clearcut
13 Recently burned—lichens apparently removed by fire
14 Too dry for good lichen growth
15 Too exposed or open for good lichen growth

16 Some of plot nonforest
17 Most of trees on plot were poor lichen substrates (differs by region)
18 Most of the diversity was on a few trees or less
19 Other

4.3.24 SAMPLING ISSUES OR PROBLEMS (Core 10.3.24)

Record on the Plot Data Card and the PDR. Record in the PDR any major problems (up to 4) that negatively impacted the collection effort. If any SAMPLING PROBLEMS = 0, no other values will be retained. Record on the Plot Data Card the reason on the "Sampling issues/problems" line.

When collected: All lichen plots visited
Field width: 1 digit
Tolerance: No errors
MQO: At least 99% of the time
Values:

0 No significant issues
1 Too wet to see lichens well
2 Too dark to see lichen well
3 Sampling compromised by heat
4 Sampling compromised by other extreme weather (e.g., hail, lightning, snow)
5 Very steep slope hindered thorough plot access
6 Access to some or all of plot blocked by natural obstacles (e.g., lingering snowpack, high water, landslide, large blowdowns)
7 Other

4.4 SAMPLE PRESERVATION, STORAGE, AND MAILING (Core 10.4)

4.4.1 SAMPLE PRESERVATION AND STORAGE (Core 10.4.1)

Specimens must be thoroughly air dried to avoid fungal decay. If specimens were damp or wet when collected, the individual packets should be spread out and dried as soon as possible. Extremely wet lichens can be blotted dry between towels, then returned to packets to continue air-drying. Dry in the sun, in an air conditioned room, or in any safe place that is as dry as possible. Lichens are dry enough to store when they have become slightly stiff and have lost their soft, wet appearance and feel. Herbarium dryers may be used, but do not use commercial food dryers, ovens, hair dryers, or other strong heat sources.

Store packets in a dry place until you mail them. Never store or ship lichen specimens damp, and never in plastic bags.

4.4.2 SAMPLE MAILING (Core 10.4.2)

Always mail specimens using a mail or parcel service that includes parcel tracking. After the first week of sample collection, mail the specimens to the lichen specialist. The purpose of this is to allow immediate feedback to the field crews concerning specimen quality and quantity. Thereafter, mail the samples each week or every other week to the lichen specialist. You should have the name and address of the lichen specialist. If not, contact your supervisor or:

Susan Will-Wolf (608-262-2754 or swwolf@wisc.edu).

Before mailing the packets, check to see that all fields on packets are filled in. Make sure there is a properly filled in Plot Data Card (Figure 47) with each set of samples. Also include a properly filled in Plot Data Card for each plot searched and found to have no lichens.

Bundles of packets should be packed closely, but without excessive crushing, in sturdy cardboard boxes. Bundles of packets from several plots can be mailed in the same box. Enclose in the box a Lichen Specimen Mailing Form (Figure 37) listing all plots, including plots with no lichens, for the box's contents. Extra copies of the Mailing Form can be found in the notebook of lichen training materials under "Mailings."

LICHEN SPECIMEN MAILING FORM

Please enclose a copy of this form whenever these specimens are mailed. Keep a copy for your records.

FIELD CREW TO LICHEN SPECIALIST: Date

Sent by: ________________ To:________________________
Sender's comments: ____
Received: ____
Comments:____
LICHEN SPECIALIST TO STORAGE: Date
Sent by: ________________ To:_____________________________
Sender's comments:____
Received: ____
Comments: ____

CONTENTS

Hex number	State	County	Collector	Notes

Figure 37. Form used for mailing lichen community specimens, one form per box. (10-5)

4.5 REFERENCES (Core 10.5)

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4.6 ACKNOWLEDGEMENTS (Core 10.6)

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CHAPTER 5
OZONE

5.1 OVERVIEW (Core 9.1)

Air pollutants, such as ground-level ozone, are known to interact with forest ecosystems. Ozone is the only regional gaseous air pollutant that is frequently measured at known phytotoxic levels (Cleveland and Graedel 1979; Lefohn and Pinkerton 1988). Ozone pollution has been shown to have an adverse effect on tree growth and alter tree succession, species composition, and pest interactions (Forest Health and Ozone 1987; Miller and Millecan 1971; Smith 1974). In addition, we know that ozone causes direct foliar injury to many species (Skelly and others 1987; Treshow and Stewart 1973). We can use this visible injury response to detect and monitor ozone stress in the forest environment. This approach is known as biomonitoring and the plant species used are known as bioindicators (Manning and Feder 1980). Ozone bioindicator plants are used to monitor changes in air quality across a region, and to assess the relationship between ozone air quality and Phase 2 and Phase 3 indicators of forest condition (e.g., growth increment and dieback).

A useful bioindicator plant may be a tree, a woody shrub, or a nonwoody herb species. The essential characteristic is that the species respond to ambient levels of ozone pollution with distinct visible foliar symptoms that are easy to diagnose. Field studies and/or fumigation experiments have identified ozone sensitive species and characterized the ozone specific foliar response for both eastern (Davis and Umbach 1981; Duchelle and Skelly 1981; Krupa and Manning 1988) and western (Richards and others 1968; Mavity and others 1995; Brace 1996) bioindicators. Foliar injury symptoms include distinct patterns of coloration, often associated with accelerated senescence.

This section describes procedures to select field sites for ozone biomonitoring using the FIA ozone grid, and to evaluate ozone injury on the foliage of sensitive plant species. Additional ozone sites, on an intensified ozone grid, may also be established by State and federal cooperators to improve the interpretive value of this indicator. This intensified sampling is done using the same methodology as the regular grid activities and is just as important.

5.1.1 SCOPE AND APPLICATION (Core 9.1.1)

The scope of this indicator is national, but procedures are amended regionally as needed, particularly with regard to suitable sites and target species. Other variables, such as number of species, number of plants, and methods of scoring are standardized nationally. The procedures, reporting, and assessment goals were developed with the following considerations:

1. Ozone plot distribution across the landscape covers both the more remote and expansive forests away from population centers and the more fragmented forests located in close proximity to urban areas;

2. Ozone plot stratification nationwide reflects regional differences in air quality regimes and perceived risks to different forest types;

3. Sampling intensity in different regions is designed to allow links between ozone biomonitoring data and other FIA indicators;

4. Seasonal variability in ozone injury is addressed. We know that ozone injury must reach an undefined threshold within a leaf before the injury becomes visible to the human eye, and then tends to be cumulative over the growing season until fall senescence masks the symptoms.

NOTE: There are certain regions of the country where ambient ozone concentrations, during the growing season, routinely exceed levels that are known to injure sensitive plants. Other regions have relatively clean air. In regions with poor air quality, the crew data underscore the extent and severity of ozone pollution in the nation's forests. In regions with better air quality, the emphasis must be on establishing a baseline for the ozone indicator. In this regard, field crews that do not find ozone injury (zero values for the ozone injury variables) are making a significant contribution to the national FIA database.

5.1.2 SUMMARY OF METHOD (Core 9.1.2)

Field procedures include the selection of a suitable site for symptom evaluation, identification of three or more known ozone-sensitive species at the site, and identification of ozone injury on the foliage of up to 30 plants of each species. Each plant is evaluated for the percentage of injured area and severity of injury on a five-point scale. Field crews record information on the location and size of the opening used for biomonitoring, and record injury amount and severity ratings for each plant.

In the East, to eliminate problems with seasonal variability in ozone response, all foliar evaluations are conducted during a four-week window towards the end of the growing season. In the West, due to differences in growing season, topography, target species, and other regional factors that influence plant response to ozone, the identification of an optimum evaluation window for this indicator is problematic. Nevertheless, to maintain national consistency and improve crew logistics, the western regions use a mid-season, five or six-week window for foliar injury evaluations.

In some States with a particular interest in air quality, foliar injury data are also collected from ozone sites on an intensified ozone grid. These supplementary ozone sites are standardized for certain site characteristics that influence ozone uptake by sensitive plants (Heck 1968; Krupa and Manning 1988), and are often co-located with physical air quality monitors. They are intended to improve the regional responsiveness of the ozone indicator.

Voucher specimens (pressed leaves with symptoms) are collected for each species for proper symptom identification. For each voucher, INJURY TYPE and INJURY LOCATION codes are recorded to fully describe the injury observed in the field. Additional quality control measures include field audits and remeasurement of 10% of the biomonitoring sites.

The implementation of an ozone grid independent of the traditional FIA plot system allows greater flexibility in plot location on the ground and greater sampling intensity in areas believed to be at high risk for ozone impact. In addition, plots are deliberately chosen for ease of access and for optimal size, species, and plant counts, thus maximizing data quality. Ozone is a regional pollutant, understood to have regional effects on vegetation. Therefore, data collected on the ozone grid will have direct application to the FIA P2 and P3 plots within the same region

No specialized safety precautions are necessary to complete the fieldwork for the ozone indicator.

5.1.3 SUMMARY OF PDR SCREENS AND TALLY PROCEDURES (Core 9.1.3)

Ozone indicator data are recorded on portable data recorders (PDRs). For crews using the Tally application, all of the ozone bioindicator data are entered under Option 07 on the Tally main menu. There are three data entry screens for ozone data: the Bioindicator Plot Identification Screen, the Plot Notes Screen, and the Bio Species Screen. On the handheld units, the corresponding screens are Plot Data, Ozone Notes, and Species Data. The Bioindicator Plot Identification Screen (Plot Data) includes a record of plot location and status as well as detail on site characteristics that influence ozone injury expression. The Plot Notes Screen (Ozone Notes) prompts crews to record safety tips and additional information that will help analysts interpret the results or assist subsequent crews collecting data at the same location. The Bio Species Screen (Species Data) prompts crews for injury AMOUNT and SEVERITY codes on a plant by plant basis. This screen includes a pop-up menu, which keeps a running total of numbers of plants and species evaluated by the field crews. Help screens may be accessed for any variable from any of the three data entry screens.

For a written summary of the data entry procedures, definitions, and codes for the ozone measurement variables refer to section 5.4 through 5.6.

5.1.4 EQUIPMENT AND SUPPLIES (Core 9.1.4)

- A large diameter, 10X hand lens for close examination of plant leaves for ozone injury.
- Reference photographs and laminated leaf samples to aid in symptom identification.
- A forester-grade plant press with cardboard inserts to store leaf vouchers collected in the field.
- Envelopes ready for mailing the leaf vouchers to the Western Regional Trainer
- Stiff paper or cardboard for protecting the leaf vouchers in the mailing envelopes.
- Flagging: for temporary marking of sites or sample plants.
- Three field data sheets: (1) For documenting Foliar Injury Data in the event of a PDR failure; (2) For preparing the plot location map; and (3) For recording Voucher Leaf Samples Data for QA. (see Appendix 9.B).

5.1.5 TRAINING AND QUALITY ASSURANCE (Core 9.1.5)

Each field crew member is trained and tested for familiarity with the site selection, species selection, and data collection procedures, and their ability to recognize ozone injury and discriminate against mimicking symptoms. Field crews are certified just prior to the beginning of the evaluation window for this indicator.

The National Ozone Advisor and one or more individuals in each region assume quality control responsibilities for the field season. Regional Advisors meet during a preseason session to refine methods and establish a unified approach to training, audits, and debriefing. Their responsibilities include: (1) training and certifying the State trainers and/or field crews as needed for their region, (2) documenting hot audits of the field crews, (3) overseeing the field crew refresher session held just prior to the evaluation window for this indicator, (4) assisting in the field with remeasurement procedures for symptom quantification, and (5) conducting a debriefing for the indicator.

A field audit crew remeasures a subsample of the ozone ground plots in each region. Auditing procedures cover species selection, symptom identification, and quantification of injury, as well as foliar sample collection, preservation and shipment.

Results of the field audits and remeasurement activities are used to determine if the measurement quality objectives are being met. Regional Advisors and Field Supervisors who are certified for the ozone indicator have the authority to implement whatever corrective action is needed in the field (e.g., retraining and retesting).

5.1.6 VOUCHER SPECIMENS (Core 9.1.6)

Leaf samples are collected by field crews, cooperators, and all QA staff. They are to be placed in a small plant press immediately after removal from the selected plant. This is to preserve the integrity of the leaf sample and the injury symptoms until they can be validated by the National Indicator Advisor. A data sheet identifying the field crew and plot location is to be filled out and mailed with each sample.

Field crews, cooperators, and all QA staff collect leaf samples on the ozone biomonitoring sites according to procedures outlined in Subsection 5.2.7. These voucher specimens are pressed and mailed to the National Indicator Advisor for validation of the ozone symptom. If QA staff and regular field crews happen to be evaluating the same site at the same time, they collect and mail separate vouchers.

5.1.7 COMMUNICATIONS (9.1.7)

Any questions arising during the field season that cannot be answered by the Field Supervisor or State Coordinator, should be directed to the National Indicator Advisor for the ozone indicator or to the Western Regional Trainer. If field crews try and are unable to reach the National Advisor or the Western Regional Trainer they may call the Regional Advisor for the North Central States, as indicated below. Keep in mind that Advisors may be in the field and, therefore, unavailable for phone calls during normal workday hours. Messages left on answering machines should clearly identify who you are and when, where, and how to return your call. Please, be aware of differences in time zones and use email, if possible.

National Advisor (East and West)

Gretchen Smith Phone: (413) 545-1680
Holdsworth Hall (978) 544-7186 (< 7am + > 7pm)
University of Massachusetts
Department of Forestry and Wildlife Management
Amherst, MA 01003-0130
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Western Regional Trainer:

Pat Temple Phone: (909) 680-1583
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Regional Coordinator for the West Coast

Sarah Butler Phone: (503) 808-2083
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5.2 OZONE BIOMONITORING PROCEDURES (Core 9.2)

NOTE: In the following discussion the words site, biosite, and plot are used interchangeably to refer to the open area used for the ozone biomonitoring evaluations.

The primary objective of the field crew procedures for the ozone indicator is to establish an ozone biomonitoring site within each polygon on the FIA ozone grid using the site selection guidelines provided in the Decision Table – section 5.2.2.

These sites are used to detect and monitor trends in ozone air pollution injury on sensitive species. Procedures include the selection of a suitable site for symptom evaluation, identification of three or more known ozone-sensitive species at the site, symptom identification and scoring on the foliage of up to 30 plants of each species, and the collection of voucher leaf samples. Each individual plant with ozone injury is scored for amount and severity of injury. Plants used for the selection of leaf vouchers are also evaluated for injury location and type. If a plant does not have ozone injury, it is still tallied with zeros for the amount and severity measurements. A hardcopy map, providing directions, plot coordinates, and key characteristics of the bioindicator site, is prepared for each plot.

All foliar evaluations are conducted during a mid-season ozone evaluation window. This helps address differences between plots that are caused by timing. During the window, all ozone sites on the ozone grid are evaluated for ozone injury. The same sites are evaluated every year.

5.2.1 EVALUATION WINDOW (Core 9.2.1)

Quantifying ozone injury on the FIA ozone plots is limited to an evaluation window starting in July and ending in mid-August. The evaluation window for crews in the Interior States begins the second week in July and extends through the third week in August. In the West Coast States, the window is open from the third week in July through the third week in August.

All established biomonitoring sites are evaluated each year. The ozone injury evaluations are generally completed over several weeks during the evaluation window depending on the size of the State and the number of crews dedicated to the ozone survey. Crews should adjust the timing of their evaluations for differences in elevation and latitude so that low elevation sites and/or more southern States use the earlier dates of the window while higher elevation sites and/or more northern States delay until the mid to later dates. Similarly, within each State, the low elevation, more southern biomonitoring sites should be evaluated first, the higher elevation, more northern sites last.

5.2.2 SITE SELECTION PROCEDURES (Core 9.2.2)

Candidate sites must be easily accessible open areas greater than one acre in size that are more than 100 feet (30 m) from a busy (paved) road. A site must contain at least 30 individuals of at least two bioindicator species to be evaluated for ozone injury. It is preferable that all sites have three or more species. The following table may be used as a decision guide for site selection:

Decision Table	First Choice = **Best Site**	Second Choice
Access:	Easy	Easy
Location:	Single location is used.	One or two locations (split-plot).
Size of opening:	>3 acres (1.2ha); wide open area; <50% crown closure.	Between 1-3 acres; long narrow or irregularly sized opening.
Species count:	More than three species.	Two or more species.
Plant count:	30 plants of 3 species; 10-30 plants of additional species.	30 plants of 2 species; 10-30 plants of additional species.
Soil conditions:	Low drought potential. Good fertility.	Moderate dry. Moderate fertility.
Site disturbance:	No recent (1-3 years) disturbance; No obvious soil compaction.	Little or no disturbance; No obvious soil compaction.

NOTE: In many parts of the West, the forested landscape is characterized by large natural openings populated by a single overstory species. Large areas with a single bioindicator species (e.g., aspen or ponderosa pine) may be selected for biomonitoring, but every attempt should be made to combine this single species site with a nearby location that includes one or more of the understory bioindicator species. Ozone is a regional pollutant, affecting large geographic areas, and sites within 3 miles of each other generally have the same ozone exposure regime.

The best ozone sites are often associated with wildlife preserves on public land. Private landowners are often eager to participate in the ozone program. State and county parks and wildlife openings also provide good ozone sites. Other examples of suitable openings include old logging sites and abandoned pasture or farmland where you are reasonably certain that soil/site conditions are stable and free of chemical contaminants. Generally, if bedrock is exposed throughout an open area, then the soil conditions may be shallow, infertile, and often too dry to allow plants to respond to ozone stress. Sites that are routinely waterlogged are similarly unsuitable for biomonitoring. Avoid open areas where plants are obviously stressed by some other factor that could mimic or inhibit the ozone response. For example, the wooded edges of large parking lots in recreational areas are often highly compacted by car and foot traffic and should not be used. Do not select a site under a high-tension power line or on or near an active or reclaimed landfill. Do not select plants within 50 feet of the open edge around a cultivated field or tree plantation.

FIA crews and State Cooperators that have an established network of ozone sites may need to select and map replacement sites when previously mapped areas become overgrown or disturbed. Some sites may be split between two nearby locations to improve species and plant counts. In the case of split-plots, separate plot files (i.e., Tally files) are maintained for each location. Both have the same plot identification number (i.e., OZONE HEXAGON NUMBER) but different values for the plot number variable (i.e., PLOT NUMBER) as defined in Subsection 5.4.4. A split-plot is considered a unique ozone plot and should not be confused with grid intensification when two or more plots with different hex numbers fall in the same polygon.

No more than one half day should be spent locating a new bioindicator evaluation site. Crews must provide geographic coordinates (i.e., latitude and longitude) for all newly established ozone sites. If a site is split between two locations, the geographic coordinates for both locations are recorded.

NOTE: A split-plot consists of two different locations within 3 miles of each other, preferably with similar site characteristics. Species and plant counts from one location are combined with the species and plant counts from the second location to meet the species and plant count standards for site selection. On the PDR or data sheet, the same OZONE HEXAGON NUMBER is assigned to each location. However, each location is assigned a unique PLOT NUMBER; PLOT NUMBER = 1 for the first location that is evaluated by the field crew and PLOT NUMBER = 2 for the second location. In this way, separate Tally files are maintained for each location. On the national grid, the two locations are considered a single and unique ozone plot and should not be viewed as an intensification of the grid.

NOTE: The following table provides additional guidance on the required number of species and plants at each biomonitoring site. The best site has a minimum of 3 bioindicator species and 30 plants of each species. The best site may consist of two locations (split-plot) within 3 miles of each other if species or plants counts at any one location are low. If more than 3 species are found on a site, evaluate at least 10 plants of each additional species. For acceptable sites, establish a second location the following field season to increase species and plant counts. Marginal sites should be replaced the following field season.

Site Ranking	Number of species	Preferred number of plants per species	Acceptable number of plants per species	Minimum number of plants per species
Best	Species1	30	25 – 30	10
	Species2	30	10 – 30	10
	Species3	30	10 – 30	10
	Species4+	10 – 30	10 – 30	10
Acceptable	Species1	30	25 – 30	20
	Species2	30	10 – 30	10
Marginal	Species1	30	25 – 30	25

5.2.3 SITE MAPPING (Core 9.2.3)

Once a bioindicator site is selected, the field crew records the estimated size of the site opening and other key site characteristics identified on the PDR or data sheet. The crew then maps the location of the site relative to some obvious and permanent marker such as a telephone pole, building, or property marker. Directions to the site, including road names and distances, are added to the map. Crews also mark the starting point for plant selection (see section 5.2.4) and approximate location of plant groupings used for evaluation (see section 5.2.5) on the site map. If available, a GPS unit is used to determine plot coordinates and elevation. Otherwise, this information is obtained from a USGS topographic map, generally the 7½ minute series quadrangle.

Ozone site maps are used by audit and regular crews in subsequent visits to the plot (see Figure 38) to ensure that the same site and the same population of plants are remeasured every year. This bioindicator site map must be kept with the appropriate state or federal cooperator so that it is readily available to whoever needs it.

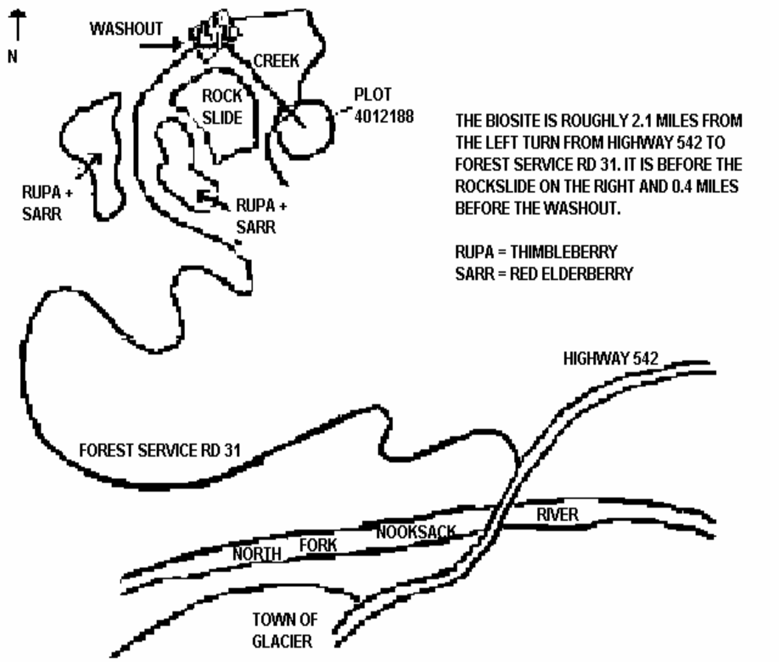

Figure 38. Example of a well-drawn map showing the location of the biosite and the approximate location of the bioindicator species and other key landmarks. Road names and North arrow are also included. (9-1)

5.2.4 SPECIES SELECTION (Core 9.2.4)

At the selected bioindicator site, the crew evaluates 30 individuals of three or more bioindicator species. If three species cannot be found at the site, then a lesser number of species is still evaluated.
Crews may combine species and plant counts from neighboring locations to obtain the required plant counts for each site. If 30 plants of two or more species cannot be found at the site, then a new site or additional location must be selected. A list of species is provided to the field crews for each region. Crews are encouraged to select from the top of the list down when several species are found at the same site. However, species with 30 or more individual plants should be a first priority for choice of species. Key identifying characteristics of each species are provided in the Appendix 9.A. Species ID information can also be accessed from the ozone indicator web site: fiaozone.net

Field crews record the species code number for each selected species in the PDR or on the data sheet. The target species and codes for each region are:

[1] *Pinus ponderosa* var. *scopulorum* (WY, CO)
[2] *Pinus jeffreyi* (NV); Alnus rubra (ID)

Interior Region

Code	Definition	Scientific Names
0122	Ponderosa pine[1]	*Pinus ponderosa*
0116	Jeffrey pine[2]	*Pinus jeffreyi*
0960	Blue elderberry	*Sambucus cerulea*
0746	Quaking aspen	*Populus tremuloides*
0924	Scouler's willow	*Salix scouleriana*
0351	Red alder[2]	*Alnus rubra*
0909	Skunk bush	*Rhus trilobata*
0905	Ninebark	*Physocarpus malvaceus*
0969	Mountain snowberry	*Symphoricarpos oreaphilus*
0907	Western wormwood	*Artemesia ludoviciana*
0961	Red elderberry	*Sambucus racemosa*
0965	Huckleberry	*Vaccinium membranaceum*
0968	Evening primrose	*Oenothera elata*

5.2.5 PLANT SELECTION (Core 9.2.5)

After site and species selection, the next task is to contiguously sample 30 individual plants of each species. Thirty plants of a target species must be sampled if they are available on site. In fact, crews are strongly encouraged to evaluate 150 plants at each site (30 plants of five species), if possible. The value of the bioindicator data increases significantly with increased numbers of plants evaluated. This is true even if the crew records 30 consecutive zeros on three different species.

NOTE: The borders of some biomonitoring sites are difficult to determine and crews may be uncertain how much ground area to cover to complete the plant selection procedures. Specific guidelines are not set because the constraints on crew time and resources vary considerably from one State to the next. Time and safety concerns should take priority. Each crew must make every effort to maximize the number of plants and species evaluated for ozone injury at each plot location. Generally, ozone injury evaluations take 1 hour per site to complete and, assuming routine travel, crews are expected to complete two ozone sites in a ten-hour workday.

The following procedures help the crews to collect the bioindicator data in as systematic (i.e., unbiased) a way as possible.

1. Identify a starting point for plant selection. This point is mapped on the site data sheet so that audit and regular crews evaluate roughly the same population of plants in subsequent visits to the plot.

2. Move away from the starting point, towards the center of the opening.

3. Begin locating individuals in a sweeping pattern, selecting plants that are growing under the same or similar growing (microhabitat) conditions. Do not skip plants with little or no injury.

4. Select the more exposed plants (high sunlight exposure) and avoid suppressed and shaded individuals. Plants along the edge of an opening may be used if, in your judgment, they receive direct sunlight for three to four hours each day.

5. Avoid plants under 12 inches in height or so tall that at least half of the crown area cannot be seen or touched.

6. Evaluate the foliage that can be seen and touched on 30 plants of each species in the opening.

7. Record the amount and severity of injury for each plant evaluated (with or without symptoms) on the PDR or data sheet.

NOTE: A pop-up menu keeps track of the plant counts by species. For any one species, stop when the pop-up display indicates that 30 plants have been tabulated, or when no additional plants of that species can be found on site. 30 plants of 5 species can be tabulated or any combination of species and plants that adds up to 150 data line entries.

Some plants spread vegetatively. This means that neighboring plants are often genetically identical. To avoid repeat sampling of clonal material, take several steps between each plant selected for evaluation. Use a systematic approach to select individual plants. For example, select the plant closest to your left side then take several steps and select the plant closest to your right side and repeat. (A comparable systematic approach should be applied to all evaluated species to minimize bias in the plant selection process.) If it is difficult to distinguish individual plants or stems, use an approximate 2-foot square area to represent a single plant.

5.2.6 SYMPTOM IDENTIFICATION AND SCORING (Core 9.2.6)

The bioindicator species selected for each region are those that have been determined through field and laboratory studies to be highly sensitive to ozone air pollution. However, within a species, differences in genetics between individuals result in differential sensitivities to ozone. This means that often an individual of a species with severe air pollution injury is found growing immediately adjacent to another individual of the same species with few or no symptoms.

In addition to genetics, the age of the leaves (position on the stem, branch, or rosette) affects a plant's susceptibility to ozone air pollution. In general, leaves at 75% full expansion are the most sensitive and tend to show symptoms most definitively toward the center of the leaf. Older leaves show symptoms more widespread over the leaf surface, while younger leaves show symptoms more commonly near the leaf tip. If leaves on one branch are affected, then leaves at a similar leaf position on another branch should be affected, especially for branches on the same side of the plant under similar environmental conditions (sun or shade leaves).

All of the western bioindicator species, except ponderosa and Jeffrey pine, have broad leaves. When scoring foliar symptoms on these broad-leafed plants, check for the following characteristics of ozone injury:

- Symptoms are more severe on mid-aged and older leaves. New leaves will have no or very little injury.
- Symptoms are most likely confined to the upper leaf surface, and are typically visible as tiny purple-red to black spots (stippling).
- Check leaves covering each other. Overlapped leaves will have no injury on the bottom leaf.
- There will be some uniformity to size and shape of the lesions (stippling) on a leaf.
- Later in the growing season, stippling may be associated with leaf yellowing or premature senescence. Check the ground for fallen leaves.

On ponderosa and Jeffrey pine, the most common needle symptom is chlorotic mottle. When scoring foliar symptoms on pines, check for the following characteristics of ozone injury:

- Symptoms are visible as diffuse yellow areas (chlorotic mottle) without sharp borders between green and yellow zones, on older needles. Not all needles in a fascicle will be uniformly affected.
- Chlorotic mottle is rarely seen on current-year needles except in high-ozone areas. On young needles it may appear more olive than yellow.
- Older needles that are directly exposed to sunlight may show the most severe chlorotic mottle. However, almost all exposed branches on a plant will be affected to some degree.
- Premature needle drop frequently occurs on ozone-injured pines, even on trees that do not show other ozone injury symptoms. Check for missing older annual whorls and for large numbers of needles on the ground. Live crowns may appear small and thin.

NOTE: Missing whorls on ponderosa pine should not be recorded as ozone injury without reliable evidence of other foliar injury symptoms, such as chlorotic mottle.

Each plant (broadleaf and conifer) with ozone injury is evaluated for the percent of the plant that is injured and the average severity of injury. For each plant located, the percentage of injured area and the severity of injury are both rated on a scale of 0 to 5 (see below). Both AMOUNT and SEVERITY estimates are confined to the exposed portion of the plant. If a plant does not have injury, it is still tallied with zeros for these measurements. For broad-leaved species, the AMOUNT and SEVERITY estimates are based on injury to the upper surface area of the leaves. For the pine species, examine all needle surfaces including the under sides, particularly if the needles have large amounts of winter fleck (NOT an ozone injury symptom) on the upper surfaces.

Percent Scale for Injury AMOUNT: Estimate and record the percentage of leaves (or needles) on the plant with ozone injury symptoms relative to the total number of leaves (or needles) on the plant.

CODE	DEFINITION
0	No injury; the plant does not have any leaves/needles with ozone symptoms.
1	1 to 6 percent of the leaves/needles have ozone symptoms.
2	7 to 25 percent of the leaves/needles are injured.
3	26 to 50 percent of the leaves/needles are injured.
4	51 to 75 percent of the leaves/needles are injured.
5	>75 percent of the leaves/needles have ozone symptoms.

Percent Scale for SEVERITY of Injury: Estimate and record the mean severity of symptoms on injured foliage.

CODE	DEFINITION
0	No injury; the plant does not have any leaves/needles with ozone symptoms.
1	On average, 1 to 6 percent of the leaf area of injured leaves/needles have ozone symptoms.
2	On average, 7 to 25 percent of the leaf area of injured leaves/needles have ozone symptoms.
3	On average, 26 to 50 percent of the leaf area of injured leaves/needles have ozone symptoms.
4	On average, 51 to 75 percent of the leaf area of injured leaves/needles have ozone symptoms.
5	On average, >75 percent of the leaf area of injured leaves/needles have ozone symptoms.

NOTE: Red and blue elderberry have compound leaves. Use the whole leaf, not each leaflet, to estimate injury AMOUNT and injury SEVERITY.

NOTE: The percent scale for ozone injury evaluations has a long history of application in plant disease research. The scale utilizes break points that correspond to the ability of the human eye to distinguish gradations of healthy and unhealthy leaf tissue (see Horsfall and Cowling 1978).

Proceed as follows:

1. Record injury AMOUNT and injury SEVERITY ratings for each plant on the PDR or data sheet.

2. Use the notes section on the PDR or data sheet to add other information that will help interpret the results (e.g., below average rainfall for the area).

3. Collect a voucher leaf sample (three leaves of each injured species evaluated at each location) and mail them to the Western Regional Trainer using the guidelines presented in section 5.2.7.

NOTE: Foliar symptoms are easiest to see under overcast skies. Bright sun will make it difficult to see the ozone stipple or chlorotic mottle. Stand so that you reduce the glare on the leaf/needle surface. Long periods without rain will inhibit symptom development even on the most sensitive plants. If there is below average rainfall for the area, please note this in the PDR or on the data sheet.

5.2.7 COLLECTION OF LEAF SAMPLES AND VOUCHER DATA (Core 9.2.7)

The voucher leaf samples (leaves and/or needles) are a critical aspect of the data collection procedures as they provide the necessary validation of the ozone injury symptom observed in the field by the field crews. A plant press is essential to the collection of useable leaf samples and must be taken into the field by the field crews. Crew data that do not include a voucher leaf sample with a completed voucher data sheet are removed from the FIA database.

A voucher leaf sample must be collected for each injured species evaluated on the bioindicator site. For each injured, broad-leaved species, the voucher consists of three leaves that clearly show the ozone injury symptom. For pine species with ozone injury, the voucher consists of two small branches (small terminal or lateral branch containing the full complement of needles) with obvious chlorotic mottle. If a field crew records ozone injury on red alder, Scouler=s willow, and ninebark then a minimum of one voucher (3 leaves) from each of the three species (9 leaves in all) is collected and mailed to the Western Regional Trainer. In this example, three voucher data sheets (one for each species) must be filled out and mailed with the leaf samples.

The most useful voucher leaf samples show obvious foliar injury symptoms. If injury symptoms are not obvious and severe, send whatever leaf sample is available even if it is only one leaf with faint symptoms. Cut the leaf at the petiole, shake off any excess moisture, and place the leaf on blotter paper in the plant press. Each leaf is placed in the press so that it does not overlap another leaf. Include a label with each leaf sample placed into the plant press that identifies which plot the sample came from (i.e., OZONE HEXAGON NUMBER) and the date. Petiole labels are provided for this purpose. Record the information on the labels with indelible ink and then wrap them around the petiole of at least one leaf per sample

NOTE: Blue and red elderberry have compound leaves. Select the whole leaf (not individual leaflets) when preparing a voucher sample.

NOTE: If QA staff and regular field crews happen to be evaluating the same site at the same time, they collect and mail separate vouchers.

NOTE: The recognition of ozone injury symptoms in the field is not an exact science, and many other foliar injury symptoms can be mistaken for ozone injury. Crews are encouraged to collect voucher specimens of both known and suspected ozone injury in the field to send to the Western Regional Trainer for verification.

The voucher data sheet must be completed for plot identification codes (e.g., STATE, COUNTY, OZONE HEXAGON NUMBER and PLOT NUMBER), CURRENT DATE, CREW ID, CREW TYPE, SPECIES code(s). This sheet is filled out at the bioindicator site on the same day the sample is collected. In addition, the plants from which the leaf vouchers are selected must be evaluated by the field crews for INJURY LOCATION and INJURY TYPE (defined below), and for the amount of injury present on the leaf that is not ozone stipple. This information, together with the visible injury symptoms on the leaf samples, is used to validate the ozone injury data observed and recorded in the field by the field crews. For each species, the INJURY LOCATION and INJURY TYPE codes are intended to represent what the crew observed on the majority of the injured plants in the sample population. In contrast, the recorded estimates of percent injury caused by some stress other than ozone are based on what the crew observed on the injured leaf samples mailed in with the voucher data sheet.

The INJURY LOCATION and INJURY TYPE codes are recorded on the upper half of the voucher data sheet as follows:

INJURY LOCATION for Broad-leaved Species: Specify the leaf age or position of the leaves with ozone injury.

Code	Definition
1	>50% of the injured leaves are younger leaves. Younger leaves are usually located towards the branch tip (e.g., aspen, willow, oak, ninebark, and huckleberry), or top of the plant (e.g., elderberry, wormwood and snowberry).
2	>50% of the injured leaves are mid-aged or older leaves. Mid-aged and older leaves are located halfway along the branch (e.g., aspen, willow, oak, ninebark, and huckleberry) or main stem of the plant (e.g., elderberry, wormwood, and snowberry), or more towards the base of the branch or stem.
3	Injured leaves are not concentrated in any one location, leaf age or position. Injury may be spread more or less evenly over the plant or is, otherwise, difficult to describe.

INJURY LOCATION for Pines: Specify the leaf age or whorl with ozone injury.

Code	Definition
1	>50% of the injured needles are on the current whorl.
2	>50% of the injured needles are on whorls 1 year old and older.
3	Injury is not concentrated on any one needle whorl but is spread more or less evenly along the branch or is, otherwise, difficult to describe.

INJURY TYPE for Broad-leaved Species: Specify the visible injury symptom.

Code	Definition
1	The injury on >50% of the injured leaves is best described as upper-leaf-surface stipple (i.e., tiny purple-red to black spots occurring between the veins). Stippling may be associated with leaf yellowing and leaf drop late in the growing season; When injury is severe, stipples may coalesce and appear as uniform discoloration of the leaf surface.
2	The injury on >50% of the injured leaves is something other than upper-leaf-surface stipple. For example, small white to tan flecks occurring between the veins, or injury that is clearly visible on both leaf surfaces, or a general discoloration of the leaf that resembles early fall coloration.
3	The visible injury is varied or, otherwise, difficult to describe.

INJURY TYPE for Pines: Specify the visible injury symptom.

Code	Definition
1	The injury on >50% of the injured needles is best described as chlorotic mottle i.e., small patches of yellow tissue with diffuse borders and surrounded by apparently healthy (green) tissue. Chlorotic mottle may be associated with premature needle drop.
2	The injury on >50% of the injured needles is something other than chlorotic mottle. For example, winter fleck on the upper surface of the needles, or tipburn (i.e., reddish brown discoloration of the needle tips).
3	The visible injury is varied or, otherwise, difficult to describe.

NOTE: Not all location and type codes are indicative of ozone injury. Certain combinations of location and type codes, considered with a questionable leaf voucher, may invalidate the injury data. Other combinations provide quality assurance for the injury assessment. Crews should describe any unusual or questionable symptoms on the upper half of the voucher data sheet.

5.2.8 VOUCHER MAILING PROCEDURE (Core 9.2.8)

Vouchers are mailed in bulk at the end of the field season, or earlier, depending on the work schedule. It is very important to mail only dry, pressed leaf samples. Before mailing, make sure the upper half of the voucher data sheet has been completed. This sheet is filled out on the same day the sample is collected, even if the sample is not mailed on that day. Please comment on the weather or general plot conditions that might help interpret the injury data. For example, *"It's been 14 days now without rain," "Every plant showed the same response and it was very obvious," or "This was a highly disturbed site."*

NOTE: Crews are encouraged to add information on the biosite location to the voucher data sheet such as the uncoded name of the county or closest town. This helps the Western Regional Trainer map the initial findings from the leaf vouchers and alert FIA staff to high ozone areas.

The lower half of the voucher data sheet is filled out by the Western Regional Trainer to whom you are sending the sample. Place the voucher data sheet and the leaf sample between two pieces of stiff paper or cardboard before placing into a mailing envelope addressed to the Western Regional Trainer. Do not tape the leaves or needles to the paper or cardboard. Taped samples often break apart when they are handled, making evaluation difficult. Include as many samples as fit easily into each mailing envelope. There must be a unique voucher data sheet for each sample or species, unless you are using the form for multi-species. Keep leaf samples and the corresponding leaf voucher data sheets together. Leaf samples that are separated from the corresponding leaf voucher data sheets may be mislaid, especially if leaf labels are missing or incomplete.

NOTE: The Western Regional Trainer will make every effort to provide immediate feedback on the leaf vouchers. To facilitate this, crews must fill in the contact information on the voucher data sheet.

5.2.9 CREW MEMBER RESPONSIBILITIES (Core 9.2.9)

1. Although one or two crew partners may be trained for this indicator, one person typically takes the lead responsibility for site selection, plant selection, and ozone injury evaluations. All procedures can be successfully completed by one person. Two person crews are recommended for safety reasons.

2. All members of the field crew may assist each other in the site selection process. Once a site is selected, one crew member is responsible for mapping the site and the location of bioindicator species on the field data sheet.

3. Only the crew member trained and certified in ozone injury evaluations may collect the amount and severity data and the leaf voucher. Other crew members may assist by recording the injury scores on the PDR or data sheet and by getting the plant press supplies ready.

4. The crew member that evaluates the plants for injury is responsible for collecting and mailing the voucher sample with air pollution symptoms.

5.2.10 FIELD PROCEDURES FOR UNTRAINED FIELD CREWS (Core 9.2.10)

There are certain procedures for the ozone indicator that may be performed by individuals that have not attended the ozone training and been certified to collect ozone data. These procedures still require some explanation and oversight by the certified crew member. Untrained personnel may assist in the selection and mapping of the ozone biomonitoring site and in the location and identification of bioindicator species on the selected site. They may not rate plant injury. It may also be helpful for the untrained crew person to act as the data recorder for the certified crew member, thus speeding up the data collection process.

5.3 SITE INTENSIFICATION (Core 9.3)

In addition to the unique ozone plots that are identified by the base ozone grid, some Cooperators have established additional biomonitoring sites to represent the local plant populations and environmental conditions. This is not an auxiliary effort, but an integral part of the monitoring activities for this indicator. In some States, additional biomonitoring sites are limited in number and are deliberately located close to weather and air quality monitoring stations. In other States, the ozone grid is intensified to allow for an unbiased allocation of additional biomonitoring sites. It is recommended that additional sites, whether few or many in number, be located on public land to facilitate the annual measurement activities.

Biomonitoring sites added to the base grid typically possess attributes of an ideal site for evaluating ozone injury on sensitive species. They are larger than three acres, contain the maximum number of indicator species, and have soil/site conditions with low drought potential and adequate fertility. They are evaluated for ozone injury using the same methods and during the same time frame as described in section 5.2. Voucher leaf samples must be collected, according to procedures described in section 5.2.7 and mailed to the Western Regional Trainer.

5.4 PLOT LEVEL DATA (Core 9.4)

All plot-level measurement codes for the ozone indicator are defined below. The codes and definitions are the same whether the crew is entering data using Tally (Paravant or Husky) or a personal data assistant (Handspring or Palm).

Ozone plots vary in size and do not have set boundaries. When describing plot-level characteristics, use the predominant characteristics where most of the plant species are located. If conditions vary markedly across the site, or by species, then describe this in the plot notes or on the site map. Specify the elevation, aspect, terrain position, soil depth, soil drainage, and disturbance for the highest priority species (section 5.4) found on the site. The soil depth, soil drainage, and disturbance variables are intended to describe general conditions on the plot and are not based on actual measurements. For a complete explanation of the procedures associated with these measurement codes, refer to section 5.2.

5.4.1 STATE (Core 9.4.1)

Record the unique FIPS (Federal Information Processing Standard) code identifying the State where the plot center is located.

When collected: All plots
Field width: 2 digits
Tolerance: No errors
MQO: At least 99% of the time
Values: See Appendix 1

5.4.2 COUNTY (Core 9.4.2)

Record the unique FIPS (Federal Information Processing Standard) code identifying the county, parish, Borough (or unit in AK) where the plot center is located.

When collected: All plots
Field width: 3 digits
Tolerance: No errors
MQO: At least 99% of the time
Values: See Appendix 1

5.4.3 OZONE HEXAGON NUMBER (Core 9.4.3)

Record the unique code assigned to each ozone hexagon. In some cases this will be a former FHM or P3 hexagon.

When collected: All plots
Field width: 7 digits
Tolerance: No errors
MQO: At least 99% of the time

5.4.4 PLOT NUMBER (Core 9.4.4)

Record the plot number that describes whether an ozone plot consists of one or two locations. If two locations are selected, they must be within 3 miles of each other. Two locations are selected as needed to obtain optimal species and plant counts for each ozone plot. The OZONE HEXAGON NUMBER is the same for both locations. Note: The PLOT NUMBER value is not related to the GRID DENSITY value.

When collected: All plots
Field width: 1 digit
Tolerance: No errors
MQO: At least 99% of the time
Values: 1 to 2

1 The ozone plot consists of a single location or this is the first location of a plot split between two locations.
2 The ozone plot is split between two locations. This code identifies the second location added by the field crew to increase species and plant counts for a single hexagon number.

5.4.5 QA STATUS (Core 9.4.5)

Record the code to indicate the type of plot data collected.

When collected: All plots
Field width: 1 digit

Tolerance: No errors
MQO: At least 99% of the time
Values: 1 to 2 and 4 to 7

1 Standard ozone plot
2 Cold check

4 Training/practice plot (off grid)
5 Botched plot file
6 Blind check
7 Hot check (production plot)

5.4.6 CREW TYPE (Core 9.4.6)

Record the code to specify what type of crew is measuring the plot.

When collected: All plots
Field width: 1 digit
Tolerance: No errors
MQO: At least 99% of the time

Values: 1 to 2

1 Standard field crew
2 QA crew (any QA crew member present collecting remeasurement data)

5.4.7 OZONE SAMPLE KIND (Core 9.4.7)

Record the code that describes the kind of plot being visited. Note: OZONE SAMPLE KIND has a value of 1 only when an ozone plot is established in a previously empty polygon.

When collected: All plots
Field width: 1 digit
Tolerance: No errors
MQO: At least 99% of the time
Values: 1 to 3

1 Initial plot establishment on the base grid or on a newly intensified grid.
2 Remeasurement of a previously established plot.
3 Replacement of a previously established plot that was replaced because the original plot could not be relocated or because it no longer met ozone plot measurement criteria.

5.4.8 CURRENT DATE (Core 9.4.8)

Record the year, month, and day that the current plot visit was completed as follows:

5.4.8.1 YEAR (Core 9.4.8.1)

Record the year that the plot was completed.

When collected: All plots
Field width: 4 digits
Tolerance: No errors
MQO: At least 99% of the time
Values: Beginning with 1998, constant for a given year

5.4.8.2 MONTH (Core 9.4.8.2)

Record the month that the plot was completed.

When collected: All plots
Field width: 2 digits
Tolerance: No errors
MQO: At least 99% of the time
Values:

January	01	May	05	September	09
February	02	June	06	October	10
March	03	July	07	November	11
April	04	August	08	December	12

5.4.8.3 DAY (Core 9.4.8.3)

Record the day of the month that the plot was completed.

When collected: All plots
Field width: 2 digits
Tolerance: No errors
MQO: At least 99% of the time
Values: 01 to 31

5.4.9 OZONE GRID DENSITY (Core 9.4.9)

Record the code that identifies whether the plot is on the base ozone grid or on an intensified ozone grid. Note: The OZONE GRID DENSITY value = 2 when there are two ozone plots with different OZONE HEXAGON NUMBERS in the same polygon. The two plots may be located in different States.

When collected: All plots
Field width: 1 digit
Tolerance: No errors
MQO: At least 99% of the time
Values: 1 to 2

1 Unique ozone plot within a polygon. (1 site:1polygon)
2 One of two or more ozone plots within the same polygon

5.4.10 PLOT SIZE (Core 9.4.10)

Record the code that indicates the size of the opening used for biomonitoring.

When collected: All plots
Field width: 1 digit
Tolerance: No errors
MQO: Repeatable estimate
Values: 1 to 2

1 Greater than three acres.
2 Greater than one acre, but less than three acres.

5.4.11 ASPECT (Core 9.4.11)

Record the code that identifies the direction of slope for land surfaces with at least 5 percent slope as measured with a hand compass to the nearest degree.

When collected: All plots
Field width: 3 digits
Tolerance: +/- 30°
MQO: At least 99% of the time
Values:

000 No aspect, slope < 5 percent
001 1 degree
002 2 degrees
. .
. .
360 360 degrees, due north

5.4.12 TERRAIN POSITION (Core 9.4.12)

Record the code that identifies the position of the plot in relation to the surrounding topography.

When collected: All plots
Field width: 1 digit
Tolerance: Repeatable estimate
MQO: At least 99% of the time

Values: 1 to 5

1	Ridge top or upper slope
2	Bench or level area along a slope
3	Lower slope
4	Flat land unrelated to slope
5	Bottom land with occasional flooding

5.4.13 SOIL DEPTH (Core 9.14.13)

Record the code that indicates the general depth of the soil where most of the bioindicator species are growing.

When collected: All plots
Field width: 1 digit
Tolerance: Repeatable estimate
MQO: At least 99% of the time
Values: 1 to 2

1	Bedrock is not exposed.
2	Bedrock is exposed; Soil is generally shallow.

5.4.14 PLOT WETNESS (Core 9.4.14)

Record the code that identifies the degree of wetness where most of the bioindicator plants are growing.

When collected: All plots
Field width: 1 digit
Tolerance: Repeatable estimate
MQO: At least 99% of the time
Values: 1 to 3

1	This is a wet plot; Riparian zone or bottomland.
2	This plot is moderately dry; Meadow or Northeast facing slope.
3	This plot is very dry; Exposed ledge, desert or alpine area.

5.4.15 DISTURBANCE (Core 9.4.15)

Record the code that identifies the presence and kind of disturbance where most of the bioindicator plants are growing. The area affected by any human caused or natural disturbance must be clearly visible and recent enough to influence plant health and condition. Disturbance that results in significant soil compaction is especially significant.

When collected: All plots
Field width: 1 digit
Tolerance: Repeatable estimate
MQO: At least 99% of the time
Values: 0 to 2

0 No recent or significant disturbance.
1 Evidence of overuse; Human activity causing obvious soil compaction or erosion.
2 Evidence of natural disturbance including fire, wind, flooding, grazing, pests, etc.

5.4.16 INJURY CHECK (Core 9.4.16)

Record the code that indicates whether ozone injury was observed on non-tallied plants or species. This variable allows a plot to be identified as impacted by ozone even though there is no quantitative data on injury severity for trend analyses. A leaf voucher must be collected to validate the injury.

When collected: All plots
Field width: 1 digit
Tolerance: No error
MQO: At least 99% of the time
Values: 0 to 1

0 No injury was observed on non-tallied plants or species.
1 Ozone injury was observed on non-tallied plants or species and a leaf voucher collected.

5.4.17 ELEVATION (Core 9.4.17)

Obtain elevation data from USGS topographic maps, generally the 7½ minute series quadrangle. Locate the area where most of the bioindicator species are growing and record elevation to the nearest foot.

When collected: When GPS UNIT = 0
Field width: 6 digits
Tolerance: +/-200 feet
MQO: At least 99% of the time

5.4.18 Plot Notes (Core 9.4.18)

Use these fields to record notes pertaining to the entire plot. If the notes apply to a specific aspect of the plot, then make that clear in the notes. Record the location where GPS coordinates were collected, and GPS file name, as needed. If no GPS Unit was available, record the geographic coordinates (i.e., latitude and longitude) of the plot center in Degrees, Minutes, and Seconds using USGS topographic maps, generally the 7½ minute series quadrangle.

5.4.18.1 REMARK1 and REMARK2 (Core 9.4.18.1)

Record any information on site characteristics, use of supplemental species, safety, plant location, injury patterns, or recent rainfall amounts that will assist subsequent crews visiting the site or help interpret the results.

When collected: All plots
Field width: Unlimited alphanumeric character field
Tolerance: N/A
MQO: N/A
Values: English language words, phrases and numbers

5.5 GPS COORDINATES (Core 9.5)

Use a global positioning system (GPS) unit to determine the plot coordinates and elevation of all ozone plot locations. GPS readings are collected according to procedures outlined in the FIA National Core Field Guide for Phase 2 & 3 Plots, Version 2.01. The ozone data entry applications accept GPS readings obtained using a geographic coordinate system (not UTM). If you are using UTM, record readings on the field data sheet for mapping and on the PDR Plot Notes screen. If GPS coordinates cannot be collected, elevation and plot coordinates are obtained from USGS topographic maps, generally the 7½ minute series quadrangle. Record elevation on the Plot ID screen and approximate latitude and longitude on the Plot Notes screen.

Use a global positioning system (GPS) unit to determine the plot coordinates and elevation of all field-visited plot locations.

NOTE: For several of the following GPS variables, the term plot center is used. There may be no obvious center to the ozone plots. Coordinates are collected as close as possible to a central location or marker that clearly locates the plot for returning crews. Explanatory notes are added to the plot map and Plot Notes screen as needed.

5.5.1 GPS Unit Settings, Datum, and COORDINATE SYSTEM (Core 9.5.1)

Consult the GPS unit operating manual or other regional instructions to ensure that the GPS unit internal settings, including Datum and Coordinate system, are correctly configured.

Each FIA unit will determine the Datum to be used in that region. Most will use the NAD 27 Datum (also known as NAS-C or NA 27 CONUS/CLK66), but coordinates collected using any appropriate datum can be converted back to a national standard for reporting purposes.

Each FIA unit will also determine which coordinate system to use. Regions using a Geographic system will collect coordinates in Degrees, Minutes, and Seconds of Latitude and Longitude; the regions using the UTM coordinate system will collect UTM Easting, Northing, and Zone.

5.5.2 Collecting Readings (Core 9.5.2)

Collect at least 180 GPS readings at the plot center (see Note above). These may be collected in a file for post-processing or may be averaged by the GPS unit. Each individual position should have an error of less than 70 feet if possible (the error of all the averaged readings is far less).

Soon after arriving at plot center, use the GPS unit to attempt to collect coordinates. If suitable positions (180 readings at error less than or equal to 70 feet) cannot be obtained, try again before leaving the plot center.

If it is still not possible to get suitable coordinates from plot center, attempt to obtain them from a location within 200 feet of plot center. Obtain the azimuth and horizontal distance from the "offset" location to plot center.

Coordinates may be collected further away than 200 feet from the plot center if a laser measuring device is used to determine the horizontal distance from the "offset" location to plot center. In all cases try to obtain at least 180 positions before recording the coordinates.

5.5.3 GPS UNIT (Core 9.5.3)

Record the kind of GPS unit used to collect coordinates. If suitable coordinates cannot be obtained, record 0.

When collected: All field visited plots
Field width: 1 digit
Tolerance: No errors
MQO: At least 99% of the time

Values: 0 to 4

- 0 GPS coordinates not collected
- 1 Rockwell Precision Lightweight GPS Receiver (PLGR)
- 2 Other brand capable of field-averaging
- 3 Other brands capable of producing files that can be post-processed
- 4 Other brands not capable of field-averaging or post-processing

5.5.4 GPS SERIAL NUMBER (Core 9.5.4)

Record the last six digits of the serial number on the GPS unit used.

When collected: When GPS UNIT >0
Field width: 6 digits
Tolerance: No errors
MQO: At least 99% of the time
Values: 000001 to 999999

5.5.5 GPS LATITUDE (Core 9.5.5)

Record the latitude of the plot center to the nearest hundredth second, as determined by GPS.

When collected: When GPS UNIT = 1, 2, 3 or 4
Field width: 8 digits (DDMMSSSS)
Tolerance: +/- 140 ft
MQO: At least 99% of the time
Values:

5.5.6 GPS LONGITUDE (Core 9.5.6)

Record the longitude of the plot center to the nearest hundredth second, as determined by GPS.

When collected: When GPS UNIT = 1, 2, 3 or 4
Field width: 9 digits (DDDMMSSSS)
Tolerance: +/- 140 ft
MQO: At least 99% of the time
Values:

5.5.7 GPS ELEVATION (Core 9.5.7)

Record the elevation above mean sea level of the plot center, in feet, as determined by GPS.
If no GPS Unit is available, record elevation from the appropriate USGS topographic map.

When collected: When GPS UNIT = 1, 2 or 4
Field width: 6 digits
Tolerance:

MQO: At least 99% of the time
Values: -00100 to 20000

5.5.8 GPS ERROR (Core 9.4.8)

Record the error as shown on the GPS unit to the nearest foot.

When collected: When GPS UNIT = 1 or 2
Field width: 3 digits
Tolerance: No errors
MQO: At least 99% of the time
Values: 000 to 070 if possible
071 to 999 if an error of less than 70 cannot be obtained

5.5.9 NUMBER OF GPS READINGS (Core 9.5.9)

Record a 3-digit code indicating how many readings were averaged by the GPS unit to calculate the plot coordinates. Collect at least 180 readings if possible.

When collected: When GPS UNIT = 1 or 2
Field width: 3 digits
Tolerance: No errors
MQO: At least 99% of the time
Values: 001 to 999

5.5.10 GPS FILENAME (CORE OPTIONAL) (Core 9.5.10)

Record the filename containing the GPS positions collected on the plot.

When collected: When GPS UNIT = 3
Field width: 8 characters.3 characters e.g. R0171519.ssf
Tolerance: No errors
MQO: At least 99% of the time
Values: Letters and numbers

5.6 FOLIAR INJURY DATA (Core 9.6)

All measurement codes for the foliar injury data are defined below. Plants selected for ozone injury evaluations are rated for the percent of injured area and the severity of injury on a scale of 0 to 5 (see section 5.2.6). If a plant does not have injury, it is tallied with zeros for these measurements. A pop-up menu keeps track of plant counts by species. The plot is complete only when 30 plants of at least 3 species have been tallied, or when no additional plants can be found on the plot. Ozone plots vary in size and do not have set boundaries. Time and safety concerns should dictate how much ground area to cover to complete the foliar injury evaluation procedures.

5.6.1 SPECIES (Core 9.6.1)

Record the three-digit code that identifies each species on the plot. Species codes may be entered in the order they are encountered as you walk through the plot evaluating plants. A pop-up menu keeps a running total of numbers of plants and species evaluated.

When collected: All plots
Field width: 4 digits
Tolerance: No error
MQO: At least 90% of the time
Values: See 9.2.4

5.6.2 AMOUNT (Core 9.6.2)

Record the code that identifies the percentage of leaves on the plant with ozone injury symptoms relative to the total number of leaves on the plant. The percent scale code and definitions are fully described in section 5.2.6.

When collected: All plots
Field width: 1 digit
Tolerance: +/- 1 class
MQO: At least 90% of the time
Values: 0 - 5

0 No injury; The evaluated plant does not have any leaves or needles with ozone symptoms.
1 1 to 6 percent of the leaves/needles have ozone symptoms
2 7 to 25 percent of the leaves/needles are injured.
3 26 to 50 percent of the leaves/needles are injured.
4 51 to 75 percent of the leaves/needles are injured.
5 Greater than 75 percent of the leaves/needles have ozone symptoms.

5.6.3 NUMBER OF PLANTS (Core 9.6.3)

Record the number of plants tallied so far with no injury. When 0 is entered for AMOUNT, the PDR prompts for the NUMBER OF PLANTS with no injury. When a number greater than zero is entered for AMOUNT, the PDR prompts for the associated SEVERITY value. Zero and non-zero values for any species can be entered as they are encountered on the plot. The pop-up menu keeps track of plant counts by species.

When collected: When AMOUNT = 0
Field width: 2 digits
Tolerance: No error
MQO: At least 90% of the time
Values: 1 to 30

5.6.4 SEVERITY (Core 9.6.4)

Record the code that identifies the mean severity of symptoms on injured foliage. The percent scale code and definitions are fully described in section 5.2.6.

When collected: When AMOUNT > 0
Field width: 1 digit
Tolerance: +/- 1 class
MQO: At least 90% of the time
Values: 0 - 5

- 0 No injury. The plant does not have any leaves or needles with ozone symptoms.
- 1 On average, 1 to 6% of the leaf area of injured leaves/needles has ozone symptoms.
- 2 On average, 7 to 25% of the leaf area of injured leaves/needles has ozone symptoms.
- 3 On average, 26 to 50% of the leaf area of injured leaves/needles has ozone symptoms.
- 4 On average, 51 to 75% of the leaf area of injured leaves/needles has ozone symptoms.
- 5 On average, >75% of the leaf area of injured leaves/needles has ozone symptoms.

5.7 REFERENCES (Core 9.7)

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5.8 ACKNOWLEDGEMENTS (Core 9.8)

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Appendix 5.A Key Identifying Characteristics of the Ozone Bioindicator Species

1. ***Ponderosa Pine*** is a large tree, up to 230 feet in height. Young tree bark is often thin and dark brown to black. Older tree bark is thick becoming yellow-red to cinnamon red and forming plates which slough off freely. Needles in bundles of three, 5-10 inches in length, not glaucous and yellow-green in color. Buds are resinous with red-brown scales and dark-hairy. Cones with a prickle at the tip of each scale. May be confused with Jeffrey pine which differs by having non-resinous, light-brown buds, and grayish blue-green glaucous needles.

2. ***Jeffrey Pine*** is a smaller tree than ponderosa pine, with darker cinnamon-red bark that may be tinged with lavender on old trunks. Needles in bundles of three, 5-10 inches in length, blue-green, and somewhat twisted. Crushed needles and twigs have a violet-like or pineapple odor. Buds are never covered with resin droplets. Cones with a prickle at the tip of each scale. May be confused with ponderosa pine.

3. ***Quaking Aspen*** is a medium sized tree up to 118 feet in height. Bark is smooth, greenish-white. Buds shiny but not resinous. Leaf petiole is strongly flattened. The leaf blade is broadly ovate (almost round) with a tapering tip and finely toothed margins, upper surface smooth, lower surface covered with a bloom. Aspen could be confused with black cottonwood which differs in its resinous buds, rough bark and round leaf petioles.

4. ***Scouler's Willow*** is a small tree or shrub up to 32 feet in height. Leaf blade is 1-4 inches in length, narrowly elliptic with the widest portion toward the tip, entire to irregularly toothed margins, lower surface smooth, upper surface shiny. This willow is NOT restricted to riparian zones. It can be easily confused with a number of other willow species. The combination of leaves widest toward the tip (mostly rounded ends and narrowly tapered bases) and the tolerance for upland (drier) habitats makes this willow relatively easy to identify.

5. ***Pacific Ninebark*** is a deciduous shrub 6-12 feet in height. Leaves alternate, 3 or 5 lobed (maple-like), 2-3 inches long, serrate, dark green and smooth above, paler and hairy below. Twigs red to grayish brown, splits longitudinally into long strips. Flowers small, white, borne in a cluster, stems hairy. Very similar to ninebark (see below) which is generally smaller, in drier habitats, and with densely hairy ovaries.

6. ***Ninebark*** is an erect, loosely branched shrub with maple-like leaves and shreddy bark. May be up to 6 feet in height. Leaves and flowers similar to Pacific ninebark except the ovaries are densely hairy. May be confused with Douglas maple which has opposite leaves, or sticky currant, which has leaves that are sticky to the touch. Often associated with ponderosa pine and Douglas-fir forests at low to mid-elevation.

7. ***Huckleberry*** is an erect shrub 3-5 feet high. Leaves 1-2 inches long, half as wide, thin and pale green on both surfaces, smooth or occasionally minutely hairy, margins toothed, apex and base both acute. Fruit deep purple to black round berry around 6 mm diameter. Twigs slender, green and ridged. Found on dry to moist sites, sun or shade. Similar, and often found with oval-leaved huckleberry which has entire (smooth) rather than toothed leaves.

8. ***Blue Elderberry*** is a tall deciduous shrub, sometimes tree-like, up to 20 feet in height. Twigs with a soft pith inside. Leaves opposite, pinnately compound, the 5-9 leaflets sharply serrate and strongly uneven at the base. Flowers small, white, flat-topped cluster. Fruit a blue-black berry covered with a white powdery bloom. This species could be confused with red elderberry which differs by having flowers in a spike and red-purple fruit. Found mostly on moist, well-drained sites in the sun; sea level to 9,000 ft.

9. ***Red Elderberry*** is a tall deciduous shrub, sometimes tree-like, up to 20 feet in height. Twigs with a soft pith inside. Leaves opposite, pinnately compound, the 5-7 leaflets sharply toothed and often uneven at the base. Flowers small, white, and clustered into a long spike. Fruit is a berry, most often red in color but sometimes purplish-black or yellow. Similar to blue elderberry which has a flat-topped flower cluster and a blue-black berry.

10. ***Western Wormwood*** is an aromatic perennial herb, 1-3 feet in height. Leaves mostly 1-4 inches long, variable in shape but most often with 3-5 narrow lobes, white hairy beneath, sometimes above as well. Flowers small and arranged in a loose, narrow flower cluster, 2-12 in long. May be confused with Douglas' wormwood which has wider leaves and is usually found in moister habitats. Also similar to Riverbank wormwood which occurs only near streams and outwash areas.

11. ***Mugwort*** is a large perennial herb 2-5 feet tall, usually found in large colonies in wet areas, ditches, or drainages. Leaves are evenly-spaced, 0.4-4.0 inches long, the upper leaves are narrowly elliptical, the lower widely oblanceolate, often coarsely 3 to 5 lobed near the leaf tip, 0.8-1.0 inch wide, green above, covered with dense white hair beneath. Differs from western wormwood in having wider lower leaves and in its generally damp habitat.

12. ***Evening Primrose*** is a large biennial with elliptical leaves up to 10 inches long in a dense rosette the first year. The large (>1m) flowering stalk with long red-tinged elliptical leaves and large bright yellow four-petaled flowers forms in the second year. Both the

leaves and stem are densely hairy, and the hairs often have red, blister-like bases. Usually found in moist, sunny habitats, like seeps or meadows.

13. ***Mountain Snowberry*** is a shrub, 1.5-5 feet in height with a solid brown pith. Bark: shreddy, brownish. Young twigs: hairy. Leaves opposite, elliptical, 0.4-1.4 inches long and half as wide. Flowers (May-June) tubular-shaped, the petals white with a pink tube. Fruit a white berry. Common snowberry differs by having non-tubular flowers and a hollow pith. Trailing snowberry is a trailing shrub with non-tubular flowers; and Utah honeysuckle has larger leaves and a solid white pith.

14. ***Red Alder*** is a deciduous tree up to 65 feet tall with dark green leaves 2.4-4.7 inches long. The leaves are coarsely toothed, with smaller teeth on the leaf margins, and the leaf veins are also tightly inrolled. Red alder is a common tree in damp situations and is a frequent colonizer of clearings, especially following clearcuts in coniferous forests.

15. **Skunkbush** is a small, diffusively-branched shrub, 1.6-3.3 feet tall. The tips of the branches often droop down almost to ground level. The leaves are alternate, compound, with three leaflets, each of which is 3-lobed. The leaves resemble those of poison oak, but the leaflets of skunkbush are smaller, more hairy, and much more deeply-lobed. The leaves of skunkbush also emit a strong, ill-scented odor when crushed. However, if unsure, DO NOT crush the leaves of a shrub with three leaflets to determine the odor. Skunkbush is usually found on dry, open, brushy hillsides, while poison oak prefers damp or shaded forested areas and riparian habitats. Skunkbush is found throughout the southwest, from California and Arizona north to Colorado and Idaho.

Appendix 5.B Data Sheets

OZONE BIOINDICATOR PLANTS - 2003

Site Characteristics

This sheet must be completed only if you have *not* entered this same information on the Bioindicator Plot ID screen.

To be filled out by the FIELD CREW or Cooperator: Refer to Field Guide 1.6 for code definitions.

State	County	Ozone Hexagon Number	Plot Number[1]	Month	Day	Crew ID	Crew Type
							regular QA

[1]Plot Number refers to the number of locations (1 or 2) used for each hexagon number. A separate sheet should be used for each location.

√ Please put a check mark beside the correct information. Please complete all data fields.

Ozone Sample Kind:	
	Initial plot establishment on the FIA ozone grid.
	Remeasurement of a previously established plot.
	Replacement of a previously established plot that was replaced to meet the site selection guidelines (or lost site).

Ozone Grid Density: (Is the grid intensified, or not?)	
	This hex number identifies a unique ozone plot within a polygon (1 site:1 polygon)
	One of two or more ozone plots within the same polygon, each with their own hexagon number.

Plot size:		Terrain position:	
	> 1.2 hectares (3.0 acres)		Ridge top or upper slope
	0.4– 1.2 hectares (1 to 3 acres)		Bench or level area along a slope
	Other: please describe		Lower slope
			Flat land unrelated to slope
			Bottom land with occasional flooding

Aspect: 000° = no aspect; 360° = N aspect	Elevation: record estimate in feet or meters	
Record to nearest degree =	Feet =	Meters =

Soil Drainage:		Soil Depth:	
	Well-drained		Bedrock not exposed
	Wet		Bedrock exposed
	Excessively dry		

Disturbance: Disturbance on the site or in localized areas where the bioindicator plants are growing.	
	No recent or significant disturbance; Do not count disturbance >3 years old.
	Evidence of overuse; Human activity causing obvious soil compaction or erosion.
	Evidence of natural disturbance including fire, wind, flooding, grazing, pests, etc.

Fill in below all that apply. Check here if geographic coordinates were obtained from a topographic map:

GPS Type:	GPS Serial Number:
Latitude =	GPS Error =
Longitude =	Number of Readings =
Elevation =	GPS File Name =

1If no GPS Unit is available, please use a map and record estimated latitude, longitude, and elevation for each plot location.

Comments: Include information on additional species in the area, safety, directions, or additional site characteristics that may be useful.

____
____
____
____
____
_____

File this completed data sheet with the sheet used for mapping the Bioindicator Site Location and then store it in the appropriate Ozone Plot Folder for your State or Region

OZONE BIOINDICATOR PLANTS - 2003

Foliar Injury Data – Use this sheet *only* if no PDR is available for data entry!

State	Cty	Hex. No.	Plot No.	Month	Day	Measurement Type (check one):
						___ Regular crew ___ QA crew

[1]Plot Number refers to the number of locations (1 or 2) used for each hexagon number. A separate sheet should be used for each location.

Record species code number (use additional sheets for >3 species at one site): **0122** Ponderosa Pine **0116** Jeffrey Pine **0746** Quaking Aspen **0924** Scouler's Willow **0351** Red Alder **0906** Pacific Ninebark **0905** Ninebark **0965** Huckleberry **0960** Blue Elderberry 0**961** Red Elderberry **0907** Western Wormwood **0908** Mugwort **0968** Evening Primrose **0969** Mountain Snowberry **0909** Skunkbush.
Then use the codes from the percent injury scale to record the percent of the leaves or needles injured relative to the total leaf number (amount) and the average severity of symptoms on the injured leaves (severity). Add notes on back of sheet as needed.

0 = No injury; 1 = 1-6%; 2 = 7-25%; 3 = 26-50%; 4 = 51-75%; 5 = >75%

	Species Code		Species Code		Species Code	
Plant	Amount	Severity	Amount	Severity	Amount	Severity
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						
16						
17						
18						
19						
20						
21						

22								
23								
24								
25								
26								
27								
28								
29								
30								

OZONE BIOINDICATOR PLANTS

Data Sheet for Mapping the Bioindicator Site Location

To be filled out by the FIELD CREW or Cooperator:

State	County	Hex. No.	Plot No.	Month	Day	Year	Crew ID

[1]Plot Number = the number of locations (1 or 2) used for each hexagon number. A separate sheet should be used for each location.

PLGR Information: (Please fill in this information, if available)

Easting	Northing	+/- Error (ft.)	Grid Zone

Include the following information on the map:

(1) Location of the site relative to some obvious and permanent marker;
(2) Road names and distances as needed;
(3) North arrow;
(4) Starting point for plant selection;
(5) Species codes and approximate location of plant groupings used for the ozone injury evaluations.

Return the original of this map to the corresponding Plot Folder so that it can be used by audit and regular crews in subsequent visits to the plot. Mail a copy to the National Indicator Advisor the year that the site is established.

OZONE BIOINDICATOR PLANTS

Data Sheet for the Voucher Leaf Samples

To be filled out by the FIELD CREW or Cooperator:

State	County	Hex. No.	Plot No.	Month	Day	Year	Crew ID

[1]Plot Number refers to the number of locations (1 or 2) used for each hexagon number. A separate sheet should be used for each location.

To be filled out by the Cooperator (only needed when the hex number and tally numbers are not known).

Ozone plot name or identification number	Name and e-mail address of data collector

Fill in the required codes. Code definitions are in the Field Guide. For quick reference, see below.

Bioindicator Species	Injury Location	Injury Type	Is the leaf sample injury close to 100% ozone stipple or chlorotic mottle or is some other leaf surface injury also present?
			Close to 100% ______ Estimated percent other _______

Notes: Add notes on the leaf samples, plot conditions, safety, and weather as needed.

Species codes: 0122 Ponderosa pine 0116 Jeffrey pine 0746 Quaking aspen 0924 Scouler's willow 0351 Red alder 0818 California black oak 0960 Blue elderberry 0961 Red elderberry 0965 Huckleberry 0905 Ninebark 0906 Pacific ninebark 0907 Western wormwood 0908 Mugwort 0909 Skunkbush 0968 Evening primrose 0969 Mountain snowberry. *Injury Location codes:* 1 = greater
than 50% of the injured leaves are younger leaves (broadleaf) or current whorl (pine); 2 = greater than 50% of the injured leaves are mid-aged or older (broadleaf) or on whorls 1 year and older (pine); 3 = injured leaves are all ages. *Injury type codes:* 1 = greater than 50% of the injury is upper-leaf-surface stipple (broadleaf) or chlorotic mottle (pine); 2 = greater than 50% is not stipple (tan flecks, bifacial or general discoloration), or something other than chlorotic mottle (pine); 3 = injury is varied or difficult to describe.

Questions? Call your Regional Advisor. **West: Pat Temple (909) 680-1583**; 264-8883
RM: Roger Boyer (801) 625-5541
National: Gretchen Smith (413) 545-1680 [gcsmith@forwild.umass.edu];

Mail this sheet with the leaf samples to:
[Note: One sheet for each species.]

Pat Temple
USDA FS, PSW Experiment Station
4955 Canyon Crest Drive
Riverside, CA 92507

QA/QC PERSON: To be filled out by the regional ozone expert.

Positive for ozone	Negative for ozone	Date validated	Date rechecked	Sample condition

Notes: Explanation of symptoms or questions for the data collector.

Chapter 6

Vegetation Diversity and Structure

6.0 INTRODUCTION (13.0)

The objectives of the Phase 3 (P3) Vegetation Indicator are to measure the type, relative abundance, and vertical position of all trees, shrubs, herbs, grasses, ferns and fern allies within each P3 plot. We use this information to assess forest ecosystem health in terms of diversity and rates of change of community structure for both native and non-native vascular plant species. While individual species can be important indicators of a site's potential productivity, economic value, and wildlife forage and shelter, changes in the composition and spatial arrangement of vascular plants in a forest may indicate the presence of chronic stresses such as discrete site degradation, climate change, and pollution. These stresses can lead to decline or local eradication of sensitive species, as well as increase and dominance of opportunistic species, such as many weedy non-native plants.

Vegetation diversity and structure data can also be used to classify P3 plots by locally defined plant communities or associations, allowing extrapolation of other forest health monitoring results to broader areas.

The accepted technique used by vegetation scientists to sample plant composition and diversity is to install nested plots of different sizes within a given plant community (Mueller-Dombois and Ellenberg 1974, Barbour and others 1987). Multi-scale sampling is necessary because different communities have different spatial patterns of species richness, so a single plot size is an arbitrary sample of species diversity. Sampling at two or more scales provides information about the structure of a plant community and distribution of individual species, which allows better comparison among communities (and forest types), allows us to estimate how many additional species might occur beyond our largest plot size (i.e., were "missed") (Stohlgren and others 1995), and allows us to measure change in composition over time.

Data will be collected by crew members who have been trained and certified in the Vegetation Indicator methods. These crew members are expected to have had previous botanical training; while we can provide some refresher training in local flora, the skills needed to be an effective field vegetation specialist are beyond the scope of what we can provide during a short training period at the beginning of the field season.

Crew members who are not certified in Vegetation Indicator methods may assist the field vegetation specialist by:

1. Sharing CONDITION CLASS number information
2. Assisting with DETAILED NONFOREST LAND USE descriptions
3. Laying out transects
4. Locating quadrat corners
5. Collecting unknown specimens
6. Entering data
7. Aiding in tree identification

6.1 SAMPLE DESIGN (13.1)

Phase 3 sampling of vegetation is focused on accessible forest condition classes. If the total area of all accessible forest land condition classes is less than 100% on a subplot, vegetation measurements are done only on the portion that is in accessible forest land condition classes. Vegetation Indicator measurements are not done on portions of the plot that are NOT accessible forest land condition classes. Canopy cover estimates are only made for the area within accessible forest condition(s).

Vegetation Indicator data is collected on all four subplots of P3 plots, and summarized to the Plot level. Specific data are collected at the subplot level for total foliar height diversity and descriptions of ground cover. Species data are collected at the quadrat level (presence/absence only) and at the subplot level (total relative abundance and abundance by height layer).

The boundaries of the subplot are 24.0 feet, horizontal distance, from the subplot center. Total cover of all vegetation foliage in four height layers (0 – 2, >2 – 6,> 6 – 16, and >16 feet) is estimated on each subplot prior to recording species. Ground variable cover estimates are also recorded on the 24.0-foot radius subplot. These estimates are only made on the portion of the subplot that is in accessible forest land.

Species data for all vascular plants are collected on two plot sizes on each subplot: three 3.28 x 3.28 feet (1 m^2) “quadrats”, and the 24.0-foot radius subplot (Figure 49). From subplot center, the quadrats are located on the right sides of lines at azimuths of 30°, 150°, and 270 °. Ideally, two corners of each quadrat are permanently marked at 15 and 18.3 feet (4.57 and 5.57m), horizontal distance, from the subplot center. (This will vary by region and land owner.) Each quadrat is assigned to the dominant condition class on the quadrat, and trampling is assessed. On the quadrats where the dominant condition class is accessible forest, species presence/absence data are collected for vascular plants rooted in the quadrat or with overhanging foliage or live material within 6 feet above the ground above the quadrat.

After the quadrats are assessed, a time-constrained search of all species on the subplot is conducted. Total canopy cover of each individual species is estimated, and then canopy cover within each of three height layers (0-6,> 6-16, and >16) are estimated on each subplot. There are no height limits for vegetation overhanging the subplot boundary; trees and shrubs that are rooted outside the subplot are included in the record if they overhang the subplot. Most species will have canopy cover in one layer only, in which case the total canopy cover and layer canopy cover will be the same. Species and canopy cover estimates are only made for the area of the subplot in accessible forest condition(s). Boundaries between multiple accessible forest conditions on a subplot are ignored during data collection.

Specimens of all measured plants that cannot be confidently identified to the species level are collected off-plot and submitted to herbaria for subsequent identification. Data are collected by certified vegetation specialists with regional knowledge to provide optimum field identification of plant species at each site.

Quality assurance measurements should be made within 2 weeks of the original plot visit. At the time of next plot measurement cycle, plots should be revisited within 2 weeks of the calendar date of the previous measurement cycle, if at all possible.

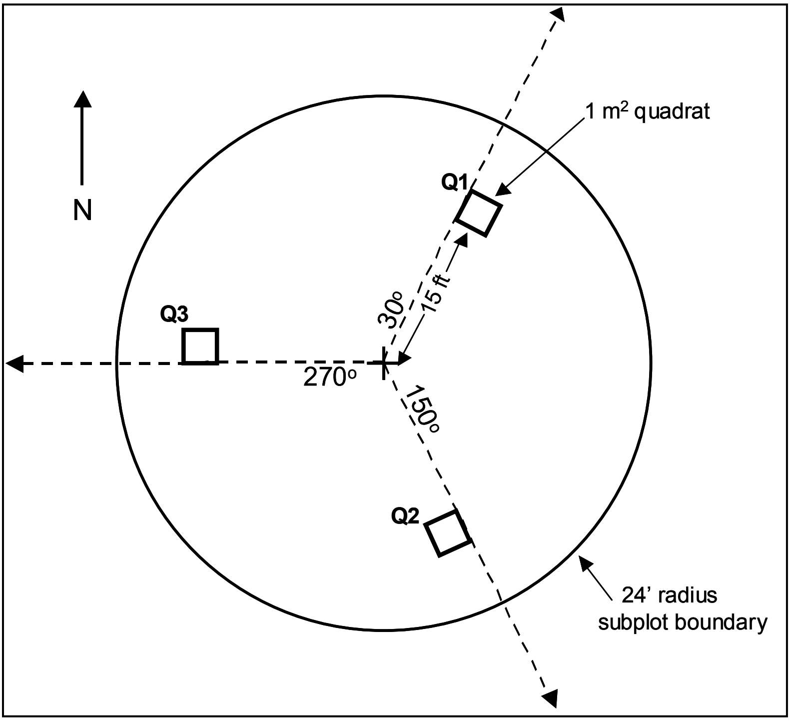

Figure 49. Layout of P3 subplot showing location of quadrats and subplot boundary (13-1)

6.2 SUGGESTED FIELD GEAR UNIQUE TO VEGETATION INDICATOR (13.2)

- 1-gal plastic bags for unknown plant specimens
- 1-m² quadrat frame
- Permanent pins/stakes to mark quadrat where allowed, or temporary pin flags
- Carpenters ruler (for height measurements)
- Hand lens
- Pre-numbered labels for unknown plant specimens (provided)
- Envelopes for bulky fruits or nuts
- Local flora keys and species lists
- Digging tool
- Large boxes to store and ship samples
- Newspaper and cardboard

- Plant press
- Access to dissecting scope with illuminator
- Mailing instructions for samples (Region specific)
- Diskettes for sending unknown sample information to herbaria
- PLANTS code dictionary with cross-walk plant names to accepted codes

6.3 PLOT AND VISIT REFERENCE INFORMATION

A. 6.3.1 STATE (13.3.1)

Record the unique FIPS (Federal Information Processing Standard) code identifying the State where the plot center is located.

When collected: All plots currently having at least one accessible forest condition.
Field width: 2 digits
Tolerance: No errors
MQO: 99% of the time
Values: See Chapter 7 of the RMRS P2 field manual

B. 6.3.2 COUNTY (13.3.2)

Record the unique FIPS (Federal Information Processing Standard) code identifying the County where the plot center is located.

When collected: All plots currently having at least one accessible forest condition
Field width: 3 digits
Tolerance: No errors
MQO: 99% of the time
Values: See Appendix 1 in the P2 field guide

C. 6.3.3 PLOT NUMBER (13.3.3)

Record the identification number, unique within a county, parish, or borough (survey unit in AK), for each plot. If SAMPLE KIND = 3, the plot number will be assigned by the National Information Management System (NIMS).

When collected: All plots currently having at least one accessible forest condition
Field width: 4 digits
Tolerance: No errors
MQO: 99% of the time
Values: 0000(0) – 9999(9)

D. 6.3.4 P3 HEXAGON NUMBER (13.3.4)

Record the unique code assigned to each Phase 3 (former FHM) hexagon.

When collected: All plots currently having at least one accessible forest condition
Field width: 7 digits
Tolerance: No errors
MQO: 99% of the time

E. Values: 0000001 to 9999999

F. 6.3.5 P3 PLOT NUMBER (13.3.5)

Record the Phase 3 PLOT NUMBER that are used to identify individual plots within the same Phase 3 (former FHM) hexagon.

When collected: All plots currently having at least one accessible forest condition
Field width: 1 digit
Tolerance: No errors
MQO: 99% of the time
Values: 0 - 9

G. 6.3.6 QA STATUS (13.3.6)

Record the code corresponding to the type of vegetation measurement conducted.

When collected: All plots currently having at least one accessible forest condition
Field width: 1 digit
Tolerance: No errors
MQO: 99% of the time

Values:

1 Standard field production plot
2 Cold Check
3 Reference plot (off grid)
4 Training/Practice plot (off grid)
5 Botched Plot file (disregard during data processing)
6 Blind Check
7 Hot Check (production plot)

H. 6.3.7 CREW TYPE (13.3.7)

Record the code corresponding to the type of crew measuring the vegetation diversity and structure.

When collected: All plots currently having at least one accessible forest condition
Field width: 1 digit
Tolerance: No errors
MQO: 99% of the time
Values:

1 Regular field crew
2 QA crew (any QA crew member present collecting data)

I. 6.3.8 SAMPLE KIND (13.3.8)

Record sample kind.

When collected: All plots
Field width: 1 digit
Tolerance: No errors
MQO: 99% of the time
Values:

1 Initial plot establishment
2 Remeasure of previously established plot
3 Replacement plot

J. 6.3.9 VEG VISIT DATE (13.3.9)

Record the year, month, and day that the current plot visit was completed as follows:

6.3.9.1 YEAR (13.3.9.1)
Record the year that the plot was completed.

When collected: All plots
Field width: 4 digits
Tolerance: No errors
MQO: At least 99% of the time
Values: ≥ 2004

6.3.9.2 MONTH (13.3.9.2)
Record the month that the plot was completed.

When collected: All plots
Field width: 2 digits
Tolerance: No errors
MQO: At least 99% of the time
Values:

January	01	May	05	September	09
February	02	June	06	October	10
March	03	July	07	November	11
April	04	August	08	December	12

6.3.9.3 DAY (13.3.9.3)
Record the day of the month that the plot was completed.

When collected: All plots
Field width: 2 digits
Tolerance: No errors
MQO: At least 99% of the time
Values: 01 to 31

K. 6.3.10 VEGETATION SPECIALIST CREW NAME (13.3.10)

Record the name of the crew member measuring vegetation diversity and structure.

When collected: All plots
Field width: 20 digits
Tolerance: No errors
MQO: 99% of the time
Values: *Lastname, firstname*

L. 6.3.11 PLOT NOTES (13.3.11)

Use these fields to record notes pertaining to the entire plot. If the notes apply only to a specific subplot or other specific aspect of the plot, then make that clear in the notes.

When collected: All plots
Field width: Unlimited alphanumeric character field
Tolerance: N/A
MQO: N/A
Values: English language words, phrases and numbers

6.4 SUBPLOT INFORMATION

M. 6.4.1 SUBPLOT NUMBER (13.4.1)

Record the code corresponding to the number of the subplot.

When collected: On all plots with at least one accessible forest condition
Field width: 1 digit
Tolerance: No errors
MQO: 99% of the time
Values:

1	Center subplot
2	North subplot
3	Southeast subplot
4	Southwest subplot

N. 6.4.2 SUBPLOT STATUS (13.4.2)

Record the code corresponding to how the subplot was sampled, and if not, why not.

When collected: Each subplot
Field width: 1 digit
Tolerance: No errors
MQO: 99% of the time
Values:

1	Sampled – at least one accessible forest land condition present
2	Sampled – no accessible forest land condition present on subplot
3	Nonsampled

O. 6.4.3 SUBPLOT NONSAMPLED REASON (13.4.3)

For subplots that cannot be sampled, and are wholly or partially within the FIA sampling population (U.S. boundary), record one of the following reasons. Codes 1-4 can be assigned to entire plots or portions of plots that are not sampled. Code 5 is assigned only when the entire plot is affected.

When collected: When Subplot Status=3.
Field width: 2 digits
Tolerance: No errors
MQO: 99% of the time
Values:

01 Outside U.S. boundary
02. Denied access area
03 Hazardous situation
04 Time Limitation
05 Lost data (office use only)
10 Other

P. 6.4.4 PERCENT SUBPLOT AREA ACCESSIBLE FOREST LAND (13.4.4)

Record the percent area of the subplot in an accessible forested condition.
When collected: When Subplot Status=1.

Field width: 3 digits
Tolerance: +/- 1 class based on the following canopy cover classes: 1-5%, 6-10%, 11-20%, 21-40%, 41-60%, 61-80%, and 81-100%
MQO: 90 % of the time
Values: 001-100.

Q. 6.4.5 DETAILED NONFOREST LAND USE (13.4.5)

Record the code corresponding to the NONFOREST land use of the portion of the subplot that is not forest. If more than one nonforest land use is present, record the code that best describes the land use occurring closet to subplot center.

When collected: SUBPLOT STATUS = 1, and PERCENT SUBPLOT AREA ACCESSIBLE FOREST LAND < 100%
Field width: 2 digits
Tolerance: No errors
MQO: 99% of the time
Values:

- 10 Agriculture
  - 11 Cropland
  - 12 Pasture
  - 13 Idle farmland
  - 14 Orchard
  - 15 Christmas tree plantation
- 20 Rangeland
- 30 Developed
- 31 Cultural (business, residential, urban buildup)
- 32 Rights-of-way (improved roads, railway, power lines, canals
- 33 Recreation (parks, ski areas, golf courses, etc.)
- 40 Other (beach, desert, noncensus water, marsh, bog)

6.5 SUBPLOT TOTAL CANOPY COVER BY LAYER (13.5)

Estimate the total canopy cover of the foliage of all vascular plants by layer above the ground surface within the accessible forested conditions on the subplot. A rapid canopy cover estimate is made, ignoring overlap among species. It may help to visualize canopy cover by collapsing each layer into a 2-dimension space and using the polygon method. Canopy cover is based on a vertically-projected polygon described by the outline of the foliage, ignoring any normal spaces occurring between the leaves of plants (Daubenmire 1959). If there is no foliage in a layer, enter 0% for that layer. Canopy cover estimates are only made for the area within accessible forest condition(s) and should not include foliage on non-forested portions of the subplot. However, record the percent cover on the forested portion as if the subplot was 100% accessible forest. That is, if cover in a layer is about equal to a circle with a radius of 5.3 ft, enter 5%, as you would for a fully forested subplot, on any partially forested subplot.

R. 6.5.1 SUBPLOT CANOPY COVER LAYER 1 (0 – 2 feet above ground) (13.5.1)

Estimate the total canopy cover of the foliage of all vascular plants in Layer 1 within the accessible forested conditions on the subplot. A rapid canopy cover estimate is made, ignoring overlap among species.

When collected: All subplots where SUBPLOT STATUS = 1
Field width: 3 digits
Tolerance: +/- 1 class based on the following canopy cover classes: 1-5%, 6-10%, 11-20%, 21-40%, 41-60%, 61-80%, and 81-100%
MQO: at least 90% of the time
Values: 000-100

S. 6.5.2 SUBPLOT CANOPY COVER LAYER 2 (>2 – 6 ft) (13.5.2)

Estimate the total canopy cover of the foliage of all vascular plants in Layer 2 within the accessible forested conditions on the subplot. A rapid canopy cover estimate is made, ignoring overlap among species.

When collected: All subplots where SUBPLOT STATUS = 1
Field width: 3 digits
Tolerance: +/- 1 class based on the following canopy cover classes: 1-5%, 6-10%, 11-20%, 21-40%, 41-60%, 61-80%, and 81-100%
MQO: at least 90% of the time
Values: 000-100

T. 6.5.3 SUBPLOT CANOPY COVER LAYER 3 (>6 – 16 ft) (13.5.3)

Estimate the total canopy cover of the foliage of all vascular plants in Layer 3 surface within the accessible forested conditions on the subplot. A rapid canopy cover estimate is made, ignoring overlap among species.

When collected: All subplots where SUBPLOT STATUS = 1
Field width: 3 digits
Tolerance: +/- 1 class based on the following canopy cover classes: 1-5%, 6-10%, 11-20%, 21-40%, 41-60%, 61-80%, and 81-100%
MQO: at least 90% of the time
Values: 000-100

U. 6.5.4 SUBPLOT CANOPY COVER LAYER 4 (> 16 ft) (13.5.4)

Estimate the total canopy cover of the foliage of all vascular plants in Layer 4 within the accessible forested conditions on the subplot. A rapid canopy cover estimate is made, ignoring overlap among species.

When collected: All subplots where SUBPLOT STATUS = 1
Field width: 3 digits
Tolerance: +/- 1 class based on the following canopy cover classes: 1-5%, 6-10%, 11-20%, 21-40%, 41-60%, 61-80%, and 81-100%
MQO: at least 90% of the time
Values: 000-100

6.6 SUBPLOT GROUND VARIABLE RECORDS (13.6)

Assess the cover of ground variables found on the accessible forest portion of the subplot. In areas with thick vegetation, you may opt to complete this section after you have collected the species data and have a better perspective on the ground cover. These describe things in contact with the ground surface and not occupied by tree boles or other vegetation basal area. Multiple ground variables often occur on a subplot. Items must be visible from above. For example, a large rock completely covered with moss would not be coded, but the moss would be. Estimate the cover of each ground variable. Cover is estimated to the nearest 1% for each ground variable. The sum of all ground variable covers must equal the percentage entered for variable 13.4.4 PERCENT SUBPLOT AREA ACCESSIBLE FOREST LAND, above.

V. 6.6.1 PERCENT CRYPTOBIOTIC CRUST COVER (13.6.1)

Record the PERCENT CRYPTOBIOTIC CRUST COVER in the subplot. Cryptobiotic crust is a layer of symbiotic lichens and algae on the soil surface (common in arid regions).

When collected: All sampled subplots with SUBPLOT STATUS = 1
Field width: 3 digits
Tolerance: +/- 1 class based on the following cover classes: 1-5%, 6-10%, 11-20%, 21-40%, 41-60%, 61-80%, and 81-100%
MQO: at least 90% of the time
Values: 000-100

W. 6.6.2 PERCENT LICHEN COVER (13.6.2)

Record the PERCENT LICHEN COVER in the subplot.

When collected: All sampled subplots with SUBPLOT STATUS = 1
Field width: 3 digits
Tolerance: +/- 1 class based on the following cover classes: 1-5%, 6-10%, 11-20%, 21-40%, 41-60%, 61-80%, and 81-100%
MQO: At least 90% of the time
Values: 000-100

X. 6.6.3 PERCENT LITTER/DUFF COVER (13.6.3)

Record the PERCENT LITTER/DUFF COVER in the subplot. This is a continuous layer of accumulated organic matter over forest mineral soil (e.g., scattered leaves over mineral soil is coded mineral soil).

When collected: All sampled subplots with SUBPLOT STATUS = 1
Field width: 3 digits
Tolerance: +/- 1 class based on the following cover classes: 1-5%, 6-10%, 11-20%, 21-40%, 41-60%, 61-80%, and 81-100%
MQO: At least 90% of the time
Values: 000-100

Y. 6.6.4 PERCENT MINERAL SOIL COVER (13.6.4)

Record the PERCENT MINERAL SOIL COVER in the subplot. This is physically weathered soil parent material that may or may not also be chemically and biologically altered.

When collected: All sampled subplots with SUBPLOT STATUS = 1
Field width: 3 digits
Tolerance: +/- 1 class based on the following cover classes: 1-5%, 6-10%, 11-20%, 21-40%, 41-60%, 61-80%, and 81-100%
MQO: At least 90% of the time
Values: 000-100

Z. 6.6.5 PERCENT MOSS COVER (13.6.5)

Record the PERCENT MOSS COVER in the subplot. If liverworts occur on the subplot, include them here with mosses.

When collected: All sampled subplots with SUBPLOT STATUS = 1
Field width: 3 digits
Tolerance: +/- 1 class based on the following cover classes: 1-5%, 6-10%, 11-20%, 21-40%, 41-60%, 61-80%, and 81-100%
MQO: At least 90% of the time
Values: 000-100

AA. 6.6.6 PERCENT ROAD/TRAIL COVER (13.6.6)

Record the PERCENT ROAD/TRAIL COVER in the portions of the subplot designated as accessible forest condition. Include any areas compacted and unvegetated from regular use by foot travel or small motorized vehicles.

When collected: All sampled subplots with SUBPLOT STATUS = 1
Field width: 3 digits
Tolerance: +/- 1 class based on the following cover classes: 1-5%, 6-10%, 11-20%, 21-40%, 41-60%, 61-80%, and 81-100%
MQO: At least 90% of the time
Values: 000-100

BB. 6.6.7 PERCENT ROCK COVER (13.6.7)

Record the PERCENT ROCK COVER in the subplot. Include any rocks, boulders, or accumulations of gravel (> 1/4 inch diameter) or pebbles

When collected: All sampled subplots with SUBPLOT STATUS = 1
Field width: 3 digits
Tolerance: +/- 1 class based on the following cover classes: 1-5%, 6-10%, 11-20%, 21-40%, 41-60%, 61-80%, and 81-100%
MQO: At least 90% of the time
Values: 000-100

CC. 6.6.8 PERCENT STANDING WATER/FLOODED COVER (13.6.8)

Record the PERCENT STANDING WATER/FLOODED COVER in the subplot. Include any ponding or flowing water that is not contained within banks.

When collected: All sampled subplots with SUBPLOT STATUS = 1
Field width: 3 digits
Tolerance: +/- 1 class based on the following cover classes: 1-5%, 6-10%, 11-20%, 21-40%, 41-60%, 61-80%, and 81-100%
MQO: At least 90% of the time
Values: 000-100

DD. 6.6.9 PERCENT STREAM/LAKE COVER (13.6.9)

Record the PERCENT STREAM/LAKE COVER in the subplot. Include any body of water contained within banks that is within a forested condition.

When collected: All sampled subplots with SUBPLOT STATUS = 1
Field width: 3 digits
Tolerance: +/- 1 class based on the following cover classes: 1-5%, 6-10%, 11-20%, 21-40%, 41-60%, 61-80%, and 81-100%
MQO: At least 90% of the time
Values: 000-100

EE. 6.6.10 PERCENT TRASH/JUNK/OTHER COVER (13.6.10)

Record the PERCENT TRASH/JUNK/OTHER COVER in the subplot.

When collected: All sampled subplots with SUBPLOT STATUS = 1
Field width: 3 digits

Tolerance: +/- 1 class based on the following cover classes: 1-5%, 6-10%, 11-20%, 21-40%, 41-60%, 61-80%, and 81-100%
MQO: At least 90% of the time
Values: 000-100

FF. 6.6.11 PERCENT WOOD COVER (13.6.11)

Record the PERCENT WOOD COVER in the subplot. Wood pieces included should average greater than 3 inches in diameter and be in contact with the ground; smaller pieces should be included in Litter/ Duff Cover. Stumps are included.

When collected: All sampled subplots with SUBPLOT STATUS = 1
Field width: 3 digits
Tolerance: +/- 1 class based on the following cover classes: 1-5%, 6-10%, 11-20%, 21-40%, 41-60%, 61-80%, and 81-100%
MQO: At least 90% of the time
Values: 000-100

6.7 QUADRAT DATA (13.7)

Place the quadrat frame to the right side of the transect line and make sure the corners are lined up with the permanent pins. Level the quadrat, if necessary, by propping up the quadrat corners. When a quadrat is located on a steep slope the vegetation specialist should be positioned next to or downhill from the quadrat to prevent sliding or falling into the quadrat. In areas of thick vegetation, quadrat sides should be slid through the vegetation. Quadrat frames can be made with hinging corners or detachable sections to improve maneuverability.

6.7.1 SUBPLOT NUMBER (13.7.1)

Record the code corresponding to the number of the subplot.

When collected: All sampled subplots with SUBPLOT STATUS = 1
Field width: 1 digit
Tolerance: No errors
MQO: 99% of the time
Values:

1	Center subplot
2	North subplot
3	Southeast subplot
4	Southwest subplot

GG. 6.7.2 QUADRAT NUMBER (13.7.2)

Record the code corresponding to the number of the quadrat.

When collected: Each quadrat
Field width: 1 digits
Tolerance: No errors
MQO: 99% of the time
Values:

1	Quadrat on 30^{o}
2	Quadrat on 150^{o}
3	Quadrat on 270^{o}

HH. 6.7.3 QUADRAT CONDITION CLASS (13.7.3)

A CONDITION CLASS number is assigned to each quadrat. If the quadrat straddles a CONDITION CLASS boundary, assign the number for the CONDITION CLASS which occupies the greatest area in the quadrat. Use the CONDITION CLASS number assigned during plot mapping by the mensuration crew (FIA National Core Field Guide, Ver. 2.01).

When collected: Each Quadrat
Field width: 1 digit
Tolerance: No errors
MQO: 99% of the time
Values: 1-9

II. 6.7.4 QUADRAT STATUS (13.7.4)

Record the code corresponding to how the quadrat was sampled. If QUADRAT STATUS is 1 or 3, continue to enter data for the quadrat. If value entered is 2, 4, or 5, leave the remaining quadrat items blank.

When collected: Each quadrat
Field width: 1 digit
Tolerance: No errors
MQO: 99% of the time
Values:

1 Quadrat sampled (most of the quadrat is in an accessible forest condition)
2 Quadrat not sampled because most or all of it does not fall in an accessible forested condition class
3 Quadrat sampled, no vascular plants rooted in or overhanging within 6 feet of the ground surface
4 Quadrat not sampled, hazard present on quadrat
5 Quadrat not sampled, other reason – enter in plot notes

JJ. 6.7.5 TRAMPLING (13.7.5)

A trampling code is assigned to each quadrat at the start of vegetation diversity measurements. Trampling is defined as damage to plants or disturbance of the ground layer by humans, livestock, or wildlife.

When collected: QUADRAT STATUS = 1 or 3
Field width: 1 digits
Tolerance: +/- one code
MQO: At least 90% of the time
Values:

1 Low: 0-10% of quadrat trampled: pristine to relatively undisturbed.
2 Moderate: 10-50% of quadrat trampled: trampling by animals or field crew
3 Heavy: >50% of quadrat trampled: hiking trail or heavily grazed.

6.8 QUADRAT SPECIES RECORDS (13.8)

KK. 6.8.1 QUADRAT SPECIES (13.8.1)

Record a code for each vascular plant species found rooted in or overhanging within 6 feet above the quadrat. Species codes must be the standardized codes in the Natural Resource Conservation Service (NRCS) PLANTS database January 2000 version. Identification to species only is expected. However, if subspecies information is known, enter the appropriate NRCS code. If a plant is not known to species, see rules below.

If a plant cannot be identified quickly and confidently, assign an unknown code, as described in rules below, to the measurement and collect a specimen away from the quadrat. As a rule of thumb: “if you have any doubts, collect it”.

If there are no live plants on the quadrat, enter the code 3 in QUADRAT STATUS.

When collected: QUADRAT STATUS = 1
Field width: 10 digits
Tolerance: No errors
MQO: 99% of the time
Values: see rules below:

KEY TO ASSIGNING SPECIES CODES, WHEN TO COLLECT:

1a. Plant is identified to species or subspecies……**Enter NRCS[1] Species Code**
1b. Plant is **NOT** identified to at least species…………………………………….**2**

2a. Plant is locally sparse[2], **OR** has less than 1% canopy cover on subplot AND no mature foliage or reproductive parts present: **DO NOT COLLECT** and assign unknown code ………………..……………………………………………………**3**
2b. Plant **IS NOT** locally sparse: **COLLECT** and assign unknown code....................................……………………………………………………**4**

(Unknowns locally sparse OR has less than 1% canopy cover AND no mature foliage or reproductive parts present **DO NOT COLLECT**)
3a. Plant is known to genus……………..…….**Enter NRCS genus code and number[3] as needed**
3b. Plant is know to Family……...**Enter UNFM[4] and NRCS family code and number as needed**
3c. Plant not known ……………….……….…...**Enter NRCS general code and number as needed**

(Unknowns **NOT** locally sparse: **COLLECT!**)
4a. Plant known to genus……………………**Enter UN[5] and either a descriptive code[6] or NRCS genus code, and number as needed**

4b. Plant is known to family………………..…**Enter UNFM and either a descriptive code or NRCS family code, and number as needed**

4c. Plant not known to genus, or family.…………………………………………**Enter UN and either a descriptive code or NRCS general code, and number as needed**

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[1]NRCS refers to the Natural Resource Conservation Service PLANTS database version downloaded January 2000. Species, genus, family and general codes from this version available from web site: http://socrates.lv-hrc.nevada.edu/fia/ia/IAWeb/Veg.htm

[2] "Locally sparse" is defined as 5 or less plants present in the entire plot (4 subplots) and immediate surrounding area.

[3] Add a sequential number when two different plant species occur which would have the same Genus, Family or general code. For example, if there are a number of 2FDA plants, you would list them as 2FDA, 2FDA2, 2FDA3, and so on if they are NOT collected. If specimens ARE collected, the codes used are UN2FDA, UN2FDA2, UN2FDA3, and so on. Descriptive text should be added on unknown spreadsheet and label when a specimen is collected, and to plot notes when not collected.

[4] A "UNFM" prefix identifies plant to Family; it may or may not represent a collected specimen, although if it was present with flower parts or fruits, and had canopy cover of 1 percent or greater on any subplot, it should have been collected. The "UNFM" prefix is needed to designate family level identification: there are many genus codes and family codes that are the same.

[5]"UN" prefix on a code signals data processors that this code represents a plant which was collected and may be identified in the future, and updates to the database will be required.

[6]When a plant is collected for identification, you may assign a descriptive name if it is easier to remember and use EXACTLY the same way when referring to the same plant species encountered elsewhere. The database will be updated with the plants' determined identity for all entries made by the VEG specialist crew who submitted the sample in a given season, so you must NOT use the same descriptive name for different species. In contrast, when generic (NRCS genus, family and general codes) unknowns are updated, they will be made on a plot by plot basis. For example, a species record is coded as UNCAREX3 on a plot is identified from a specimen collected on that plot. All UNCAREX3 records from that plot are updated with the identified species code, but specimens recorded as UNCAREX3 on a different plot are NOT updated with that code, unless a specimen collected on the different plot is identified to the same species.

6.9 SUBPLOT SPECIES RECORDS (13.9)

After completing the three quadrats on a subplot the vegetation specialist does a search of the entire accessible forest condition area of the subplot, ignoring any condition class boundaries within the accessible forest. **Only** species rooted in or overhanging accessible forest condition(s) are included. The vegetation specialist records all species, searching for no more than an average of 45 minutes per subplot. Some vegetation specialists find they spend more time on the first subplot, but less time on other subplots because most plants have been identified and coded. Only emergent plants are recorded in wetland forest situations. Epiphytes (Spanish moss, ferns, orchids, mistletoes) are recorded as best as possible as seen from the ground level. Two types of canopy cover estimates are made for each species: total canopy cover and canopy cover within each of three layers. The majority of plants will have canopy cover in only one layer, in which case the total and layer canopy covers will be identical.

LL. 6.9.1 SUBPLOT NUMBER (13.9.1)

Record the code corresponding to the number of the subplot.

When collected: All subplots with subplot status = 1
Field width: 1 digit
Tolerance: No errors
MQO: At least 99% of the time
Values:

1	Center subplot
2	North subplot
3	Southeast subplot
4	Southwest subplot

MM. 6.9.2 SUBPLOT SPECIES (13.9.2)

See section 13.8 for guidelines concerning species codes and section 13.10 for guidelines concerning unknown plants. Only codes from the accepted PLANTS database or "unknown codes" are acceptable. Record species within accessible forested condition(s); include plants rooted in and/or overhanging accessible forested conditions (even if the overhanging species are rooted outside the subplot).

When collected: All subplots with subplot status = 1
Field width: 10 digits
Tolerance: No errors
MQO: 99% of the time
Values: see section 13.8.1

NN. 6.9.3 SUBPLOT SPECIES TOTAL PERCENT CANOPY COVER (13.9.3)

A rapid canopy cover estimate is made for each species occurring within accessible forested condition(s). Estimate SUBPLOT SPECIES TOTAL PERCENT CANOPY COVER over the entire forested condition portion of the subplot, ignoring any boundaries between forested condition(s). Canopy cover is based on a vertically-projected polygon described by the outline of the foliage, ignoring any normal spaces occurring between the leaves of plants (Daubenmire 1959). Canopy cover estimates are only made for the area within accessible forest condition(s) and should not include foliage on non-forested portions of the subplot. However, record the percent cover on the forested portion as if the subplot was 100% accessible forest. That is, if total cover for a given species is about equal to a circle with a radius of 5.3 ft, enter 5%, as you would for a fully forested subplot, on any partially forested subplot.

For species of moderate cover, it may be easiest to divide the subplots into quarters, estimate canopy cover of each quarter separately, and then add them together. Record a trace of canopy cover as 1%. The following area-cover sizes may be useful in developing estimates for an entirely forested subplot:

Subplot radius = 24.0 feet, Subplot area = 1809 ft^2

Cover	Area (ft^2)	Length of a side of a square(ft)	Radius of circular area(ft)
1%	18	4.3	2.4
3%	54	7.4	4.1
5%	90	9.5	5.3
10%	181	13.4	7.6
20%	362	19	10.7

For any species: total cover must be less than or equal to the sum of cover assigned for all layers, but greater than or equal to the greatest cover assigned for any one layer.
(greatest single layer cover $\leq$ total cover $\leq$ sum of all layers).

When collected: Each subplot species recorded
Field width: 3 digits
Tolerance: +/- 1 class based on the following canopy cover classes: 1-5%, 6-10%, 11-20%, 21-40%, 41-60%, 61-80%, and 81-100%
MQO: at least 90% of the time
Values: 001 to 100

OO. 6.9.4 SUBPLOT SPECIES PERCENT CANOPY COVER LAYER 1 AND 2 (13.9.4)

A rapid canopy cover estimate is made for each species in a combined Layer1 and 2. Estimate SUBPLOT SPECIES PERCENT CANOPY COVER LAYER 1 AND 2 over the entire forested condition portion of the subplot, ignoring any forested condition class boundaries present, from ground level to 6 feet above the ground. For plants rooted in the subplot, but with no foliage in the combined layer, enter 0. Cover assigned to any one layer cannot be greater than the value assigned for total cover for that species. Canopy cover is based on a vertically-projected polygon described by the outline of the foliage, ignoring any normal spaces occurring between the leaves of plants (Daubenmire 1959). Canopy cover estimates are only made for the area within accessible forest condition(s) and should not include foliage on non-forested portions of the subplot. However, record the percent cover on the forested portion as if the subplot was 100% accessible forest. That is, if total cover for a given species is about equal to a circle with a radius of 5.3 ft, enter 5%, as you would for a fully forested subplot, on any partially forested subplot.

When collected: Each subplot species recorded
Field width: 3 digits
Tolerance: +/- 1 class based on the following canopy cover classes: 0, 1-5%, 6-10%, 11-20%, 21-40%, 41-60%, 61-80%, and 81-100%
MQO: at least 90% of the time
Values: 000 to 100

PP. 6.9.5 SUBPLOT SPECIES PERCENT CANOPY COVER LAYER 3 (13.9.5)

A rapid canopy cover estimate is made for each species in Layer 3. Estimate SUBPLOT SPECIES PERCENT CANOPY COVER LAYER 3 (from >6-16 feet above the ground) over the entire forested condition portion of the subplot, ignoring any forested condition class boundaries present. For plants rooted in the subplot, but with no foliage in layer 3, enter 0. Cover assigned to any one layer cannot be greater than the value assigned for total cover for that species. Canopy cover is based on a vertically-projected polygon described by the outline of the foliage, ignoring any normal spaces occurring between the leaves of plants (Daubenmire 1959). Canopy cover estimates are only made for the area within accessible forest condition(s) and should not include foliage on non-forested portions of the subplot. However, record the percent cover on the forested portion as if the subplot was 100% accessible forest. That is, if total cover for a given species is about equal to a circle with a radius of 5.3 ft, enter 5%, as you would for a fully forested subplot, on any partially forested subplot.

When collected: Each subplot species recorded
Field width: 3 digits

Tolerance: +/- 1 class based on the following canopy cover classes: 0, 1-5%, 6-10%, 11-20%, 21-40%, 41-60%, 61-80%, and 81-100%
MQO: at least 90% of the time
Values: 000 to 100

QQ. 6.9.6 SUBPLOT SPECIES PERCENT CANOPY COVER LAYER 4 (13.9.6)

A rapid canopy cover estimate is made for each species in Layer 4. Estimate SUBPLOT SPECIES PERCENT CANOPY COVER LAYER 4 (>16 feet above the ground) over the entire forested condition portion of the subplot, ignoring any forested condition class boundaries present. For plants rooted in the subplot, but with no foliage in layer 4, enter 0. Cover assigned to any one layer cannot be greater than the value assigned for total cover for that species. Canopy cover is based on a vertically-projected polygon described by the outline of the foliage, ignoring any normal spaces occurring between the leaves of plants (Daubenmire 1959). Canopy cover estimates are only made for the area within accessible forest condition(s) and should not include foliage on non-forested portions of the subplot. However, record the percent cover on the forested portion as if the subplot was 100% accessible forest. That is, if total cover for a given species is about equal to a circle with a radius of 5.3 ft, enter 5%, as you would for a fully forested subplot, on any partially forested subplot.

When collected: Each subplot species recorded
Field width: 3 digits
Tolerance: +/- 1 class based on the following canopy cover classes: 0, 1-5%, 6-10%, 11-20%, 21-40%, 41-60%, 61-80%, and 81-100%
MQO: at least 90% of the time
Values: 000 to 100

6.10 UNKNOWN PLANTS AND VOUCHER SPECIMEN COLLECTION (13.10)

When you encounter a plant you do not recognize and you cannot identify it quickly and confidently, using field guides, follow these basic steps:

1. Assign an Unknown code
2. Make a frequency record or canopy cover estimate for the sample unit where plant was encountered.
3. Document and describe on the unknown spreadsheet and label
4. Collect a sample off the subplot
5. Press and label if not identified by the end of the day

RR. 6.10.1 Assign an Unknown code (13.10.1)

See section 13.8.1 for rules.

SS. 6.10.2 Plot data (13.10.2)

Record the plant where encountered (Quadrat: section (6.8.1) or Subplot section (6.9)).

TT. 6.10.3 Documenting unknown specimens: labels and unknown spreadsheet (13.10.3)

6.10.3.1 Specimen Label (13.10.3.1)

Each vegetation specialist will be issued a set of pre-printed labels for unknown specimens (Figure 50). Information contained on the label include variables listed in Table 6.1 below: Pre-printed labels should be completed in the field to the extent required by the Region handling the unknown and should accompany the plant as it is collected, pressed, dried, and shipped. Properly used labels are essential for tracking specimens and updating species records.

Label Number:1 PLANTS CODE:
Hexagon: 9999999 Plot: 1 Subplot: 1
Quad: 2 Date: 8/06/03
Unknown Code: unminty2 Veg Spec. crew: John Doe
State: MN County: Hubbard
Community: Spruce-Fir
Description: opposite leaves, square stem, purple flowers, minty fragrance, possibly peppermint
Scientific Name:

Figure 50. Example of label for unknown specimen.

6.10.3.2 Unknown spreadsheet (13.10.3.2)

Any time you encounter an unknown plant, the plant must be recorded on your **Unknown Spreadsheet**. Each Region should train the Vegetation specialists which set of variables are mandatory for tracking of unknowns. The Unknown Spreadsheet contains the fields for variables listed in Table 6.1:

Table 6.1 Summary of Variables for Unknown Specimen labels and spreadsheets

*Descriptor used, i.e., State and County NAMES, rather than FIPS code so that information has meaning to independent botanist or herbarium making the identification.

** PLANTS CODE and scientific name entry to label is highly recommended if specimen is kept for future reference.

Variable	Label	Unknown Spreadsheet	Source
Label Number	X	X	Preprinted by Region for each VEG crew
Unknown code	X	X	13.8.1 (As assigned by VEG crew)
VEG spec. crew name	X	X	13.3.7
Hexagon Number	X	X	13.3.3
P2 Plot Number	X	X	13.3.4
P3 Plot Number	X	X	13.3.5
State	(descriptor*)	(descriptor)	13.3.1
County	(descriptor*)	(descriptor)	13.3.2
Subplot Number	X	X	13.9.1
Quadrat Number	X	X	13.7.2, if recorded on a quadrat
Date (Collected)	X	X	13.3.9
Community	X	X	Text entered by VEG crew
Description (of plant)	X	X	Text entered by VEG crew
PLANTS CODE	OPTIONAL**	X	NRCS code entered by identifier
Scientific Name	OPTIONAL**	X	Scientific Name of corresponding NRCS code

UU. 6.10.4 Specimen Collection and Handling (13.10.4)

A good rule of thumb for when to collect unknown specimens is “when in doubt, ***collect!***” Specimens of all plants present in the quadrats and subplots that cannot be quickly and confidently identified to species should be collected ***away from quadrats*** and off of the subplot, if possible. If fewer than 5 of the unknown plants are present DO NOT COLLECT (see section 6.8.1).

Use a digging tool to extract the entire plant, including any underground portions, flowers, fruits, and leaves. If the plant is abundant, collection of two samples will increase the likelihood of a good specimen. All specimens must be labeled, pressed, and dried for shipping and subsequent identification by the vegetation specialist, cooperating herbarium or specialist.

Collected unknown specimens should be transported in the field and from the field in the 1 and/or 2 gallon zip-lock bags provided. Only one species and label may be placed in a single bag. Acceptable methods of transporting collected specimens include:

Use a 3-hole-punch to punch holes in the bottom of your bags prior to traveling in the field. Place the punched bags into a 2-inch 3-ring binder with the zip-lock portion facing outward. Plants can then be placed with labels into the bag directly in the binder. This method prevents crumpling, tearing, and destroying the specimen during transportation.

Use a 1-hole-punch to punch a hole in the one upper corner of each bag. The hole should be placed in such a manner that it cannot easily be torn. Place the bags on an aluminum carabineer (available at drug stores) or on heavy twine and fasten to your field vest or backpack. Be careful to seal the plants and labels securely inside the bags to prevent accidental loss.

Pressing specimens

1. Each specimen representing a unique species should be placed individually inside a single layer of folded newsprint. Each specimen is to be accompanied by its corresponding unknown specimen label. Small plant specimens are to be pressed individually. Large plant specimens may be folded in a “v”, “z”, or “w” arrangement to fit on a single newsprint page. Arrange the specimen so that at least one upper and one lower leaf surface is exposed. Plants may be trimmed to reduce bulk, so long as all diagnostic parts are included. Diagnostic portions include stem sections, petioles, leaves, roots, flowers, and fruits. Bulky fruits or nuts may be stored separately in a paper envelope that is taped to the newsprint and is accompanied by an identical copy of the specimen’s unknown label. Unknown codes can be written on the outside of the folded newspaper to aid sorting as specimens are processed.

2. Stack the specimens in their individual newsprint sleeves between two pieces of cardboard. Bind the cardboard and plants together using a piece of twine or flat cloth ribbon wrapped around the length and width of the cardboard bundle. For mailing numerous specimens, several bundles may be used. Place all bundles inside a cardboard box for shipping.

Unknown specimens are to be packaged and shipped at the end of every work week. Exceptions will be made when extended field excursions prevent the vegetation specialist from reaching a post office.

All packaged specimens are to be accompanied by the following:

- Name and address to which final identifications are to be mailed
- One paper and one digital copy of the Unknown Spreadsheet

6.11 REFERENCES (13.11)

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DATA SHEETS: Plot and Subplot Information

State:	Sample Kind:	Plot Notes:		
County:	Year:			
Plot Number:	Month: Day:			
P3 Hexagon Number:				
P3 Plot:	VEG Crew Name:			
QA Status:				
Crew Type:				
	Subplot 1	**Subplot 2**	**Subplot 3**	**Subplot 4**
Subplot status				
Non-sample reason				
Percent Subplot Area in Accessible Forest Condition(s)				
Nonforest Land Use				
Layer Total Cover in Accessible Forest Condition(s)				
1 (0-2)				
2 (2-6)				
3 (6-16)				
4 (16+)				
Ground Variable Cover in Accessible Forest Condition(s)				
Cryptobiotic crust				
Lichen				
Litter/Duff				
Soil				
Moss				
Road/Trail				
Rock				
Water				
Stream				
Trash/Junk				
Wood				

VEG Crew Name(s):		Qd1	Qd2	Qd3
	Quadrat status			
Year: Month: Day:	Condition Class #			
Hex:	Trampling (1-3)			
Subplot:				
Notes				

Plant Name	NRCS	UnCode/#	Qd 1	Qd2	Qd3	SP TCv	SP Cvr1&2	SP Cvr3	SP Cvr4

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