INTERIOR WEST FOREST INVENTORY & ANALYSIS

P3 FIELD PROCEDURES

JANUARY 2007
(V3.01)

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FOREST INVENTORY AND ANALYSIS
NATIONAL CORE FIELD GUIDE
(With Interior West Regional Additions)

VOLUME II: FIELD DATA COLLECTION PROCEDURES FOR PHASE 3 PLOTS

Version 3.01

RM Introduction

This document describes the standards, codes, methods, and definitions for Forest Inventory and Analysis (FIA) Phase 3 (P3) field data items and should be used in conjunction with the Interior West Forest Inventory & Analysis Field Procedures manual. The objective is to describe CORE FIA field procedures that are consistent and uniform across all FIA units. This CORE is the framework for regional FIA programs; individual programs may add variables, but may not change the CORE requirements. Unless otherwise noted (See Field Guide Layout), the items in this field guide are considered CORE, that is, the information will be collected by all FIA Units as specified. Items or codes specified as CORE OPTIONAL are not required by individual units; however, if the item is collected or coded, it will be done as specified in this field guide.

The FIA program is in transition, changing in response to legislation and new customer demands. One of these demands is for increased consistency, which this field guide begins to address. Another change was the merger of the FIA program with the field plot component of the Forest Health Monitoring (FHM) program's Detection Monitoring. A systematic grid was established that includes some, but not all former FIA plots. This grid contains the Phase 2 plots, the annual survey plots that are designed for measurement on a rotation such that a portion of the plots are measured each year. The rotation length varies by region. The former FHM Detection Monitoring field plots are the Phase 3 plots, a subset of the Phase 2 plots. The same basic plot and sampling designs are used on all the plots.

The focus of Volume I (Interior West Forest Inventory & Analysis Field Procedures) is on data that are collected in the field on all Phase 2 plots in the FIA sample. The methods in Volume I are also used on Phase 3 plots except when specifically noted otherwise in the methods text. Volume II (this manual) of the series describes an additional, expanded suite of data collected on the Phase 3 subset of

plots. Volume II contains methods for the following indicators: ozone bioindicator plants (not collected in 2006); lichen communities; soils (physical and chemical characteristics); crown condition; vegetation diversity and structure (not collected in 2006); and down woody material.

RM Field Guide Layout

Each section of the field guide corresponds to one of the following sections:

9 Ozone Bioindicator Plants (not collected in RM for 2007)
10 Lichen Communities
11 Soil Measurement and Sampling
12 Crowns: Measurements and Sampling
13 Vegetation Diversity and Structure (not collected in RM for 2007)
14 Down Woody Material (DWM)

Each section begins with a general overview of the data elements collected at that level and background necessary to prepare field crews for data collection. Data elements labeled with "RM" refer to Rocky Mountain Area (Interior West FIA) regional variables. These are only collected in the RM area. Descriptions of data elements follow in this format:

Data Element Name

Brief Variable Description:

When collected: <when data element is recorded>
Field width: <X digits>
Tolerance: <range of measurement that is acceptable>
MQO: <measurement quality objective>
Values: <legal values for coded variables>

Data elements, descriptions of when to collect the data elements, field width, tolerances, MQO's, and values, apply to both Phase 2 plots (formerly called FIA plots) and Phase 3 plots (formerly called FHM Detection Monitoring plots) unless specifically noted. Field width designates the number of columns (or spaces) needed to properly record the data element.

Tolerances may be stated in +/- terms or number of classes for ordered categorical data elements (e.g., +/- 2 classes); in absolute terms for

some continuous variables (e.g., +/- 0.2 inches); or in terms of percent of the value of the data element (e.g., +/- 10 percent of the value). For some data elements, no errors are tolerated (e.g., PLOT NUMBER).

MQO's state the percentage of time that the collected data are required to be within tolerance. Percentage of time within tolerance is generally expressed as "at least X percent of the time," meaning that crews are expected to be within tolerance at least X percent of the time.

PLOT NOTES will be available on every PDR screen for ease in recording notes.

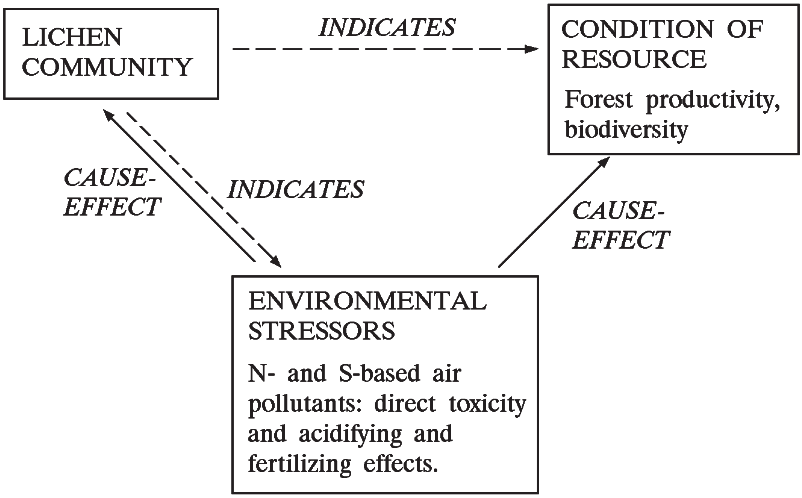
Section 10. Lichen Communities

10.1 OVERVIEW

10.1.1 Scope and Application

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 10-1). Lichens not only indicate the health of our forests, but there is a clearly established linkage to environmental stressors, as described below.



10.1.2 Summary of Method

The objectives of this task are to determine the presence and ABUNDANCE (section 10.3.9) 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 10.3.9) 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.

10.1.3 Equipment and Supplies

10.1.3.1 Consumable Supplies

- 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 10-3) 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 10-5).

- 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.

10.1.3.2 Equipment and Apparatus

- 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.

10.1.4 Procedure

Note: This indicator is CORE OPTIONAL on all phase 2 plots.

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 10-2). The area of the lichen plot is 40830 $ft^2 \approx$ 3793 $m^2 \approx$ 0.379 ha $\approx$ 0.937 acres.

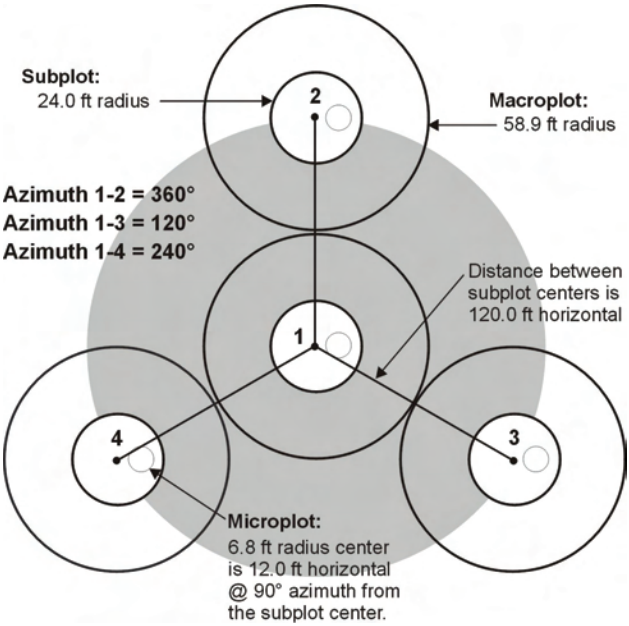


Figure 10-1. Conceptual model of the lichen community indicator.

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

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 10.2, "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.

10.1.5 Safety

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.

10.1.6 Assistance From Persons Not Certified For Lichens

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.

10.2 DATA COLLECTION 1: SAMPLE PROCUREMENT

The set of lichen samples you collect, with the accompanying written information (See 10.3 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 10-3) as follows:

   - Number packets sequentially as collected.
   - Record relative ABUNDANCE on the packet using the codes listed in section 10.3.9. (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 10-3. 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.

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 10-4) 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 10.4 *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 FIA
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 10-4. Plot data card for lichen communities. Complete this form and bundle it with the packets for each plot.

10.3 DATA COLLECTION 2: PDR AND WRITTEN DATA

10.3.1 OVERVIEW

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.

10.3.2 P3 HEXAGON NUMBER

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

10.3.3 FIA PLOT NUMBER

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

10.3.4 STATE

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

10.3.5 COUNTY

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

10.3.6 DATE

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

10.3.7 LICHEN PROJECT

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

10.3.8 COLLECTION NUMBER

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

10.3.9 ABUNDANCE

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.

10.3.10 CREW MEMBER NAME

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

10.3.11 CREW TYPE

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)

10.3.12 QA STATUS

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)

10.3.13 LICHENS COLLECTED

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

10.3.14 TIME LICHEN SAMPLING BEGAN

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

10.3.15 TIME LICHEN SAMPLING ENDED

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

10.3.16 % COVER LICHEN PLOT CONIFERS

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: 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	96-100%

Note: With the exception of class code 99 for 96% to 100%, class code is the percentage of the upper limits of the class, i.e., Code 10 is 6% to 10%, etc. Estimates are recorded to the nearest 5 percent to be consistent throughout this guide with other procedures and to allow estimator flexibility.

10.3.17 % COVER LICHEN PLOT HARDWOODS

Percent canopy cover of overstory hardwoods (not of lichens). Total of % COVER LICHEN PLOT CONIFERS (10.3.16) plus % COVER LICHEN PLOT HARDWOODS plus % COVER LICHEN PLOT TALL SHRUBS (10.3.18) may be >100%. Total of % COVER LICHEN PLOT CONIFERS (10.3.16) 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: 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	96-100%

Note: With the exception of class code 99 for 96% to 100%, class code is the percentage of the upper limits of the class, i.e., Code 10 is 6% to 10%, etc. Estimates are recorded to the nearest

5 percent to be consistent throughout this guide with other procedures and to allow estimator flexibility.

10.3.18 % COVER LICHEN PLOT TALL SHRUBS

Percent canopy cover of tall shrubs (not of lichens). Total of % COVER LICHEN PLOT CONIFERS (10.3.16) plus % COVER LICHEN PLOT HARDWOODS (10.3.17) plus % COVER LICHEN PLOT TALL SHRUBS may be >100%. Total of % COVER LICHEN PLOT CONIFERS (10.3.16) plus % COVER LICHEN PLOT HARDWOODS (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: 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	96-100%

Note: With the exception of class code 99 for 96% to 100%, class code is the percentage of the upper limits of the class, i.e., Code 10 is 6% to 10%, etc. Estimates are recorded to the nearest 5 percent to be consistent throughout this guide with other procedures and to allow estimator flexibility.

10.3.19 MOST IMPORTANT TREE AND SHRUB SPECIES

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

10.3.20 IMPORTANT SUBSTRATE SPECIES NOT ON SUBPLOTS

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

10.3.21 Gap

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

10.3.21.1 % GAP

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

10.3.21.2 RECENT

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

10.3.21.3 TALL SHRUBS

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

10.3.22 SIZE CLASS OF 3 LARGEST TREES ENCOUNTERED ON THE LICHEN PLOT

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

10.3.23 FEATURES IMPORTANT FOR HIGH/LOW LICHEN DIVERSITY

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

10.3.24 SAMPLING ISSUES OR PROBLEMS

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

10.4 SAMPLE PRESERVATION, STORAGE, AND MAILING

10.4.1 SAMPLE PRESERVATION AND STORAGE

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.

10.4.2 SAMPLE MAILING

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 10-4) 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 10-5) 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 10-5. Form used for mailing lichen community specimens, one form per box.

10.5 REFERENCES

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10.6 ACKNOWLEDGEMENTS

Contact information for the Indicator Advisor for this indicator is: Susan Will-Wolf, Department of Botany, Birge Hall, University of Wisconsin, 430 Lincoln Drive, Madison, WI 53706-1381 or email swwolf@wisc.edu

Section 11. Soil Measurements and Sampling

11.0 INTRODUCTION

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.

11.1 SUMMARY OF METHOD

Note: This indicator is CORE OPTIONAL on all phase 2 plots.

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.

11.2 DEFINITIONS

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.

11.3 EQUIPMENT AND SUPPLIES

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

11.3.1 Field Gear Unique to the Soil Indicator

- 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.

11.3.2 Optional Soils Equipment

- 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.

11.3.3 Required Equipment not Unique to the Soil Indicator:

- 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.

11.4 LABORATORY ANALYSES

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.

11.5 QUALITY ASSURANCE (QA)

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. Tolerances have been established for each of the measurements. The tolerances 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.

11.5.1 Training And Certification

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.

11.5.2 Hot Checks, Cold Checks, and Blind Checks

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.

11.5.3 Reference Plots

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.

11.5.4 Debriefing

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.

11.6 SOIL EROSION AND COMPACTION

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.

11.6.1 PERCENT COVER OF BARE SOIL

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%	70	66-70%
30	26-30%				

11.6.2 PERCENT COMPACTED AREA ON THE SUBPLOT

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%		

11.6.3 TYPE OF COMPACTION - RUTTED TRAIL

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

11.6.4 TYPE OF COMPACTION – COMPACTED TRAIL

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

11.6.5 TYPE OF COMPACTION – COMPACTED AREA

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

11.6.6 TYPE OF COMPACTION – OTHER

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

11.7 SOIL SAMPLE COLLECTION

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 11-1). 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°) from the center of subplot 2.
- Subplot 3 soil measurement site: 30 feet northwest (300°) from the center of subplot 3.
- Subplot 4 soil measurement site: 30 feet northeast (60°) 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.

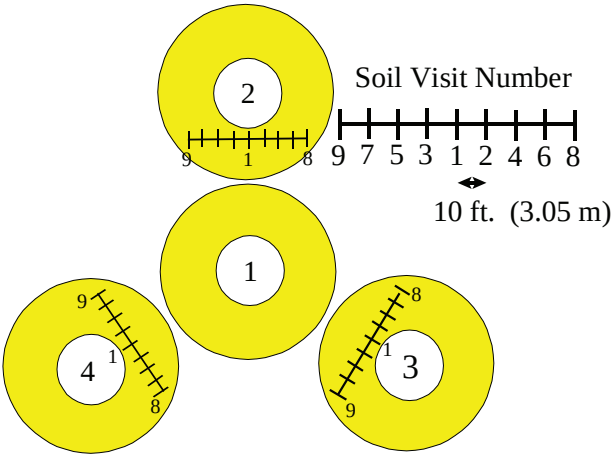

Figure 11-1. Location of soil sampling sites

11.7.1 Forest Floor

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 11-2).

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 0.1 inch 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.

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

The impact driven core sampler (Figure 11-3) 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.

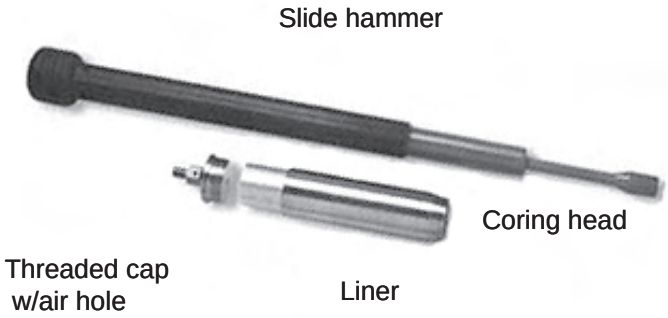

Diagram of Impact Driven Soil Corer

Figure 11-3. Diagram of Impact Driven Soil Corer

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.

11.7.3 Mineral Soil

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 11-2).

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 11.5. 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.

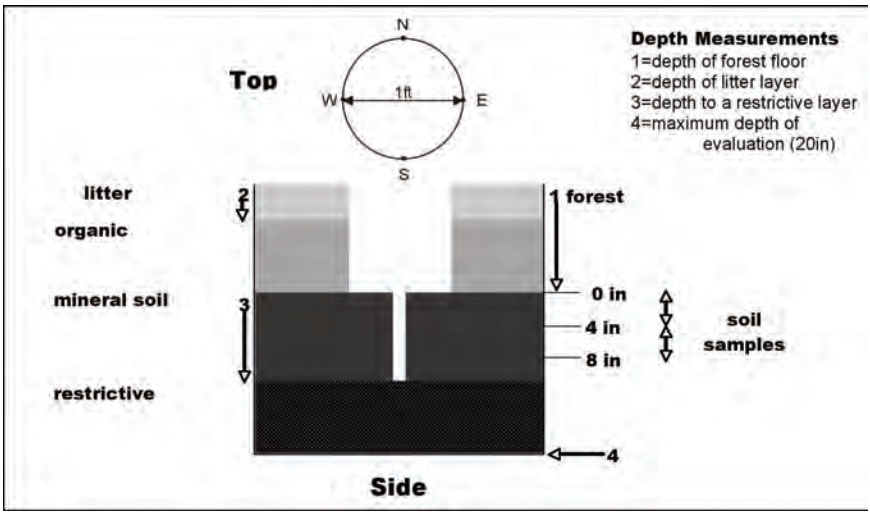

Figure 11-2. Cross-sectional views of sampling sites (top view and side view).

11.7.4 Regulations Governing Sample Collection (National Historic Preservation Act)

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.

11.7.5 Alternate Sampling Methods for "Problem" Soils

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 11.7.6.

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.

11.7.6 Commonly Encountered Problems

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 depth of 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 11.7.5).

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 11.7.5.

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 11.7.5. 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)

11.7.7 Organic soils

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 11.7.1).

- 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 11.7.5).

11.7.8 SUBPLOT NUMBER

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

11.7.9 CONDITION CLASS

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

11.7.10 VISIT NUMBER

Record the number of the soil sampling location (Figure 11-1) 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

11.7.11 SOIL SAMPLE STATUS

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

11.7.12 FOREST FLOOR THICKNESS – NORTH

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 20.0 inches. If the thickness of the forest floor is greater than 20.0 inches, then code “20.0”. For locations where bare soil or bedrock material is exposed, enter “00.0” inches depth. On organic soils, measure the entire thickness of the forest floor (to 20.0 inches) even though you will only sample the litter layer.

When Collected: When SOIL SAMPLE STATUS = 1
Field Width: 3 digits
Tolerance: +/- 2 in
MQO: 90% of the time
Values: 00.0 to 20.0

11.7.13 FOREST FLOOR THICKNESS – EAST

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 20.0 inches. If the thickness of the forest floor is greater than 20.0 inches, then code “20.0”. For locations where bare soil or bedrock material is exposed, enter “00.0” 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: 3 digits
Tolerance: +/- 2 inches
MQO: 90% of the time
Values: 00.0 to 20.0

11.7.14 FOREST FLOOR THICKNESS – SOUTH

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 20.0 inches. If the thickness of the forest floor is greater than 20.0 inches, then code “20.0”. For locations where bare soil or bedrock material is exposed, enter “00.0” inches depth. On organic soils, measure the entire thickness of the forest floor (to 20.0 inches) even though you will only sample the litter layer.

When Collected: When SOIL SAMPLE STATUS = 1
Field Width: 3 digits
Tolerance: +/- 2 in
MQO: 90% of the time
Values: 00.0 to 20.0

11.7.15 FOREST FLOOR THICKNESS – WEST

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 20.0 inches. If the thickness of the forest floor is greater than 20.0 inches, then code “20.0”. For locations where bare soil or bedrock material is exposed, enter “00.0” inches depth. On organic soils, measure the entire thickness of the forest floor (to 20.0 inches) even though you will only sample the litter layer.

When Collected: SOIL SAMPLE STATUS = 1
Field Width: 3 digits
Tolerance: +/- 2 in
MQO: 90% of the time
Values: 00.0 to 20.0

11.7.16 THICKNESS OF THE LITTER LAYER - NORTH

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 “00.0” inches depth.

When Collected: SOIL SAMPLE STATUS = 1
Field Width: 3 digits
Tolerance: +/- 2 in
MQO: 90% of the time
Values: 00.0 to 20.0

11.7.17 THICKNESS OF THE LITTER LAYER - EAST

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 “00.0” inches depth.

When Collected: SOIL SAMPLE STATUS = 1
Field Width: 3 digits
Tolerance: +/- 2 in
MQO: 90% of the time
Values: 00.0 to 20.0

11.7.18 THICKNESS OF THE LITTER LAYER - SOUTH

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 “00.0” inches depth.

When Collected: SOIL SAMPLE STATUS = 1
Field Width: 3 digits
Tolerance: +/- 2 in
MQO: 90% of the time
Values: 00.0 to 20.0

11.7.19 THICKNESS OF THE LITTER LAYER - WEST

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 “00.0” inches depth.

When Collected: SOIL SAMPLE STATUS = 1
Field Width: 3 digits
Tolerance: +/- 2 in
MQO: 90% of the time
Values: 00.0 to 20.0

11.7.20 DEPTH TO RESTRICTIVE HORIZON

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 (to the nearest 0.1 inch). The maximum depth for testing for a restrictive horizon is 20.0 inches. If a restrictive layer is encountered within the 20.0 inches, record the median depth (to the nearest 0.1 inch) to the restrictive horizon of the five locations probed. Record:
20.0 if a restrictive horizon is not encountered.
00.0 if superficial bedrock is present.
99.9 if too many rock fragments or cobbles prevent inserting soil probe.

When Collected: SOIL SAMPLE STATUS = 1
Field Width: 3 digits
Tolerance: +/- 6 in
MQO: 90% of the time
Values: 00.0 to 20.0, 99.9

11.7.21 SOIL TEXTURE IN THE 0-4 INCH LAYER

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
9 Not measured – make plot note

11.7.22 SOIL TEXTURE IN THE 4-8 INCH LAYER

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
9 Not measured – make plot note

11.8 SAMPLE LABELS

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 11-4.

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 11-4. Example soil 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)

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 11-1. 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

11.9 SAMPLE SHIPPING

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.

11.9.1 Shipping Forms

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 11-5.

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 _____

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

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

Soil & Water Analysis
Forestry Sciences Lab
860 N. 1200 E.
Logan, UT 84321
Phone: 435-755-3560

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.

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.

11.9.2 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.

11.10 TASKS THAT CAN BE PERFORMED BY OTHER CREW MEMBERS

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.

11.11 REFERENCES

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11.12 ACKNOWLEDGEMENTS

The West 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. The East Advisor may be contacted at: Charles H. (Hobie) Perry, USDA Forest Service, North Central Research Station, 1992 Folwell Avenue, St. Paul MN 55108, via phone at (651) 649-5191 or via email at charleshperry@fs.fed.us .

11.13 EXAMPLE DATA SHEETS

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	Sampling Code	Sampler Min 1	Min 2
Subplot 2:	_____	_____	____	____
Subplot 3:	_____	_____	____	____
Subplot 4:	_____	_____	____	____

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)

Sampler
1 = Bulk density
2 = Other

Forest Floor Thickness (inches)

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

Litter Layer Thickness (inches)

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

Depth to Subsoil Restrictive Layer (inches)

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)	_____
	Mineral 2 (4-8 in)	_____
Subplot 3 Soil Sampling Site:	Mineral 1 (0-4 in)	_____
	Mineral 2 (4-8 in)	_____
Subplot 4 Soil Sampling Site:	Mineral 1 (0-4 in)	_____
	Mineral 2 (4-8 in)	

0 = Organic
1 = Loamy
2 = Clayey
3 = Sandy
4 = Coarse sandy

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

Soil Compaction Measurements:

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

*Explanations: _____
_____
_____
_____
_____

Section 12. Crowns: Measurements and Sampling

12.1 OVERVIEW

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.

Note: This indicator is CORE OPTIONAL for all phase 2 plots.

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 12.3). 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).

12.2 CROWN DEFINITIONS

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 12-1).

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.

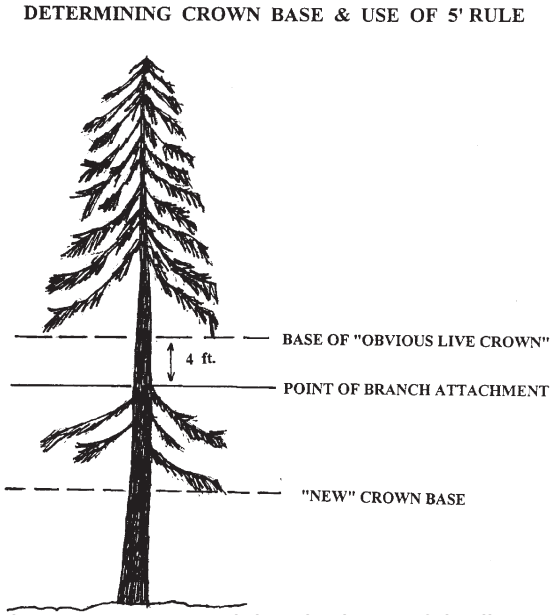


Figure 12-1. Determining the base of the live crown.

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

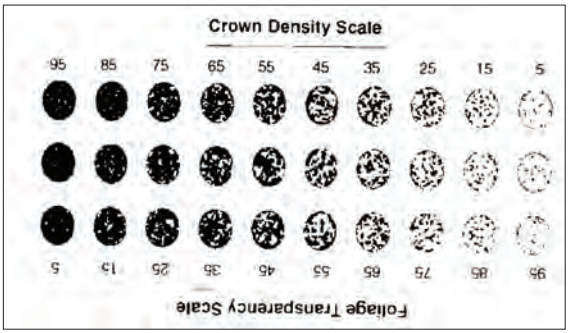
Any woody or non-woody lateral growth, without secondary branching, less than 1.0 inch in diameter at the base above the swelling at the point of attachment to a branch or crown stem.

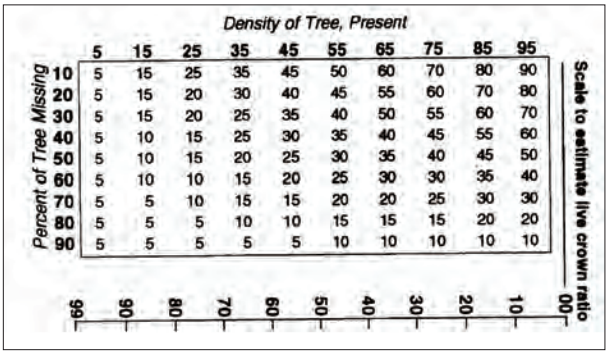
Twig

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.

12.3 CROWN DENSITY-FOLIAGE TRANSPARENCY CARD

Front





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

00 10 20 30 40 50 60 70 80 90 99

Back

Figure 12-2. Density-Transparency card

The crown density - foliage transparency card (Figure 12-2) 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.

12.4 CROWN RATING PRECAUTIONS

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 12-3). 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.

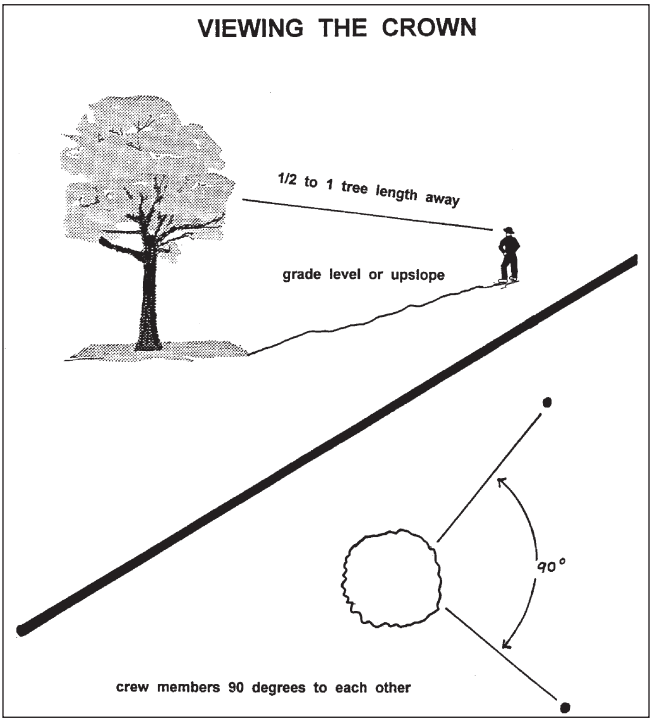


Figure 12-3. Crew positions for viewing crowns.

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

Heavy defoliation -
During heavy defoliation, CROWN DIEBACK may be overestimated and FOLIAGE TRANSPARENCY may be underestimated due to the difficulty in differentiating dead twigs from defoliated twigs. The use of binoculars may help in separating dead twigs from defoliated twigs.

Leaning trees -
So that crown dimensions are measured consistently on both leaning and upright trees, UNCOMPACTED LIVE CROWN RATIO and CROWN DENSITY for leaning and down trees must be rated in relation to the actual length of the tree bole (as opposed to height above the ground). CROWN POSITION and CROWN LIGHT EXPOSURE should still be estimated relative to the tree's actual location in the canopy. FOLIAGE TRANSPARENCY will rarely be affected by lean angle. Place a note in the PDR TREE NOTES field that the tree is leaning if it is leaning more than 45 degrees from vertical.

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.

12.5 UNCOMPACTED LIVE CROWN RATIO

UNCOMPACTED LIVE CROWN RATIO is a percentage determined by dividing the live crown length by the actual tree length (Figure 12-5). Record the UNCOMPACTED LIVE CROWN RATIO to the nearest 1%.

Saplings

Determine sapling UNCOMPACTED LIVE CROWN RATIO by dividing the live crown length by actual tree length, then enter the appropriate code into the PDR. Live crown length 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 12-4).

When the two estimates do not agree, follow the guidelines listed at the end of section 12.1 *Overview*.

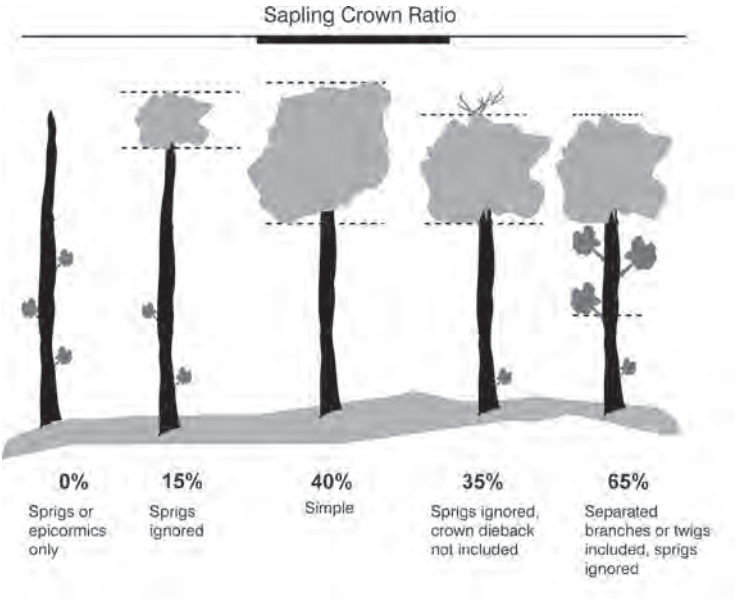


Figure12-4. Sapling UNCOMPACTED LIVE CROWN RATIO determination examples.

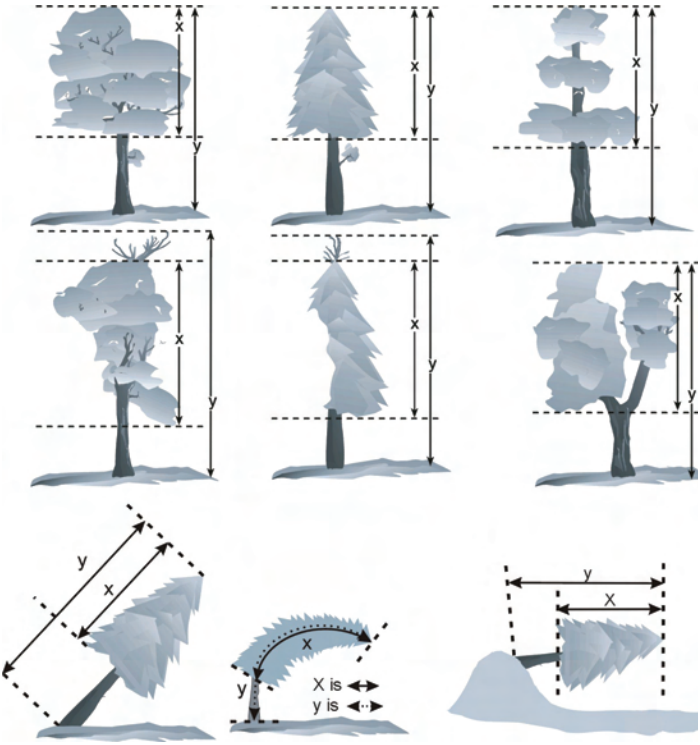


Figure 12-5. UNCOMPACTED LIVE CROWN RATIO examples.

Trees

Live crown length 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 12-6). 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 12-1). 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 12-2). 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. A clinometer can also be used to verify the UNCOMPACTED LIVE CROWN RATIO by determining the values of both lengths 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 12.1 *Overview*.

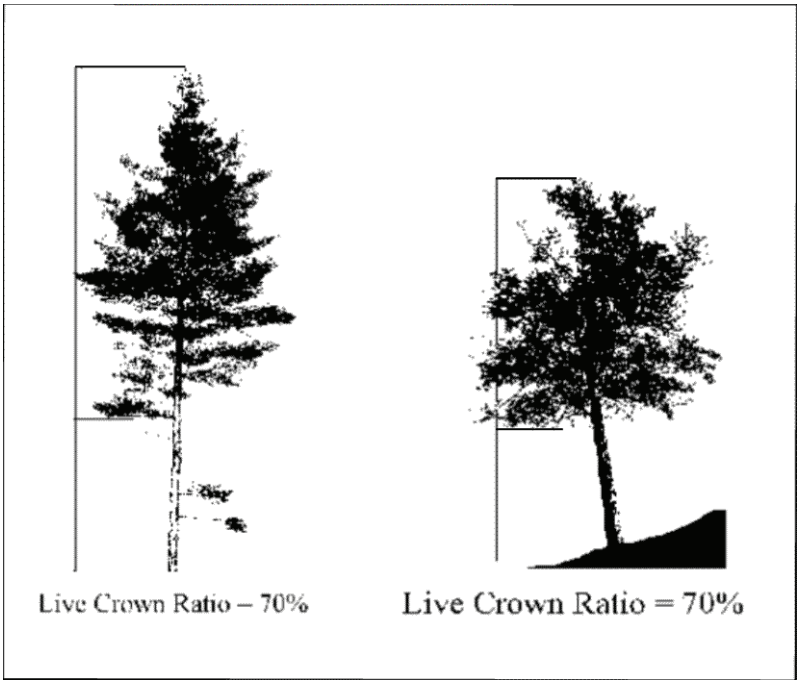


Figure 12-6. UNCOMPACTED LIVE CROWN RATIO outline and rating examples

When collected: All live trees ≥ 1.0 in DBH/DRC
Field width: 2 digits
Tolerance: +/- 10%
MQO: At least 90% of the time
Values: 00 to

12.6 CROWN LIGHT EXPOSURE

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., 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 12-7).

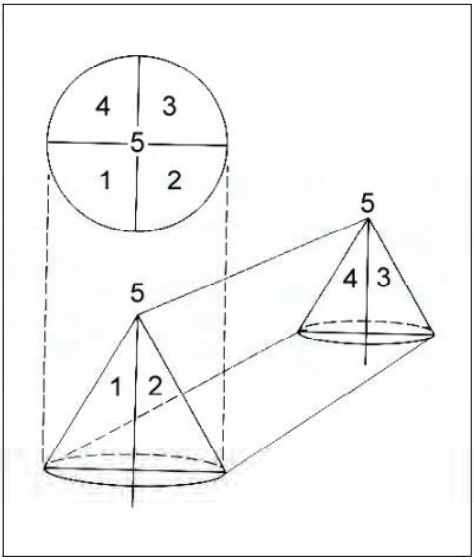


Figure 12-7. Dividing the crown.

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 maximumcrown exposure of one. Individual sides with less than 35 percent UNCOMPACTED LIVE CROWN RATIO should not be counted (Figure 12-8).

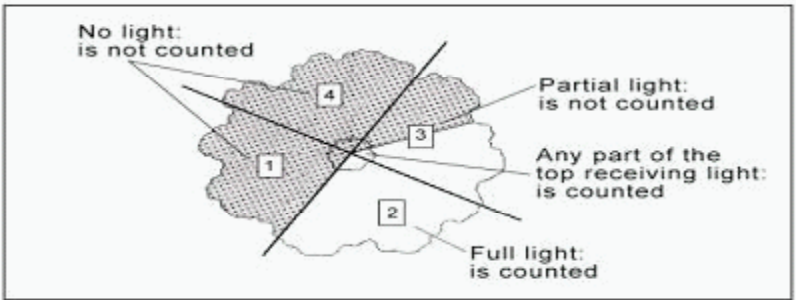


Figure 12-8. CROWN LIGHT EXPOSURE.

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.

12.7 CROWN POSITION

Determine the relative position of each tree in relation to the overstory canopy zone (Figure 12-9). 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.

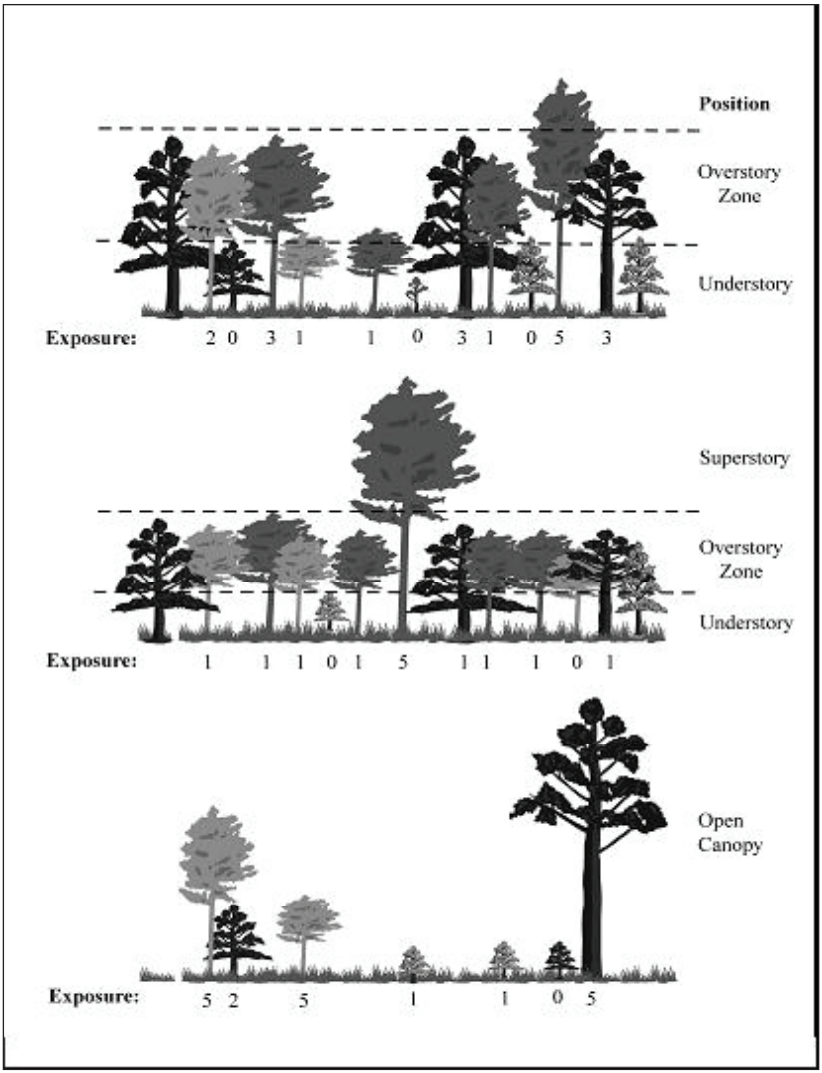


Figure 12-9. CROWN LIGHT EXPOSURE and CROWN POSITION.

When collected: All live trees ≥ 1.0 in DBH/DRC
Field width: 1 digit
Tolerance: No errors
MQO: At least 85% of the time
Values:

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.

12.8 CROWN VIGOR CLASS

See Figure 12-10 for a visual description of the sapling CROWN VIGOR classes.

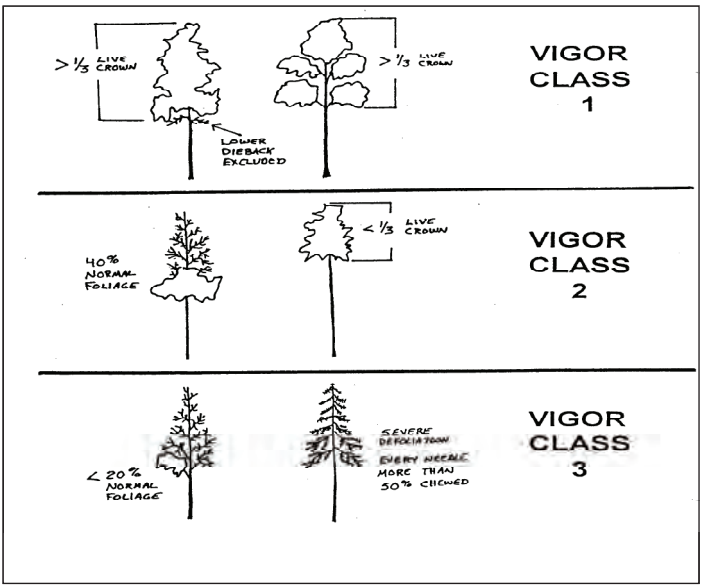


Figure 12-10. Sapling CROWN VIGOR classes.

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.

12.9 CROWN DENSITY

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 12-1). Include CROWN DIEBACK and open areas in this outline (Figures 12-11 and 12-12).

After determining the crown shape, each person should use the crown density - foliage transparency card (Figure 12-2). 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 12.1 *Overview*. The estimate is placed into one of 21 percentage classes.

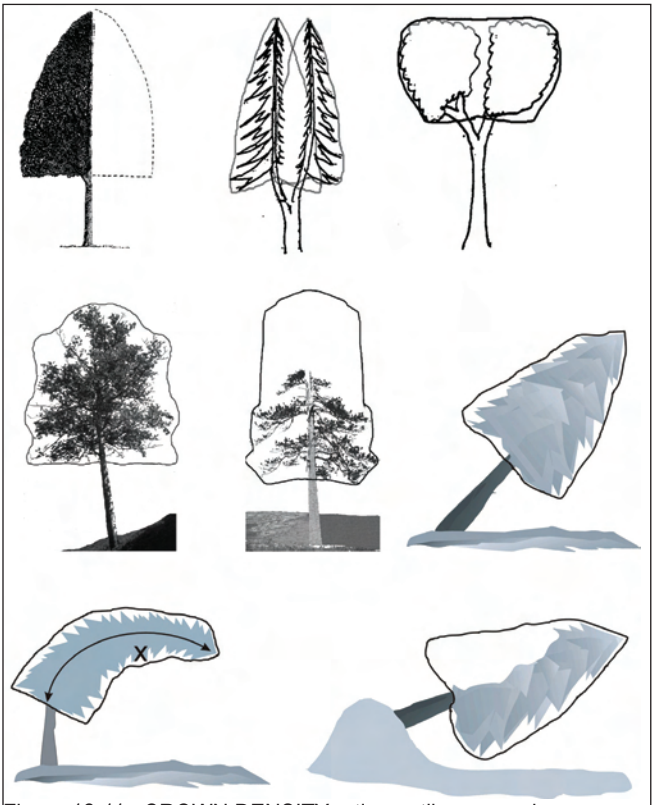


Figure 12-11. CROWN DENSITY rating outline examples.

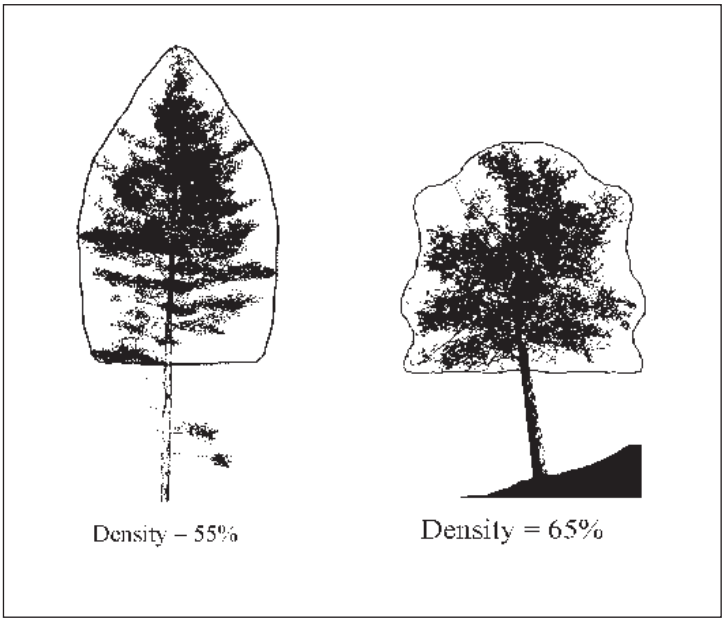


Figure 12-12. Crown density outline and rating examples

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

12.10 CROWN DIEBACK

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 12-13 and 12-14).

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 12.1 *Overview*. The estimate is placed into one of 21 percentage classes.

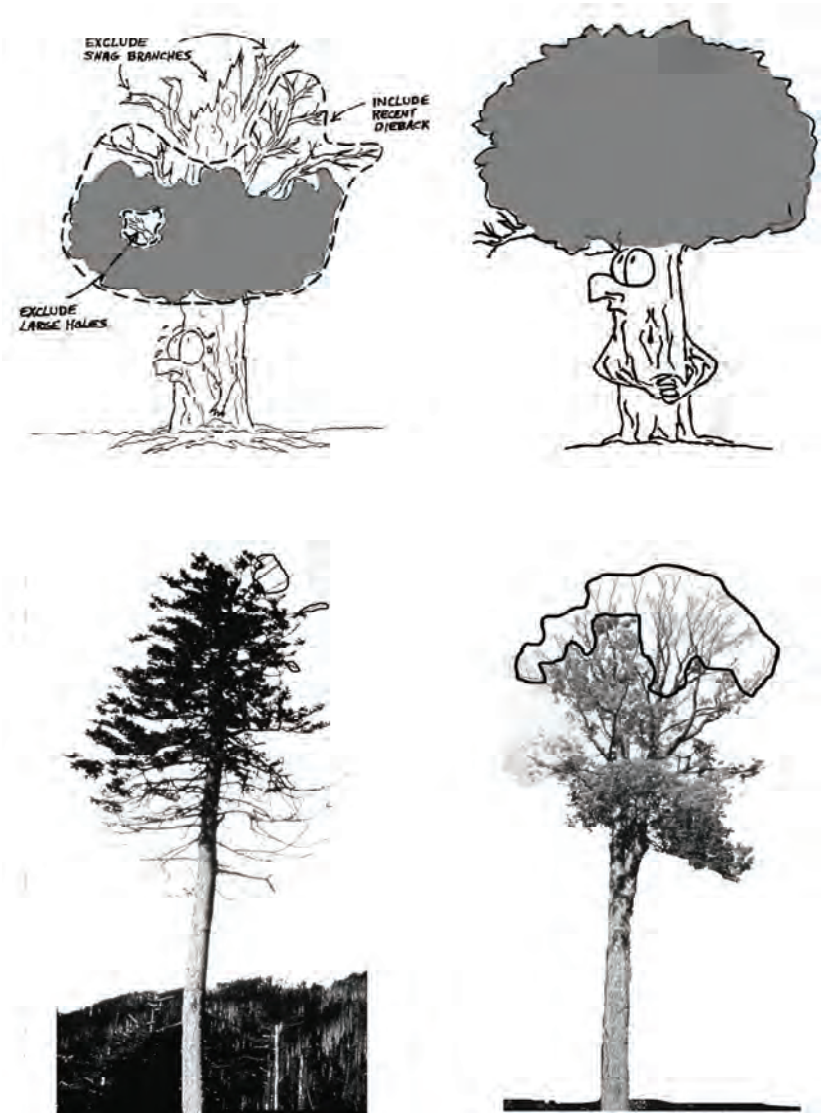


Figure 12-13. CROWN DIEBACK rating outline examples.

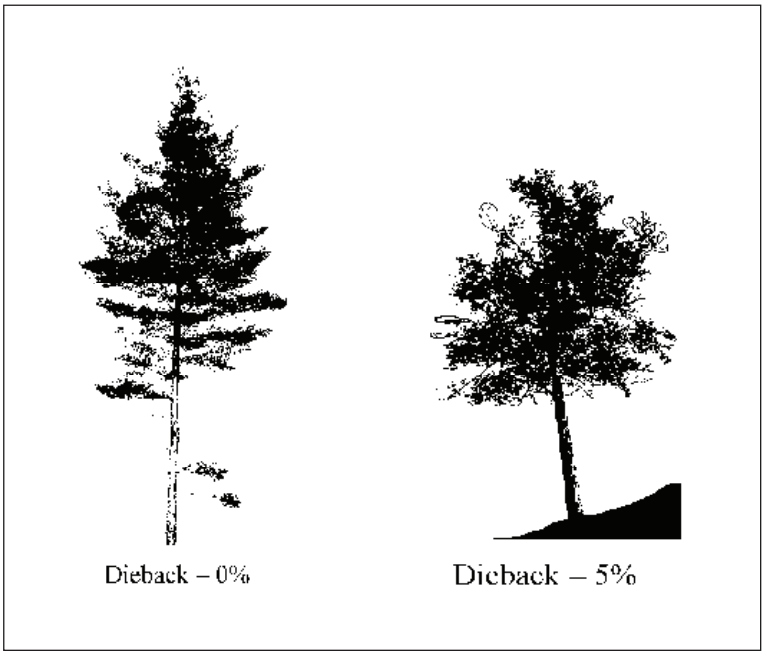


Figure 12-14. Dieback outline and rating examples.

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	96-100%

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

12.11 FOLIAGE TRANSPARENCY

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 12-2). 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 12-15).

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 12-15. FOLIAGE TRANSPARENCY rating outline examples.

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	96-100%

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

12.12 ACKNOWLEDGEMENTS

Contact information for the National Advisor for this indicator is: Michael Schomaker, 5400 Vardon Way, Fort Collins, CO 80528-9114 or email mschomak@lamar.colostate.edu .

Section 14. Down Woody Materials

14.0 INTRODUCTION

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 14.3) 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 14.2). 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 14.8, Sampling Residue Piles).

Note: This indicator is CORE OPTIONAL on all phase 2 plots.

14.1 DEFINITION OF DOWN WOODY MATERIALS

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)

14.2 LOCATING AND ESTABLISHING LINE TRANSECTS

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).

14.2.1 CWD transects

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 14-1). 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.

14.2.2 FWD transects

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.

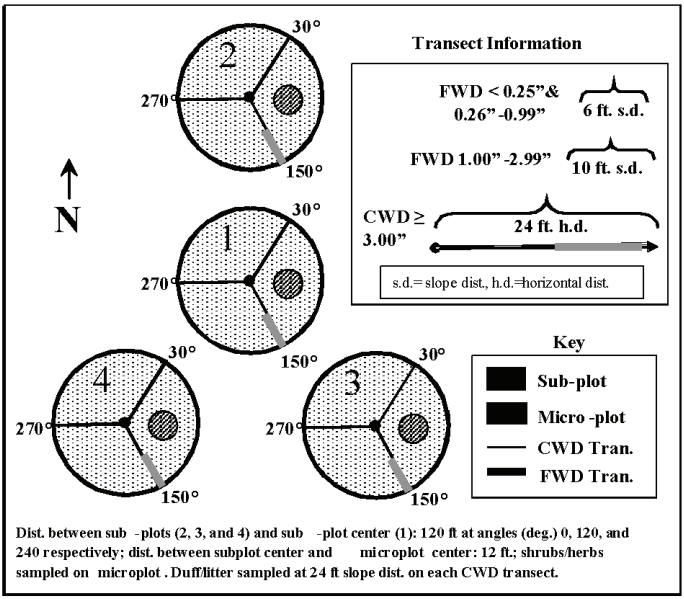


Figure 14-1. Plot layout for sampling CWD, FWD, and fuels.

14.3 TRANSECT LINE SEGMENTING

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 14-2). 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.

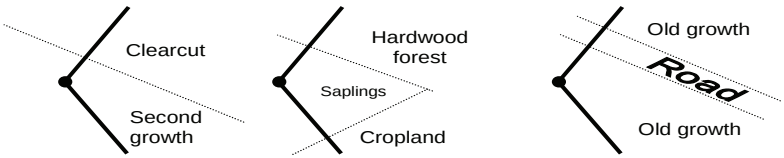


Figure 14-2. Transects are installed across condition class boundaries.

14.3.1 SUBPLOT NUMBER

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

14.3.2 TRANSECT

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

14.3.3 CONDITION CLASS NUMBER

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

14.3.4 BEGINNING DISTANCE

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

14.3.5 SLOPE PERCENT

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

14.3.6 ENDING DISTANCE

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

14.4 SAMPLING METHODS FOR COARSE WOODY DEBRIS (CWD)

14.4.1 Tally Rules for Coarse Woody Debris (CWD)

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 14-3). The entire piece is assigned to this condition.

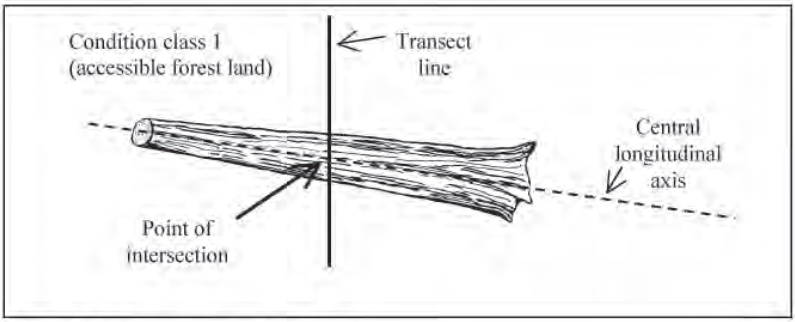


Figure 14-3. Tally rules for CWD.

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 total length measure the length to the nearest 0.1 foot to determine if it is >3.0 feet. CWD TOTAL LENGTH (14.4.3.7) is the length of the piece that lies between the piece's recorded DIAMETER AT THE SMALL END AND DIAMETER AT THE LARGE END (14.4.3.6.2 & 14.4.3.6.3).

4. Decay class of the piece determines whether or not the piece is tallied (see section 14.4.3.4).

For decay classes 1 to 4: 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 > 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 14-4).

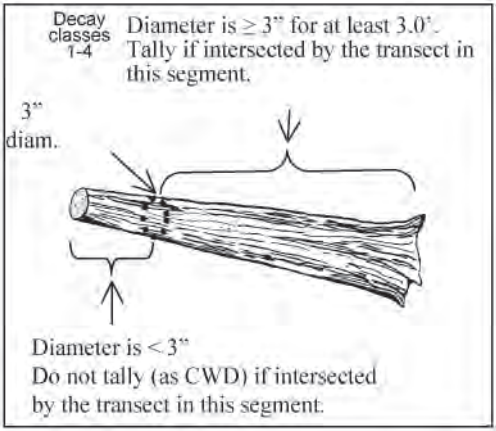


Figure 14-4. CWD tally rules for decay classes 1-4.

For decay class 5: tally a piece if it is > 5.0 inches in diameter at the point of intersection and > 5.0 inches high from the ground. The piece must be > 3.0 feet in length and > 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 break age 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 14.8 '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 14-5).

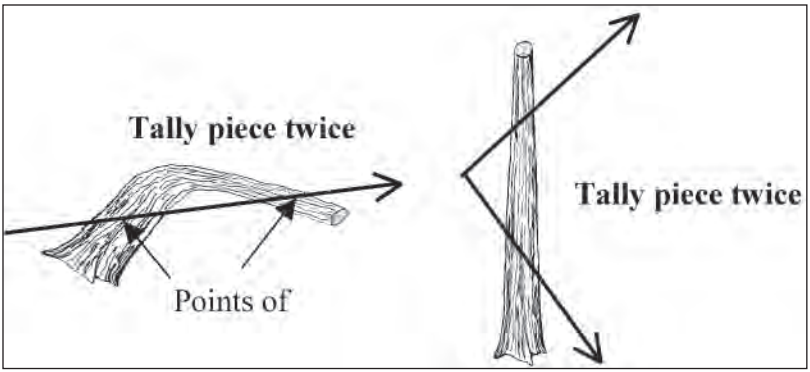


Figure 14-5. CWD tally rules: intersections.

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 piece intersected 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 14-6).

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

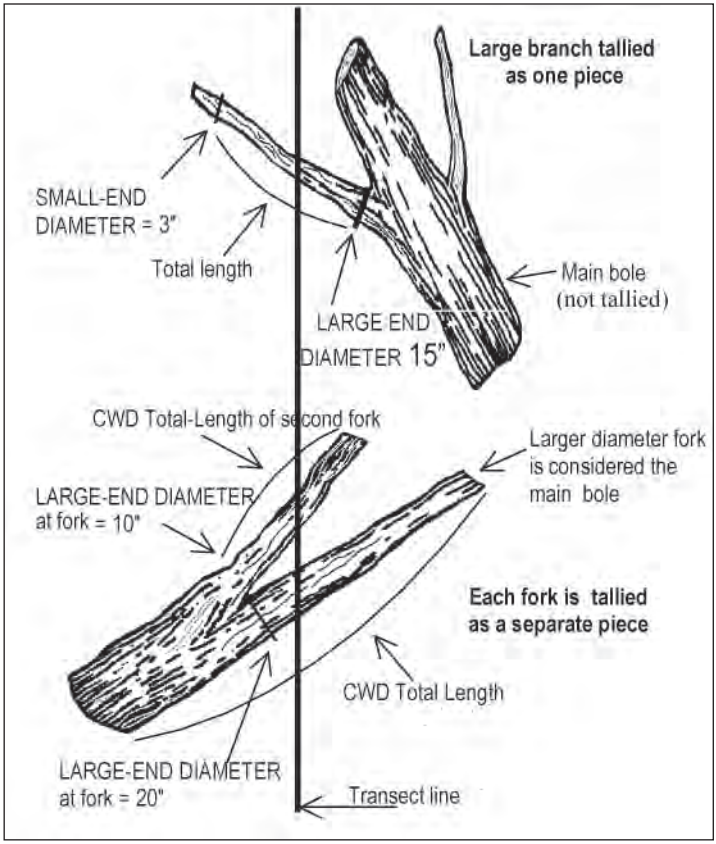


Figure 14-6. CWD tally rules for forked trees.

14.4.2 Marking CWD

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 14.3 Transect Line Segmenting, for information on the required marking of the transect line.

14.4.3 Recording Procedures for CWD

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.

14.4.3.1 SUBPLOT NUMBER

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

14.4.3.2 TRANSECT

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

14.4.3.3 CWD SLOPE DISTANCE

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

14.4.3.4 CWD DECAY CLASS

Record a 1-digit code indicating the decay class of the piece. Code the decay class which predominates along the recorded CWD TOTAL LENGTH (14.4.3.7) 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).

14.4.3.5 SPECIES

Record the code indicating the species of the piece. Species codes are the same as those used in P2 (see Appendix 3 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.

14.4.3.6 Diameters

The diameter is most commonly measured by holding a tape above the log, at a position perpendicular to the length (Figure 14-7). 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.

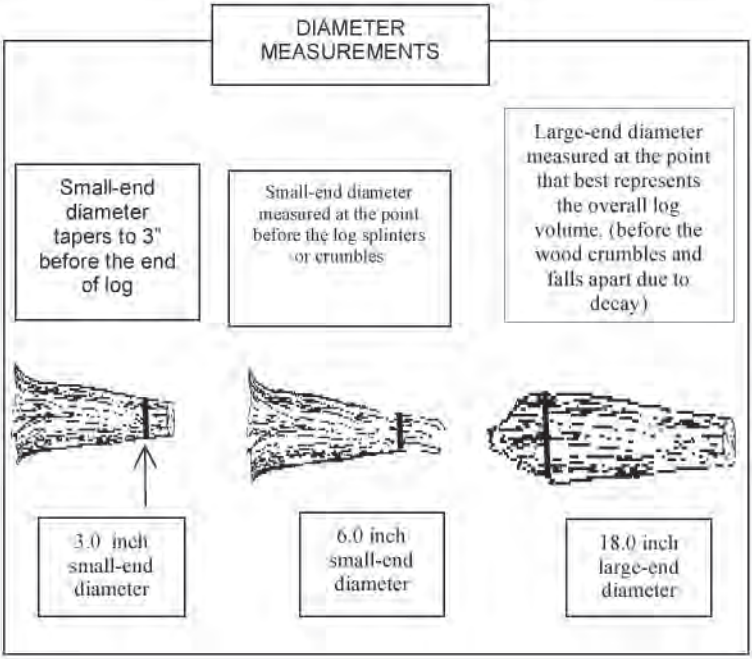


Figure 14-7. Diameter measurements

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 14-8), and enter the average in the diameter field. This technique applies to intersect, small-end, and large-end diameters.

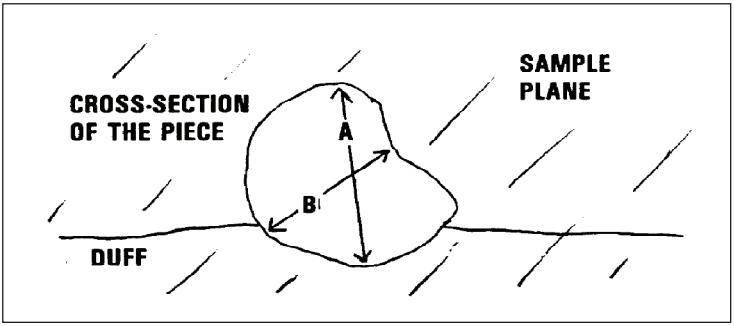


Figure 14-8. Estimating the diameter of pieces that are not round in cross-section.

If the transect intersects the log at the decayed or splintered end (Figure 14-9) (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.

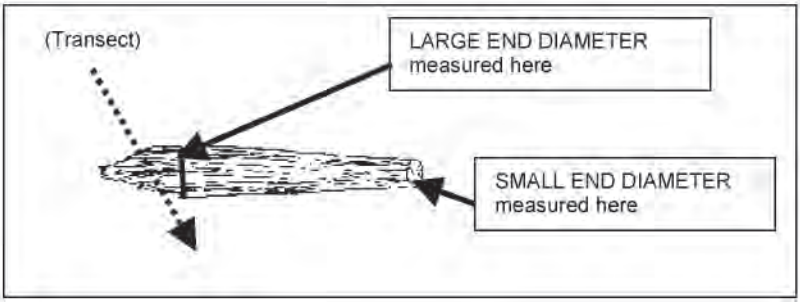


Figure 14-9. Example of decayed end intersecting the transect

14.4.3.6.1 DIAMETER AT POINT OF INTERSECTION

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

14.4.3.6.2 DIAMETER AT THE SMALL END

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 14.4.3.6.1 (see Figure 14-7).

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

14.4.3.6.3 DIAMETER AT THE LARGE END

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 14.4.3.6.1.

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

14.4.3.7 CWD TOTAL LENGTH

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 (14.4.3.6.2 & 14.4.3.6.3). 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

14.4.3.8 IS THE PIECE HOLLOW?

Record the code indicating whether or not the piece is hollow (see Figure 14-10).

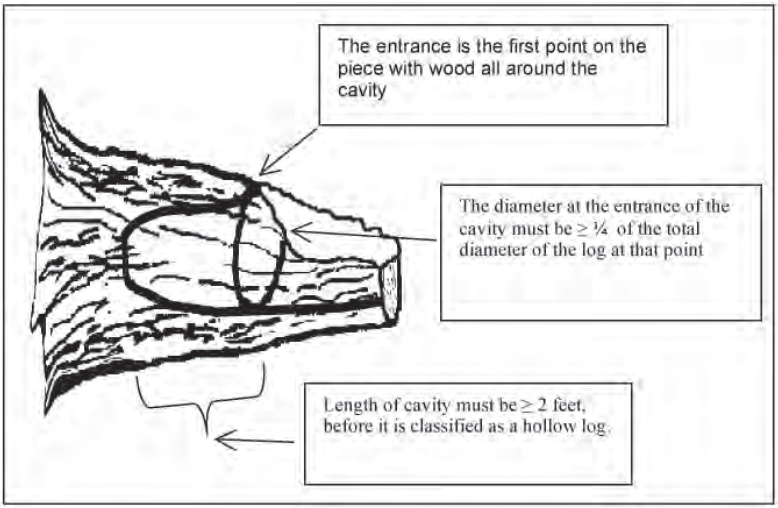


Figure 14-10. Determining if the piece is hollow

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

14.4.3.9 CWD HISTORY

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

14.5 SAMPLING METHODS FOR FINE WOODY DEBRIS (FWD)

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 14.5.6).

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.

14.5.1 SUBPLOT NUMBER

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

14.5.2 CONDITION CLASS NUMBER

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

14.5.3 SMALL FWD COUNT

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 14.5, #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

14.5.4 MEDIUM FWD COUNT

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 14.5, #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

14.5.5 LARGE FWD COUNT

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 14.5, #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

14.5.6 HIGH COUNT REASON

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 >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

14.5.7 RESIDUE PILE ON TRANSECT

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

14.6 DUFF, LITTER, and FUELBED DEPTH MEASUREMENTS

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.

14.6.1 Definitions

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.

14.6.2 Overview of Measurements

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).

14.6.2.1 Duff and Litter

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.

14.6.2.2 Fuelbed

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.

14.6.3 SUBPLOT NUMBER

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

14.6.4 TRANSECT

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

14.6.5 DUFF, LITTER, and FUELBED SAMPLE

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

14.6.6 DUFF DEPTH

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

14.6.7 LITTER DEPTH

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

14.6.8 FUELBED DEPTH

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

14.7 FUEL LOADING ON THE MICROPLOT

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

14.7.1 SUBPLOT NUMBER

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

14.7.2 LIVE SHRUB PERCENT COVER

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%

14.7.3 LIVE SHRUB HEIGHT

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

14.7.4 DEAD SHRUBS PERCENT COVER

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%

14.7.5 DEAD SHRUB HEIGHT

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

14.7.6 LIVE HERBS PERCENT COVER

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%

14.7.7 LIVE HERBS HEIGHT

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

14.7.8 DEAD HERBS PERCENT COVER

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%

14.7.9 DEAD HERBS HEIGHT

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

14.7.10 LITTER PERCENT COVER

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%

14.8 SAMPLING RESIDUE PILES

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 14-11):

- 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 > 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 > 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.

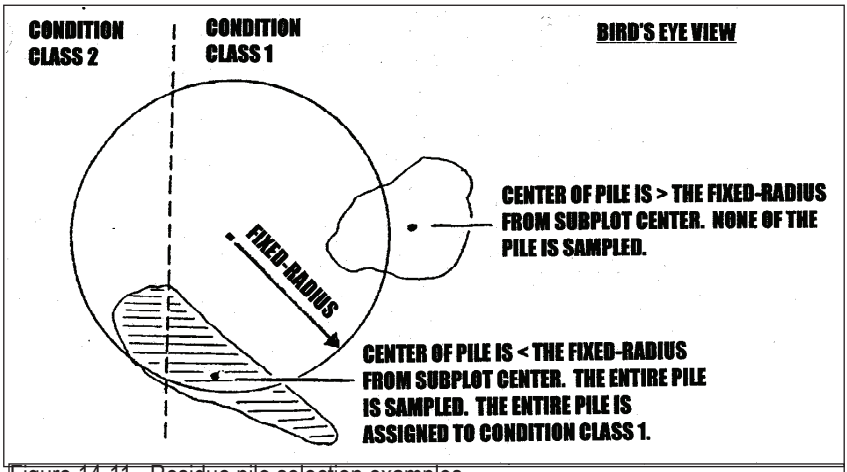


Figure 14-11. Residue pile selection examples.

14.8.1 SUBPLOT NUMBER

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

14.8.2 CONDITION CLASS

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

14.8.3 PILE AZIMUTH

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

14.8.4 PILE SHAPE

Record the code indicating the shape of the pile. Determine which of the four shapes diagrammed in Figure 14-12 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

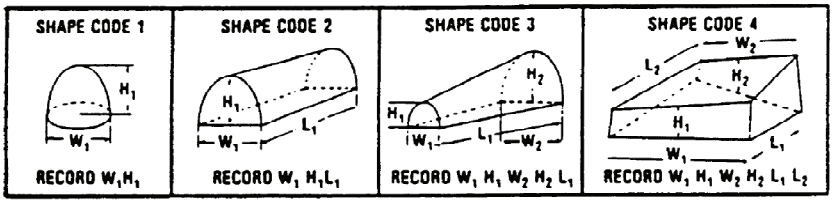


Figure 14-12. PILE SHAPE codes.

14.8.5 PILE LENGTH 1

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

14.8.6 PILE LENGTH 2

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

14.8.7 PILE WIDTH 1

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

14.8.8 PILE WIDTH 2

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

14.8.9 PILE HEIGHT 1

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

14.8.10 PILE HEIGHT 2

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

14.8.11 PILE DENSITY

Record the code estimating the percent of the pile that consists of wood. Use the PILE DENSITY variable to estimate the percent of the pile that contains woody material > 3 inches. 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%

14.9 ACKNOWLEDGEMENTS

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

DOWN WOODY MATERIALS – TRANSECT SEGMENT DATA FORM

HEX # _____ DATE ____/____/____

CWM TRANSECT SEGMENTS

SUB PL	T	CC	SLP DIST1 (0.1ft)	SLP DIST2 (0.1ft)	SLP PCT	HOR DIST (0.1ft)
xx	Xxx	x	xxx.y	xxx.y	xxx	xxx.y

FWM DATA FORM

HEX # _____ DATE ____/____/____

CWD TRANSECT SEGMENTS

SUBPLOT	CONDITION CLASS	SMALL FWD 0.1" TO 0.25"	MED FWD 0.25" TO 1"	LARGE FWD 1" TO 3"	REASON FOR HIGH COUNT	RESIDUE PILE ON TRANSECT?
x	X	xxx	Xxx	xxx	x	x

FWM DATA FORM

HEX # _____ DATE ____/____/____

FINE WOODY DEBRIS COUNT

SUBPLOT	CONDITION CLASS	SMALL FWD 0.1" TO 0.25"	MED FWD 0.25" TO 1"	LARGE FWD 1" TO 3"	REASON FOR HIGH COUNT	RESIDUE PILE ON TRANSECT?
x	X	xxx	Xxx	xxx	x	x

COARSE WOODY DEBRIS DATA FORM

HEX # _____DATE ____/____/____PAGE ____ OF____

SUB PLT	TRAN	CWD DIST	SPC	TRAN DIAM	SML DIAM	LRG DIAM	TOTAL LENGTH	DECAY CLASS	HOL?	CWD HIST
1	2	3	4	5	6	7	8	9	10	11
x	xxx	xx.y	xxx	xxx	xxx	xxx	xx	x	x	x

FUELS ASSESSMENT DATA FORM

HEX # _____ DATE ____/_ ___/____

MICROPLOT FUEL LOADING

SUBPLOT	LIVE SHRUB %	LIVE SHRUB HT	DEAD SHRUB %	DEAD SHRUB HT	LIVE HERB %	LIVE HERB HT	DEAD HERB %	DEAD HERB HT	LITTER %
	xx	xx.y	xx	xx.y	xx	xx.y	xx	xx.y	xx
1									
2									
3									
4									

DWM Combined Data Form

Date Hexagon # FIA Plot # P-3 Plot #

Transect Segment Data

Sub plot xx	Trans. xxx	Cond. x	Dist Start xxx.y (ft)	Dist End xxx.y (ft)	Slope xxx (%)

Duff, Litter and Fuelbed Depths

Trans.	Sample x	Duff xx.y (in)	Lit. xx.y (in)	Fuel. xx.y (ft)
1 30				
1 15z0				
1 270				
2 30				
2 150				
2 270				
3 30				
3 150				
3 270				
4 30				
4 150				
4 270				

CWD Form

Sub Plot xx	Trans. xxx	Dist xx.y (ft)	Spec. xxx	Tran. Dia xxx (in)	Sm. End xxx (in)	Lg. End xxx (in)	Length xxx (ft)	Decay x	Hol. x	Hist. x

FWD Form Sub Plot	Cond.	0.00 - .25 Small	.25 - 1.00 Med	1.00 - 3.00 Large	H. Count Reason	Res. Pile
	x	xxx	xxx	xxx	x	x
1						
2						
3						
4						

History		Microplot Cover	
1	Natural	0	None
2	<=15 yrs.	1	Trace
3	>15 yrs.	10	1-10
4	Firewood	20	11 - 20
5	Unknown	99	91 - 100

Microplot Fuel Loading

Sub Plot	Live Shrub xx (%)	Height xx.y (ft)	Dead Shrub xx (%)	Height xx.y (ft)	Live Herb xx (%)	Hght. xx.y (ft)	Dead Herb xx (%)	Hght. xx.y (ft)	Lit. % xx (%)
1									
2									
3									
4									

Residue Pile

Sub Plot xx	Cond. xx (%)	Az. xxx (deg)	PILE Shape x	Length 1 xx (ft)	Length 2 xx (ft)	Width 1 xx (ft)	Width 2 xx (ft)	Hght. 1 xx (ft)	Hght. 2 xx (ft)	Dens. xx (%)

DUFF, LITTER, FUELBED ASSESSMENT DATA FORM

HEX # _____ DATE ____/____/____

DUFF, LITTER, & FUELBED DEPTHS

SUBPLOT	TRANSECT	DL_SAMP	DUFFLITTER DEPTH	LITTER DEPTH	FUELBED DEPTH
x	xxx	X	xx.y	xx.y	xx.y

RESIDUE PILE DATA FORM

HEX # _____ DATE ____/____/____

RESIDUE PILES

SUB PL	CC	PILE AZM	SHP	LNG1 (ft)	LNG2 (ft)	WID1 (ft)	WID2 (ft)	HT1 (ft)	HT2 (ft)	PILE DENS
xx	x	xxx	X	xx	xx	xx	xx	xx	xx	Xx

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