

Changes in the Phase 3 Indicator Field Guide Chapters from version 2.0 to version 3.0

Changes documented in change proposals are indicated in **bold** type. The corresponding proposal name can be seen using the comments feature in the electronic file.

Ozone Bioindicator Plants (East)

- **Modified: 9.1.7 Communications.** Changed the phone number for the Regional Advisor for the North Central States and added another Regional Advisor for the South.
- **Clarified: 9.2.4 SPLIT PLOTS.** Clarified the discussion of split plots. Also replaced the split plot drawing with a revised drawing.
- **Clarified: 9.2.8 COLLECTION OF LEAF SAMPLES AND VOUCHER DATA.** Clarified this section by adding a few words to the text.
- **Changed: 9.4.4 PLOT NUMBER.** Changed this variable name to OZONE PLOT NUMBER to match the variable name already in the IM system.
- **Clarified: 9.4.7 OZONE SAMPLE KIND.** Clarified the descriptive text to match what is communicated at training.
- **Clarified: 9.4.9 OZONE GRID DENSITY.** Clarified the descriptive text.
- **Clarified: 9.5.1 GPS Unit Settings, Datum, and COORDINATE SYSTEM.** Clarified the national standard for reporting purposes by adding “(NAD 83)”.
- **Added: 9.5.5 GPS DATUM.** Added this new variable and renumbered variables following.
- **Deleted: Old 9.5.5 LATITUDE.** The variable LATITUDE was deleted and this renumbered section (9.5.6) was modified to be a general introduction to three new variables that take the place of the old LATITUDE variable: LATITUDE DEGREES, LATITUDE MINUTES, and LATITUDE SECONDS.
- **Added: 9.5.6.1 LATITUDE DEGREES.** Added this new variable.
- **Added: 9.5.6.2 LATITUDE MINUTES.** Added this new variable.
- **Added: 9.5.6.3 LATITUDE SECONDS.** Added this new variable.
- **Deleted: Old 9.5.6 LONGITUDE.** The variable LONGITUDE was deleted and this renumbered section (9.5.7) was modified to be a general introduction to three new variables that take the place of the old LONGITUDE variable: LONGITUDE DEGREES, LONGITUDE MINUTES, and LONGITUDE SECONDS.

- **Added: 9.5.7.1 LONGITUDE DEGREES. Added this new variable.**
- **Added: 9.5.7.2 LONGITUDE MINUTES. Added this new variable.**
- **Added: 9.5.7.3 LONGITUDE SECONDS. Added this new variable.**
- Clarified: Appendix 9.B and Appendix 9.C DATA SHEETS. Clarified and revised the data sheets for ease of the field crews.

Ozone Bioindicator Plants (West)

- Modified: 9.1.7 Communications. The Regional Coordinator for the Interior West was changed from Roger Boyer to Bill Dunning. Also added another Regional Advisor for the South.
- Clarified: 9.2.2 SITE SELECTION PROCEDURES. Clarified the discussion of split plots.
- Clarified: 9.2.7 COLLECTION OF LEAF SAMPLES AND VOUCHER DATA. Clarified this section by adding a few words to the text.
- Changed: 9.4.4 PLOT NUMBER. Changed this variable name to OZONE PLOT NUMBER to match the variable name already in the IM system.
- Clarified: 9.4.7 OZONE SAMPLE KIND. Clarified the descriptive text to match what is communicated at training.
- Clarified: 9.4.9 OZONE GRID DENSITY. Clarified the descriptive text.
- Clarified: 9.5.1 GPS Unit Settings, Datum, and COORDINATE SYSTEM. Clarified the national standard for reporting purposes by adding “(NAD 83)”.
- **Deleted: Old 9.5.5 LATITUDE. The variable LATITUDE was deleted and this renumbered section (9.5.6) was modified to be a general introduction to three new variables that take the place of the old LATITUDE variable: LATITUDE DEGREES, LATITUDE MINUTES, and LATITUDE SECONDS.**
- **Added: 9.5.6.1 LATITUDE DEGREES. Added this new variable.**
- **Added: 9.5.6.2 LATITUDE MINUTES. Added this new variable.**
- **Added: 9.5.6.3 LATITUDE SECONDS. Added this new variable.**
- **Deleted: Old 9.5.6 LONGITUDE. The variable LONGITUDE was deleted and this renumbered section (9.5.7) was modified to be a general introduction to three new**

variables that take the place of the old LONGITUDE variable: LONGITUDE DEGREES, LONGITUDE MINUTES, and LONGITUDE SECONDS.

- **Added: 9.5.7.1 LONGITUDE DEGREES.** Added this new variable.
- **Added: 9.5.7.2 LONGITUDE MINUTES.** Added this new variable.
- **Added: 9.5.7.3 LONGITUDE SECONDS.** Added this new variable.
- **Clarified: Appendix 9.B DATA SHEETS.** Clarified and revised the data sheets for ease of the field crews.

Lichen Communities

- **Corrected: 10.1.4 Procedure.** Corrected the area of a lichen plot as listed in the field guide from “The area of the lichen plot is $40715 \text{ ft}^2 = 3782 \text{ m}^2 = 0.378 \text{ ha} = 0.935 \text{ acres}$.” to “The area of the lichen plot is $40830 \text{ ft}^2 \approx 3793 \text{ m}^2 \approx 0.379 \text{ ha} \approx 0.937 \text{ acres}$.”
- **Modified: Figure 10-2.** Changed “Annular plot” to “Macroplot” in the figure.
- **Added: 10.1.4 Procedure.** Added a note that this indicator is CORE OPTIONAL on all phase 2 plots.
- **Modified: 10.3.16 % COVER LICHEN PLOT CONIFERS.** Modified *Field width* from “3 digits” to “2 digits”; added “(2 classes)” to *Tolerance*; modified *MQO* from “At least 99% of the time” to “At least 90% of the time”; *Values* from “1-100” to a table representing 5% classes. Also added text to the Note under the *Values* table indicating that code 99 indicates 96% to 100% rather than indicating the upper limit of the 5 percent class.
- **Modified: 10.3.17 % COVER LICHEN PLOT HARDWOODS.** Modified *Field width* from “3 digits” to “2 digits”; added “(2 classes)” to *Tolerance*; modified *MQO* from “At least 99% of the time” to “At least 90% of the time”; *Values* from “1-100” to a table representing 5% classes. Also added text to the Note under the *Values* table indicating that code 99 indicates 96% to 100% rather than indicating the upper limit of the 5 percent class.
- **Modified: 10.3.18 % COVER LICHEN PLOT TALL SHRUBS.** Modified *Field width* from “3 digits” to “2 digits”; added “(2 classes)” to *Tolerance*; modified *MQO* from “At least 99% of the time” to “At least 90% of the time”; *Values* from “1-100” to a table representing 5% classes. Also added text to the Note under the *Values* table indicating that code 99 indicates 96% to 100% rather than indicating the upper limit of the 5 percent class.

Soil Measurements and Sampling

- **Added: 11.1 SUMMARY OF METHOD.** Added a note that this indicator is **CORE OPTIONAL** on all phase 2 plots.
- Clarified: 11.5 QUALITY ASSURANCE (QA). The text was clarified by changing measurement quality objectives to tolerances.
- Modified: 11.7.1 Forest Floor. Modified a metric measurement to an English system measurement.
- Modified: Figure 11-2. The metric measurements were modified to English measurements.
- Moved: 11.7.2 Mineral Soil and 11.7.3 Assembly and Operation of Impact Driven Soil Corer (Bulk Density Sampler). The order of these two sections was reversed. The new sections are: 11.7.2 Assembly and Operation of Impact Driven Soil Corer (Bulk Density Sampler) and 11.7.3 Mineral Soil.
- Clarified: 11.7.6 Commonly Encountered Problems. Some additional text was added to 1. Rocky Soils.
- Clarified: 11.7.20 DEPTH TO RESTRICTIVE HORIZON. A decimal point was added to the value '999' so that the value is now '99.9' to be consistent with the PDR.
- Clarified: 11.7.21 SOIL TEXTURE IN THE 0-4 INCH LAYER. Text explaining how to tell the difference between the bottom of the forest floor and the top of an organic-rich mineral horizon was moved from this section to section 11.7.1 and section 11.7.12.
- Added: 11.7.21 SOIL TEXTURE IN THE 0-4 INCH LAYER. A code "9 Not measured – make a plot note" was added to the field guide text to make the text consistent with the existing Tally program.
- Added: 11.7.22 SOIL TEXTURE IN THE 4-8 INCH LAYER. A code "9 Not measured – make a plot note" was added to the field guide text to make the text consistent with the existing Tally program.
- Modified: Figure 11-5. Don Nagel was removed as the contact for the laboratory in Grand Rapids, MN (address will be listed without a contact name); the address was corrected for the Soil Characterization Laboratory, and the instructions at the bottom of the form were modified to be consistent with the main section text.
- Added: 11.12 Acknowledgements. Added the East Indicator Advisor contact information for Charles H. (Hobie) Perry.
- Modified: 11.13 EXAMPLE DATA SHEETS. On Soil Data Sheet 1, the metric units were changed to English units.

Crowns: Measurements and Sampling

- **Added: 12.1 OVERVIEW.** Added a note that this indicator is **CORE OPTIONAL** on all phase 2 plots.
- **Modified: 12.4 CROWN RATING PRECAUTIONS.** Modified the text of “Leaning trees”.
- **Modified: 12.5 UNCOMPACTED LIVE CROWN RATIO.** Modified “height” to “length” in the text.
- **Modified: 12.5 UNCOMPACTED LIVE CROWN RATIO.** Modified *Values* from 5% classes to “00 to 99 percent”. **UNCOMPACTED LIVE CROWN RATIO** now recorded to the nearest 1%.
- **Deleted: 12.5 UNCOMPACTED LIVE CROWN RATIO.** Deleted two additional lines of text for consistency with the change to 1% classes.
- **Modified: 12.6 CROWN LIGHT EXPOSURE.** Modified text to remove reference to leaning trees.
- **Modified: Figure 12-5**
- **Modified: Figure 12-11**

Vegetation Diversity and Structure

- **Added: 13.0 INTRODUCTION.** Added a note that this indicator is **CORE OPTIONAL** on all phase 2 plots.
- **Clarified: 13.1 SAMPLE DESIGN.** Added and rearranged some text for clarity.
- **Clarified: 13.3.3 PLOT NUMBER.** Added text to clarify use of code 99999.
- **Deleted: 13.3.4 P3 HEXAGON NUMBER.** Deleted this variable. The information is available in a cross-walk for office use.
- **Deleted: 13.3.5 P3 PLOT NUMBER.** Deleted this variable. The information is available in a cross-walk for office use.
- **Changed: New 13.3.5 CREW TYPE.** Changed variable name to “**VEG CREW TYPE.**”
- **Changed: New 13.3.6 SAMPLE KIND.** Changed variable name to “**VEG SAMPLE KIND.**” Also, added “**P3 VEG**” to code definitions.

- **Changed: New 13.3.7.1 YEAR.** Changed *Values* from “ ≥ 2004 ” to “ ≥ 2005 ”.
- **Changed: New 13.3.9 PLOT NOTES.** Changed variable name to “VEG PLOT NOTES.” Also, Changed *Field width* from “Unlimited alphanumeric characters” to “160 alphanumeric characters.”
- **Changed: 13.4.1 SUBPLOT NUMBER.** Changed *When collected* from “On all plots...” to “Every subplot on all plots...”.
- **Changed: 13.4.2. SUBPLOT STATUS.** Changed variable name to “VEG SUBPLOT STATUS.”
- **Changed: 13.4.3 SUBPLOT NONSAMPLED REASON.** Changed variable to “VEG SUBPLOT NONSAMPLED REASON.”
- **Added: 13.4.6 OPTIONAL COMMUNITY DESCRIPTION FOR SPECIMEN LABELS (CORE OPTIONAL).** Added this variable.
- **Added: 13.4.7 VEG SUBPLOT NOTES.** Added this variable.
- **Changed: 13.7.3 QUADRAT CONDITION CLASS.** Changed variable name to “QUADRAT CONDITION CLASS NUMBER.” Also, added text to *When collected*.
- **Clarified: 13.7.4 QUADRAT STATUS.** Added text to *When collected*.
- **Added: 13.7.6 VEG QUADRAT NOTES.** Added this variable.
- **Clarified: 13.8. QUADRAT SPECIES RECORDS.** Changed to heading name to “SPECIES RECORDS” and added text to clarify this section.
- **Added: 13.8.1 Plot Species List.** Added this section header as part of the chapter rearrangement. Also renumbered the sections following this one.
- **Changed: 13.8.1.1 QUADRAT SPECIES.** Changed the name to SPECIES CODE, clarified the descriptive text, *When collected*, and the *Values*. Also deleted the “Key to Assigning Species Codes, When to Collect:”
- **Added: 13.8.1.2 UNIQUE SPECIES NUMBER.** Added this variable.
- **Added: 13 8.1.3 SPECIMEN OFFICIALLY COLLECTED.** Added this variable.
- **Added: 13.8.1.4 SPECIMEN LABEL NUMBER.** Added this variable.

- **Added: 13.8.1.5 SPECIMEN NOT COLLECTED REASON CODE.** Added this variable.
- **Added: 13.8.1.6 PLOT SPECIES NOTES.** Added this variable. Name changed from “QUADRAT” to “PLOT” in second change proposal.
- **Added: 13.8.2 QUADRAT SPECIES DATA COLLECTION.** Added this section as part of a chapter rearrangement.
- **Added: 13.8.2.1 SPECIES PRESENCE/ABSENCE ON QUADRAT.** Added this variable.
- **Added: 13.8.3 SUBPLOT SPECIES DATA COLLECTION.** Added this section as part of a chapter rearrangement.
- **Deleted: Old 13.9.1 SUBPLOT NUMBER.** Deleted this code and renumbered rest of new sections.
- **Added: Old 13.9.3 (New 13.8.3.1) SUPPLOT SPECIES TOTAL PERCENT CANOPY COVER.** Added a possible *Value* of “t”, defined as trace (less than 1%). Also clarified *When collected* from “Each subplot species recorded” to “Each unique species present on current subplot with SUBPLOT STATUS = 1”.
- **Added: Old 13.9.4 (New 13.8.3.2) SUPPLOT SPECIES CANOPY COVER LAYER 1 AND 2.** Added a possible *Value* of “t”, defined as trace (less than 1%). Also clarified *When collected* from “Each subplot species recorded” to “Each unique species present on current subplot with SUBPLOT STATUS = 1”.
- **Added: Old 13.9.5 (New 13.8.3.3) SUPPLOT SPECIES CANOPY COVER LAYER 3.** Added a possible *Value* of “t”, defined as trace (less than 1%). Also clarified *When collected* from “Each subplot species recorded” to “Each unique species present on current subplot with SUBPLOT STATUS = 1”.
- **Added: Old 13.9.6 (New 13.8.3.4) SUPPLOT SPECIES CANOPY COVER LAYER 4.** Added a possible *Value* of “t”, defined as trace (less than 1%). Also clarified *When collected* from “Each subplot species recorded” to “Each unique species present on current subplot with SUBPLOT STATUS = 1”.
- **Deleted: A variable SUBPLOT SPECIES NOTES** was added in the first change proposal and dropped in the second change proposal.
- **Clarified: 13.10 UNKNOWN PLANTS AND VOUCHER SPECIMEN COLLECTION.** Clarified the steps for processing an unknown plant, and changed “PLANTS” to “SPECIES” in the variable name. Clarified Figure 13-2 Example of field label for unknown specimen. Added Figure 13-3 Example of Official Specimen label for unknown specimen.

- **Clarified: 13.10.2 Unknown spreadsheet.** Clarified the name to “Unknown Report” and clarified the information in Table 13.1. Also, clarified Figure 13-2 ‘Example of field label for unknown specimen’, and added Figure 13-3 ‘Example of official specimen label for unknown specimen’.
- **Added: 13.13. CODES FOR UNKNOWN PLANTS.** Added a new table of codes. Also added new data sheets.

Down Woody Materials

- **Added: 14.0 INTRODUCTION.** Added a note that this indicator is **CORE OPTIONAL** on all phase 2 plots.
- **Clarified: 14.4.1 Tally Rules for Coarse Woody Debris (CWD).** Clarified the third rule by adding some text.
- **Modified: Figure 14-6.** Corrected the location of the **LARGE-END DIAMETER** and the corresponding label.
- **Clarified: 14.8.11 PILE DENSITY.** Added a line of text to the variable description.
- **Modified: Fuels Assessment Data Form.** In the microplot fuel loading table, the third subplot listed was corrected from “2” to “3”.

Section 9. Ozone Bioindicator Plants (East)

9.1 OVERVIEW	3
9.1.1 SCOPE AND APPLICATION	3
9.1.2 SUMMARY OF METHOD	4
9.1.3 SUMMARY OF PDR SCREENS AND TALLY PROCEDURES.....	4
9.1.4 EQUIPMENT AND SUPPLIES.....	4
9.1.5 TRAINING AND QUALITY ASSURANCE.....	5
9.1.6 VOUCHER SPECIMENS.....	5
9.1.7 COMMUNICATIONS.....	5
9.2 OZONE BIOMONITORING PROCEDURES	6
9.2.1 EVALUATION WINDOW.....	6
9.2.2 SITE SELECTION PROCEDURES	7
9.2.3 SITE MAPPING.....	7
9.2.4 SPLIT PLOTS	8
9.2.5 SPECIES SELECTION	9
9.2.6 PLANT SELECTION	10
9.2.7 SYMPTOM IDENTIFICATION AND SCORING	11
9.2.8 COLLECTION OF LEAF SAMPLES AND VOUCHER DATA.....	12
9.2.9 VOUCHER MAILING PROCEDURES.....	14
9.2.10 CREW MEMBER RESPONSIBILITIES	14
9.2.11 FIELD PROCEDURES FOR UNTRAINED FIELD CREWS	14
9.3 SITE INTENSIFICATION	14
9.4 PLOT LEVEL DATA	15
9.4.1 STATE.....	15
9.4.2 COUNTY	15
9.4.3 OZONE HEXAGON NUMBER.....	15
9.4.4 OZONE PLOT NUMBER	16
9.4.5 QA STATUS.....	16
9.4.6 CREW TYPE.....	16
9.4.7 OZONE SAMPLE KIND	16
9.4.8 CURRENT DATE	17
9.4.8.1 YEAR	17
9.4.8.2 MONTH.....	17
9.4.8.3 DAY.....	17
9.4.9 OZONE GRID DENSITY	17
9.4.10 PLOT SIZE	18
9.4.11 ASPECT.....	18
9.4.12 TERRAIN POSITION	18
9.4.13 SOIL DEPTH.....	18
9.4.14 SOIL DRAINAGE	19
9.4.15 DISTURBANCE	19
9.4.16 INJURY CHECK.....	19
9.4.17 ELEVATION	20
9.4.18 Plot Notes.....	20
9.4.18.1 REMARK1 and REMARK2	20
9.5 GPS COORDINATES	20
9.5.1 GPS Unit Settings, Datum, and COORDINATE SYSTEM.....	20
9.5.2 Collecting Readings	21
9.5.3 GPS UNIT	21
9.5.4 GPS SERIAL NUMBER	21
9.5.5 GPS DATUM.....	22
9.5.6 Latitude.....	22
9.5.6.1 LATITUDE DEGREES.....	22
9.5.6.2 LATITUDE MINUTES	22

3.0 Phase 3 Field Guide – Ozone Bioindicator Plants (east)
October, 2005

9.5.6.3	LATITUDE SECONDS.....	22
9.5.7	Longitude.....	23
9.5.7.1	LONGITUDE DEGREES	23
9.5.7.2	LONGITUDE MINUTES.....	23
9.5.7.3	LONGITUDE SECONDS	23
9.5.8	GPS ELEVATION	23
9.5.9	GPS ERROR.....	23
9.5.10	NUMBER OF GPS READINGS	24
9.5.11	GPS FILENAME (CORE OPTIONAL).....	24
9.6	FOLIAR INJURY DATA.....	24
9.6.1	SPECIES.....	24
9.6.2	AMOUNT.....	24
9.6.3	NUMBER OF PLANTS.....	25
9.6.4	SEVERITY	25
9.7	REFERENCES.....	25
9.8	ACKNOWLEDGEMENTS.....	26
Appendix 9.A	Key Identifying Characteristics of the Ozone Bioindicator Species	27
Appendix 9.B	Ozone Data Sheets.....	28
Appendix 9.C	Detailed Procedures for Handling Leaf Vouchers.....	32
Appendix 9.D	Plain States – Special Insert.....	33

9.1 OVERVIEW

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

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

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

9.1.1 SCOPE AND APPLICATION

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

1. Ozone plot distribution across the landscape covers both the more remote and expansive forests away from population centers and the more fragmented forests located in close proximity to urban areas;
2. Ozone plot stratification nation-wide reflects regional differences in air quality regimes and perceived risks to different forest types;
3. Sampling intensity in different regions is designed to allow links between ozone biomonitoring data and other FIA indicators;
4. Seasonal variability in ozone injury is addressed. We know that ozone injury must reach an undefined threshold within a leaf before the injury becomes visible to the human eye, and then tends to be cumulative over the growing season until fall senescence masks the symptoms.

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

9.1.2 SUMMARY OF METHOD

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

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

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

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

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

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

9.1.3 SUMMARY OF PDR SCREENS AND TALLY PROCEDURES

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

For a written summary of the data entry procedures, definitions, and codes for the ozone measurement variables refer to section 9.4 through 9.6.

9.1.4 EQUIPMENT AND SUPPLIES

- A large diameter, 10X hand lens for close examination of plant leaves for ozone injury.
- Reference photographs and laminated leaf samples to aid in symptom identification.
- A forester-grade PLANT PRESS with cardboard inserts to store leaf vouchers collected in the field.

- Envelopes ready for mailing the leaf vouchers to the National Ozone Advisor.
- Stiff paper or cardboard for protecting the leaf vouchers in the mailing envelopes.
- Flagging: for temporary marking of sites or sample plants.
- Three field data sheets: (1) For documenting Foliar Injury Data in the event of a PDR failure; (2) For preparing the plot location map; and (3) For recording Voucher Leaf Samples Data for QA. (see Appendix 9.B).

9.1.5 TRAINING AND QUALITY ASSURANCE

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

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

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

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

9.1.6 VOUCHER SPECIMENS

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

Field crews, cooperators, and all QA staff collect leaf samples on the ozone biomonitoring sites according to procedures outlined in Subsection 9.2.7. These voucher specimens are pressed and mailed to the National Indicator Advisor for validation of the ozone symptom. If QA staff and regular field crews happen to be evaluating the same site at the same time, they collect and mail separate vouchers.

9.1.7 COMMUNICATIONS

Any questions arising during the field season that cannot be answered by the Field Supervisor or State Coordinator, should be directed to the Regional Advisor for the ozone indicator. If any field crew or cooperator is uncertain about whom to call for information, or if a Regional Advisor is not indicated, they should contact the National Ozone Advisor. Keep in mind that Advisors may be in the field and, therefore, unavailable for phone calls during normal workday hours. Messages left on answering machines should clearly identify who you are and when, where, and how to return your call. Field crews should be aware of differences in time zones and use email, if possible.

**3.0 Phase 3 Field Guide – Ozone Bioindicator Plants (east)
October, 2005**

National Advisor (East and West) and Regional Advisor for the Northeast and Mid-Atlantic States:

Gretchen Smith Phone: (413) 545-1680
Holdsworth Hall
University of Massachusetts
Department of Forestry and Wildlife Management
Amherst, MA 01003-0130
e-mail: gcsmith@forwild.umass.edu

Regional Advisor for the North Central States:

Ed Jepsen Phone: (608) 244-8847
Wisconsin Department of Natural Resources
101 South Webster Street
Madison, WI 53707
e-mail: jepsee@dnr.state.wi.us

Regional Advisors for the South:

Dan Stratton Phone: (828) 257-4352
USDA Forest Service
P.O. Box 2680
Asheville, NC 28802
e-mail: dstratton@fs.fed.us

John Simpson Phone: (828) 259-0542
USDA Forest Service
P.O. Box 2680
Asheville, NC 28802
e-mail: jsimpson03@fs.fed.us

9.2 OZONE BIOMONITORING PROCEDURES

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

The primary objective of the field crew procedures for the ozone indicator is to establish an ozone biomonitoring site within each polygon on the FIA ozone grid using the site selection guidelines provided in the Decision Table – section 9.2.2. These sites are used to detect and monitor trends in ozone air pollution injury on sensitive species. Procedures include the selection of a suitable site for symptom evaluation, identification of three or more known ozone-sensitive species at the site, symptom identification and scoring on the foliage of up to 30 plants of each species, and the collection of voucher leaf samples. Each individual plant with ozone injury is scored for amount and severity of injury. Plants used for the selection of leaf vouchers are also evaluated for injury location and type. If a plant does not have ozone injury, it is still tallied with zeros for the amount and severity measurements. A hardcopy map, providing directions, plot coordinates, and key characteristics of the bioindicator site, is prepared for each plot.

All foliar evaluations are conducted during the latter half of the field season. This is necessary to eliminate differences between plots that are caused by timing. During the evaluation window, all ozone sites on the ozone grid are evaluated for ozone injury. The same sites are evaluated every year.

9.2.1 EVALUATION WINDOW

The evaluation window for crews in the Northern Regions begins the last week of July and extends through the third week in August. In the Southern Region, the window is open from the third week in July through the third week in August.

All established biomonitoring sites are evaluated each year. The ozone injury evaluations are generally completed over a 5 to 20 day period during the window depending on the size of the State and the number of crews dedicated to the ozone survey. If possible, crews should adjust the timing of their evaluations so that the biomonitoring sites within each State are done at approximately the same time every year.

NOTE: States in the Northern Region that border the southern regions and have ozone exposure seasons more typical of the South may choose to select the evaluation window for the Southern Region. This may only be done with approval from the National Advisor.

9.2.2 SITE SELECTION PROCEDURES

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

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

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

FIA crews and State Cooperators that have an established network of ozone sites may need to select and map replacement sites when previously mapped areas become overgrown or disturbed. Some sites may be split between two near-by locations to improve species and plant counts. In the case of split-plots, separate plot files (i.e., Tally files) are maintained for each location. Both have the same plot identification number (i.e., OZONE HEXAGON NUMBER) but different values for the ozone plot number variable (i.e., OZONE PLOT NUMBER) as defined in Subsection 9.4.4. A split-plot is considered a unique ozone plot and should not be confused with grid intensification when two or more plots with different hex numbers fall in the same polygon.

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

9.2.3 SITE MAPPING

Once a bioindicator site is selected, the field crew records the estimated size of the site opening and other key site characteristics identified on the PDR or data sheet. The crew then maps the location of the site relative to some obvious and permanent marker such as a telephone pole, building, or property marker. Directions to the site, including road names and distances, are added to the map. Crews also mark the starting point for plant selection (see section 9.2.5) and approximate location of plant groupings used for

**3.0 Phase 3 Field Guide – Ozone Bioindicator Plants (east)
October, 2005**

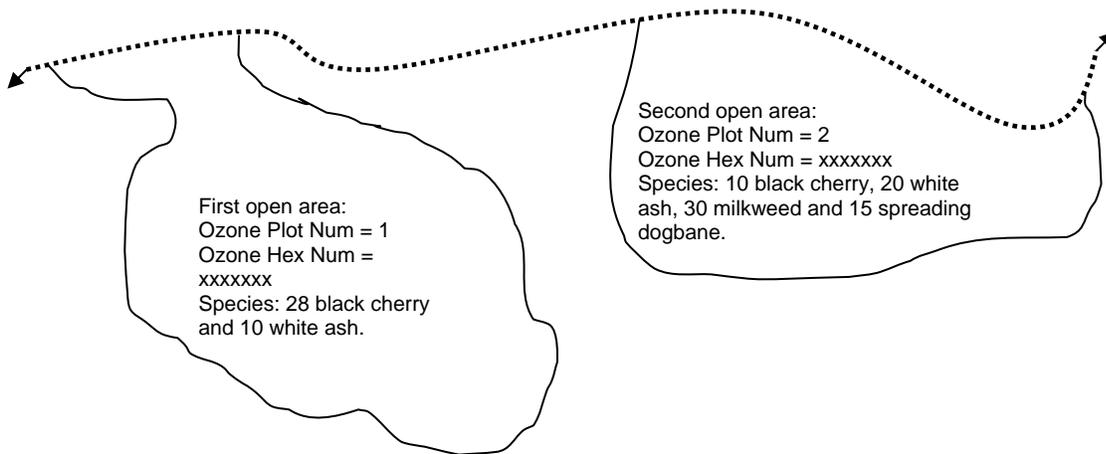
evaluation (see section 9.2.6) on the site map. If available, a GPS unit is used to determine plot coordinates and elevation. Otherwise, this information is obtained from a USGS topographic map, generally the 7½ minute series quadrangle.

Ozone site maps are used by audit and regular crews in subsequent visits to the plot (see Figure 9-1) to ensure that the same site and the same population of plants are remeasured every year. This bioindicator site map must be kept with the appropriate state or federal cooperator so that it is readily available to whoever needs it.

9.2.4 SPLIT PLOTS

Maximizing the quality of each ozone plot with respect to the number of plants and species that are evaluated for ozone injury is a priority. As indicated in the site selection Decision Table in section 9.2.2, the best sites have more than 3 species; 30 plants of 3 species and between 10 and 30 plants of 1, 2, or 3 additional species. Finding high plant counts at a single wide-open location can be challenging. Split plots are intended to address this challenge. A split-plot consists of two different locations within 3 miles of each other, preferably with similar site characteristics. Species and plant counts from one location are combined with the species and plant counts from the second location to meet the species and plant count standards for site selection. On the PDR or data sheet, the same OZONE HEXAGON NUMBER is assigned to each location. However, each location is assigned a unique OZONE PLOT NUMBER; OZONE PLOT NUMBER = 1 for the first location that is evaluated by the field crew and OZONE PLOT NUMBER = 2 for the second location. In this way, separate Tally files are maintained for each location. In the following example, the site selection criteria for a high quality ozone plot are met as the total species and plant counts for OZONE HEXAGON NUMBER XXXXXXXX are black cherry = 38, white ash = 30, milkweed = 30, and dogbane = 15.

Split plot example: Distance between open areas along the access road is about 2 miles.



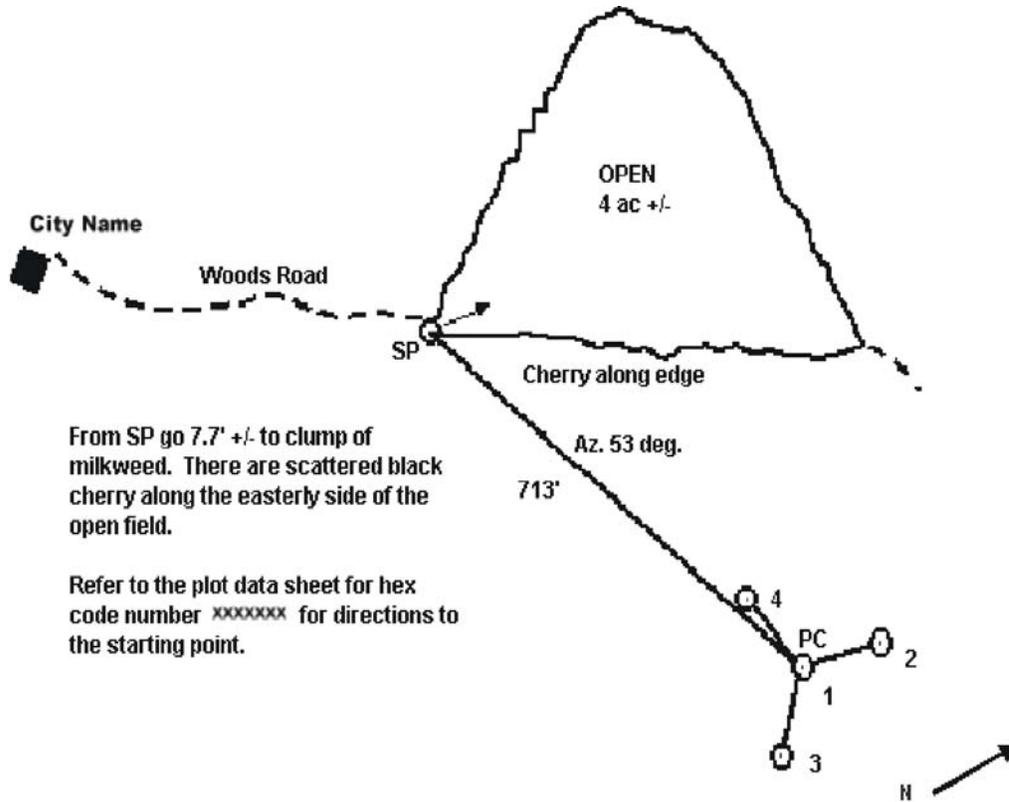


Figure 9-1. Example of a well-drawn map showing the location of the biosite and the approximate location of the bioindicator species and other key landmarks. Road names and north arrow are also included.

9.2.5 SPECIES SELECTION

At the selected bioindicator site, the crew evaluates 30 individuals of three or more bioindicator species. If three species cannot be found at the site, then two species are still evaluated. Crews may combine species and plant counts from neighboring locations to obtain the required plant counts for each site. If 30 plants of two or more species cannot be found at the site, then a new site or additional location must be selected. A prioritized list of species is provided to the field crews for each region. The top three species in each list are the most common throughout the sampling region and should be selected for evaluation whenever possible. Species with 30 or more individual plants should be a first priority for choice of species, regardless of their position on the list. Key identifying characteristics of each species are provided in the Appendix 9.A.

Field crews record the species code number for each selected species in the PDR or on the data sheet. The target species and codes for the North and South Regions are presented in the following table.

Code	Definition – Bioindicator Species	Scientific Names
0915	Blackberry	<i>Rubus allegheniensis</i> (second year canes only)
0762	Black Cherry	<i>Prunus serotina</i>
0365	Common and Tall Milkweed	<i>Asclepias</i> spp.
0621	Yellow Poplar	<i>Liriodendron tulipifera</i>
0541	White Ash	<i>Fraxinus americana</i>
0931	Sassafras	<i>Sassafras albidum</i>
0366	Spreading Dogbane	<i>Apocynum androsaemifolium</i>
0364	Big Leaf Aster	<i>Aster macrophyllum</i>
0611	Sweetgum	<i>Liquidambar styraciflua</i>
0761	Pin Cherry	<i>Prunus pennsylvanica</i>

3.0 Phase 3 Field Guide – Ozone Bioindicator Plants (east) October, 2005

NOTE: Site selection requirements for species and plant counts (section 9.2.2, Decision Table for site selection) must be met using the species listed on the preceding table. Field crews may receive supplemental lists of regional species (e.g., Paw-paw, *Asimina triloba* in the South) that may be used as additional species for a selected biomonitoring site. Species on supplemental lists are for field trials only as they have not yet been adequately tested for ozone sensitivity under controlled conditions. Use the Plot Notes screen to make a record of when supplemental species have been used at a site.

SPECIAL NOTE: Field crews in the Plains States including North Dakota, South Dakota, Nebraska, Kansas, Oklahoma and Texas should refer to Appendix 9.D for a special insert on western bioindicator species that can be used in addition to the target species and codes presented in the preceding table.

9.2.6 PLANT SELECTION

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

NOTE: The borders of some biomonitoring sites are difficult to determine and crews may be uncertain how much ground area to cover to complete the plant selection procedures. Specific guidelines are not set because the constraints on crew time and resources vary considerably from one State to the next. Time and safety concerns should take priority. Each crew must make every effort to maximize the number of plants and species evaluated for ozone injury at each plot location. Generally, ozone injury evaluations take 1 hour to complete and, assuming routine travel, crews are expected to complete 3 ozone sites in a ten hour work day.

The following procedures help crews to collect the bioindicator data in as systematic or unbiased a way as possible.

1. Identify a starting point at the edge of the opening. This point is mapped on the site data sheet so that audit and regular crews evaluate roughly the same population of plants in subsequent visits to the plot.
2. Move away from the starting point, towards the center of the opening.
3. Begin locating individuals in a sweeping pattern, selecting plants that are growing under the same or similar growing (microhabitat) conditions. Do not skip plants with little or no injury.
4. Select the more exposed plants (high sunlight exposure) and avoid suppressed and shaded individuals. Plants along the edge of an opening may be used if, in your judgment, they receive direct sunlight for three to four hours each day.
5. Avoid plants under 12 inches in height or so tall that you cannot see or touch at least half of the crown area.
6. Evaluate the foliage that you can see and touch on 30 plants of each species in the opening.
7. Record the amount and severity of injury for each plant evaluated (with or without symptoms) on the PDR, personal data assistant, or data sheet.

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

Several bioindicator species (e.g., milkweed and blackberry) can spread vegetatively. This means that neighboring plants are often genetically identical. To avoid repeat sampling of clonal material, take several steps between each plant selected for evaluation. This same approach should be used for all species to minimize bias in the plant selection process. For example, select the plant closest to your left side then take several steps and select the plant closest to your right side and repeat. In addition, it is often difficult to distinguish individual plants or stems for species, like blackberry, that grow in clumps. In this case, use an approximate 2-foot square area to represent a single plant.

9.2.7 SYMPTOM IDENTIFICATION AND SCORING

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

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

When scoring foliar symptoms on bioindicator plants check for the following characteristics of ozone injury.

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

Each plant with ozone injury is evaluated for the percent of the plant that is injured and the average severity of injury. For each plant located, the percentage of injured area and the severity of injury are both rated on a scale of 0 to 5 (see below). Both injury AMOUNT and injury SEVERITY estimates are confined to the exposed portion of the plant. If a plant does not have injury, it is still tallied with zeros for these measurements.

Percent Scale for injury AMOUNT: Estimate and record the percentage of leaves on the plant with ozone injury symptoms relative to the total number of leaves on the plant.

CODE DEFINITION

- | | |
|---|--|
| 0 | No injury; the plant does not have any leaves with ozone symptoms. |
| 1 | 1 to 6 percent of the leaves have ozone symptoms. |
| 2 | 7 to 25 percent of the leaves are injured. |
| 3 | 26 to 50 percent of the leaves are injured. |
| 4 | 51 to 75 percent of the leaves are injured. |
| 5 | >75 percent of the leaves have ozone symptoms. |

3.0 Phase 3 Field Guide – Ozone Bioindicator Plants (east)
October, 2005

Percent Scale for SEVERITY of injury: Estimate and record the mean severity of symptoms on injured foliage.

CODE DEFINITION

0	No injury; the plant does not have any leaves with ozone symptoms.
1	On average, 1 to 6 percent of the leaf area of injured leaves have ozone symptoms.
2	On average, 7 to 25 percent of the leaf area of injured leaves have ozone symptoms.
3	On average, 26 to 50 percent of the leaf area of injured leaves have ozone symptoms.
4	On average, 51 to 75 percent of the leaf area of injured leaves have ozone symptoms.
5	On average, >75 percent of the leaf area of injured leaves have ozone symptoms.

NOTE: Blackberry and white ash have compound leaves. Use the whole leaf, not each leaflet, to estimate injury AMOUNT and injury SEVERITY. A typical clump of blackberry plants will have both current year (vegetative) and second year (flower and fruit bearing) canes available for evaluation. The injury AMOUNT and injury SEVERITY measurements are confined to the foliage on the second year canes. The foliage on the current year canes is naturally resistant to ozone injury. Do not use blackberry if you can find only current year canes.

NOTE: The recognition of ozone injury symptoms in the field is not an exact science, and mimicking symptoms can make field diagnosis difficult. Crews are expected to record AMOUNT and SEVERITY estimates for injury that they are unsure of as well as the more obvious or classic injury symptoms.

Proceed as follows:

1. Record the injury AMOUNT and the injury SEVERITY ratings for each plant on the PDR or data sheet.
2. Use the notes section on the PDR or data sheet to add other information that will help interpret the results (e.g., below average rainfall for the area).
3. Collect a voucher leaf sample (three leaves of each injured species evaluated at each location) and mail them to the National Advisor using the guidelines presented in Subsection 9.6.7.

NOTE: Do not take measurements in steady rain. Foliar symptoms are easiest to see under overcast skies. Bright sun will make it difficult to see the ozone stipple. Stand so that you reduce the glare on the leaf surface. Long periods without rain will inhibit symptom development even on the most sensitive plants. If you are experiencing below average rainfall for your area, please note this in the PDR or on the data sheet.

9.2.8 COLLECTION OF LEAF SAMPLES AND VOUCHER DATA

The voucher leaf samples are a critical aspect of the data collection procedures as they provide the necessary validation of the ozone injury symptom observed in the field by the field crews. A plant press is essential to the collection of useable leaf samples and must be taken into the field by the field crews. Crew data that do not include a useable voucher leaf sample with a completed voucher data sheet are removed from the FIA database.

During the evaluation window, a voucher leaf sample must be collected for each injured species evaluated on the bioindicator site. For each injured species, the voucher consists of three leaves that clearly show the ozone injury symptom. For example, if a field crew records ozone injury on blackberry, black cherry, and milkweed then a minimum of one voucher (3 LEAVES) from each of the three species (9 LEAVES IN ALL) is collected and mailed, with the corresponding voucher data sheet(s), to the National Indicator Advisor.

The most useful voucher leaf samples show obvious foliar injury symptoms. If injury symptoms are not obvious and severe, send whatever leaf sample is available even if it is only one leaf with faint symptoms. Cut the leaf at the petiole, shake off any excess moisture, and place the leaf on blotter paper in the plant press. Each leaf is placed in the press so that it does not overlap another leaf. Include a label with each leaf sample placed into the plant press that identifies which plot the sample came from (i.e., OZONE HEXAGON

3.0 Phase 3 Field Guide – Ozone Bioindicator Plants (east)
October, 2005

NUMBER) and the date. Petiole labels are provided for this purpose. Record the information on the labels with indelible ink and then wrap them around the petiole of at least one leaf per sample

NOTE: Blackberry and white ash have compound leaves. Select the whole leaf (not individual leaflets) when preparing a voucher sample.

NOTE: If QA staff and regular field crews happen to be evaluating the same site at the same time, they collect and mail separate vouchers.

NOTE: The recognition of ozone injury symptoms in the field is not an exact science, and many other foliar injury symptoms can be mistaken for ozone injury. Crews are encouraged to collect and mail in voucher specimens of both known and suspected ozone injury for verification by the National Advisor.

The voucher data sheet must be completed for plot identification codes (e.g., STATE, COUNTY, OZONE HEXAGON NUMBER and OZONE PLOT NUMBER), CURRENT DATE, CREW ID, CREW TYPE, and SPECIES code(s). This sheet is filled out at the bioindicator site on the same day the sample is collected. In addition, the population of plants from which the leaf vouchers are selected must be evaluated by the field crews for INJURY LOCATION and INJURY TYPE (defined below), and for the amount of injury present on the leaf that is not ozone stipple. This information, together with the visible injury symptoms on the leaf samples, is used to validate the ozone injury data observed and recorded in the field by the field crews. For each species, the INJURY LOCATION and INJURY TYPE codes are intended to represent what the crew observed on the majority of the injured plants in the sample population. In contrast, the recorded estimates of percent injury caused by some stress other than ozone are based on what the crew observed on the injured leaf samples mailed in with the voucher data sheet.

The INJURY LOCATION and INJURY TYPE codes are recorded on the upper half of the voucher data sheet as follows:

INJURY LOCATION: Specify the leaf age or position of the leaves with ozone injury.

CODE	DEFINITION
1	>50% of the injured leaves are younger leaves. Younger leaves are usually located towards the branch tip (e.g., blackberry, black cherry, yellow poplar, white ash, sassafras, sweetgum, pin cherry, and spreading dogbane) or top of the plant (e.g., milkweed and big-leaf aster).
2	>50% of the injured leaves are mid-aged or older leaves. Mid-aged and older leaves are located halfway along the branch (e.g., blackberry, black cherry, yellow poplar, white ash, sassafras, sweetgum, pin cherry, and spreading dogbane), or main stem of the plant (e.g., milkweed and big-leaf aster), or more towards the base of the branch or stem.
3	Injured leaves are not concentrated in any one location, leaf age or position. Injury may be spread more or less evenly over the plant or is, otherwise, difficult to describe.

INJURY TYPE: Specify the visible injury symptom.

CODE	DEFINITION
1	The injury on >50% of the injured leaves is best described as upper-leaf-surface stipple, i.e., tiny purple-red to black spots occurring between the veins. Stippling may be associated with leaf yellowing and leaf drop late in the evaluation window; When injury is severe, stipples may coalesce and appear as uniform discoloration of the leaf surface.
2	The injury on >50% of the injured leaves is something other than upper-leaf-surface stipple. For example, small white to tan flecks occurring between the veins, or injury that is clearly visible on both leaf surfaces, or a general discoloration of the leaf that resembles early fall coloration.
3	The visible injury is varied or, otherwise, difficult to describe.

NOTE: Not all location and type codes are indicative of ozone injury. Certain combinations of location and type codes, considered with a questionable leaf voucher, may invalidate the injury data. Other combinations provide quality assurance for the injury assessment. Crews should describe any unusual or questionable symptoms on the upper half of the voucher data sheet.

9.2.9 VOUCHER MAILING PROCEDURES

Vouchers are mailed in bulk at the end of the evaluation window, or earlier, depending on the crew's work schedule. It is very important to mail only dry, pressed leaf samples. Before mailing, make sure the upper half of the voucher data sheet is filled out. This sheet is filled out on the same day the sample is collected even if the sample is not mailed on that day. Please comment on the weather or general plot conditions that might help interpret the injury data. For example, *"It's been 14 days now without rain," "Every plant showed the same response and it was very obvious,"* or *"This was a highly disturbed site."* Avoid noting whether the crew thinks the leaf sample shows ozone injury or a mimicking symptom, and referring to the amount and severity ratings so as not to influence the validation process.

The lower half of the voucher data sheet is filled out by the National Ozone Advisor to whom the sample is being sent. Place the voucher data sheet and the leaf sample between two pieces of stiff paper or cardboard before placing into a mailing envelope addressed to the National Advisor. Manila folders and newspaper may also be used for voucher mailings. Do not tape the leaves to the folders, paper or cardboard. Taped samples often break apart when they are handled, making evaluation difficult. Include as many samples as fit easily into each mailing envelope. There must be a unique voucher data sheet for each sample or species, unless the form is being used for multi-species. Keep leaf samples and the corresponding leaf voucher data sheets together. Leaf samples that are separated from the corresponding leaf voucher data sheets may be mislaid, especially if the petiole leaf labels are missing or incomplete.

9.2.10 CREW MEMBER RESPONSIBILITIES

1. Although one or two crew partners may be trained for this indicator, one person typically takes the lead responsibility for site selection, plant selection, and ozone injury evaluations. All procedures can be successfully completed by one person. Two person crews are recommended for safety reasons.
2. All members of the field crew may assist each other in the site selection process. Once a site is selected, one crew member is responsible for mapping the site and the location of bioindicator species on the field data sheet.
3. Only the crew member trained and certified in ozone injury evaluations may collect the amount and severity data and the leaf voucher. Other crew members may assist by recording the injury scores on the PDR or data sheet and by getting the plant press supplies ready.
4. The crew member that evaluates the plants for injury is responsible for collecting and mailing the voucher sample with air pollution symptoms.

9.2.11 FIELD PROCEDURES FOR UNTRAINED FIELD CREWS

There are certain procedures for the ozone indicator that may be performed by individuals that have not attended the ozone training and been certified to collect ozone data. These procedures still require some explanation and oversight by the certified crew member. Untrained personnel may assist in the selection and mapping of the ozone biomonitoring site and in the location and identification of bioindicator species on the selected site. They may not rate plant injury. It may also be helpful for the untrained crew person to act as the data recorder for the certified crew member, thus speeding up the data collection process.

9.3 SITE INTENSIFICATION

In addition to the unique ozone plots that are identified by the base ozone grid, some Cooperators have established additional biomonitoring sites to represent the local plant populations and environmental conditions. This is not an auxiliary effort, but an integral part of the monitoring activities for this indicator. In some States, additional biomonitoring sites are limited in number and are deliberately located close to weather and air quality monitoring stations. In other States, the ozone grid is intensified to allow for an

unbiased allocation of additional biomonitoring sites. It is recommended that additional sites, whether few or many in number, be located on public land to facilitate the annual measurement activities.

Ozone biomonitoring sites added to the base grid typically possess attributes of an ideal site for evaluating ozone injury on sensitive species. They are larger than three acres, contain the maximum number of indicator species, and have soil/site conditions with low drought potential and adequate fertility. They are evaluated for ozone injury using the same methods and during the same time frame as described above in section 9.2.

9.4 PLOT LEVEL DATA

All plot-level measurement codes for the ozone indicator are defined below. The codes and definitions are the same whether the crew is entering data using Tally (Paravant¹ or Husky) or a personal data assistant (Handspring or Palm).

Ozone plots vary in size and do not have set boundaries. When describing plot-level characteristics, use the predominant characteristics where most of the plant species are located. If conditions vary markedly across the site, or by species, then describe this in the plot notes or on the site map. Specify the elevation, aspect, terrain position, soil depth, soil drainage, and disturbance for the highest priority species (Subsection 9.6.4) found on the site. The soil depth, soil drainage, and disturbance variables are intended to describe general conditions on the plot and are not based on actual measurements. For a complete explanation of the procedures associated with these measurement codes, refer to section 9.2.

9.4.1 STATE

Record the unique FIPS (Federal Information Processing Standard) code identifying the State where the plot center is located.

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

9.4.2 COUNTY

Record the unique FIPS (Federal Information Processing Standard) code identifying the county, parish, Borough (or unit in AK) where the plot center is located.

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

9.4.3 OZONE HEXAGON NUMBER

Record the unique code assigned to each ozone hexagon. In some cases this will be a former FHM or P3 hexagon.

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

¹ The use of trade or firm names in this publication is for reader information only and does not imply endorsement by the U.S. Department of Agriculture of any product or service.

9.4.4 OZONE PLOT NUMBER

Record the plot number that describes whether an ozone plot consists of one or two locations. If two locations are selected, they must be within 3 miles of each other. Two locations are selected as needed to obtain optimal species and plant counts for each ozone plot. The OZONE HEXAGON NUMBER is the same for both locations.

When collected: All plots
Field width: 1 digit
Tolerance: No errors
MQO: At least 99% of the time
Values: 1 to 2

- 1 The ozone plot consists of a single location or this is the first location of a plot split between two locations.
- 2 The ozone plot is split between two locations. This code identifies the second location added by the field crew to increase species and plant counts for a single hexagon number.

9.4.5 QA STATUS

Record the code to indicate the type of plot data collected.

When collected: All plots
Field width: 1 digit
Tolerance: No errors
MQO: At least 99% of the time
Values: 1 to 2 and 4 to 7

- 1 Standard ozone plot
- 2 Cold check

- 4 Training/practice plot (off grid)
- 5 Botched plot file
- 6 Blind check
- 7 Hot check (production plot)

9.4.6 CREW TYPE

Record the code to specify what type of crew is measuring the plot.

When collected: All plots
Field width: 1 digit
Tolerance: No errors
MQO: At least 99% of the time
Values: 1 to 2

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

9.4.7 OZONE SAMPLE KIND

Record the code that describes the kind of plot being visited. OZONE SAMPLE KIND has a value of 1 when an ozone plot is established in a previously empty polygon. OZONE SAMPLE KIND has a value of 2 when remeasurement occurs at the same location, or when the replacement plot is within 3 miles of the previously established plot. OZONE SAMPLE KIND has a value of 3 when the replacement plot is more than 3 miles away from the previously established plot.

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

- 1 Initial plot establishment on the base grid or on a newly intensified grid.
- 2 Remeasurement of a previously established plot.
- 3 Replacement of a previously established plot that was replaced because the original plot could not be relocated or because it no longer met ozone plot measurement criteria.

9.4.8 CURRENT DATE

Record the year, month, and day that the current plot visit was completed as follows:

9.4.8.1 YEAR

Record the year that the plot was completed.

When collected: All plots
Field width: 4 digits
Tolerance: No errors
MQO: At least 99% of the time
Values: Beginning with 1998, constant for a given year

9.4.8.2 MONTH

Record the month that the plot was completed.

When collected: All plots
Field width: 2 digits
Tolerance: No errors
MQO: At least 99% of the time
Values:

January	01	May	05	September	09
February	02	June	06	October	10
March	03	July	07	November	11
April	04	August	08	December	12

9.4.8.3 DAY

Record the day of the month that the plot was completed.

When collected: All plots
Field width: 2 digits
Tolerance: No errors
MQO: At least 99% of the time
Values: 01 to 31

9.4.9 OZONE GRID DENSITY

Record the code that identifies whether the plot is on the base ozone grid or on an intensified ozone grid. Note: The OZONE GRID DENSITY value = 2 when there are two ozone plots with different OZONE HEXAGON NUMBERS in the same polygon.

When collected: All plots
Field width: 1 digit
Tolerance: No errors

3.0 Phase 3 Field Guide – Ozone Bioindicator Plants (east)
October, 2005

MQO: At least 99% of the time
Values: 1 to 2

- 1 Unique ozone plot within a polygon. (1 site:1polygon)
- 2 One of two or more ozone plots within the same polygon.

9.4.10 PLOT SIZE

Record the code that indicates the size of the opening used for biomonitoring.

When collected: All plots
Field width: 1 digit
Tolerance: No errors
MQO: Repeatable estimate
Values: 1 to 2

- 1 Greater than three acres.
- 2 Greater than one acre, but less than three acres.

9.4.11 ASPECT

Record the code that identifies the direction of slope for land surfaces with at least 5 percent slope as measured with a hand compass to the nearest degree.

When collected: All plots
Field width: 3 digits
Tolerance: +/- 30°
MQO: At least 99% of the time
Values:

- 000 No aspect, slope < 5 percent
- 001 1 degree
- 002 2 degrees
- .
- .
- .
- 360 360 degrees, due north

9.4.12 TERRAIN POSITION

Record the code that identifies the position of the plot in relation to the surrounding topography.

When collected: All plots
Field width: 1 digit
Tolerance: Repeatable estimate
MQO: At least 99% of the time
Values: 1 to 5

- 1 Ridge top or upper slope
- 2 Bench or level area along a slope
- 3 Lower slope
- 4 Flat land unrelated to slope
- 5 Bottom land with occasional flooding

9.4.13 SOIL DEPTH

Record the code that indicates the general depth of the soil where most of the bioindicator species are growing.

When collected: All plots
Field width: 1 digit
Tolerance: Repeatable estimate
MQO: At least 99% of the time
Values: 1 to 2

- 1 Bedrock is not exposed.
- 2 Bedrock is exposed; Soil is generally shallow.

9.4.14 SOIL DRAINAGE

Record the code that identifies the general soil drainage conditions where most of the bioindicator species are growing.

When collected: All plots
Field width: 1 digit
Tolerance: Repeatable estimate
MQO: At least 99% of the time
Values: 1 to 3

- 1 Soil is well drained
- 2 Soil is generally wet
- 3 Soil is excessively dry

9.4.15 DISTURBANCE

Record the code that identifies the presence and kind of disturbance where most of the bioindicator plants are growing. The area affected by any human caused or natural disturbance must be clearly visible and recent enough to influence plant health and condition. Disturbance that results in significant soil compaction is especially significant.

When collected: All plots
Field width: 1 digit
Tolerance: Repeatable estimate
MQO: At least 99% of the time
Values: 0 to 2

- 0 No recent or significant disturbance.
- 1 Evidence of overuse; Human activity causing obvious soil compaction or erosion.
- 2 Evidence of natural disturbance including fire, wind, flooding, grazing, pests, etc.

9.4.16 INJURY CHECK

Record the code that indicates whether ozone injury was observed on non-tallied plants or species. This variable allows a plot to be identified as impacted by ozone even though there is no quantitative data on injury severity for trend analyses. A leaf voucher must be collected to validate the injury.

When collected: All plots
Field width: 1 digit
Tolerance: No error
MQO: At least 99% of the time
Values: 0 to 1

- 0 No injury was observed on non-tallied plants or species.
- 1 Ozone injury was observed on non-tallied plants or species and a leaf voucher collected.

9.4.17 ELEVATION

Obtain elevation data from USGS topographic maps, generally the 7½ minute series quadrangle. Locate the area where most of the bioindicator species are growing and record elevation to the nearest foot.

When collected: When GPS UNIT = 0

Field width: 6 digits

Tolerance: +/-200 feet

MQO: At least 99% of the time

Values:

9.4.18 Plot Notes

Use these fields to record notes pertaining to the entire plot. If the notes apply to a specific aspect of the plot, then make that clear in the notes. Record the location where GPS coordinates were collected, and GPS file name, as needed. If no GPS Unit was available, record the geographic coordinates (i.e., latitude and longitude) of the plot center in Degrees, Minutes, and Seconds using USGS topographic maps, generally the 7½ minute series quadrangle.

9.4.18.1 REMARK1 and REMARK2

Record any information on site characteristics, use of supplemental species, safety, plant location, injury patterns, or recent rainfall amounts that will assist subsequent crews visiting the site or help interpret the results.

When collected: All plots

Field width: Unlimited alphanumeric character field

Tolerance: N/A

MQO: N/A

Values: English language words, phrases and numbers

9.5 GPS COORDINATES

Use a global positioning system (GPS) unit to determine the plot coordinates and elevation of all ozone plot locations. GPS readings are collected according to procedures outlined in the FIA National Core Field Guide for Phase 2 & 3 Plots, Version 2.0. The ozone data entry applications accept GPS readings obtained using a geographic coordinate system (not UTM). If you are using UTM, record readings on the field data sheet for mapping and on the PDR Plot Notes screen. If GPS coordinates cannot be collected, elevation and plot coordinates are obtained from USGS topographic maps, generally the 7½ minute series quadrangle. Record ELEVATION on the Plot ID screen and approximate latitude and longitude on the Plot Notes screen.

Use a global positioning system (GPS) unit to determine the plot coordinates and elevation of all field-visited plot locations.

NOTE: For several of the following GPS variables, the term plot center is used. There may be no obvious center to the ozone plots. Coordinates are collected as close as possible to a central location or marker that clearly locates the plot for returning crews. Explanatory notes are added to the plot map and Plot Notes screen as needed.

9.5.1 GPS Unit Settings, Datum, and COORDINATE SYSTEM

Consult the GPS unit operating manual or other regional instructions to ensure that the GPS unit internal settings, including Datum and Coordinate system, are correctly configured.

**3.0 Phase 3 Field Guide – Ozone Bioindicator Plants (east)
October, 2005**

Each FIA unit will determine the Datum to be used in that region. Most will use the NAD 27 Datum (also known as NAS-C or NA 27 CONUS/CLK66), but coordinates collected using any appropriate datum can be converted back to a national standard (NAD83) for reporting purposes.

Each FIA unit will also determine which coordinate system to use. Regions using a Geographic system will collect coordinates in Degrees, Minutes, and Seconds of Latitude and Longitude; the regions using the UTM coordinate system will collect UTM Easting, Northing, and Zone.

9.5.2 Collecting Readings

Collect at least 180 GPS readings at the plot center (see Note above). These may be collected in a file for post-processing or may be averaged by the GPS unit. Each individual position should have an error of less than 70 feet if possible (the error of all the averaged readings is far less).

Soon after arriving at plot center, use the GPS unit to attempt to collect coordinates. If suitable positions (180 readings at error less than or equal to 70 feet) cannot be obtained, try again before leaving the plot center.

If it is still not possible to get suitable coordinates from plot center, attempt to obtain them from a location within 200 feet of plot center. Obtain the azimuth and horizontal distance from the "offset" location to plot center. If a PLGR unit is used, use the Rng-Calc function in the PLGR to compute the coordinates of the plot center. If another type of GPS unit is used, record the azimuth and horizontal distance as described in Sections 1.14.12 and 1.14.13.

Coordinates may be collected further away than 200 feet from the plot center if a laser measuring device is used to determine the horizontal distance from the "offset" location to plot center. Again, if a PLGR unit is used, use the Rng-Calc function in the PLGR to compute the coordinates of the plot center. If another type of GPS unit is used, record the azimuth and horizontal distance as described in Sections 1.14.12 and 1.14.13.

In all cases try to obtain at least 180 positions before recording the coordinates.

9.5.3 GPS UNIT

Record the kind of GPS unit used to collect coordinates. If suitable coordinates cannot be obtained, record 0.

When collected: All field visited plots

Field width: 1 digit

Tolerance: No errors

MQO: At least 99% of the time

Values:

- 0 GPS coordinates not collected
- 1 Rockwell Precision Lightweight GPS Receiver (PLGR)
- 2 Other brand capable of field-averaging
- 3 Other brands capable of producing files that can be post-processed
- 4 Other brands not capable of field-averaging or post processing

9.5.4 GPS SERIAL NUMBER

Record the last six digits of the serial number on the GPS unit used.

When collected: When GPS UNIT >0

Field width: 6 digits

Tolerance: No errors

MQO: At least 99% of the time

Values: 000001 to 999999

9.5.5 GPS DATUM

Record the acronym indicating the map datum that the GPS coordinates are collected in (i.e., the map datum selected on the GPS unit to display the coordinates).

When collected: When GPS UNIT >0

Field width: 5 characters (ccnn)

Tolerance: No errors

MQO: At least 99% of the time

Values:

NAD27	North American Datum of 1927
NAD83	North American Datum of 1983
WGS84	World Geodetic System of 1984

9.5.6 Latitude

Record the latitude of the plot center to the nearest hundredth second, as determined by GPS.

NOTE: The following can be customized at the region level (e.g., decimal minutes to the nearest thousandth) as long as the final results recorded are within the specified tolerance to the nearest hundredth of a second or +/- 1.01 ft.

9.5.6.1 LATITUDE DEGREES

Record the latitude degrees of the plot center as determined by GPS.

When collected: When GPS UNIT = 1, 2, 3 or 4

Field width: 2 digits

Tolerance: No errors

MQO: At least 99% of the time

Values:

9.5.6.2 LATITUDE MINUTES

Record the latitude minutes of the plot center as determined by GPS.

When collected: When GPS UNIT = 1, 2, 3 or 4

Field width: 2 digits

Tolerance: No errors

MQO: At least 99% of the time

Values: 1 – 59

9.5.6.3 LATITUDE SECONDS

Record the latitude decimal seconds of the plot center to the nearest hundredth place as determined by GPS.

When collected: When GPS UNIT = 1, 2, 3 or 4

Field width: 4 digits

Tolerance: +/- 140 ft

MQO: At least 99% of the time

Values: 0.00 – 59.99

9.5.7 Longitude

Record the longitude of the plot center to the nearest hundredth second, as determined by GPS.

NOTE: The following can be customized at the region level (e.g., decimal minutes to the nearest thousandth) as long as the final results recorded are within the specified tolerance to the nearest hundredth of a second or +/- 1.01 ft.

9.5.7.1 LONGITUDE DEGREES

Record the longitude degrees of the plot center as determined by GPS

When collected: When GPS UNIT = 1, 2, 3 or 4

Field width: 3 digits

Tolerance: No errors

MQO: At least 99% of the time

Values:

9.5.7.2 LONGITUDE MINUTES

Record the longitude minutes of the plot center as determined by GPS.

When collected: When GPS UNIT = 1, 2, 3 or 4

Field width: 2 digits

Tolerance: No errors

MQO: At least 99% of the time

Values: 1 – 59

9.5.7.3 LONGITUDE SECONDS

Record the longitude decimal seconds of the plot center to the nearest hundredth place as determined by GPS.

When collected: When GPS UNIT = 1, 2, 3 or 4

Field width: 4 digits

Tolerance: +/- 140 ft

MQO: At least 99% of the time

Values: 0.00 – 59.99

9.5.8 GPS ELEVATION

Record the elevation above mean sea level of the plot center, in feet, as determined by GPS. If no GPS Unit is available, record elevation from the appropriate USGS topographic map.

When collected: When GPS UNIT = 1, 2 or 4

Field width: 6 digits

Tolerance:

MQO: At least 99% of the time

Values: -00100 to 20000

9.5.9 GPS ERROR

Record the error as shown on the GPS unit to the nearest foot.

When collected: When GPS UNIT = 1 or 2

Field width: 3 digits

Tolerance: No errors

MQO: At least 99% of the time

Values: 000 to 070 if possible

071 to 999 if an error of less than 70 cannot be obtained

9.5.10 NUMBER OF GPS READINGS

Record a 3-digit code indicating how many readings were averaged by the GPS unit to calculate the plot coordinates. Collect at least 180 readings if possible.

When collected: When GPS UNIT = 1 or 2
Field width: 3 digits
Tolerance: No errors
MQO: At least 99% of the time
Values: 001 to 999

9.5.11 GPS FILENAME (CORE OPTIONAL)

Record the filename containing the GPS positions collected on the plot.

When collected: When GPS UNIT = 3
Field width: 8 characters.3 characters e.g. R0171519.ssf
Tolerance: No errors
MQO: At least 99% of the time
Values: Letters and numbers

9.6 FOLIAR INJURY DATA

All measurement codes for the foliar injury data are defined below. Plants selected for ozone injury evaluations are rated for the percent of injured area and the severity of injury on a scale of 0 to 5 (see section 9.2.6). If a plant does not have injury, it is tallied with zeros for these measurements. A pop-up menu keeps track of plant counts by species. The plot is complete only when you have tallied 30 plants of at least 3 species, or when no additional plants can be found on the plot. Ozone plots vary in size and do not have set boundaries. Time and safety concerns should dictate how much ground area to cover to complete the foliar injury evaluation procedures.

9.6.1 SPECIES

Record the three-digit code that identifies each species on the plot. Species codes may be entered in the order they are encountered as you walk through the plot evaluating plants. A pop-up menu keeps a running total of numbers of plants and species evaluated.

When collected: All plots
Field width: 4 digits
Tolerance: No error
MQO: At least 90% of the time
Values: See 9.2.5

9.6.2 AMOUNT

Record the code that identifies the percentage of leaves on the plant with ozone injury symptoms relative to the total number of leaves on the plant. The percent scale code and definitions are fully described in Subsection 9.2.7.

When collected: All plots
Field width: 1 digit
Tolerance: +/- 1 class
MQO: At least 90% of the time

Values: 0 - 5

- 0 No injury; The evaluated plant does not have any leaves with ozone symptoms.
- 1 1 to 6 percent of the leaves have ozone symptoms
- 2 7 to 25 percent of the leaves are injured.
- 3 26 to 50 percent of the leaves are injured.
- 4 51 to 75 percent of the leaves are injured.
- 5 Greater than 75 percent of the leaves have ozone symptoms.

9.6.3 NUMBER OF PLANTS

Record the number of plants tallied so far with no injury. When 0 is entered for AMOUNT, the PDR prompts for the NUMBER OF PLANTS with no injury. When a number greater than zero is entered for AMOUNT, the PDR prompts for the associated SEVERITY value. Zero and non-zero values for any species can be entered as they are encountered on the plot. The pop-up menu keeps track of plant counts by species.

When collected: When AMOUNT = 0
Field width: 2 digits
Tolerance: No error
MQO: At least 90% of the time
Values: 1 to 30

9.6.4 SEVERITY

Record the code that identifies the mean severity of symptoms on injured foliage. The percent scale code and definitions are fully described in Subsection 9.2.7.

When collected: When AMOUNT > 0
Field width: 1 digit
Tolerance: +/- 1 class
MQO: At least 90% of the time
Values: 0 - 5

- 0 No injury. The evaluated plant does not have any leaves with ozone symptoms.
- 1 On average, 1 to 6 percent of the leaf area of injured leaves has ozone symptoms.
- 2 On average, 7 to 25 percent of the leaf area of injured leaves has ozone symptoms.
- 3 On average, 26 to 50 percent of the leaf area of injured leaves has ozone symptoms.
- 4 On average, 51 to 75 percent of the leaf area of injured leaves has ozone symptoms.
- 5 On average, greater than 75 percent of the leaf area of injured leaves has ozone symptoms.

9.7 REFERENCES

- Brace, S. 1996. The spatial distribution of ozone in the Mount Rainier national park region. MS Thesis. University of Washington. 79 p.
- Cleveland, W.S.; Graedel, T.E. 1979. Photochemical air pollution in the Northeast United States. Science 204: 1273-1278.
- Davis, D.D.; Umbach, D.M. 1981. Susceptibility of tree and shrub species and response of black cherry foliage to ozone. Plant Disease 65:904-907.
- Duchelle, S.F.; Skelly, J.M. 1981. Response of common milkweed to oxidant pollution in the Shenandoah National Park in Virginia. Plant Disease 65: 661-663.
- Forest Health and Ozone*. 1987. ed: C. Hakkarienen. EPRI, EA-5135-SR. Special Report.

**3.0 Phase 3 Field Guide – Ozone Bioindicator Plants (east)
October, 2005**

- Horsefall, J.G.; Cowling, E.B. 1978. Pathometry: the measurement of plant disease, pp. 119- 136. In: J.G. Horsefall and E.B. Cowling (eds.), Plant Disease, an Advanced Treatise, Vol II. New York: Academic Press, 436 pp.
- Krupa, S.V.; Manning, W.J. 1988. "Atmospheric ozone: formation and effects on vegetation," Environ. Pollut. 50:101-137.
- Lefohn, A.S.; Pinkerton, J.E. 1988. High resolution characterization of ozone data for sites located in forested areas of the United States. JAPCA 38(12):1504-1511.
- Manning, W.J.; Feder, W.A. 1980. Biomonitoring Air Pollutants with Plants, London: Applied Science Publ. Ltd., 142pp.
- Mavity, E.; Stratton, D.; Barrang, P. 1995. Effects of ozone on several species of plants which are native to the western United States. Dry Branch, GA: USDA Forest Service Center for Forest Environmental Studies. 12 p.
- Miller, P.R.; Millecan, A.A. 1971. Extent of oxidant air pollution damage to some pines and other conifers in California. Plant Disease Reporter 55(6):555-559.
- Richards, B.L. Sr.; Taylor, O.C; Edmunds, F.G. Jr. 1968. Ozone needle mottle of pines in southern California. JAPCA 18:73-77.
- Skelly, J.M.; Davis, D.D.; Merrill, W. [and others]. 1987. *Diagnosing Injury to Eastern Forest Trees*. USDA Forest Service and Penn State Univ. 122pp.
- Smith, W.H. 1974. Air pollution - Effects on the structure and function of the temperate forest ecosystem. Environ. Pollut. 6:111-129.
- Treshow, M.; Stewart, D. 1973. Ozone sensitivity of plants in natural communities. Biol. Conservation 5:209-214.

9.8 ACKNOWLEDGEMENTS

The National Advisor for the ozone indicator wishes to thank the individuals within FHM and FIA, as well as those outside the Forest Service, who have helped to review and improve this guide and provide slides for training. Special thanks to Sally Campbell, Pat Temple, Jay Lackey, Teague Prichard, Ed Jepsen, William Manning, Art Chappelka, Jim Renfro, Robert Kohut, and John Skelly. The National Advisor for this indicator may be contacted at: Gretchen Smith, Department of Natural Resources Conservation, 160 Holdsworth Way University of Massachusetts, Amherst, MA 01003-4210 or via email at gcsmith@forwild.umass.edu

Appendix 9.A Key Identifying Characteristics of the Ozone Bioindicator Species

1. **Blackberry** is an upright or arching shrub; greenish to greenish-red stems are ridged with stout prickles. Alternate leaves have 3-7, mostly 5, leaflets, sparingly pubescent above, velvety beneath, green on both sides. Flowers white, May-July. Fruits black, July-September. Dewberry is very similar to common blackberry, but it is a vine with prickly stems trailing over the ground. Raspberry has smaller leaves and rounded stems covered with a whitish bloom. Blackberry is found in dry fields, clearings, and sunny thickets.
2. **Black Cherry** is a small to large tree. Twigs have a bitter-almond smell and taste. The alternate leaves are narrow, shiny, 2-6 inches long, and blunt-toothed, with the midrib prominently fringed beneath with white to brown hair. Leaves of choke cherry, a similar species, have a hairless midrib beneath and are sharp toothed. Leaves of pin cherry are longer and narrower with finely serrated margins. Black cherry is found on a variety of forest soils, deep and moist to dry and gravelly, and along the edges of disturbed areas.
3. **Common Milkweed** is recognized by a solitary, simple stem 1-6 feet tall that may or may not be covered with hair. The opposite or whorled leaves are twice as long (2 to 12 inches) as they are wide, have smooth margins, and stems with milky juice. The surface of the leaf is hairy below and smooth above. The petioles are short and thick. Flowers are borne in large clusters on stalks in the upper nodes. They appear rose or greenish-white, from June to August. You may see developmental stages of the Monarch butterfly or feeding injury on the plants. Milkweed is common along roadsides, in fields and meadows.
4. **Yellow Poplar** is a tall, straight, forest tree found on good sites with many hardwoods and loblolly pine in the South. Leaves are 4 to 6 inches in diameter, squarish at base, mostly 4-lobed, with smooth margins. Twigs stout, bitter to taste, with diaphragmed pith. Bud shaped like a duck's bill.
5. **White ash** is characterized by opposite, compound leaves; leaflets 5-9, stalked, green above and white or pale beneath, usually with smooth margins, slightly toothed near the leaf tips. Buds are inset in the leaf scar. Twigs are round, shiny, and mostly hairless. White ash is difficult to distinguish from green ash; Green ash leaves tend to be narrower, with more teeth, and hairy beneath; buds are set above the leaf scar and branch stems are usually hairy. Ash is sometimes confused with hickory, but can be readily distinguished by its opposite leaves and buds.
6. **Sassafras** has a characteristic odor and taste, spicy. Leaves are simple, narrowly lobed (mitten shaped) or entire. Twigs are green. Found from southwestern Maine, south to Florida, north to central Michigan, and west.
7. **Sweetgum** has star shaped leaves, deeply 5-7 lobed, margin finely serrate, bright green above, hairy in the axils of the leaf veins below. Twigs shiny and green to yellowish brown, somewhat fragrant when crushed. Fruit a spiny ball, often hanging. Common on bottomland soils and old fields from southern Connecticut, south to Florida and west.
8. **Pin Cherry** is a small, shrubby tree often found on cut over, burned, or abandoned sites. Leaves are long, narrow, finely serrate, and yellow-green; less shiny than those of black cherry. Pin cherry leaves may look like black cherry leaves, but they have no hair beneath. Maine to northern Georgia and west.
9. **Spreading Dogbane** is a perennial herb characterized by its opposite leaves with smooth margins and red stems with milky juice. The simple leaves are oblong or egg-shaped, dark green above and pale beneath; 2-3 inches long. The plant grows 1-4 feet high and has wide-spreading branches that give the plant an awkward appearance. It flowers throughout the summer; pinkish with a pink stripe in the center. Pods are long and narrow, in pairs. Young milkweed may be confused with dogbane, but differs in having larger, thicker leaves, hairy on the under surface. If evident, milkweed flowers are showy and the pods are large. Dogbane prefers the edges of dry woods from Canada to Mexico, but is also found in dry fields and thickets.
10. **Bigleaf Aster** is a perennial wild flower commonly found as an understory plant in dry woods. The leaves of this aster are heart shaped, 3 or more inches wide, with unevenly toothed margins, and have a stem nearly as long as the length of the leaf. Near the flat-topped flower cluster, the leaves become smaller and the stems are margined by a wavy leaf portion called a wing. Flowers may be violet, lavender, or light blue; evident in August and September. The plant grows 1-4 feet high and is native over eastern U.S. and south to North Carolina, west to Illinois.

Appendix 9.B Ozone Data Sheets.

OZONE BIOINDICATOR PLANTS - BIOSITE CHARACTERISTICS

Crew Reminder: Take this sheet to the Biosite! Complete it in the field!

This sheet must be completed only if you have *not* entered this same information on the Bioindicator Plot ID screen.

To be filled out by the FIELD CREW or Cooperator: Refer to Ozone Field Guide for code definitions.

State	County	Ozone Hexagon Number	O3Plot Number ¹	Month	Day	Year	Crew ID	Crew Type
								Regular QA

¹O3Plot Number refers to the number of locations (1 or 2) used for each hexagon number. A separate sheet should be used for each location.

√ Please put a check mark beside the correct information. Please complete all data fields.

Ozone Sample Kind:	
<input type="checkbox"/>	Initial biosite establishment on the FIA ozone grid. (Data collection in a previously empty polygon)
<input type="checkbox"/>	Remeasurement of a previously established biosite. (Data collection at the same ground location as last year)
<input type="checkbox"/>	Replacement of a previously established biosite that was replaced to meet site selection guidelines (or lost site).

Ozone Grid Density: (Is the grid intensified, or not?)	
<input type="checkbox"/>	This hex number identifies a unique ozone biosite within a polygon (1 site:1 polygon)
<input type="checkbox"/>	One of two or more ozone biosites within the same polygon, each with their own hexagon number.

Biosite size (Plot Size):	Terrain position:
<input type="checkbox"/> > 3.0 acres (1.2 hectares)	<input type="checkbox"/> Ridge top or upper slope
<input type="checkbox"/> 1to 3 acres (0.4 – 1.2 hectares)	<input type="checkbox"/> Bench or level area along a slope
<input type="checkbox"/> Other: please describe	<input type="checkbox"/> Lower slope
	<input type="checkbox"/> Flat land unrelated to slope
	<input type="checkbox"/> Bottom land with occasional flooding

Aspect: 000° = no aspect; 360° = N aspect	Elevation: record estimate in feet or meters	
Record to nearest degree =	Feet =	Meters =

Soil Drainage:	Soil Depth:
<input type="checkbox"/> Well-drained	<input type="checkbox"/> Bedrock not exposed
<input type="checkbox"/> Wet	<input type="checkbox"/> Bedrock exposed
<input type="checkbox"/> Excessively dry	

Disturbance: Disturbance on the site or in localized areas where the bioindicator plants are growing.	
<input type="checkbox"/>	No recent or significant disturbance; Do not count disturbance >3 years old.
<input type="checkbox"/>	Evidence of overuse; Human activity causing obvious soil compaction or erosion.
<input type="checkbox"/>	Evidence of natural disturbance including fire, wind, flooding, grazing, pests, etc.

Fill in below all that apply. Check here if geographic coordinates were obtained from a topographic map:

GPS Type:	Datum:	GPS Serial Number:
Latitude =		GPS Error =
Longitude =		Number of Readings =
Elevation =		GPS File Name =

¹If no GPS Unit is available, please use a map and record estimated latitude, longitude, and elevation for each biosite location.

Comments: Include information on additional species in the area, safety, directions, or additional site characteristics that may be useful.

File this completed data sheet with the sheet used for mapping the Bioindicator Site Location and then store it in the appropriate Ozone Plot Folder for your State or Region.

OZONE BIOINDICATOR FOLIAR INJURY DATA SHEET

State	County	O3Hexagon No.	O3Plot No.	Month	Day	Year	Measurement Type
							__ Reg. Crew/Cooperator __ QA crew

Code	Species
915	Blackberry
762	Black Cherry
365	Milkweed
621	Yellow Poplar
541	White Ash
931	Sassafras
366	Spreading Dogbane
364	Big Leaf Aster
611	Sweetgum
761	Pin Cherry

Amount of Injury – % of leaves injured relative to the total leaf number
Severity of Injury – Average severity of symptoms on the injured leaves

Code	Scale
0	No Injury
1	1-6%
2	7-25%
3	26-50%
4	51-75%
5	>75%

Example 1

Amount: 8 inj out of 8 = 100%, Code 5
Severity: mean of 8 inj lvs = Code 4

Example 2

Amount: 4 inj out of 8 = 50%, Code 3
Severity: mean of 4 inj lvs = Code 2

Plant	Species Code									
	Amount	Severity								
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										
13										
14										
15										
16										
17										
18										
19										
20										
21										
22										
23										
24										
25										
26										
27										
28										
29										
30										

Did you collect 3 leaves that clearly show ozone stipple, for each injured species? Enter injury location and type codes for the collected leaf vouchers.

<input checked="" type="checkbox"/>					
<input checked="" type="checkbox"/>	Location = Type =				

Refer to the Ozone Bioindicator Plants section of the FIA Field Guide for codes and definitions.

Notes:

OZONE BIOINDICATOR PLANTS
Data Sheet for Mapping the Bioindicator Site Location

To be filled out by the FIELD CREW or Cooperator: Refer to the Field Guide for code definitions.

State	County	Ozone Hexagon Number	O3Plot Number ¹	Month	Day	Year	Crew ID

¹O3Plot Number refers to the number of locations (1 or 2) used for each hexagon number. A separate sheet should be used for each location.

Include the following information on the map. Use a legend that indicates distances between obvious points on the map.

- (1) Location of the site relative to some obvious and permanent marker.
- (2) Road names and distances as needed.
- (3) North arrow.
- (4) Species codes and approximate location of plant groupings used for the ozone injury evaluations.
- (5) Starting point
- (6) Location of and distance to two major roads
- (7) Distance and direction to two major towns
- (8) Gazetteer reference page if available.

Return the original of this map to the corresponding Plot Folder so it can be used by audit and regular crews in subsequent visits to the biosite. Mail a copy to the National Indicator Advisor the year that the site is established.

GEOGRAPHIC COORDINATES	Datum =
GPS Latitude =	GPS Longitude =
Latitude estimated from a topographic map =	
Longitude estimated from a topographic map =	

REDRAW THE MAP AND ADD NEW INFORMATION EACH YEAR AS NEEDED!

OZONE BIOINDICATOR PLANTS
Data Sheet for the Voucher Leaf Samples

To be filled out by the FIELD CREW or Cooperator: Refer to the Ozone Field Guide for code definitions.

State	County	Ozone Hexagon Number	O3Plot Number ¹	Month	Day	Year	Crew ID	Crew Type
								regular QA

¹O3Plot Number refers to the number of locations (1 or 2) used for each hexagon number. Separate sheets should be used for each location.

Fill in the required codes. ONE SPECIES PER LINE. Code definitions are in the Field Guide.

Bioindicator Species Code or Common Name	Injury Location	Injury Type	Is the leaf sample injury close to 100% ozone stipple (✓), or is some other upper-leaf-surface injury also present (e.g., insect injury or fungal lesions)?
1 st			Close to 100% _____ Estimated percent other _____
2 nd			Close to 100% _____ Estimated percent other _____
3 rd			Close to 100% _____ Estimated percent other _____
4 th			Close to 100% _____ Estimated percent other _____

Species codes:

- 915 Blackberry
- 762 Black cherry
- 365 Milkweed
- 621 Yellow poplar
- 541 White ash
- 931 Sassafras
- 611 Sweetgum
- 761 Pin cherry
- 366 Spreading dogbane
- 364 Bigleaf aster.
- 999 Unknown
- 111 Supplemental

(write out common name)

Injury Location codes:

- 1 = greater than 50% of the injured leaves are younger leaves;
- 2 = greater than 50% of the injured leaves are mid-aged or older;
- 3 = injured leaves are all ages.

Injury type codes:

- 1 = greater than 50% of the injury is upper-leaf-surface stipple;
- 2 = greater than 50% is not stipple (tan flecks, bifacial or general discoloration);
- 3 = injury is varied or difficult to describe.

Biosite Notes:

CHECK ✓ all that apply:

- Voucher leaves are from 1 plant:
- Voucher leaves are from multiple plants:
- Voucher leaves are undersized:
- Normal sized leaves were uninjured or unavailable:
- Voucher leaves are from NON-TALLIED plants:

- Weather has been very dry:
- Weather has been very wet:
- Biosite growth conditions are poor:
- Biosite conditions are unsafe:
- Comment on back:

Mail this sheet with the leaf samples to:

Gretchen Smith
Department of Natural Resources Conservation
160 Holdsworth Way
University of Massachusetts
Amherst, MA 01003

QA/QC PERSON: To be filled out by the National Ozone Advisor or Regional Expert. ✓

Date checked	Date rechecked	Sample condition			Plot Status	
		GOOD easy to read - ID obvious	FAIR	POOR samples unreadable or not labeled correctly	(+ozone)	(- ozone)

Bioindicator Species	Positive for ozone	Negative for ozone	Explanation

Appendix 9.C Detailed Procedures for Handling Leaf Vouchers

Leaf Collection in the Field

1. Collect 3 leaves from each species showing ozone injury symptoms
 - These 3 leaves should be from different plants, if possible
 - These 3 leaves should show obvious injury rather than the range of different symptoms you may have observed
2. Once the leaf vouchers are cut from a plant they should be placed immediately into a plant press
 - Each leaf should have its own space on the blotter paper – do not overlap leaves
 - Each leaf should be marked with the date and the hex number in case they get shuffled
 - Leaves that are not put into a plant press immediately will wrinkle and break easily when handled
 - Leaves that are laid on top of each other will “bleed” such that all overlapped leaves become murky and the ozone injury symptom is no longer visible
3. Before you leave the plot where you have collected voucher leaves, fill out the leaf voucher data sheet and complete the Tally PlotID screen on the PDR. There is important information on the voucher sheet and on the PDR screen that you need to record while you are standing on the biosite. You will not remember these details later on, so take the time to get it right while you are on the plot.
4. Pressed leaves can be removed from the plant press after 36 hours. Once they are flat and dry they can be kept in mailing envelopes, folders, or newspaper until you have time to mail them in to be validated.

Leaf Preparation for Mailing

1. First, label each mailing envelope with the 7-digit hex numbers that you insert into each envelope. Mark the outside of the mailing envelope on the side where the list of numbers will not interfere with the address information.
2. Each mailing envelope may contain the leaves from ONE or SEVERAL hexes (biosites). Use common sense to decide how many leaves will fit comfortably into each envelope. Don't forget to mark the outside with each OZONE HEXAGON NUMBER that has been included.
3. Each pile of leaves from each plot should be placed on top of the corresponding voucher data sheet. It is very helpful to include an additional blank piece of recycled paper or newspaper to help keep larger piles of leaves separated from each other.
4. At least 1 of the 3 leaves (and preferably all 3 leaves) you have selected for each species should have a petiole label with the hex number written on it. This will prevent data loss, if the leaf pile is dropped and separated from its corresponding voucher data sheet when the leaves are removed from the envelope.
 - Do not put large piles of leaves into a single mailing envelope. Help minimize human error by mailing the leaves and data sheets 1 plot per envelope or, up to 5 plots per envelope, depending on how many species were injured and how many leaves and data sheets must be mailed in.
 - Use the 10"x12" size mailing envelopes that are provided at training. If you make a substitution, make sure it is approximately the same size or larger.
 - If you choose to mail larger piles in a single large mailing container, please use newspaper or manila folders to separate vouchers and their corresponding data sheets by OZONE HEXAGON NUMBER.
 - The only way it is safe and acceptable to mail unmarked leaves (no petiole label), is if each group of leaves from each biosite is contained in a separate mailing envelope (10"x12") that contains the corresponding voucher data sheet and is clearly marked with the appropriate OZONE HEXAGON NUMBER.
5. If you have the time and the resources, supply a cover sheet that lists all of the hex numbers you have included in your mailing(s). It is also extremely helpful if the leaves and vouchers are organized by OZONE HEXAGON NUMBER in increasing or decreasing order, e.g., XXXXX28, XXXXX22, XXXXX21, etc.
6. Feel free to ask for the return of your leaves and a copy of the voucher data sheets. This will only be done on request. Remember that the validation process begins in mid-September and may take until December to complete. If you have a time constraint and need a quick response, please note this on the OUTSIDE of the mailing envelope so that it will be noticed upon arrival.
7. If you have mailed extra leaves (>3 per species) for any purpose, please attach a handwritten note explaining what you have done. Clearly mark which 3 leaves should be used to validate the ozone injury at each site. Explain clearly what additional review of leaf samples is of interest to you and include a separate voucher data sheet for this purpose.
8. If you have mailed in samples of supplementary species that are not on the official bioindicator list, please keep these separated by hex number or off grid location and provide a separate data sheet for these extra species, 1 sheet per species. If possible, provide GPS coordinates of any off-grid sampling locations. Species found within approximately 3 miles of the established biosite are still on the grid and do not require additional GPS data.

Appendix 9.D Plain States – Special Insert

For: ND, SD, NE, KS, OK, and TX.

Includes: (1) species key for western bioindicators, (2) foliar injury data sheet for western bioindicators, and (3) voucher data sheet for western bioindicators.

Key Identifying Characteristics of the Western Ozone Bioindicator Species**

NOTE: A double asterisk () denotes the 8 western species that may be used by field crews working in North and South Dakota, Nebraska, Kansas, Oklahoma, and Texas in addition to the 10 species on the eastern bioindicator list. Additional western species shown here and on the Foliar Injury Data Sheet are considered supplemental and should not be used to meet site selection guidelines. Use the Plot Notes screen to make a record of when supplemental species have been used at a site.

1. ****Ponderosa Pine** is a large tree, up to 230 feet in height. Young tree bark is often thin and dark brown to black. Older tree bark is thick becoming yellow-red to cinnamon red and forming plates which slough off freely. Needles in bundles of three, 5-10 inches in length, not glaucous and yellow-green in color. Buds are resinous with red-brown scales and dark-hairy. Cones with a prickle at the tip of each scale. May be confused with Jeffrey pine which differs by having non-resinous, light-brown buds, and grayish blue-green glaucous needles.
2. **Jeffrey Pine** is a smaller tree than ponderosa pine, with darker cinnamon-red bark that may be tinged with lavender on old trunks. Needles in bundles of three, 5-10 inches in length, blue-green, and somewhat twisted. Crushed needles and twigs have a violet-like or pineapple odor. Buds are *never* covered with resin droplets. Cones with a prickle at the tip of each scale. May be confused with ponderosa pine.
3. ****Quaking Aspen** is a medium sized tree up to 118 feet in height. Bark is smooth, greenish-white. Buds shiny but not resinous. Leaf petiole is strongly flattened. The leaf blade is broadly ovate (almost round) with a tapering tip and finely toothed margins, upper surface smooth, lower surface covered with a bloom. Aspen could be confused with black cottonwood which differs in its resinous buds, rough bark and round leaf petioles.
4. **Scouler's Willow** is a small tree or shrub up to 32 feet in height. Leaf blade is 1-4 inches in length, narrowly elliptic with the widest portion toward the tip, entire to irregularly toothed margins, lower surface smooth, upper surface shiny. This willow is NOT restricted to riparian zones. It can be easily confused with a number of other willow species. The combination of leaves widest toward the tip (mostly rounded ends and narrowly tapered bases) and the tolerance for upland (drier) habitats makes this willow relatively easy to identify.
5. **Pacific Ninebark** is a deciduous shrub 6-12 feet in height. Leaves alternate, 3 or 5 lobed (maple-like), 2-3 inches long, serrate, dark green and smooth above, paler and hairy below. Twigs red to grayish brown, splits longitudinally into long strips. Flowers small, white, borne in a cluster, stems hairy. Very similar to ninebark (see below) which is generally smaller, in drier habitats, and with densely hairy ovaries.
6. ****Ninebark** is an erect, loosely branched shrub with maple-like leaves and shreddy bark. May be up to 6 feet in height. Leaves and flowers similar to Pacific ninebark except the ovaries are densely hairy. May be confused with Douglas maple which has opposite leaves, or sticky currant, which has leaves that are sticky to the touch. Often associated with ponderosa pine and Douglas-fir forests at low to mid-elevation.
7. **Huckleberry** is an erect shrub 3 to 5 feet high. Leaves 1 to 2 inches long, half as wide, thin and pale green on both surfaces, smooth or occasionally minutely hairy, margins toothed, apex and base both acute. Fruit deep purple to black round berry around 6 mm diameter. Twigs slender, green and ridged. Found on dry to moist sites, sun or shade. Similar, and often found with oval-leaved huckleberry which has entire (smooth) rather than toothed leaves.
8. **Blue Elderberry** is a tall deciduous shrub, sometimes tree-like, up to 20 feet in height. Twigs with a soft pith inside. Leaves opposite, pinnately compound, the 5-9 leaflets sharply serrate and strongly uneven at the base. Flowers small, white, flat-topped cluster. Fruit a blue-black berry covered with a white powdery bloom. This species could be confused with red elderberry which differs by having flowers in a spike and red-purple fruit. Found mostly on moist, well-drained sites in the sun; sea level to 9,000 ft.
9. **Red Elderberry** is a tall deciduous shrub, sometimes tree-like, up to 20 feet in height. Twigs with a soft pith inside. Leaves opposite, pinnately compound, the 5-7 leaflets sharply toothed and often uneven at the base. Flowers small, white, and clustered into a long spike. Fruit is a berry, most often red in color but sometimes purplish-black or yellow. Similar to blue elderberry which has a flat-topped flower cluster and a blue-black berry.
10. ****Western Wormwood** is an aromatic perennial herb, 1 to 3 feet in height. Leaves mostly 3-11 1-4 in cm long, variable in shape but most often with 3-5 narrow lobes, white hairy beneath, sometimes above as well. Flowers small and

3.0 Phase 3 Field Guide – Ozone Bioindicator Plants (east)
October, 2005

arranged in a loose, narrow flower cluster, 2-12 inches long. May be confused with Douglas' wormwood which has wider leaves and is usually found in moister habitats. Also similar to Riverbank wormwood which occurs only near streams and outwash areas.

11. ****Mugwort** is a large perennial herb 2 to 5 feet tall, usually found in large colonies in wet areas, ditches, or drainages. Leaves are evenly-spaced, 0.4 to 4.0 inches long, the upper leaves are narrowly elliptical, the lower widely oblanceolate, often coarsely 3 to 5 lobed near the leaf tip, 0.8 to 1.0 inches wide, green above, covered with dense white hair beneath. Differs from western wormwood in having wider lower leaves and in its generally damp habitat.
12. ****Evening Primrose** is a large biennial with elliptical leaves up to 10 inches long in a dense rosette the first year. The large (>3ft) flowering stalk with long red-tinged elliptical leaves and large bright yellow four-petaled flowers forms in the second year. Both the leaves and stem are densely hairy, and the hairs often have red, blister-like bases. Usually found in moist, sunny habitats, like seeps or meadows.
13. ****Mountain Snowberry** is a shrub, 1.5 to 5 feet in height with a solid brown pith. Bark: shreddy, brownish. Young twigs: hairy. Leaves opposite, elliptical, 0.4 to 1.4 inches long and half as wide. Flowers (May-June) tubular-shaped, the petals white with a pink tube. Fruit a white berry. Common snowberry differs by having non-tubular flowers and a hollow pith. Trailing snowberry is a trailing shrub with non-tubular flowers; and Utah honeysuckle has larger leaves and a solid white pith.
14. **Red Alder** is a deciduous tree up to 65 feet tall with dark green leaves 2.4 to 4.7 inches long. The leaves are coarsely toothed, with smaller teeth on the leaf margins, and the leaf veins are also tightly inrolled. Red alder is a common tree in damp situations and is a frequent colonizer of clearings, especially following clearcuts in coniferous forests.
15. ****Skunkbush** is a small, diffusively-branched shrub, 1.6 to 3.3 feet tall. The tips of the branches often droop down almost to ground level. The leaves are alternate, compound, with three leaflets, each of which is 3-lobed. The leaves resemble those of poison oak, but the leaflets of skunkbush are smaller, more hairy, and much more deeply-lobed. The leaves of skunkbush also emit a strong, ill-scented odor when crushed. However, if unsure, DO NOT crush the leaves of a shrub with three leaflets to determine the odor. Skunkbush is usually found on dry, open, brushy hillsides, while poison oak prefers damp or shaded forested areas and riparian habitats. Skunkbush is found throughout the southwest, from California and Arizona north to Colorado and Idaho.

OZONE BIOINDICATOR PLANTS

Foliar Injury Data – Use this sheet *only* if no PDR is available for data entry!

State	County	Ozone Hexagon Number	Ozone Plot Number ¹	Month	Day	Year	Crew ID	Crew Type
								regular QA

¹Ozone Plot Number refers to the number of locations (1 or 2) used for each hexagon number. A separate sheet should be used for each location.

Record species code number (use additional sheets for >3 species at one site): **0122** Ponderosa Pine **0116** Jeffrey Pine **0746** Quaking Aspen **0924** Scouler's Willow **0351** Red Alder **0906** Pacific Ninebark **0905** Ninebark **0965** Huckleberry **0960** Blue Elderberry **0961** Red Elderberry **0907** Western Wormwood **0908** Mugwort **0968** Evening Primrose **0969** Mountain Snowberry **0909** Skunkbush. Then use the codes from the percent injury scale to record the percent of the leaves or needles injured relative to the total leaf number (amount) and the average severity of symptoms on the injured leaves (severity). Add notes on back of sheet as needed.

0 = No injury; 1 = 1-6%; 2 = 7-25%; 3 = 26-50%; 4 = 51-75%; 5 = >75%

Plant	Species Code		Plant	Species Code		Plant	Species Code	
	Amount	Severity		Amount	Severity		Amount	Severity
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								
13								
14								
15								
16								
17								
18								
19								
20								
21								
22								
23								
24								
25								
26								
27								
28								
29								
30								

OZONE BIOINDICATOR PLANTS
Data Sheet for the Voucher Leaf Samples – PLAIN STATES

To be filled out by the FIELD CREW or Cooperator: Refer to the Ozone Field Guide for code definitions.

State	County	Ozone Hexagon Number	O3Plot Number ¹	Month	Day	Year	Crew ID	Crew Type
								regular QA

¹O3Plot Number refers to the number of locations (1 or 2) used for each hexagon number. Separate sheets should be used for each location.

Fill in the required codes. ONE SPECIES PER LINE. Code definitions are in the Field Guide.

Bioindicator Species Code or Common Name	Injury Location	Injury Type	Is the leaf sample injury close to 100% ozone stipple (✓), or is some other upper-leaf-surface injury also present (e.g., insect injury or fungal lesions)?
1 st			Close to 100% _____ Estimated percent other _____
2 nd			Close to 100% _____ Estimated percent other _____
3 rd			Close to 100% _____ Estimated percent other _____
4 th			Close to 100% _____ Estimated percent other _____

Species codes:

- 915 Blackberry
 - 762 Black cherry
 - 365 Milkweed
 - 621 Yellow poplar
 - 541 White ash
 - 931 Sassafras
 - 611 Sweetgum
 - 761 Pin cherry
 - 366 Spreading dogbane
 - 364 Bigleaf aster.
 -
 - 122 Ponderosa pine
 - 746 Quaking aspen
 - 905 Ninebark
 - 907 Wormwood
 - 908 Mugwort
 - 909 Skunkbush
 - 968 Evening primrose
 - 969 Snowberry
 - 111 Supplemental (e.g. Rudbeckia sp.)
- please write out common name

Injury Location codes:

- 1 = greater than 50% of the injured leaves are younger leaves (or current whorl);
- 2 = greater than 50% of the injured leaves are mid-aged or older (older whorls);
- 3 = injured leaves are all ages.

Injury type codes:

- 1 = greater than 50% of the injury is upper-leaf-surface stipple (or chlorotic mottle);
- 2 = greater than 50% is not stipple (tan flecks, bifacial or general discoloration);
- 3 = injury is varied or difficult to describe.

Biosite Notes:

CHECK ✓ all that apply:

- Voucher leaves are from 1 plant:
- Voucher leaves are from multiple plants:
- Voucher leaves are undersized:
- Normal sized leaves were uninjured or unavailable:
- Voucher leaves are from NON-TALLIED plants:

- Weather has been very dry:
- Weather has been very wet:
- Biosite growth conditions are poor:
- Biosite conditions are unsafe:
- Comment on back:

Mail This Sheet With Leaf Samples To:

[EASTERN SPECIES]

Gretchen Smith
Department of Natural Resources Conservation
160 Holdsworth Way
University of Massachusetts
Amherst, MA 01003

[WESTERN SPECIES]

Pat Temple
USDA FS, PSW Experiment Station
4955 Canyon Crest Drive
Riverside, CA 92507

QA/QC PERSON: To be filled out by the National Ozone Advisor or Regional Expert. ✓

Date checked	Date rechecked	Sample condition			Plot Status	
		GOOD easy to read - ID obvious	FAIR	POOR samples unreadable or not labeled correctly	(+ozone)	(- ozone)

Bioindicator Species	Positive for ozone	Negative for ozone	Explanation

Section 9. Ozone Bioindicator Plants (West)

9.1 OVERVIEW	3
9.1.1 SCOPE AND APPLICATION	3
9.1.2 SUMMARY OF METHOD	4
9.1.3 SUMMARY OF PDR SCREENS AND TALLY PROCEDURES	4
9.1.4 EQUIPMENT AND SUPPLIES	5
9.1.5 TRAINING AND QUALITY ASSURANCE	5
9.1.6 VOUCHER SPECIMENS	5
9.1.7 COMMUNICATIONS	5
9.2 OZONE BIOMONITORING PROCEDURES	6
9.2.1 EVALUATION WINDOW	7
9.2.2 SITE SELECTION PROCEDURES	7
9.2.3 SITE MAPPING	8
9.2.4 SPECIES SELECTION	9
9.2.5 PLANT SELECTION	10
9.2.6 SYMPTOM IDENTIFICATION AND SCORING	11
9.2.7 COLLECTION OF LEAF SAMPLES AND VOUCHER DATA	13
9.2.8 VOUCHER MAILING PROCEDURE	15
9.2.9 CREW MEMBER RESPONSIBILITIES	16
9.2.10 FIELD PROCEDURES FOR UNTRAINED FIELD CREWS	16
9.3 SITE INTENSIFICATION	16
9.4 PLOT LEVEL DATA	16
9.4.1 STATE	17
9.4.2 COUNTY	17
9.4.3 OZONE HEXAGON NUMBER	17
9.4.4 PLOT NUMBER	17
9.4.5 QA STATUS	18
9.4.6 CREW TYPE	18
9.4.7 OZONE SAMPLE KIND	18
9.4.8 CURRENT DATE	18
9.4.8.1 YEAR	19
9.4.8.2 MONTH	19
9.4.8.3 DAY	19
9.4.9 OZONE GRID DENSITY	19
9.4.10 PLOT SIZE	19
9.4.11 ASPECT	20
9.4.12 TERRAIN POSITION	20
9.4.13 SOIL DEPTH	20
9.4.14 PLOT WETNESS	20
9.4.15 DISTURBANCE	21
9.4.16 INJURY CHECK	21
9.4.17 ELEVATION	21
9.4.18 Plot Notes	22
9.4.18.1 REMARK1 and REMARK2	22
9.5 GPS COORDINATES	22
9.5.1 GPS Unit Settings, Datum, and COORDINATE SYSTEM	22
9.5.2 Collecting Readings	23
9.5.3 GPS UNIT	23
9.5.4 GPS SERIAL NUMBER	23
9.5.5 GPS DATUM	23
9.5.6 Latitude	24
9.5.6.1 LATITUDE DEGREES	24
9.5.6.2 LATITUDE MINUTES	24
9.5.6.3 LATITUDE SECONDS	24
9.5.7 Longitude	24
9.5.7.1 LONGITUDE DEGREES	25

9.5.7.2	LONGITUDE MINUTES	25
9.5.7.3	LONGITUDE SECONDS	25
9.5.8	GPS ELEVATION	25
9.5.9	GPS ERROR	25
9.5.10	NUMBER OF GPS READINGS	25
9.5.11	GPS FILENAME (CORE OPTIONAL)	26
9.6	FOLIAR INJURY DATA.....	26
9.6.1	SPECIES	26
9.6.2	AMOUNT	26
9.6.3	NUMBER OF PLANTS	27
9.6.4	SEVERITY	27
9.7	REFERENCES.....	27
9.8	ACKNOWLEDGEMENTS.....	28
Appendix 9.A Key Identifying Characteristics of the Ozone Bioindicator Species		29
Appendix 9.B Data Sheets.....		31

9.1 OVERVIEW

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

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

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

9.1.1 SCOPE AND APPLICATION

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

1. Ozone plot distribution across the landscape covers both the more remote and expansive forests away from population centers and the more fragmented forests located in close proximity to urban areas;
2. Ozone plot stratification nationwide reflects regional differences in air quality regimes and perceived risks to different forest types;
3. Sampling intensity in different regions is designed to allow links between ozone biomonitoring data and other FIA indicators;
4. Seasonal variability in ozone injury is addressed. We know that ozone injury must reach an undefined threshold within a leaf before the injury becomes visible to the human eye, and then tends to be cumulative over the growing season until fall senescence masks the symptoms.

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

9.1.2 SUMMARY OF METHOD

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

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

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

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

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

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

9.1.3 SUMMARY OF PDR SCREENS AND TALLY PROCEDURES

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

For a written summary of the data entry procedures, definitions, and codes for the ozone measurement variables refer to section 9.4 through 9.6.

9.1.4 EQUIPMENT AND SUPPLIES

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

9.1.5 TRAINING AND QUALITY ASSURANCE

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

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

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

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

9.1.6 VOUCHER SPECIMENS

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

Field crews, cooperators, and all QA staff collect leaf samples on the ozone biomonitoring sites according to procedures outlined in Subsection 9.2.7. These voucher specimens are pressed and mailed to the National Indicator Advisor for validation of the ozone symptom. If QA staff and regular field crews happen to be evaluating the same site at the same time, they collect and mail separate vouchers.

9.1.7 COMMUNICATIONS

Any questions arising during the field season that cannot be answered by the Field Supervisor or State Coordinator, should be directed to the National Indicator Advisor for the ozone indicator or to the Western Regional Trainer. If field crews try and are unable to reach the National Advisor or the Western Regional Trainer they may call the Regional Advisor for the North Central States, as indicated below. Keep in mind that Advisors may be in the field and, therefore, unavailable for phone calls during normal workday hours.

Messages left on answering machines should clearly identify who you are and when, where, and how to return your call. Please, be aware of differences in time zones and use email, if possible.

National Advisor (East and West)

Gretchen Smith Phone: (413) 545-1680
Holdsworth Hall
University of Massachusetts
Department of Forestry and Wildlife Management
Amherst, MA 01003-0130
e-mail: gcsmith@forwild.umass.edu

Western Regional Trainer:

Pat Temple Phone: (909) 680-1583
USDA Forest Service
PSW Experiment Station
4955 Canyon Crest Drive
Riverside, CA 92507
e-mail: ptemple@fs.fed.us
or: temple_p@msn.com

Regional Coordinator for the West Coast

Sarah Butler Phone: (503) 808-2083
USDA Forest Service
Portland Forestry Sciences Laboratory
620 SW Main, Suite 400
Portland, OR 97205
e-mail: sbutler@fs.fed.us

Regional Coordinator for the Interior West

Bill Dunning Phone: (801) 625-5463
USDA Forest Service
Rocky Mountain Research Station
507 25th Street
Ogden, UT 84401
e-mail: bdunning@fs.fed.us

Regional Advisors for the South:

Dan Stratton Phone: (828) 257-4352
USDA Forest Service
P.O. Box 2680
Asheville, NC 28802
e-mail: dstratton@fs.fed.us

John Simpson Phone: (828) 259-0542
USDA Forest Service
P.O. Box 2680
Asheville, NC 28802
e-mail: jsimpson03@fs.fed.us

9.2 OZONE BIOMONITORING PROCEDURES

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

The primary objective of the field crew procedures for the ozone indicator is to establish an ozone biomonitoring site within each polygon on the FIA ozone grid using the site selection guidelines provided in the Decision Table – section 9.2.2. These sites are used to detect and monitor trends in ozone air pollution

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

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

9.2.1 EVALUATION WINDOW

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

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

9.2.2 SITE SELECTION PROCEDURES

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

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

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

The best ozone sites are often associated with wildlife preserves on public land. Private landowners are often eager to participate in the ozone program. State and county parks and wildlife openings also provide

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

FIA crews and State Cooperators that have an established network of ozone sites may need to select and map replacement sites when previously mapped areas become overgrown or disturbed. Some sites may be split between two nearby locations to improve species and plant counts. In the case of split-plots, separate plot files (i.e., Tally files) are maintained for each location. Both have the same plot identification number (i.e., OZONE HEXAGON NUMBER) but different values for the plot number variable (i.e., OZONE PLOT NUMBER) as defined in Subsection 9.4.4.

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

NOTE: A split-plot consists of two different locations within 3 miles of each other, preferably with similar site characteristics. Species and plant counts from one location are combined with the species and plant counts from the second location to meet the species and plant count standards for site selection. On the PDR or data sheet, the same OZONE HEXAGON NUMBER is assigned to each location. However, each location is assigned a unique OZONE PLOT NUMBER; OZONE PLOT NUMBER = 1 for the first location that is evaluated by the field crew and OZONE PLOT NUMBER = 2 for the second location. In this way, separate Tally files are maintained for each location.

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

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

9.2.3 SITE MAPPING

Once a bioindicator site is selected, the field crew records the estimated size of the site opening and other key site characteristics identified on the PDR or data sheet. The crew then maps the location of the site relative to some obvious and permanent marker such as a telephone pole, building, or property marker. Directions to the site, including road names and distances, are added to the map. Crews also mark the starting point for plant selection (see section 9.2.4) and approximate location of plant groupings used for

evaluation (see section 9.2.5) on the site map. If available, a GPS unit is used to determine plot coordinates and elevation. Otherwise, this information is obtained from a USGS topographic map, generally the 7½ minute series quadrangle.

Ozone site maps are used by audit and regular crews in subsequent visits to the plot (see Figure 9-1) to ensure that the same site and the same population of plants are remeasured every year. This bioindicator site map must be kept with the appropriate state or federal cooperator so that it is readily available to whoever needs it.

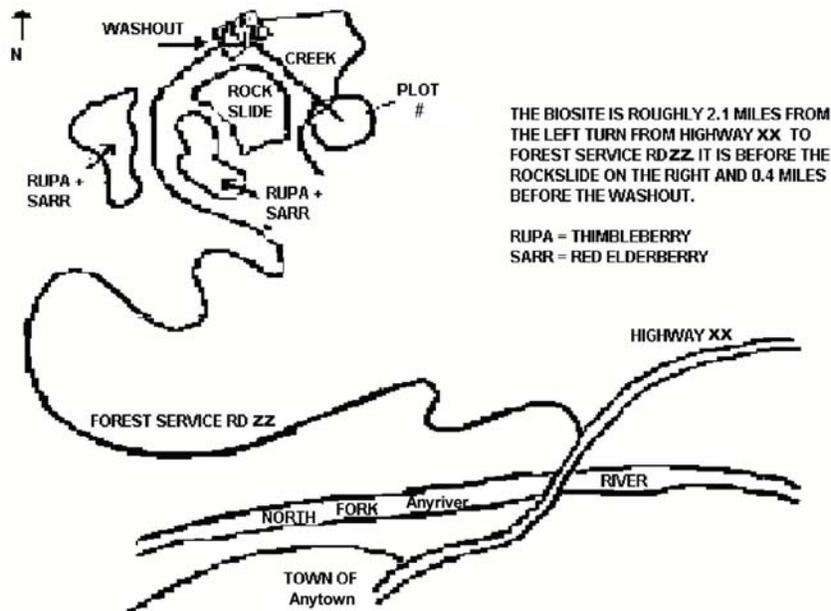


Figure 9-1. Example of a well-drawn map showing the location of the biosite and the approximate location of the bioindicator species and other key landmarks. Road names and North arrow are also included.

9.2.4 SPECIES SELECTION

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

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

Interior Region

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

¹ *Pinus ponderosa* var. *scopulorum* (WY, CO)

² *Pinus jeffreyi* (NV); *Alnus rubra* (ID)

West Coast Region

Code	Definition	Scientific Names
0122	Ponderosa pine ¹	<i>Pinus ponderosa</i>
0116	Jeffrey pine	<i>Pinus jeffreyi</i>
0960	Blue elderberry	<i>Sambucus cerulea</i>
0908	Mugwort	<i>Artemisia douglasiana</i>
0746	Quaking aspen	<i>Populus tremuloides</i>
0924	Scouler's willow	<i>Salix scouleriana</i>
0351	Red alder	<i>Alnus rubra</i>
0906	Pacific Ninebark (WC) ³	<i>Physocarpus capitatus</i>
0909	Skunk bush	<i>Rhus trilobata</i>
0905	Ninebark	<i>Physocarpus mlvaceus</i>
0969	Mountain snowberry	<i>Symphoricarpos oreap</i>
0907	Western wormwood	<i>Artemisia ludoviciana</i>
0961	Red elderberry	<i>Sambucus racemose</i>
0965	Huckleberry	<i>Vaccinium membranaceum</i>
0968	Evening primrose	<i>Oenothera elata</i>

¹ *Pinus ponderosa* var. *ponderosa*

² WC = This species is only found west of the Cascades.

9.2.5 PLANT SELECTION

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

NOTE: The borders of some biomonitoring sites are difficult to determine and crews may be uncertain how much ground area to cover to complete the plant selection procedures. Specific guidelines are not set because the constraints on crew time and resources vary considerably from one State to the next.

Time and safety concerns should take priority. Each crew must make every effort to maximize the number of plants and species evaluated for ozone injury at each plot location. Generally, ozone injury evaluations take 1 hour per site to complete and, assuming routine travel, crews are expected to complete two ozone sites in a ten-hour workday.

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

1. Identify a starting point for plant selection. This point is mapped on the site data sheet so that audit and regular crews evaluate roughly the same population of plants in subsequent visits to the plot.
2. Move away from the starting point, towards the center of the opening.
3. Begin locating individuals in a sweeping pattern, selecting plants that are growing under the same or similar growing (microhabitat) conditions. Do not skip plants with little or no injury.
4. Select the more exposed plants (high sunlight exposure) and avoid suppressed and shaded individuals. Plants along the edge of an opening may be used if, in your judgment, they receive direct sunlight for three to four hours each day.
5. Avoid plants under 12 inches in height or so tall that at least half of the crown area cannot be seen or touched.
6. Evaluate the foliage that can be seen and touched on 30 plants of each species in the opening.
7. Record the amount and severity of injury for each plant evaluated (with or without symptoms) on the PDR or data sheet.

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

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

9.2.6 SYMPTOM IDENTIFICATION AND SCORING

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

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

affected, especially for branches on the same side of the plant under similar environmental conditions (sun or shade leaves).

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

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

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

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

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

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

Percent Scale for Injury AMOUNT: Estimate and record the percentage of leaves (or needles) on the plant with ozone injury symptoms relative to the total number of leaves (or needles) on the plant.

CODE	DEFINITION
0	No injury; the plant does not have any leaves/needles with ozone symptoms.
1	1 to 6 percent of the leaves/needles have ozone symptoms.
2	7 to 25 percent of the leaves/needles are injured.
3	26 to 50 percent of the leaves/needles are injured.
4	51 to 75 percent of the leaves/needles are injured.
5	>75 percent of the leaves/needles have ozone symptoms.

Percent Scale for SEVERITY of Injury: Estimate and record the mean severity of symptoms on injured foliage.

CODE	DEFINITION
0	No injury; the plant does not have any leaves/needles with ozone symptoms.
1	On average, 1 to 6 percent of the leaf area of injured leaves/needles have ozone symptoms.
2	On average, 7 to 25 percent of the leaf area of injured leaves/needles have ozone symptoms.
3	On average, 26 to 50 percent of the leaf area of injured leaves/needles have ozone symptoms.
4	On average, 51 to 75 percent of the leaf area of injured leaves/needles have ozone symptoms.
5	On average, >75 percent of the leaf area of injured leaves/needles have ozone symptoms.

NOTE: Red and blue elderberry have compound leaves. Use the whole leaf, not each leaflet, to estimate injury AMOUNT and injury SEVERITY.

NOTE: The percent scale for ozone injury evaluations has a long history of application in plant disease research. The scale utilizes break points that correspond to the ability of the human eye to distinguish gradations of healthy and unhealthy leaf tissue (see Horsfall and Cowling 1978).

Proceed as follows:

1. Record injury AMOUNT and injury SEVERITY ratings for each plant on the PDR or data sheet.
2. Use the notes section on the PDR or data sheet to add other information that will help interpret the results (e.g., below average rainfall for the area).
3. Collect a voucher leaf sample (three leaves of each injured species evaluated at each location) and mail them to the Western Regional Trainer using the guidelines presented in section 9.2.7.

NOTE: Foliar symptoms are easiest to see under overcast skies. Bright sun will make it difficult to see the ozone stipple or chlorotic mottle. Stand so that you reduce the glare on the leaf/needle surface. Long periods without rain will inhibit symptom development even on the most sensitive plants. If there is below average rainfall for the area, please note this in the PDR or on the data sheet.

9.2.7 COLLECTION OF LEAF SAMPLES AND VOUCHER DATA

The voucher leaf samples (leaves and/or needles) are a critical aspect of the data collection procedures as they provide the necessary validation of the ozone injury symptom observed in the field by the field crews. A plant press is essential to the collection of useable leaf samples and must be taken into the field by the field crews. Crew data that do not include a voucher leaf sample with a completed voucher data sheet are removed from the FIA database.

A voucher leaf sample must be collected for each injured species evaluated on the bioindicator site. For each injured, broad-leaved species, the voucher consists of three leaves that clearly show the ozone injury symptom. For pine species with ozone injury, the voucher consists of two small branches (small terminal or lateral branch containing the full complement of needles) with obvious chlorotic mottle. If a field crew records ozone injury on red alder, Scouler's willow, and ninebark then a minimum of one voucher (3 leaves) from each of the three species (9 leaves in all) is collected and mailed to the Western Regional Trainer. In this example, three voucher data sheets (one for each species) must be filled out and mailed with the leaf samples.

The most useful voucher leaf samples show obvious foliar injury symptoms. If injury symptoms are not obvious and severe, send whatever leaf sample is available even if it is only one leaf with faint symptoms.

Cut the leaf at the petiole, shake off any excess moisture, and place the leaf on blotter paper in the plant press. Each leaf is placed in the press so that it does not overlap another leaf. Include a label with each leaf sample placed into the plant press that identifies which plot the sample came from (i.e., OZONE

HEXAGON NUMBER) and the date. Petiole labels are provided for this purpose. Record the information on the labels with indelible ink and then wrap them around the petiole of at least one leaf per sample

NOTE: Blue and red elderberry have compound leaves. Select the whole leaf (not individual leaflets) when preparing a voucher sample.

NOTE: If QA staff and regular field crews happen to be evaluating the same site at the same time, they collect and mail separate vouchers.

NOTE: The recognition of ozone injury symptoms in the field is not an exact science, and many other foliar injury symptoms can be mistaken for ozone injury. Crews are encouraged to collect voucher specimens of both known and suspected ozone injury in the field to send to the Western Regional Trainer for verification.

The voucher data sheet must be completed for plot identification codes (e.g., STATE, COUNTY, OZONE HEXAGON NUMBER and OZONE PLOT NUMBER), CURRENT DATE, CREW ID, CREW TYPE, SPECIES code(s). This sheet is filled out at the bioindicator site on the same day the sample is collected. In addition, the population of plants from which the leaf vouchers are selected must be evaluated by the field crews for INJURY LOCATION and INJURY TYPE (defined below), and for the amount of injury present on the leaf that is not ozone stipple. This information, together with the visible injury symptoms on the leaf samples, is used to validate the ozone injury data observed and recorded in the field by the field crews. For each species, the INJURY LOCATION and INJURY TYPE codes are intended to represent what the crew observed on the majority of the injured plants in the sample population. In contrast, the recorded estimates of percent injury caused by some stress other than ozone are based on what the crew observed on the injured leaf samples mailed in with the voucher data sheet.

The INJURY LOCATION and INJURY TYPE codes are recorded on the upper half of the voucher data sheet as follows:

INJURY LOCATION for Broad-leaved Species: Specify the leaf age or position of the leaves with ozone injury.

Code	Definition
1	>50% of the injured leaves are younger leaves. Younger leaves are usually located towards the branch tip (e.g., aspen, willow, oak, ninebark, and huckleberry), or top of the plant (e.g., elderberry, wormwood and snowberry).
2	>50% of the injured leaves are mid-aged or older leaves. Mid-aged and older leaves are located halfway along the branch (e.g., aspen, willow, oak, ninebark, and huckleberry) or main stem of the plant (e.g., elderberry, wormwood, and snowberry), or more towards the base of the branch or stem.
3	Injured leaves are not concentrated in any one location, leaf age or position. Injury may be spread more or less evenly over the plant or is, otherwise, difficult to describe.

INJURY LOCATION for Pines: Specify the leaf age or whorl with ozone injury.

Code	Definition
1	>50% of the injured needles are on the current whorl.
2	>50% of the injured needles are on whorls 1 year old and older.
3	Injury is not concentrated on any one needle whorl but is spread more or less evenly along the branch or is, otherwise, difficult to describe.

INJURY TYPE for Broad-leaved Species: Specify the visible injury symptom.

Code	Definition
1	The injury on >50% of the injured leaves is best described as upper-leaf-surface stipple (i.e., tiny purple-red to black spots occurring between the veins). Stippling may be associated with leaf yellowing and leaf drop late in the growing season; When injury is severe, stipples may coalesce and appear as uniform discoloration of the leaf surface.
2	The injury on >50% of the injured leaves is something other than upper-leaf-surface stipple. For example, small white to tan flecks occurring between the veins, or injury that is clearly visible on both leaf surfaces, or a general discoloration of the leaf that resembles early fall coloration.
3	The visible injury is varied or, otherwise, difficult to describe.

INJURY TYPE for Pines: Specify the visible injury symptom.

Code	Definition
1	The injury on >50% of the injured needles is best described as chlorotic mottle i.e., small patches of yellow tissue with diffuse borders and surrounded by apparently healthy (green) tissue. Chlorotic mottle may be associated with premature needle drop.
2	The injury on >50% of the injured needles is something other than chlorotic mottle. For example, winter fleck on the upper surface of the needles, or tipburn (i.e., reddish brown discoloration of the needle tips).
3	The visible injury is varied or, otherwise, difficult to describe.

NOTE: Not all location and type codes are indicative of ozone injury. Certain combinations of location and type codes, considered with a questionable leaf voucher, may invalidate the injury data. Other combinations provide quality assurance for the injury assessment. Crews should describe any unusual or questionable symptoms on the upper half of the voucher data sheet.

9.2.8 VOUCHER MAILING PROCEDURE

Vouchers are mailed in bulk at the end of the field season, or earlier, depending on the work schedule. It is very important to mail only dry, pressed leaf samples. Before mailing, make sure the upper half of the voucher data sheet has been completed. This sheet is filled out on the same day the sample is collected, even if the sample is not mailed on that day. Please comment on the weather or general plot conditions that might help interpret the injury data. For example, *"It's been 14 days now without rain," "Every plant showed the same response and it was very obvious,"* or *"This was a highly disturbed site."*

NOTE: Crews are encouraged to add information on the biosite location to the voucher data sheet such as the uncoded name of the county or closest town. This helps the Western Regional Trainer map the initial findings from the leaf vouchers and alert FIA staff to high ozone areas.

The lower half of the voucher data sheet is filled out by the Western Regional Trainer to whom you are sending the sample. Place the voucher data sheet and the leaf sample between two pieces of stiff paper or cardboard before placing into a mailing envelope addressed to the Western Regional Trainer. Do not tape the leaves or needles to the paper or cardboard. Taped samples often break apart when they are handled, making evaluation difficult. Include as many samples as fit easily into each mailing envelope. There must be a unique voucher data sheet for each sample or species, unless you are using the form for multi-species. Keep leaf samples and the corresponding leaf voucher data sheets together. Leaf samples that are separated from the corresponding leaf voucher data sheets may be mislaid, especially if leaf labels are missing or incomplete.

NOTE: The Western Regional Trainer will make every effort to provide immediate feedback on the leaf vouchers. To facilitate this, crews must fill in the contact information on the voucher data sheet.

9.2.9 CREW MEMBER RESPONSIBILITIES

1. Although one or two crew partners may be trained for this indicator, one person typically takes the lead responsibility for site selection, plant selection, and ozone injury evaluations. All procedures can be successfully completed by one person. Two person crews are recommended for safety reasons.
2. All members of the field crew may assist each other in the site selection process. Once a site is selected, one crew member is responsible for mapping the site and the location of bioindicator species on the field data sheet.
3. Only the crew member trained and certified in ozone injury evaluations may collect the amount and severity data and the leaf voucher. Other crew members may assist by recording the injury scores on the PDR or data sheet and by getting the plant press supplies ready.
4. The crew member that evaluates the plants for injury is responsible for collecting and mailing the voucher sample with air pollution symptoms.

9.2.10 FIELD PROCEDURES FOR UNTRAINED FIELD CREWS

There are certain procedures for the ozone indicator that may be performed by individuals that have not attended the ozone training and been certified to collect ozone data. These procedures still require some explanation and oversight by the certified crew member. Untrained personnel may assist in the selection and mapping of the ozone biomonitoring site and in the location and identification of bioindicator species on the selected site. They may not rate plant injury. It may also be helpful for the untrained crew person to act as the data recorder for the certified crew member, thus speeding up the data collection process.

9.3 SITE INTENSIFICATION

In addition to the unique ozone plots that are identified by the base ozone grid, some Cooperators have established additional biomonitoring sites to represent the local plant populations and environmental conditions. This is not an auxiliary effort, but an integral part of the monitoring activities for this indicator. In some States, additional biomonitoring sites are limited in number and are deliberately located close to weather and air quality monitoring stations. In other States, the ozone grid is intensified to allow for an unbiased allocation of additional biomonitoring sites. It is recommended that additional sites, whether few or many in number, be located on public land to facilitate the annual measurement activities.

Biomonitoring sites added to the base grid typically possess attributes of an ideal site for evaluating ozone injury on sensitive species. They are larger than three acres, contain the maximum number of indicator species, and have soil/site conditions with low drought potential and adequate fertility. They are evaluated for ozone injury using the same methods and during the same time frame as described in section 9.2. Voucher leaf samples must be collected, according to procedures described in section 9.2.7 and mailed to the Western Regional Trainer.

9.4 PLOT LEVEL DATA

All plot-level measurement codes for the ozone indicator are defined below. The codes and definitions are the same whether the crew is entering data using Tally (Paravant¹ or Husky) or a personal data assistant (Handspring or Palm).

¹ The use of trade or firm names in this publication is for reader information only and does not imply endorsement by the U.S. Department of Agriculture of any product or service.

Ozone plots vary in size and do not have set boundaries. When describing plot-level characteristics, use the predominant characteristics where most of the plant species are located. If conditions vary markedly across the site, or by species, then describe this in the plot notes or on the site map. Specify the elevation, aspect, terrain position, soil depth, soil drainage, and disturbance for the highest priority species (section 9.4) found on the site. The soil depth, soil drainage, and disturbance variables are intended to describe general conditions on the plot and are not based on actual measurements. For a complete explanation of the procedures associated with these measurement codes, refer to section 9.2.

9.4.1 STATE

Record the unique FIPS (Federal Information Processing Standard) code identifying the State where the plot center is located.

When collected: All plots

Field width: 2 digits

Tolerance: No errors

MQO: At least 99% of the time

Values: See Appendix 1

9.4.2 COUNTY

Record the unique FIPS (Federal Information Processing Standard) code identifying the county, parish, Borough (or unit in AK) where the plot center is located.

When collected: All plots

Field width: 3 digits

Tolerance: No errors

MQO: At least 99% of the time

Values: See Appendix 1

9.4.3 OZONE HEXAGON NUMBER

Record the unique code assigned to each ozone hexagon. In some cases this will be a former FHM or P3 hexagon.

When collected: All plots

Field width: 7 digits

Tolerance: No errors

MQO: At least 99% of the time

Values:

9.4.4 OZONE PLOT NUMBER

Record the plot number that describes whether an ozone plot consists of one or two locations. If two locations are selected, they must be within 3 miles of each other. Two locations are selected as needed to obtain optimal species and plant counts for each ozone plot. The OZONE HEXAGON NUMBER is the same for both locations.

When collected: All plots

Field width: 1 digit

Tolerance: No errors

MQO: At least 99% of the time

Values: 1 to 2

- 1 The ozone plot consists of a single location or this is the first location of a plot split between two locations.
- 2 The ozone plot is split between two locations. This code identifies the second location added by the field crew to increase species and plant counts for a single hexagon number.

9.4.5 QA STATUS

Record the code to indicate the type of plot data collected.

When collected: All plots

Field width: 1 digit

Tolerance: No errors

MQO: At least 99% of the time

Values: 1 to 2 and 4 to 7

- 1 Standard ozone plot
- 2 Cold check

- 4 Training/practice plot (off grid)
- 5 Botched plot file
- 6 Blind check
- 7 Hot check (production plot)

9.4.6 CREW TYPE

Record the code to specify what type of crew is measuring the plot.

When collected: All plots

Field width: 1 digit

Tolerance: No errors

MQO: At least 99% of the time

Values: 1 to 2

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

9.4.7 OZONE SAMPLE KIND

Record the code that describes the kind of plot being visited. OZONE SAMPLE KIND has a value of 1 when an ozone plot is established in a previously empty polygon. OZONE SAMPLE KIND has a value of 2 when remeasurement occurs at the same location, or when the replacement plot is within 3 miles of the previously established plot. OZONE SAMPLE KIND has a value of 3 when the replacement plot is more than 3 miles away from the previously established plot.

When collected: All plots

Field width: 1 digit

Tolerance: No errors

MQO: At least 99% of the time

Values: 1 to 3

- 1 Initial plot establishment on the base grid or on a newly intensified grid.
- 2 Remeasurement of a previously established plot.
- 3 Replacement of a previously established plot that was replaced because the original plot could not be relocated or because it no longer met ozone plot measurement criteria.

9.4.8 CURRENT DATE

Record the year, month, and day that the current plot visit was completed as follows:

9.4.8.1 YEAR

Record the year that the plot was completed.

When collected: All plots

Field width: 4 digits

Tolerance: No errors

MQO: At least 99% of the time

Values: Beginning with 1998, constant for a given year

9.4.8.2 MONTH

Record the month that the plot was completed.

When collected: All plots

Field width: 2 digits

Tolerance: No errors

MQO: At least 99% of the time

Values:

January	01	May	05	September	09
February	02	June	06	October	10
March	03	July	07	November	11
April	04	August	08	December	12

9.4.8.3 DAY

Record the day of the month that the plot was completed.

When collected: All plots

Field width: 2 digits

Tolerance: No errors

MQO: At least 99% of the time

Values: 01 to 31

9.4.9 OZONE GRID DENSITY

Record the code that identifies whether the plot is on the base ozone grid or on an intensified ozone grid. Note: The OZONE GRID DENSITY value = 2 when there are two ozone plots with different OZONE HEXAGON NUMBERS in the same polygon.

When collected: All plots

Field width: 1 digit

Tolerance: No errors

MQO: At least 99% of the time

Values: 1 to 2

- 1 Unique ozone plot within a polygon. (1 site:1polygon)
- 2 One of two or more ozone plots within the same polygon

9.4.10 PLOT SIZE

Record the code that indicates the size of the opening used for biomonitoring.

When collected: All plots

Field width: 1 digit

Tolerance: No errors

MQO: Repeatable estimate

Values: 1 to 2

- 1 Greater than three acres.
- 2 Greater than one acre, but less than three acres.

9.4.11 ASPECT

Record the code that identifies the direction of slope for land surfaces with at least 5 percent slope as measured with a hand compass to the nearest degree.

When collected: All plots

Field width: 3 digits

Tolerance: +/- 30°

MQO: At least 99% of the time

Values:

- | | |
|-----|------------------------------|
| 000 | No aspect, slope < 5 percent |
| 001 | 1 degree |
| 002 | 2 degrees |
| . | . |
| . | . |
| 360 | 360 degrees, due north |

9.4.12 TERRAIN POSITION

Record the code that identifies the position of the plot in relation to the surrounding topography.

When collected: All plots

Field width: 1 digit

Tolerance: Repeatable estimate

MQO: At least 99% of the time

Values: 1 to 5

- 1 Ridge top or upper slope
- 2 Bench or level area along a slope
- 3 Lower slope
- 4 Flat land unrelated to slope
- 5 Bottom land with occasional flooding

9.4.13 SOIL DEPTH

Record the code that indicates the general depth of the soil where most of the bioindicator species are growing.

When collected: All plots

Field width: 1 digit

Tolerance: Repeatable estimate

MQO: At least 99% of the time

Values: 1 to 2

- 1 Bedrock is not exposed.
- 2 Bedrock is exposed; Soil is generally shallow.

9.4.14 PLOT WETNESS

Record the code that identifies the degree of wetness where most of the bioindicator plants are growing.

When collected: All plots
Field width: 1 digit
Tolerance: Repeatable estimate
MQO: At least 99% of the time
Values: 1 to 3

- 1 This is a wet plot; Riparian zone or bottomland.
- 2 This plot is moderately dry; Meadow or Northeast facing slope.
- 3 This plot is very dry; Exposed ledge, desert or alpine area.

9.4.15 DISTURBANCE

Record the code that identifies the presence and kind of disturbance where most of the bioindicator plants are growing. The area affected by any human caused or natural disturbance must be clearly visible and recent enough to influence plant health and condition. Disturbance that results in significant soil compaction is especially significant.

When collected: All plots
Field width: 1 digit
Tolerance: Repeatable estimate
MQO: At least 99% of the time
Values: 0 to 2

- 0 No recent or significant disturbance.
- 1 Evidence of overuse; Human activity causing obvious soil compaction or erosion.
- 2 Evidence of natural disturbance including fire, wind, flooding, grazing, pests, etc.

9.4.16 INJURY CHECK

Record the code that indicates whether ozone injury was observed on non-tallied plants or species. This variable allows a plot to be identified as impacted by ozone even though there is no quantitative data on injury severity for trend analyses. A leaf voucher must be collected to validate the injury.

When collected: All plots
Field width: 1 digit
Tolerance: No error
MQO: At least 99% of the time
Values: 0 to 1

- 0 No injury was observed on non-tallied plants or species.
- 1 Ozone injury was observed on non-tallied plants or species and a leaf voucher collected.

9.4.17 ELEVATION

Obtain elevation data from USGS topographic maps, generally the 7½ minute series quadrangle. Locate the area where most of the bioindicator species are growing and record elevation to the nearest foot.

When collected: When GPS UNIT = 0
Field width: 6 digits
Tolerance: +/-200 feet
MQO: At least 99% of the time
Values:

9.4.18 Plot Notes

Use these fields to record notes pertaining to the entire plot. If the notes apply to a specific aspect of the plot, then make that clear in the notes. Record the location where GPS coordinates were collected, and GPS file name, as needed. If no GPS Unit was available, record the geographic coordinates (i.e., latitude and longitude) of the plot center in Degrees, Minutes, and Seconds using USGS topographic maps, generally the 7½ minute series quadrangle.

9.4.18.1 REMARK1 and REMARK2

Record any information on site characteristics, use of supplemental species, safety, plant location, injury patterns, or recent rainfall amounts that will assist subsequent crews visiting the site or help interpret the results.

When collected: All plots

Field width: Unlimited alphanumeric character field

Tolerance: N/A

MQO: N/A

Values: English language words, phrases and numbers

9.5 GPS COORDINATES

Use a global positioning system (GPS) unit to determine the plot coordinates and elevation of all ozone plot locations. GPS readings are collected according to procedures outlined in the FIA National Core Field Guide for Phase 2 & 3 Plots, Version 2.0. The ozone data entry applications accept GPS readings obtained using a geographic coordinate system (not UTM). If you are using UTM, record readings on the field data sheet for mapping and on the PDR Plot Notes screen. If GPS coordinates cannot be collected, elevation and plot coordinates are obtained from USGS topographic maps, generally the 7½ minute series quadrangle. Record ELEVATION on the Plot ID screen and approximate latitude and longitude on the Plot Notes screen.

Use a global positioning system (GPS) unit to determine the plot coordinates and elevation of all field-visited plot locations.

NOTE: For several of the following GPS variables, the term plot center is used. There may be no obvious center to the ozone plots. Coordinates are collected as close as possible to a central location or marker that clearly locates the plot for returning crews. Explanatory notes are added to the plot map and Plot Notes screen as needed.

9.5.1 GPS Unit Settings, Datum, and COORDINATE SYSTEM

Consult the GPS unit operating manual or other regional instructions to ensure that the GPS unit internal settings, including Datum and Coordinate system, are correctly configured.

Each FIA unit will determine the Datum to be used in that region. Most will use the NAD 27 Datum (also known as NAS-C or NA 27 CONUS/CLK66), but coordinates collected using any appropriate datum can be converted back to a national standard (NAD 83) for reporting purposes.

Each FIA unit will also determine which coordinate system to use. Regions using a Geographic system will collect coordinates in Degrees, Minutes, and Seconds of Latitude and Longitude; the regions using the UTM coordinate system will collect UTM Easting, Northing, and Zone.

9.5.2 Collecting Readings

Collect at least 180 GPS readings at the plot center (see Note above). These may be collected in a file for post-processing or may be averaged by the GPS unit. Each individual position should have an error of less than 70 feet if possible (the error of all the averaged readings is far less).

Soon after arriving at plot center, use the GPS unit to attempt to collect coordinates. If suitable positions (180 readings at error less than or equal to 70 feet) cannot be obtained, try again before leaving the plot center.

If it is still not possible to get suitable coordinates from plot center, attempt to obtain them from a location within 200 feet of plot center. Obtain the azimuth and horizontal distance from the "offset" location to plot center. If a PLGR unit is used, use the Rng-Calc function in the PLGR to compute the coordinates of the plot center. If another type of GPS unit is used, record the azimuth and horizontal distance as described in Sections 1.14.12 and 1.14.13.

Coordinates may be collected further away than 200 feet from the plot center if a laser measuring device is used to determine the horizontal distance from the "offset" location to plot center. Again, if a PLGR unit is used, use the Rng-Calc function in the PLGR to compute the coordinates of the plot center. If another type of GPS unit is used, record the azimuth and horizontal distance as described in Sections 1.14.12 and 1.14.13.

In all cases try to obtain at least 180 positions before recording the coordinates.

9.5.3 GPS UNIT

Record the kind of GPS unit used to collect coordinates. If suitable coordinates cannot be obtained, record 0.

When collected: All field visited plots
Field width: 1 digit
Tolerance: No errors
MQO: At least 99% of the time
Values: 0 to 4

- 0 GPS coordinates not collected
- 1 Rockwell Precision Lightweight GPS Receiver (PLGR)
- 2 Other brand capable of field-averaging
- 3 Other brands capable of producing files that can be post-processed
- 4 Other brands not capable of field-averaging or post-processing

9.5.4 GPS SERIAL NUMBER

Record the last six digits of the serial number on the GPS unit used.

When collected: When GPS UNIT >0
Field width: 6 digits
Tolerance: No errors
MQO: At least 99% of the time
Values: 000001 to 999999

9.5.5 GPS DATUM

Record the acronym indicating the map datum that the GPS coordinates are collected in (i.e., the map datum selected on the GPS unit to display the coordinates).

When collected: When GPS UNIT >0
Field width: 5 characters (ccn)

Tolerance: No errors
MQO: At least 99% of the time
Values:

NAD27	North American Datum of 1927
NAD83	North American Datum of 1983
WGS84	World Geodetic System of 1984

9.5.6 Latitude

Record the latitude of the plot center to the nearest hundredth second, as determined by GPS.

NOTE: The following can be customized at the region level (e.g., decimal minutes to the nearest thousandth) as long as the final results recorded are within the specified tolerance to the nearest hundredth of a second or +/- 1.01 ft.

9.5.6.1 LATITUDE DEGREES

Record the latitude degrees of the plot center as determined by GPS.

When collected: When GPS UNIT = 1, 2, 3 or 4
Field width: 2 digits
Tolerance: No errors
MQO: At least 99% of the time
Values:

9.5.6.2 LATITUDE MINUTES

Record the latitude minutes of the plot center as determined by GPS.

When collected: When GPS UNIT = 1,2,3 or 4
Field width: 2 digits
Tolerance: No errors
MQO: At least 99% of the time
Values: 1 – 59

9.5.6.3 LATITUDE SECONDS

Record the latitude decimal seconds of the plot center to the nearest hundredth place as determined by GPS.

When collected: When GPS UNIT = 1, 2, 3 or 4
Field width: 4 digits
Tolerance: +/- 140 ft
MQO: At least 99% of the time
Values: 0.00 – 59.99

9.5.7 Longitude

Record the longitude of the plot center to the nearest hundredth second, as determined by GPS.

NOTE: The following can be customized at the region level (e.g., decimal minutes to the nearest thousandth) as long as the final results recorded are within the specified tolerance to the nearest hundredth of a second or +/- 1.01 ft.

9.5.7.1 LONGITUDE DEGREES

Record the longitude degrees of the plot center as determined by GPS.

When collected: When GPS UNIT = 1, 2, 3 or 4

Field width: 3 digits

Tolerance: No errors

MQO: At least 99% of the time

Values:

9.5.7.2 LONGITUDE MINUTES

Record the longitude minutes of the plot center as determined by GPS.

When collected: When GPS UNIT = 1, 2, 3 or 4

Field width: 2 digits

Tolerance: No errors

MQO: At least 99% of the time

Values: 1 – 59

9.5.7.3 LONGITUDE SECONDS

Record the longitude decimal seconds of the plot center to the nearest hundredth place as determined by GPS.

When collected: When GPS UNIT = 1, 2, 3 or 4

Field width: 4 digits

Tolerance: +/- 140 ft

MQO: At least 99% of the time

Values: 0.00 – 59.99

9.5.8 GPS ELEVATION

Record the elevation above mean sea level of the plot center, in feet, as determined by GPS. If no GPS Unit is available, record elevation from the appropriate USGS topographic map.

When collected: When GPS UNIT = 1, 2 or 4

Field width: 6 digits

Tolerance:

MQO: At least 99% of the time

Values: -00100 to 20000

9.5.9 GPS ERROR

Record the error as shown on the GPS unit to the nearest foot.

When collected: When GPS UNIT = 1 or 2

Field width: 3 digits

Tolerance: No errors

MQO: At least 99% of the time

Values: 000 to 070 if possible

071 to 999 if an error of less than 70 cannot be obtained

9.5.10 NUMBER OF GPS READINGS

Record a 3-digit code indicating how many readings were averaged by the GPS unit to calculate the plot coordinates. Collect at least 180 readings if possible.

When collected: When GPS UNIT = 1 or 2
Field width: 3 digits
Tolerance: No errors
MQO: At least 99% of the time
Values: 001 to 999

9.5.11 GPS FILENAME (CORE OPTIONAL)

Record the filename containing the GPS positions collected on the plot.

When collected: When GPS UNIT = 3
Field width: 8 characters.3 characters e.g. R0171519.ssf
Tolerance: No errors
MQO: At least 99% of the time
Values: Letters and numbers

9.6 FOLIAR INJURY DATA

All measurement codes for the foliar injury data are defined below. Plants selected for ozone injury evaluations are rated for the percent of injured area and the severity of injury on a scale of 0 to 5 (see section 9.2.6). If a plant does not have injury, it is tallied with zeros for these measurements. A pop-up menu keeps track of plant counts by species. The plot is complete only when 30 plants of at least 3 species have been tallied, or when no additional plants can be found on the plot. Ozone plots vary in size and do not have set boundaries. Time and safety concerns should dictate how much ground area to cover to complete the foliar injury evaluation procedures.

9.6.1 SPECIES

Record the three-digit code that identifies each species on the plot. Species codes may be entered in the order they are encountered as you walk through the plot evaluating plants. A pop-up menu keeps a running total of numbers of plants and species evaluated.

When collected: All plots
Field width: 4 digits
Tolerance: No error
MQO: At least 90% of the time
Values: See 9.2.4

9.6.2 AMOUNT

Record the code that identifies the percentage of leaves on the plant with ozone injury symptoms relative to the total number of leaves on the plant. The percent scale code and definitions are fully described in section 9.2.6.

When collected: All plots
Field width: 1 digit
Tolerance: +/- 1 class
MQO: At least 90% of the time
Values: 0 - 5

- 0 No injury; The evaluated plant does not have any leaves or needles with ozone symptoms.
- 1 1 to 6 percent of the leaves/needles have ozone symptoms
- 2 7 to 25 percent of the leaves/needles are injured.
- 3 26 to 50 percent of the leaves/needles are injured.
- 4 51 to 75 percent of the leaves/needles are injured.
- 5 Greater than 75 percent of the leaves/needles have ozone symptoms.

9.6.3 NUMBER OF PLANTS

Record the number of plants tallied so far with no injury. When 0 is entered for AMOUNT, the PDR prompts for the NUMBER OF PLANTS with no injury. When a number greater than zero is entered for AMOUNT, the PDR prompts for the associated SEVERITY value. Zero and non-zero values for any species can be entered as they are encountered on the plot. The pop-up menu keeps track of plant counts by species.

When collected: When AMOUNT = 0

Field width: 2 digits

Tolerance: No error

MQO: At least 90% of the time

Values: 1 to 30

9.6.4 SEVERITY

Record the code that identifies the mean severity of symptoms on injured foliage. The percent scale code and definitions are fully described in section 9.2.6.

When collected: When AMOUNT > 0

Field width: 1 digit

Tolerance: +/- 1 class

MQO: At least 90% of the time

Values: 0 - 5

- 0 No injury. The plant does not have any leaves or needles with ozone symptoms.
- 1 On average, 1 to 6% of the leaf area of injured leaves/needles has ozone symptoms.
- 2 On average, 7 to 25% of the leaf area of injured leaves/needles has ozone symptoms.
- 3 On average, 26 to 50% of the leaf area of injured leaves/needles has ozone symptoms.
- 4 On average, 51 to 75% of the leaf area of injured leaves/needles has ozone symptoms.
- 5 On average, >75% of the leaf area of injured leaves/needles has ozone symptoms.

9.7 REFERENCES

- Brace, S. 1996. The spatial distribution of ozone in the Mount Rainier national park region. MS Thesis. University of Washington. 79 p.
- Cleveland, W.S.; Graedel, T.E. 1979. Photochemical air pollution in the Northeast United States. *Science* 204: 1273-1278.
- Davis, D.D.; Umbach, D.M. 1981. Susceptibility of tree and shrub species and response of black cherry foliage to ozone. *Plant Disease* 65:904-907.
- Duchelle, S.F.; Skelly, J.M. 1981. Response of common milkweed to oxidant pollution in the Shenandoah National Park in Virginia. *Plant Disease* 65: 661-663.
- Forest Health and Ozone*. 1987. ed: C. Hakkarinen. EPRI, EA-5135-SR. Special Report.
- Heck, Walter W. 1968. Factors influencing expression of oxidant damage to plants. *Ann. Rev. of Phytopath.* 6:165-187.
- Horsfall, J.G.; Cowling, E.B. 1978. Pathometry: the measurement of plant disease, pp. 119- 136. In: J.G. Horsfall and E.B. Cowling (eds.), *Plant Disease, an Advanced Treatise, Vol II*. New York: Academic Press, 436 pp.

- Krupa, S.V.; Manning, W.J. 1988. Atmospheric ozone: formation and effects on vegetation, *Environ. Pollut.* 50:101-137.
- Lefohn, A.S.; Pinkerton, J.E. 1988. High resolution characterization of ozone data for sites located in forested areas of the United States. *JAPCA* 38(12):1504-1511.
- Manning, W.J.; Feder, W.A. 1980. *Biomonitoring Air Pollutants with Plants*, London: Applied Science Publ. Ltd., 142pp.
- Mavity, E.; Stratton, D.; Barrang, P. 1995. Effects of ozone on several species of plants which are native to the western United States. Dry Branch, GA: USDA Forest Service Center for Forest Environmental Studies. 12 p.
- Miller, P.R.; Millecan, A.A. 1971. Extent of oxidant air pollution damage to some pines and other conifers in California. *Plant Disease Reporter* 55(6):555-559.
- Richards, B.L. Sr.; Taylor, O.C.; Edmunds, F.G., Jr. 1968. Ozone needle mottle of pines in southern California. *JAPCA* 18:73-77.
- Skelly, J.M.; Davis, D.D.; Merrill, W. [and others]. 1987. *Diagnosing Injury to Eastern Forest Trees*. USDA Forest Service and Penn State Univ. 122pp.
- Smith, W.H. 1974. Air pollution - Effects on the structure and function of the temperate forest ecosystem. *Environ. Pollut.* 6:111-129.
- Treshow, M.; Stewart, D. 1973. Ozone sensitivity of plants in natural communities. *Biol. Conservation* 5:209-214.

9.8 ACKNOWLEDGEMENTS

The National Advisor for the ozone indicator wishes to thank the individuals within FIA and FHM, as well as those outside the Forest Service that took the time to review this training section and offer suggestions for improvement and essential information to complete the guide. Special thanks to Pat Temple for his contributions to the text and to Pat, Dan Duriscoe, John Pronos, David Karnosky, Robert Kohut, and Dave Peterson who provided slides demonstrating ozone injury symptoms on the target bioindicator species for the western FIA regions. The National Advisor for this indicator may be contacted at: Gretchen Smith, Department of Natural Resources Conservation, 160 Holdsworth Way, University of Massachusetts, Amherst, MA 01003-4210 or via email at gcsmith@forwild.umass.edu

Appendix 9.A Key Identifying Characteristics of the Ozone Bioindicator Species

1. **Ponderosa Pine** is a large tree, up to 230 feet in height. Young tree bark is often thin and dark brown to black. Older tree bark is thick becoming yellow-red to cinnamon red and forming plates which slough off freely. Needles in bundles of three, 5-10 inches in length, not glaucous and yellow-green in color. Buds are resinous with red-brown scales and dark-hairy. Cones with a prickle at the tip of each scale. May be confused with Jeffrey pine which differs by having non-resinous, light-brown buds, and grayish blue-green glaucous needles.
2. **Jeffrey Pine** is a smaller tree than ponderosa pine, with darker cinnamon-red bark that may be tinged with lavender on old trunks. Needles in bundles of three, 5-10 inches in length, blue-green, and somewhat twisted. Crushed needles and twigs have a violet-like or pineapple odor. Buds are never covered with resin droplets. Cones with a prickle at the tip of each scale. May be confused with ponderosa pine.
3. **Quaking Aspen** is a medium sized tree up to 118 feet in height. Bark is smooth, greenish-white. Buds shiny but not resinous. Leaf petiole is strongly flattened. The leaf blade is broadly ovate (almost round) with a tapering tip and finely toothed margins, upper surface smooth, lower surface covered with a bloom. Aspen could be confused with black cottonwood which differs in its resinous buds, rough bark and round leaf petioles.
4. **Scouler's Willow** is a small tree or shrub up to 32 feet in height. Leaf blade is 1-4 inches in length, narrowly elliptic with the widest portion toward the tip, entire to irregularly toothed margins, lower surface smooth, upper surface shiny. This willow is NOT restricted to riparian zones. It can be easily confused with a number of other willow species. The combination of leaves widest toward the tip (mostly rounded ends and narrowly tapered bases) and the tolerance for upland (drier) habitats makes this willow relatively easy to identify.
5. **Pacific Ninebark** is a deciduous shrub 6-12 feet in height. Leaves alternate, 3 or 5 lobed (maple-like), 2-3 inches long, serrate, dark green and smooth above, paler and hairy below. Twigs red to grayish brown, splits longitudinally into long strips. Flowers small, white, borne in a cluster, stems hairy. Very similar to ninebark (see below) which is generally smaller, in drier habitats, and with densely hairy ovaries.
6. **Ninebark** is an erect, loosely branched shrub with maple-like leaves and shreddy bark. May be up to 6 feet in height. Leaves and flowers similar to Pacific ninebark except the ovaries are densely hairy. May be confused with Douglas maple which has opposite leaves, or sticky currant, which has leaves that are sticky to the touch. Often associated with ponderosa pine and Douglas-fir forests at low to mid-elevation.
7. **Huckleberry** is an erect shrub 3-5 feet high. Leaves 1-2 inches long, half as wide, thin and pale green on both surfaces, smooth or occasionally minutely hairy, margins toothed, apex and base both acute. Fruit deep purple to black round berry around 6 mm diameter. Twigs slender, green and ridged. Found on dry to moist sites, sun or shade. Similar, and often found with oval-leaved huckleberry which has entire (smooth) rather than toothed leaves.
8. **Blue Elderberry** is a tall deciduous shrub, sometimes tree-like, up to 20 feet in height. Twigs with a soft pith inside. Leaves opposite, pinnately compound, the 5-9 leaflets sharply serrate and strongly uneven at the base. Flowers small, white, flat-topped cluster. Fruit a blue-black berry covered with a white powdery bloom. This species could be confused with red elderberry which differs by having flowers in a spike and red-purple fruit. Found mostly on moist, well-drained sites in the sun; sea level to 9,000 ft.
9. **Red Elderberry** is a tall deciduous shrub, sometimes tree-like, up to 20 feet in height. Twigs with a soft pith inside. Leaves opposite, pinnately compound, the 5-7 leaflets sharply toothed and often uneven at the base. Flowers small, white, and clustered into a long spike. Fruit is a berry, most often red in color but sometimes purplish-black or yellow. Similar to blue elderberry which has a flat-topped flower cluster and a blue-black berry.
10. **Western Wormwood** is an aromatic perennial herb, 1-3 feet in height. Leaves mostly 1-4 inches long, variable in shape but most often with 3-5 narrow lobes, white hairy beneath, sometimes above as well. Flowers small and arranged in a loose, narrow flower cluster, 2-12 in long. May be confused with Douglas' wormwood which has wider leaves and is usually found in moister habitats. Also similar to Riverbank wormwood which occurs only near streams and outwash areas.
11. **Mugwort** is a large perennial herb 2-5 feet tall, usually found in large colonies in wet areas, ditches, or drainages. Leaves are evenly-spaced, 0.4-4.0 inches long, the upper leaves are narrowly elliptical, the lower widely oblanceolate, often coarsely 3 to 5 lobed near the leaf tip, 0.8-1.0 inch wide, green above, covered with dense white hair beneath. Differs from western wormwood in having wider lower leaves and in its generally damp habitat.

12. **Evening Primrose** is a large biennial with elliptical leaves up to 10 inches long in a dense rosette the first year. The large (>1m) flowering stalk with long red-tinged elliptical leaves and large bright yellow four-petaled flowers forms in the second year. Both the leaves and stem are densely hairy, and the hairs often have red, blister-like bases. Usually found in moist, sunny habitats, like seeps or meadows.
13. **Mountain Snowberry** is a shrub, 1.5-5 feet in height with a solid brown pith. Bark: shreddy, brownish. Young twigs: hairy. Leaves opposite, elliptical, 0.4-1.4 inches long and half as wide. Flowers (May-June) tubular-shaped, the petals white with a pink tube. Fruit a white berry. Common snowberry differs by having non-tubular flowers and a hollow pith. Trailing snowberry is a trailing shrub with non-tubular flowers; and Utah honeysuckle has larger leaves and a solid white pith.
14. **Red Alder** is a deciduous tree up to 65 feet tall with dark green leaves 2.4-4.7 inches long. The leaves are coarsely toothed, with smaller teeth on the leaf margins, and the leaf veins are also tightly inrolled. Red alder is a common tree in damp situations and is a frequent colonizer of clearings, especially following clearcuts in coniferous forests.
15. **Skunkbush** is a small, diffusively-branched shrub, 1.6-3.3 feet tall. The tips of the branches often droop down almost to ground level. The leaves are alternate, compound, with three leaflets, each of which is 3-lobed. The leaves resemble those of poison oak, but the leaflets of skunkbush are smaller, more hairy, and much more deeply-lobed. The leaves of skunkbush also emit a strong, ill-scented odor when crushed. However, if unsure, DO NOT crush the leaves of a shrub with three leaflets to determine the odor. Skunkbush is usually found on dry, open, brushy hillsides, while poison oak prefers damp or shaded forested areas and riparian habitats. Skunkbush is found throughout the southwest, from California and Arizona north to Colorado and Idaho.

Appendix 9.B Data Sheets

OZONE BIOINDICATOR PLANTS

BioSite Characteristics – West

This sheet must be completed only if you have *not* entered this same information on the Bioindicator Plot ID screen.

To be filled out by the FIELD CREW or Cooperator: Refer to Field Guide for code definitions.

State	County	Ozone Hexagon Number	O3Plot Number ¹	Month	Day	Year	Crew ID	Crew Type
								Regular QA

¹O3Plot Number refers to the number of locations (1 or 2) used for each hexagon number. A separate sheet should be used for each location.

Ozone Sample Kind:	
	Initial biosite establishment on the FIA ozone grid. (Data collection in a previously empty polygon)
	Remeasurement of a previously established biosite. (Data collection at the same ground location as last year)
	Replacement of a previously established biosite that was replaced to meet site selection guidelines (or lost site).

Ozone Grid Density: (Is the grid intensified, or not?)	
	This hex number identifies a unique ozone biosite within a polygon (1 site:1 polygon)
	One of two or more ozone biosites within the same polygon, each with their own hexagon number.

√ Please put a check mark beside the correct information. Please complete all data fields.

BioSite size: (Plot Size)		Terrain position:	
	> 3.0 acres (1.2 hectares)		Ridge top or upper slope
	1 to 3 acres (0.4 – 1.2 hectares)		Bench or level area along a slope
	Other: please describe		Lower slope
			Flat land unrelated to slope
			Bottom land with occasional flooding

Aspect: 000° = no aspect; 360° = N aspect		Elevation: record estimate in feet or meters	
Record to nearest degree =		Feet =	Meters =

BioSite Wetness (PlotWet):		Soil Drainage: [option]		Soil Depth:	
	Wet site Ex: riparian zones, bottomland.		Well-drained		Bedrock not exposed
	Moderately dry Ex: meadow, NE slopes.		Wet		Bedrock exposed
	Very dry Ex: exposed ledge, desert, alpine.		Excessively dry		

Disturbance: Disturbance on the site or in localized areas where the bioindicator plants are growing.	
	No recent or significant disturbance; Do not count disturbance >3 years old.
	Evidence of overuse; Human activity causing obvious soil compaction or erosion.
	Evidence of natural disturbance including fire, wind, flooding, grazing, pests, etc.

Fill in below all that apply. Check here if geographic coordinates were obtained from a topographic map:

GPS Type:	Datum:	GPS Serial Number:	
Latitude =		GPS Error =	
Longitude =		Number of Readings =	
Elevation =		GPS File Name =	
Easting:	Northing:	+/-Error(ft.):	Grid Zone:

Comments: Include information on additional species in the area, safety, directions, or additional site characteristics that may be useful.

File this completed data sheet with the bioindicator site map and driving directions in the ozone plot files for your State or Region.

OZONE BIOINDICATOR FOLIAR INJURY DATA SHEET
West Coast and Interior West and Plain States

State	County	O3HexagonNum	O3PlotNum	Month	Day	Year	Measurement Type
							___ Reg. Crew/Cooperator ___ QA crew

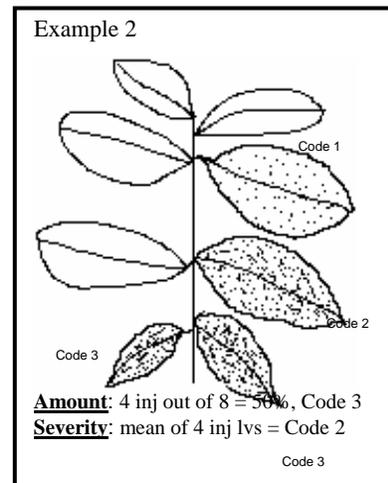
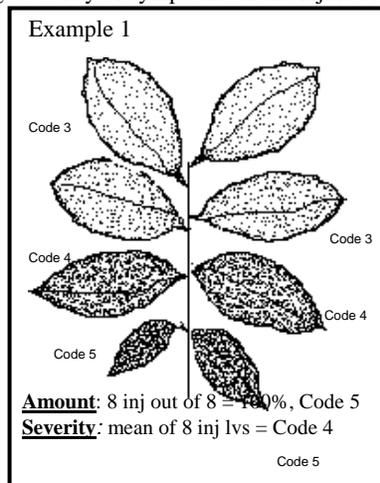
Code	Species
122	Ponderosa pine
746	Quaking aspen
924	Scouler's willow
116	Jeffrey pine
351	Red alder
969	Snowberry spp.
905	Ninebark
906	Pacific Ninebark
965	Huckleberry
960	Blue elderberry
961	Red elderberry
907	Western wormwood
908	Mugwort
909	Skunk bush
968	Evening primrose

Amount of Injury – % of leaves injured relative to the total leaf number

Severity of Injury – Average severity of symptoms on the injured leaves

Code	Scale
0	No Injury
1	1-6%
2	7-25%
3	26-50%
4	51-75%
5	>75%

Add Injury Location and Injury Type Codes to the bottom of this sheet under each Species Column. Refer to the FIA Field Guide for all codes and definitions.



Plant	Species Code									
	Amount	Severity								
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										
13										
14										
15										
16										
17										
18										
19										
20										
21										
22										
23										
24										
25										
26										
27										
28										
29										
30										

Did you collect 3 leaves that clearly show ozone stipple, for each injured species?

<input checked="" type="checkbox"/>	<input type="checkbox"/>				
-------------------------------------	--------------------------	--------------------------	--------------------------	--------------------------	--------------------------

Notes:

OZONE BIOINDICATOR PLANTS
Data Sheet for Directions and Mapping for the Bioindicator Site Location

To be filled out by the FIELD CREW or Cooperator: Refer to Field Guide for code definitions.

State	County	Ozone Hexagon Number	O3Plot Number ¹	Month	Day	Year	Crew ID

¹O3Plot Number refers to the number of locations (1 or 2) used for each hexagon number. A separate sheet should be used for each location.

Include the following information on the map:

1. Location of the site relative to some obvious and permanent marker.
2. Road names and distances as needed.
3. North arrow.
4. Species codes and approximate location of plant groupings used for the ozone injury evaluations.
5. Location and distance to two major roads; distance and direction to two major towns.
6. Gazetteer reference page if available.

Return the original of this map to the corresponding Biosite Folder so that it can be used by audit and regular crews in subsequent visits to the plot. Mail a copy to the National Indicator Advisor the year that the site is established.

GPS Type:	Datum =	GPS Serial Number:
Latitude =		GPS Error =
Longitude =		Number of Readings =
Elevation =		GPS File Name =
Easting:	Northing:	+/-Error(ft.):
		Grid Zone:

OZONE BIOINDICATOR PLANTS General Information

Preferred site characteristics:

- large, easily accessible opening
- good soil conditions
- 30 plants of 3 or more species
- free from chemical contaminants

Sampling the bioindicator site:

- identify starting point (put on map)
- select plants in a random manner
- do not skip plants with little or no injury
- avoid suppressed or shaded plants
- evaluate leaves on each plant for amount and severity of injury

Ozone injury characteristics:

- on broad-leaf plants injury is present on mid-aged and older leaves on the upper leaf surfaces
- overlapped leaves will have no injury on the bottom leaf
- stippled lesions are uniform in size and shape, most often tiny purple-red to black spots located between the veins on the upper-leaf surface
- on pine, ozone injury is usually present on older needles as small patches of yellow tissue with diffuse borders, surrounded by green tissue
- collect, press, and mail injured leaf samples for injury validation

Injury Scale

Percent Scale for Injury Amount: Estimate and record the percentage of leaves (or needles) on the plant with ozone injury symptoms relative to the total number of leaves (or needles) on the plant.

<u>CODE</u>	<u>DEFINITION</u>
-------------	-------------------

0	No injury; the plant does not have any leaves or needles with ozone symptoms.
1	1 to 6 percent of the leaves have ozone symptoms.
2	7 to 25 percent of the leaves are injured.
3	26 to 50 percent of the leaves are injured.
4	51 to 75 percent of the leaves are injured.
5	>75 percent of the leaves have ozone symptoms.

Percent Scale for Severity of Injury: Estimate and record the mean severity of symptoms on injured foliage.

<u>CODE</u>	<u>DEFINITION</u>
-------------	-------------------

0	No injury; the plant does not have any leaves or needles with ozone symptoms.
1	On average, 1 to 6 percent of the leaf area of injured leaves have ozone symptoms.
2	On average, 7 to 25 percent of the leaf area of injured leaves have ozone symptoms.
3	On average, 26 to 50 percent of the leaf area of injured leaves have ozone symptoms.
4	On average, 51 to 75 percent of the leaf area of injured leaves have ozone symptoms.
5	On average, >75 percent of the leaf area of injured leaves have ozone symptoms.

Species Codes

0122 Ponderosa Pine
0116 Jeffrey Pine
0746 Quaking Aspen
0351 Red alder
0924 Scouler's Willow
0960 Blue Elderberry
0961 Red Elderberry
0965 Huckleberry

0905 Ninebark
0906 Pacific Ninebark
0907 Western Wormwood
0908 Mugwort
0909 Skunkbush
0968 Evening Primrose
0969 Mountain Snowberry

Note: (1) The best biomonitoring site is a large opening or stand with <40 percent crown closure where many individuals (>30) of more than 2 species are growing under good conditions of soil nutrition and moisture. The site must be easy to access. (2) A leaf sample must be collected and mailed to the regional ozone expert for every species showing ozone injury symptoms on each site visited by the field crew. Failing to collect a leaf voucher means the data cannot be used.

Web Site address: fiaozone.net

OZONE BIOINDICATOR PLANTS
Data Sheet for the Voucher Leaf Samples

To be filled out by the FIELD CREW or Cooperator: Refer to the Field Guide for code definitions.

State	County	Ozone Hexagon Number	O3Plot Number ¹	Month	Day	Year	Crew ID	Crew Type
								regular QA

¹O3Plot Number refers to the number of locations (1 or 2) used for each hexagon number. Separate sheets should be used for each location.

Crew Name(s)	e-mail address	Phone number

Fill in the required codes. Code definitions are in the Field Guide. For quick reference, see below.

Bioindicator Species Code or Common Name	Injury Location	Injury Type	Is the leaf sample injury close to 100% ozone stipple (✓), or is some other upper-leaf-surface injury also present (e.g., insect or fungal lesion)?
1 st			Close to 100% _____ Estimated percent other _____
2 nd			Close to 100% _____ Estimated percent other _____
3 rd			Close to 100% _____ Estimated percent other _____
4 th			Close to 100% _____ Estimated percent other _____

List species evaluated at this location that did not have ozone symptoms: →

Notes: Add notes on the leaf samples, plot conditions, safety, and weather as needed.

122 Ponderosa pine	116 Jeffrey pine	746 Quaking aspen	924 Scouler's willow	351 Red alder
960 Blue elderberry	961 Red elderberry	965 Huckleberry	905 Ninebark	906 Pacific ninebark
907 Western wormwood	908 Mugwort	909 Skunk bush	968 Evening primrose	969 Snowberry

Injury Location Codes:
 1= greater than 50% of the injured leaves are younger leaves (broadleaf) or current whorl (pine)
 2= greater than 50% of the injured leaves are mid-aged or older (broadleaf) or on whorls 1 year and older (pine)
 3= injured leaves are all ages.

Injury Type Codes:
 1= greater than 50% of the injury is upper-leaf-surface stipple (broadleaf) or chlorotic mottle (pine).
 2= greater than 50% is not stipple (tan flecks, bifacial or general discoloration), or something other than chlorotic mottle (pine)
 3= injury is varied or difficult to describe.

Mail this sheet with the leaf samples to:

[Do not write below this line]

Pat Temple
 USDA FS, PSW Experiment Station
 4955 canyon Crest Drive
 Riverside, CA 92507

QA/QC PERSON: To be filled out by the National Ozone Advisor or Regional Expert. ✓

Date checked	Date rechecked	Sample condition			Plot Status	
		GOOD Easy to read – ID obvious	FAIR	POOR Samples unreadable or not labeled correctly	(+ozone)	(-ozone)

Bioindicator Species	Positive for ozone	Negative for ozone	Explanation

Additional questions for the data collector:

Section 10. Lichen Communities

10.1 OVERVIEW..... 2

 10.1.1 Scope and Application 2

 10.1.2 Summary of Method..... 2

 10.1.3 Equipment and Supplies 3

 10.1.3.1 Consumable Supplies 3

 10.1.3.2 Equipment and Apparatus 3

 10.1.4 Procedure..... 4

 10.1.5 Safety 6

 10.1.6 Assistance From Persons Not Certified For Lichens..... 6

10.2 DATA COLLECTION 1: SAMPLE PROCUREMENT..... 6

10.3 DATA COLLECTION 2: PDR AND WRITTEN DATA 8

 10.3.1 OVERVIEW..... 8

 10.3.2 P3 HEXAGON NUMBER 9

 10.3.3 FIA PLOT NUMBER 9

 10.3.4 STATE..... 9

 10.3.5 COUNTY 9

 10.3.6 DATE..... 10

 10.3.7 LICHEN PROJECT 10

 10.3.8 COLLECTION NUMBER 10

 10.3.9 ABUNDANCE 10

 10.3.10 CREW MEMBER NAME 11

 10.3.11 CREW TYPE..... 11

 10.3.12 QA STATUS..... 11

 10.3.13 LICHENS COLLECTED 12

 10.3.14 TIME LICHEN SAMPLING BEGAN..... 12

 10.3.15 TIME LICHEN SAMPLING ENDED 12

 10.3.16 % COVER LICHEN PLOT CONIFERS..... 12

 10.3.17 % COVER LICHEN PLOT HARDWOODS 13

 10.3.18 % COVER LICHEN PLOT TALL SHRUBS..... 13

 10.3.19 MOST IMPORTANT TREE AND SHRUB SPECIES..... 14

 10.3.20 IMPORTANT SUBSTRATE SPECIES NOT ON SUBPLOTS 14

 10.3.21 Gap 14

 10.3.21.1 % GAP 14

 10.3.21.2 RECENT 15

 10.3.21.3 TALL SHRUBS 15

 10.3.22 SIZE CLASS OF 3 LARGEST TREES ENCOUNTERED ON THE LICHEN PLOT..... 15

 10.3.23 FEATURES IMPORTANT FOR HIGH/LOW LICHEN DIVERSITY 15

 10.3.24 SAMPLING ISSUES OR PROBLEMS..... 16

10.4 SAMPLE PRESERVATION, STORAGE, AND MAILING 17

10.5 REFERENCES..... 18

10.6 ACKNOWLEDGEMENTS 19

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.

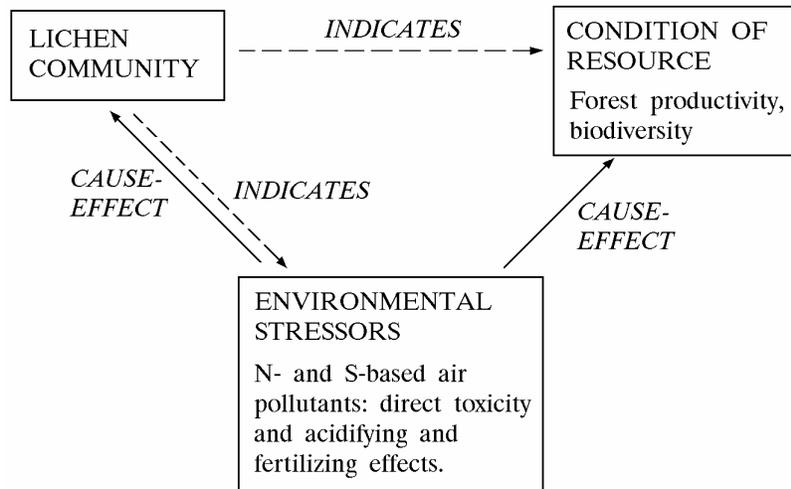


Figure 10-1. Conceptual model of the lichen community indicator.

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.

3.0 Phase 3 Field Guide – Lichen Communities
October 1, 2005

- 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 $40830 \text{ ft}^2 \approx 3793 \text{ m}^2 \approx 0.379 \text{ ha} \approx 0.937 \text{ acres}$.

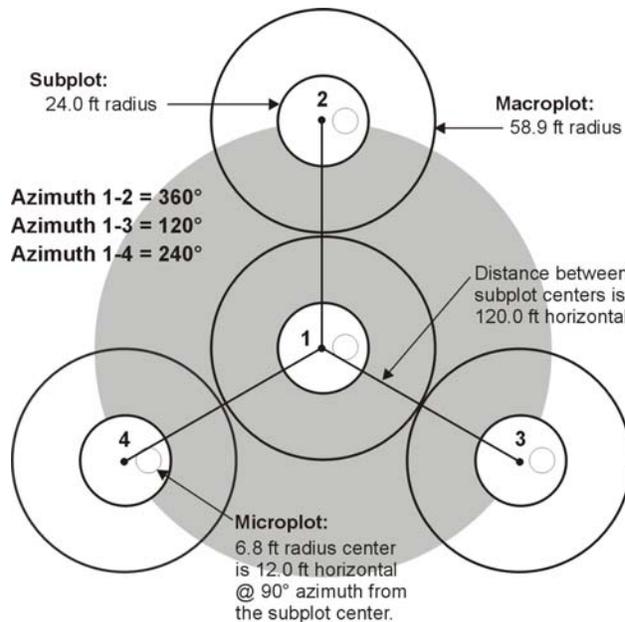


Figure 10-2. Lichen sampling area. The shaded area is the lichen plot.

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.)

<u>Code</u>	<u>Abundance</u>
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.

- 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.
- Label all of the packets from that day with STATE, COUNTY, P3 HEXAGON NUMBER, CURRENT DATE, PACKET NUMBER, and ABUNDANCE.
- 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**.
- 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).
- 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*.
- 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:			
<ul style="list-style-type: none"> • 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:

<u>Code</u>	<u>Abundance</u>
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:

<u>Code</u>	<u>Size class (DBH, inches)</u>
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."

- McCune, B. 1988. Lichen communities along O₃ and SO₂ gradients in Indianapolis. *Bryologist* 91: 223-228.
- McCune, B. 1992. Field Key to the Lichens of the Northwest Forests West of the Cascade Crest. Dept. Botany and Plant Pathology, Oregon State University, Corvallis. 19 pp.
- McCune, B. and L. Geiser. 1997. *Macrolichens of the Pacific Northwest*. Oregon State University Press, Corvallis. 386 pp.
- McCune, B. and T. Goward. 1995. *Macrolichens of the Northern Rocky Mountains*. Eureka, CA: Mad River Press. 208 pp.
- McCune B. and J. Peck. 1994. Lichen Communities Training Document. Oregon State University, Department of Botany and Plant Pathology, Corvallis, Oregon.
- Pollard, J.E.; Palmer, C.J. 1998. Forest health monitoring plot component quality assurance plan (national 1998). Research Triangle Park, NC: U.S. Department of Agriculture Forest Service, National Forest Health Monitoring Program.
- Smith, C., L. Geiser, L. Gough, B. McCune, B. Ryan, and R. Showman. 1993. Species and communities. Chapter 4 in *Lichen as Bioindicators of Air Quality*. USDA Forest Service Gen. Tech. Rep. RM-224.
- van Dobben, H. 1993. Vegetation as a monitor for deposition of nitrogen and acidity. PhD Dissertation, Utrecht University, Netherlands. 214 pp. (privately published)
- Vitt, D.H., J.E. Marsh, and R.B. Bovey. 1988. *Mosses, Lichens and Ferns of Northwest North America*. Lonepine Publishing. 296 pp.

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	2
11.1 SUMMARY OF METHOD	2
11.2 DEFINITIONS	3
11.3 EQUIPMENT AND SUPPLIES	4
11.3.1 Field Gear Unique to the Soil Indicator	4
11.3.2 Optional Soils Equipment	4
11.3.3 Required Equipment not Unique to the Soil Indicator:	4
11.4 LABORATORY ANALYSES	5
11.5 QUALITY ASSURANCE (QA)	5
11.5.1 Training And Certification	5
11.5.2 Hot Checks, Cold Checks, and Blind Checks.....	5
11.5.3 Reference Plots	6
11.5.4 Debriefing	6
11.6 SOIL EROSION AND COMPACTION	6
11.6.1 PERCENT COVER OF BARE SOIL.....	7
11.6.2 PERCENT COMPACTED AREA ON THE SUBPLOT	7
11.6.3 TYPE OF COMPACTION - RUTTED TRAIL.....	8
11.6.4 TYPE OF COMPACTION – COMPACTED TRAIL.....	8
11.6.5 TYPE OF COMPACTION – COMPACTED AREA	8
11.6.6 TYPE OF COMPACTION – OTHER	9
11.7 SOIL SAMPLE COLLECTION	9
11.7.1 Forest Floor.....	10
11.7.2 Assembly and Operation of Impact Driven Soil Corer (Bulk Density Sampler)	11
11.7.3 Mineral Soil	13
11.7.4 Regulations Governing Sample Collection (National Historic Preservation Act)	13
11.7.5 Alternate Sampling Methods for “Problem” Soils.....	14
11.7.6 Commonly Encountered Problems	14
11.7.7 Organic soils	15
11.7.8 SUBPLOT NUMBER	16
11.7.9 CONDITION CLASS.....	16
11.7.10 VISIT NUMBER	16
11.7.11 SOIL SAMPLE STATUS.....	16
11.7.12 FOREST FLOOR THICKNESS – NORTH	17
11.7.13 FOREST FLOOR THICKNESS – EAST.....	17
11.7.14 FOREST FLOOR THICKNESS – SOUTH.....	18
11.7.15 FOREST FLOOR THICKNESS – WEST.....	18
11.7.16 THICKNESS OF THE LITTER LAYER - NORTH.....	18
11.7.17 THICKNESS OF THE LITTER LAYER - EAST	19
11.7.18 THICKNESS OF THE LITTER LAYER - SOUTH.....	19
11.7.19 THICKNESS OF THE LITTER LAYER - WEST	19
11.7.20 DEPTH TO RESTRICTIVE HORIZON	19
11.7.21 SOIL TEXTURE IN THE 0-4 INCH LAYER	20
11.7.22 SOIL TEXTURE IN THE 4-8 INCH LAYER	20
11.8 SAMPLE LABELS	21
11.9 SAMPLE SHIPPING	22
11.9.1 Shipping Forms.....	22
11.9.2 Government Regulations For Pest-Regulated States (Southern Region, NY, AZ, NM, CA, and HI)	26
11.10 TASKS THAT CAN BE PERFORMED BY OTHER CREW MEMBERS	26
11.11 REFERENCES	26
11.12 ACKNOWLEDGEMENTS	27
11.13 EXAMPLE DATA SHEETS	28

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,

3.0 Phase 3 Field Guide – Soil Measurements and Sampling October, 2005

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 (<u>Humus</u>)	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 or ruler graduated in tenths of an inch 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.

**3.0 Phase 3 Field Guide – Soil Measurements and Sampling
October, 2005**

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%	
30 26-30%	70 66-70%	

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

**3.0 Phase 3 Field Guide – Soil Measurements and Sampling
October, 2005**

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.

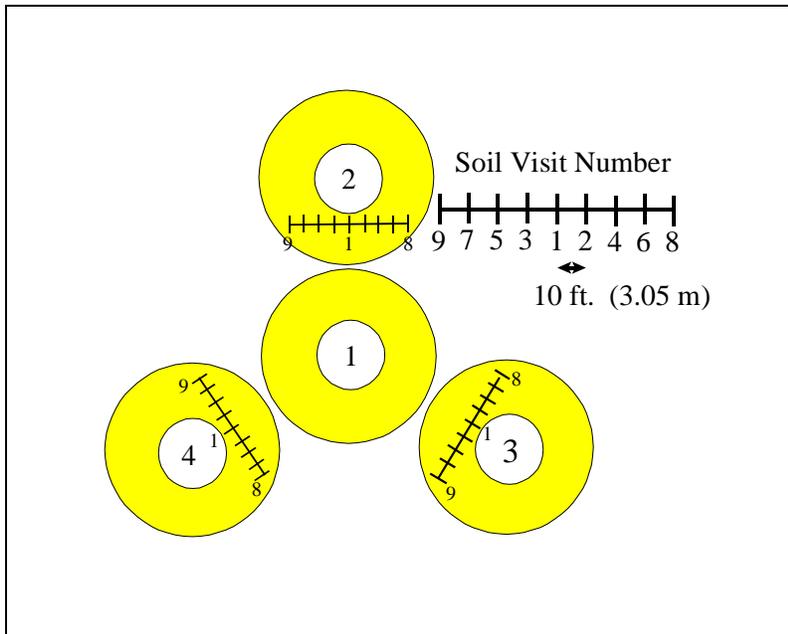


Figure 11-1. Location of soil sampling sites

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.

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.

3.0 Phase 3 Field Guide – Soil Measurements and Sampling
October, 2005

- 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).
3. Replace the soil sampling frame. Using a pair of clippers, carefully remove all live vegetation from the sample area. Living mosses should be clipped at the base of the green, photosynthetic material.
 4. Using a sharp knife or a pair of clippers, carefully cut through the forest floor along the inner surface of the frame to separate it from the surrounding soil.
 5. Using inward scooping motions, carefully remove the entire volume of the forest floor from within the confines of the sampling frame. Discard all woody debris (including pine cones, large pieces of bark, and decomposed wood) above 0.25 inches in diameter (approximately the diameter of a pencil). Discard any rocks or pebbles collected with the forest floor material.
 6. Working over the tarp, place the entire forest floor layer sample into a pre-labeled gallon sample bag. In some areas more than one bag might be required to hold the sample. If so, label the bags with identical information, then add "1 of 2" and "2 of 2" respectively.

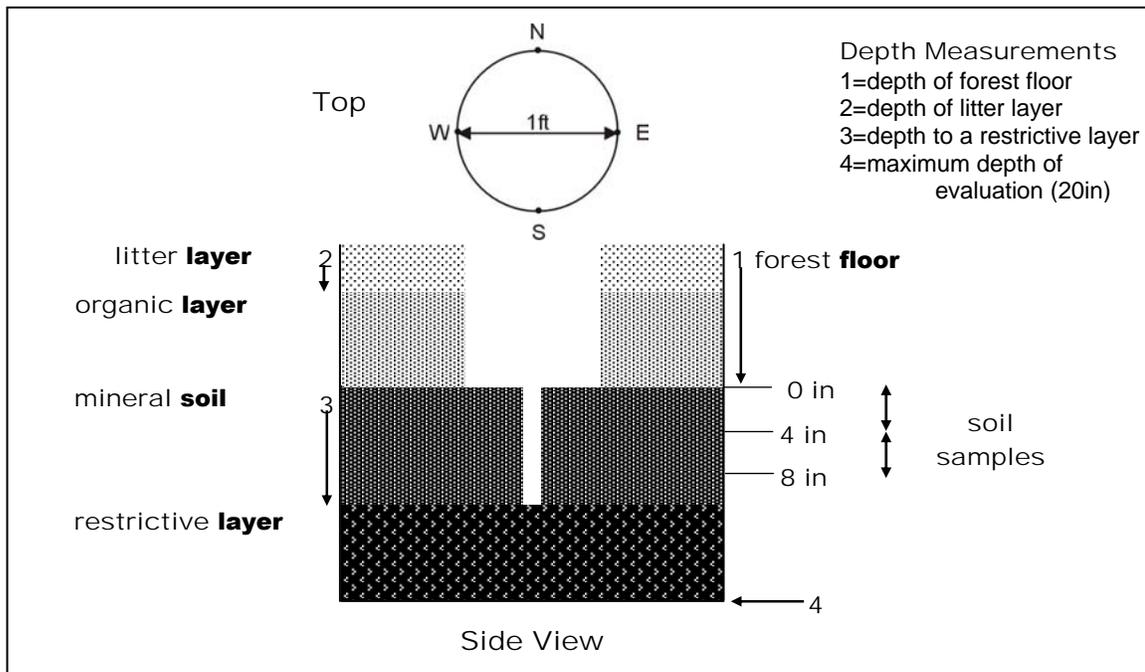


Figure 11-2. Cross-sectional views of sampling sites (top view and side view).

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.

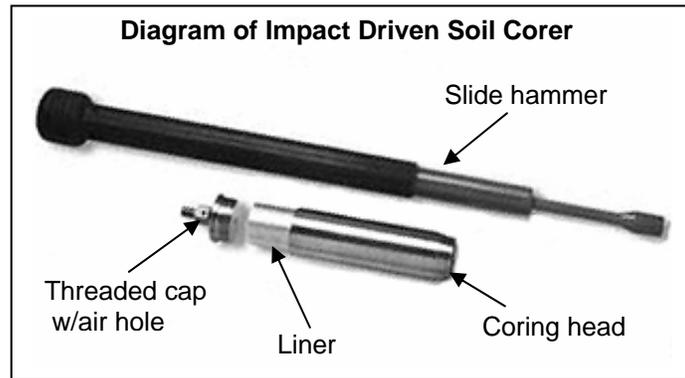


Figure 11-3. Diagram of Impact Driven Soil Corer

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.

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

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).

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

**3.0 Phase 3 Field Guide – Soil Measurements and Sampling
October, 2005**

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.

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
Sampler:	Bulk density	Other

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.

**3.0 Phase 3 Field Guide – Soil Measurements and Sampling
October, 2005**

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

3.0 Phase 3 Field Guide – Soil Measurements and Sampling October, 2005

- 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.

NAME:

Enter your name here.

SHIPPED VIA:

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

SIGNATURE:

Sign your name here.

TRACKING NUMBER:

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

STATE CODE:

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

DATE:

Enter the date on which samples were shipped.

CREW NUMBER:

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

QA STATUS:

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

P3 HEXAGON NUMBER:

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

STATE

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

COUNTY

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

PLOT NUMBER

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

DATE SAMPLED:

Enter the date that the soil sample was collected.

LAYER TYPE:

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

SUBPLOT NUMBER:

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

BAGS/SAMPLE

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

TOTAL NUMBER OF BAGS SENT:

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

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

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

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

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

3.0 Phase 3 Field Guide – Soil Measurements and Sampling October, 2005

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

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

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

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

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

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.

**3.0 Phase 3 Field Guide – Soil Measurements and Sampling
October, 2005**

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		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
Subplot 2:	_____	_____	_____	_____		
Subplot 3:	_____	_____	_____	_____		
Subplot 4:	_____	_____	_____	_____		
Forest Floor Thickness (inches)						
		<u> N </u>	<u> E </u>	<u> S </u>	<u> W </u>	
Subplot 2 Soil Sampling Site:		_____	_____	_____	_____	
Subplot 3 Soil Sampling Site:		_____	_____	_____	_____	
Subplot 4 Soil Sampling Site:		_____	_____	_____	_____	
Litter Layer Thickness (inches)						
		<u> N </u>	<u> E </u>	<u> S </u>	<u> W </u>	
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) _____			0 = Organic	
Subplot 3 Soil Sampling Site:	Mineral 1 (0-4 in) _____	Mineral 2 (4-8 in) _____			1 = Loamy	
Subplot 4 Soil Sampling Site:	Mineral 1 (0-4 in) _____	Mineral 2 (4-8 in) _____			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

**3.0 Phase 3 Field Guide – Soil Measurements and Sampling
October, 2005**

**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 2
12.2 CROWN DEFINITIONS..... 2
12.3 CROWN DENSITY-FOLIAGE TRANSPARENCY CARD..... 5
12.4 CROWN RATING PRECAUTIONS 6
12.5 UNCOMPACTED LIVE CROWN RATIO..... 7
12.6 CROWN LIGHT EXPOSURE..... 10
12.7 CROWN POSITION 12
12.8 CROWN VIGOR CLASS..... 13
12.9 CROWN DENSITY 14
12.10 CROWN DIEBACK 16
12.11 FOLIAGE TRANSPARENCY..... 19
12.12 ACKNOWLEDGEMENTS 20

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.

DETERMINING CROWN BASE & USE OF 5' RULE

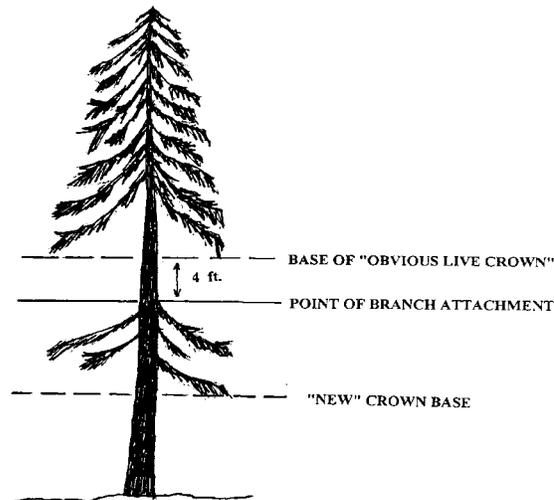


Figure 12-1. Determining the base of the live crown.

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

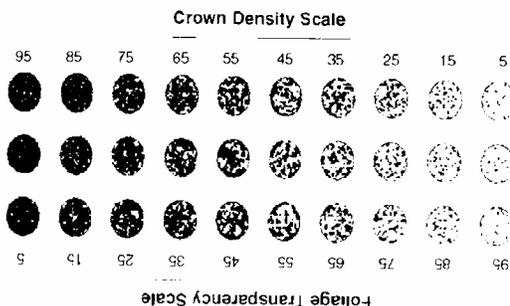
Any woody or non-woody lateral growth, without secondary branching, less than 1.0 inch in diameter at the base above the swelling at the point of attachment to a branch or crown stem.

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



Back

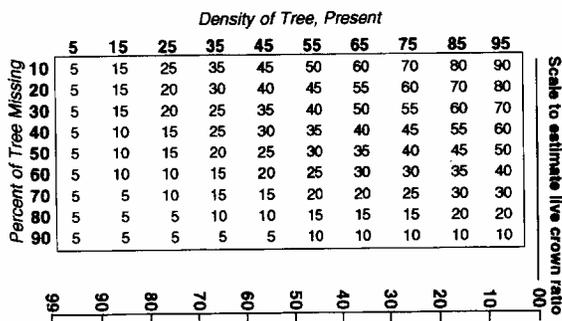


Figure 12-2. Density-Transparency card

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.

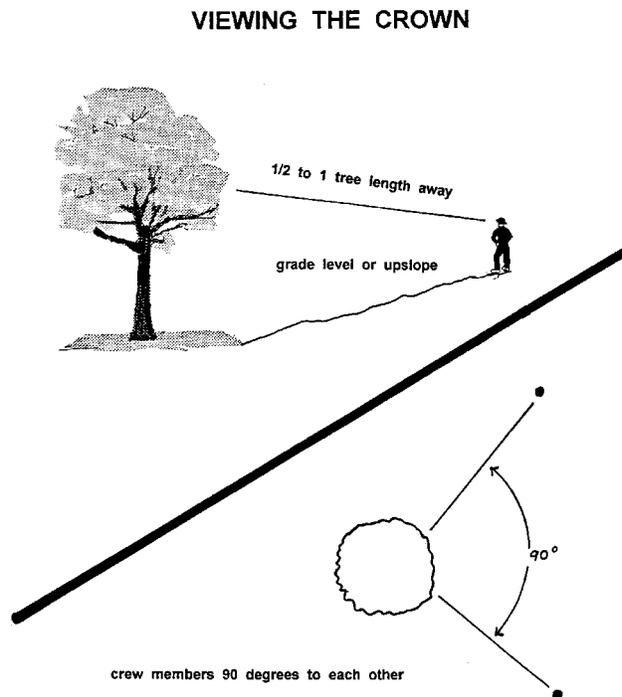


Figure 12-3. Crew positions for viewing crowns.

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*.

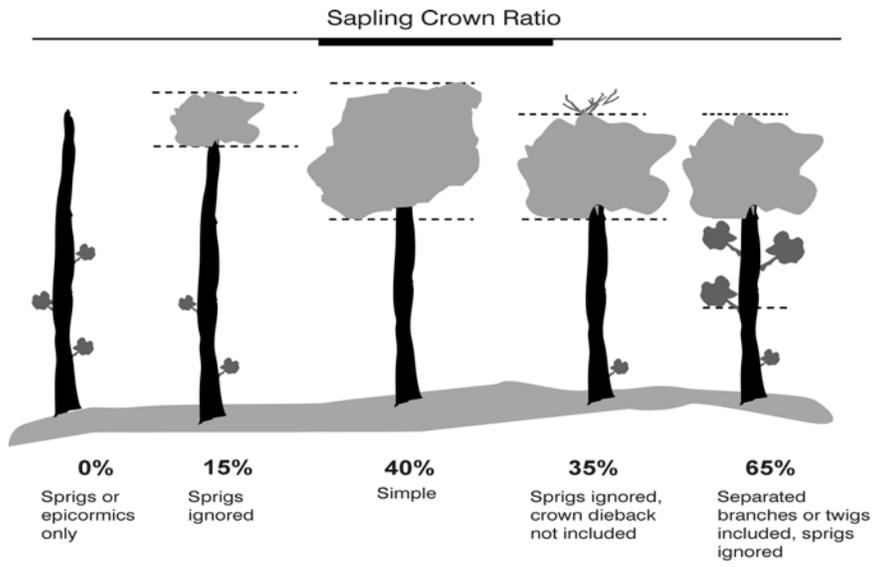


Figure12-4. Sapling UNCOMPACTED LIVE CROWN RATIO determination examples.

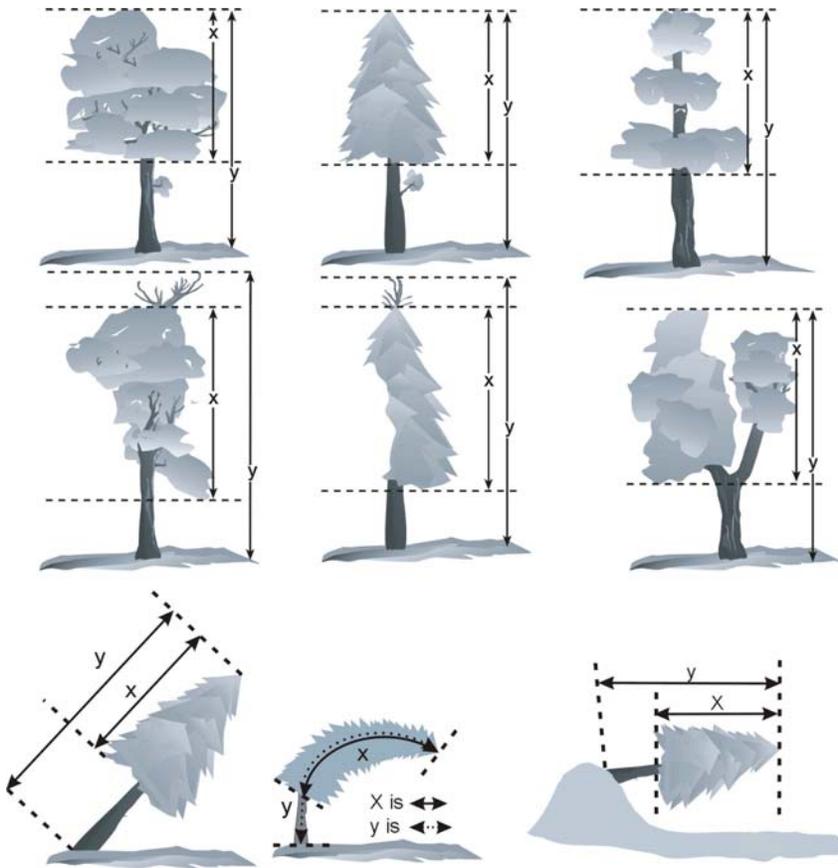


Figure 12-5. UNCOMPACTED LIVE CROWN RATIO examples.

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*.

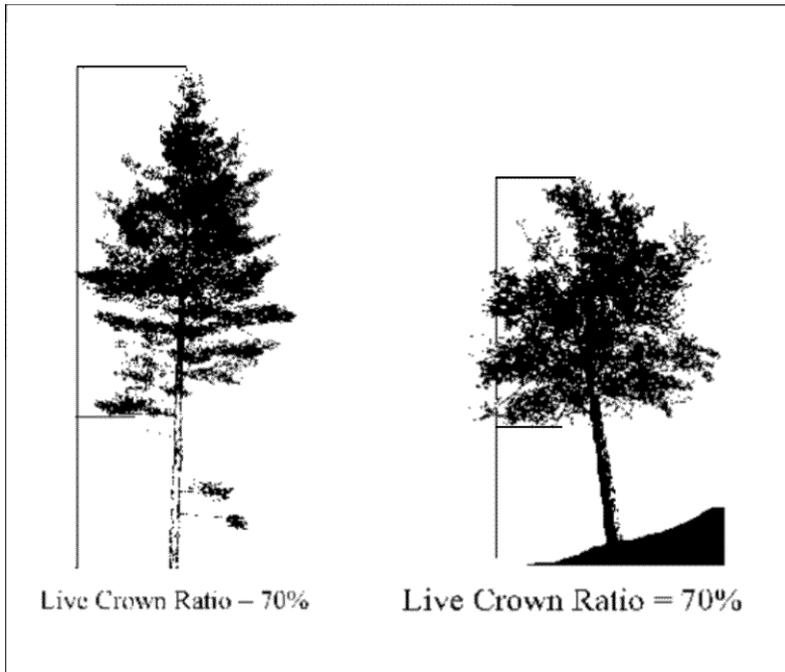


Figure 12-6. UNCOMPACTED LIVE CROWN RATIO outline and rating examples

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 99 percent

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 uncompact 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).

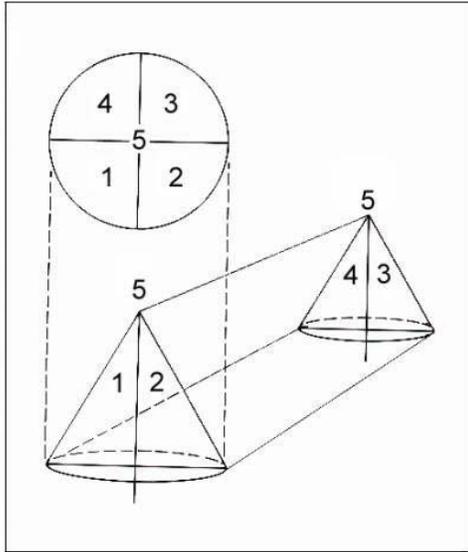


Figure 12-7. Dividing the crown.

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

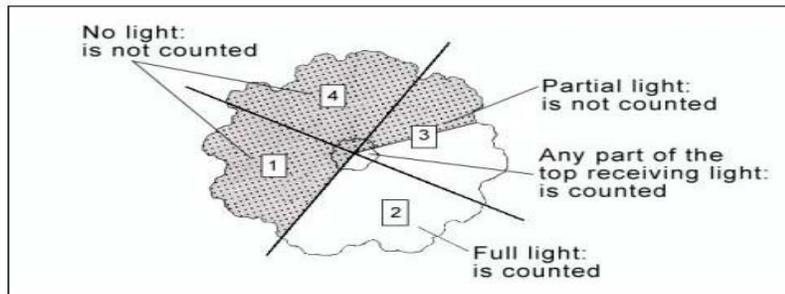


Figure 12-8. CROWN LIGHT EXPOSURE.

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.

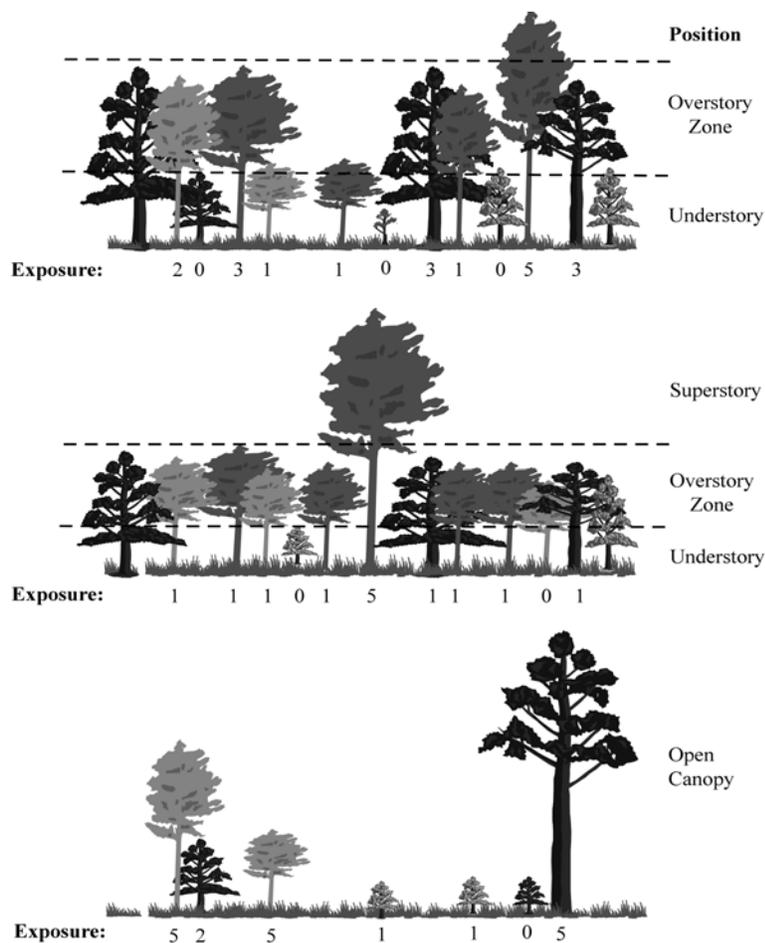


Figure 12-9. CROWN LIGHT EXPOSURE and CROWN POSITION.

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.

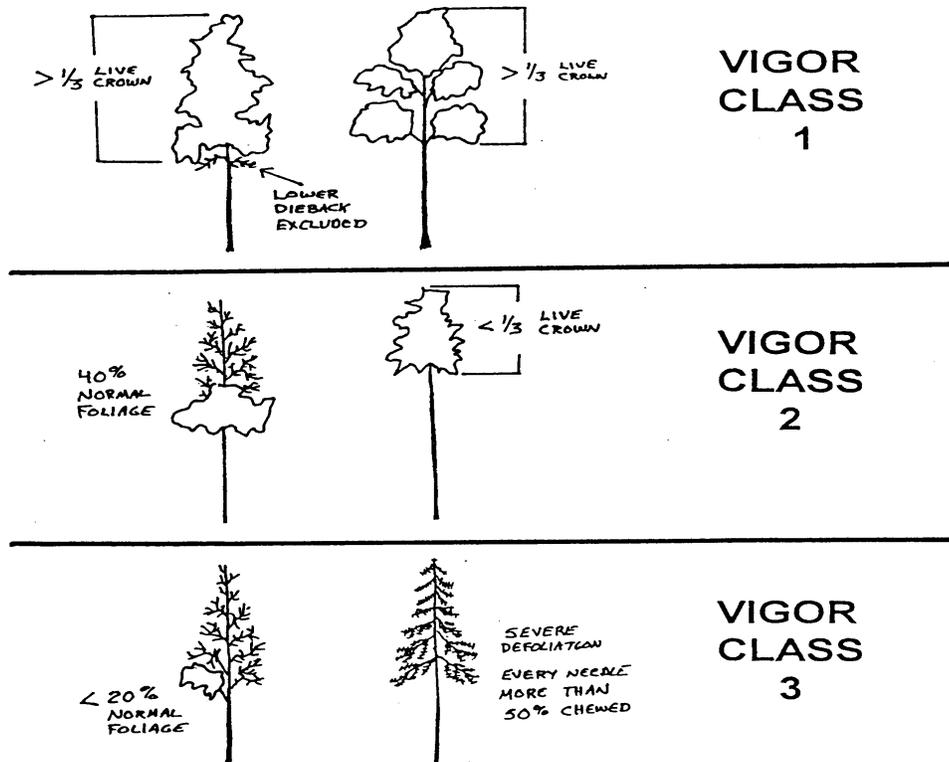


Figure 12-10. Sapling CROWN VIGOR classes.

3.0 Phase 3 Field Guide - Crowns: Measurements and Sampling October, 2005

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:

<u>Class/Code</u>	<u>Definition</u>
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.

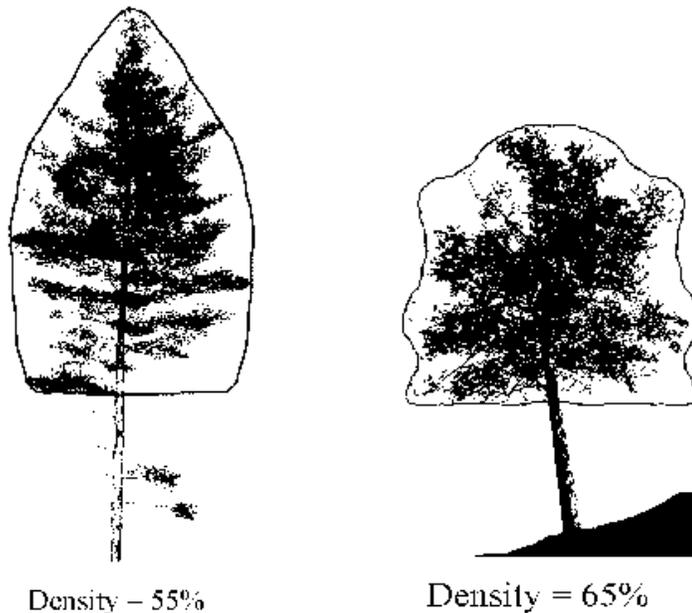


Figure 12-12. Crown density outline and rating examples

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).

3.0 Phase 3 Field Guide - Crowns: Measurements and Sampling
October, 2005

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.

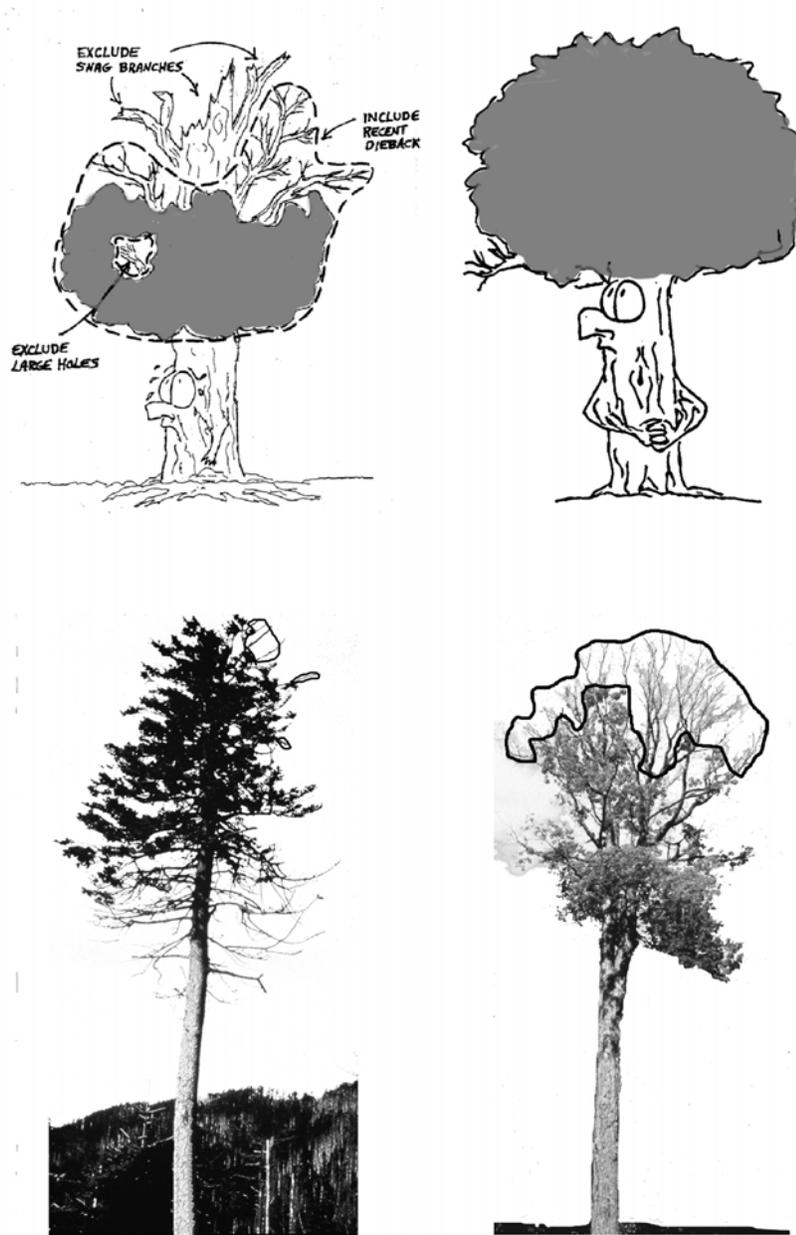


Figure 12-13. CROWN DIEBACK rating outline examples.

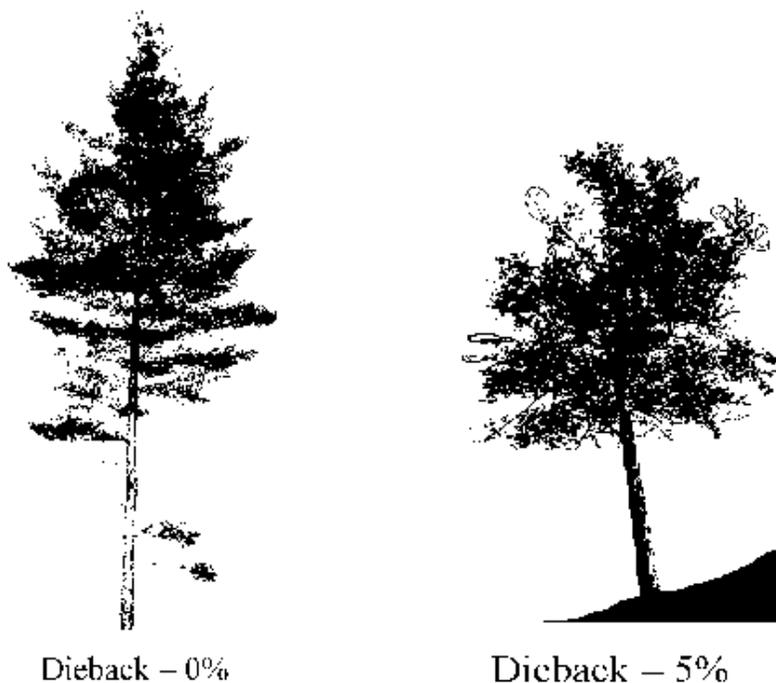


Figure 12-14. Dieback outline and rating examples.

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).

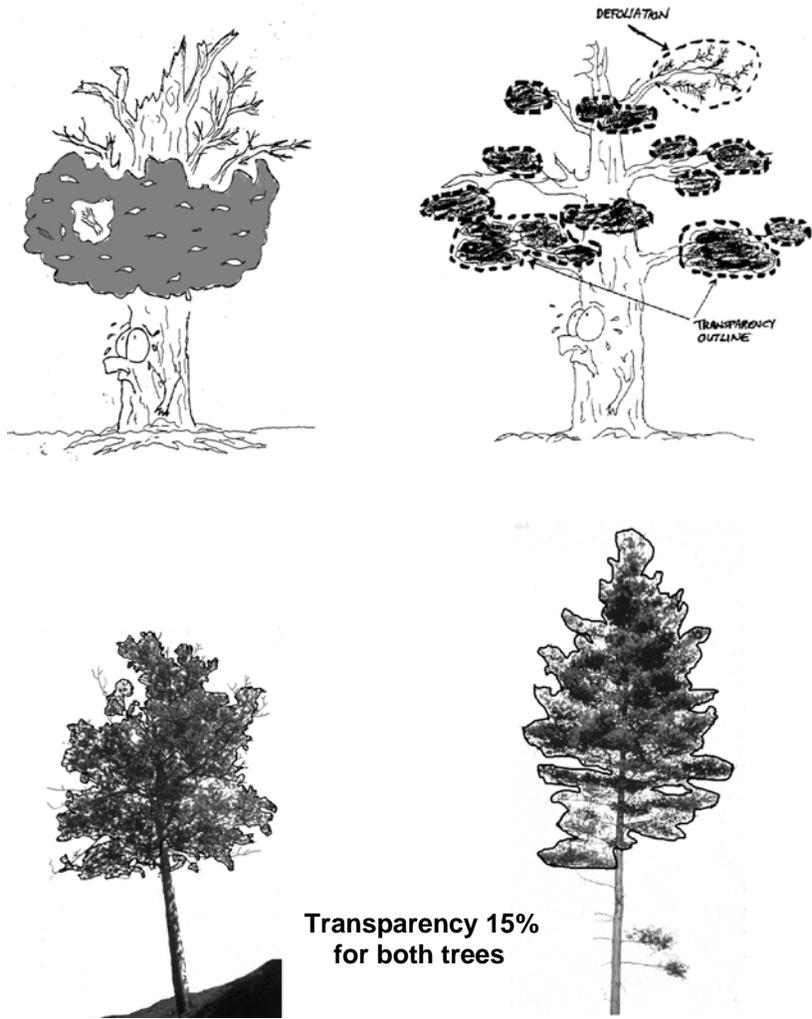
When defoliation is severe, branches alone will screen the light, but you should exclude the branches from the foliage outline and rate the area as if the light was penetrating those branches. For example, an almost completely defoliated dense spruce may have less than 20 percent skylight coming through 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.

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.



Transparency 15%
for both trees

Figure 12-15. FOLIAGE TRANSPARENCY rating outline examples.

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 .

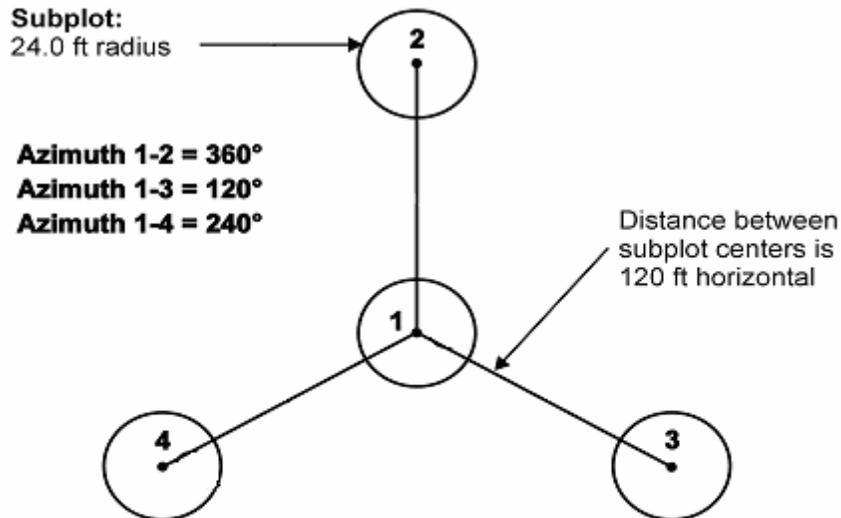
3.0 Phase 3 Field Guide – Vegetation Diversity and Structure
October, 2005

Section 13. Vegetation Diversity and Structure

13.0	INTRODUCTION	3
13.1	SAMPLE DESIGN	3
13.2	SUGGESTED FIELD GEAR UNIQUE TO VEGETATION INDICATOR	5
13.3	PLOT AND VISIT REFERENCE INFORMATION	6
13.3.1	STATE	6
13.3.2	COUNTY	6
13.3.3	PLOT NUMBER	6
13.3.4	QA STATUS.....	6
13.3.5	VEG CREW TYPE	7
13.3.6	VEG SAMPLE KIND	7
13.3.7	VEG VISIT DATE.....	7
13.3.8	VEGETATION SPECIALIST CREW NAME	8
13.3.9	VEG PLOT NOTES.....	8
13.4	SUBPLOT INFORMATION	8
13.4.1	SUBPLOT NUMBER.....	8
13.4.2	VEG SUBPLOT STATUS	8
13.4.3	VEG SUBPLOT NONSAMPLED REASON	9
13.4.4	PERCENT SUBPLOT AREA ACCESSIBLE FOREST LAND	9
13.4.5	DETAILED NONFOREST LAND USE.....	9
13.4.6	COMMUNITY DESCRIPTION FOR SPECIMEN LABELS (CORE OPTIONAL).....	10
13.4.7	VEG SUBPLOT NOTES	10
13.5	SUBPLOT TOTAL CANOPY COVER BY LAYER	10
13.5.1	SUBPLOT CANOPY COVER LAYER 1 (0 – 2 feet above ground)	11
13.5.2	SUBPLOT CANOPY COVER LAYER 2 (>2 – 6 ft).....	11
13.5.3	SUBPLOT CANOPY COVER LAYER 3 (>6 – 16 ft)	11
13.5.4	SUBPLOT CANOPY COVER LAYER 4 (> 16 ft).....	11
13.6	SUBPLOT GROUND VARIABLE RECORDS	11
13.6.1	PERCENT CRYPTOBIOTIC CRUST COVER	12
13.6.2	PERCENT LICHEN COVER.....	12
13.6.3	PERCENT LITTER/DUFF COVER.....	12
13.6.4	PERCENT MINERAL SOIL COVER.....	12
13.6.5	PERCENT MOSS COVER	13
13.6.6	PERCENT ROAD/TRAIL COVER	13
13.6.7	PERCENT ROCK COVER	13
13.6.8	PERCENT STANDING WATER/FLOODED COVER.....	13
13.6.9	PERCENT STREAM/LAKE COVER.....	13
13.6.10	PERCENT TRASH/JUNK/OTHER COVER.....	14
13.6.11	PERCENT WOOD COVER	14
13.7	QUADRAT DATA	14
13.7.1	SUBPLOT NUMBER.....	14
13.7.2	QUADRAT NUMBER.....	15
13.7.3	QUADRAT CONDITION CLASS NUMBER.....	15
13.7.4	QUADRAT STATUS	15
13.7.5	TRAMPLING	15
13.7.6	VEG QUADRAT NOTES	16
13.8	SPECIES RECORDS	16

3.0 Phase 3 Field Guide – Vegetation Diversity and Structure
October, 2005

13.8.1 Plot Species List.....	16
13.8.1.1 SPECIES CODE	16
13.8.1.2 UNIQUE SPECIES NUMBER.....	17
13.8.1.3 SPECIMEN OFFICIALLY COLLECTED.....	17
13.8.1.4 SPECIMEN LABEL NUMBER	17
13.8.1.5 SPECIMEN NOT COLLECTED REASON CODE	17
13.8.1.6 PLOT SPECIES NOTES.....	18
13.8.2 Quadrat Species Data Collection	18
13.8.2.1 SPECIES PRESENCE/ABSENCE ON QUADRAT	18
13.8.3 Subplot Species Data Collection	18
13.8.3.1 SUBPLOT SPECIES TOTAL PERCENT CANOPY COVER	19
13.8.3.2 SUBPLOT SPECIES PERCENT CANOPY COVER LAYER 1 AND 2	19
13.8.3.3 SUBPLOT SPECIES PERCENT CANOPY COVER LAYER 3	20
13.8.3.4 SUBPLOT SPECIES PERCENT CANOPY COVER LAYER 4	20
13.9 UNKNOWN SPECIES AND VOUCHER SPECIMEN COLLECTION	21
13.9.1 Field Specimen Label.....	21
13.9.2 Official Specimen Label	21
13.9.3 Specimen Collection and Handling	23
13.10 REFERENCES	24
13.11 ACKNOWLEDGEMENTS	25
13.12 CODES FOR UNKNOWN PLANTS	26
P3 VEG DATA SHEETS: Plot and Subplot Information	27



FIA plot diagram.

13.0 INTRODUCTION

The objectives of the Phase 3 (P3) Vegetation Indicator are to measure the type, relative abundance, and vertical position of all trees, shrubs, herbs, grasses, ferns and fern allies within each P3 plot. We use this information to assess forest ecosystem health in terms of diversity and rates of change of community structure for both native and non-native vascular plant species. While individual species can be important indicators of a site's potential productivity, economic value, and wildlife forage and shelter, changes in the composition and spatial arrangement of vascular plants in a forest may indicate the presence of chronic stresses such as discrete site degradation, climate change, and pollution. These stresses can lead to decline or local eradication of sensitive species, as well as increase and dominance of opportunistic species, such as many weedy non-native plants.

Vegetation diversity and structure data can also be used to classify P3 plots by locally defined plant communities or associations, allowing extrapolation of other forest health monitoring results to broader areas.

The accepted technique used by vegetation scientists to sample plant composition and diversity is to install nested plots of different sizes within a given plant community (Mueller-Dombois and Ellenberg 1974, Barbour and others 1987). Multi-scale sampling is necessary because different communities have different spatial patterns of species richness, so a single plot size is an arbitrary sample of species diversity. Sampling at two or more scales provides information about the structure of a plant community and distribution of individual species, which allows better comparison among communities (and forest types), allows us to estimate how many additional species might occur beyond our largest plot size (i.e., were "missed") (Stohlgren and others 1995), and allows us to measure change in composition over time.

Data will be collected by crew members who have been trained and certified in the Vegetation Indicator methods. These crew members are expected to have had previous botanical training; while we can provide some refresher training in local flora, the skills needed to be an effective field vegetation specialist are beyond the scope of what we can provide during a short training period at the beginning of the field season.

Crew members who are not certified in Vegetation Indicator methods may assist the field vegetation specialist by:

1. Sharing CONDITION CLASS number information
2. Assisting with DETAILED NONFOREST LAND USE descriptions
3. Laying out transects
4. Locating quadrat corners
5. Collecting unknown specimens
6. Entering data
7. Aiding in tree identification

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

13.1 SAMPLE DESIGN

Phase 3 sampling of vegetation is focused on accessible forest condition classes. If the total area of all accessible forest land condition classes is less than 100% on a subplot, vegetation measurements are done only on the portion that is in accessible forest land condition classes. Vegetation Indicator measurements are not done on portions of the

3.0 Phase 3 Field Guide – Vegetation Diversity and Structure October, 2005

plot that are NOT accessible forest land condition classes. Canopy cover estimates are only made for the area within accessible forest condition(s).

Vegetation Indicator data are collected on all four subplots of P3 plots or portions of subplots that are accessible forest land. The boundaries of the subplot are 24.0 feet, horizontal distance, from the subplot center. Data are collected on two plot sizes on each subplot: three 3.28 x 3.28 feet (1 m²) “quadrats”, and the 24.0-foot radius subplot (Figure 13-1). From subplot center, the quadrats are located on the right sides of lines at azimuths of 30°, 150°, and 270°. Ideally, two corners of each quadrat are permanently marked at 15 and 18.3 feet (4.57 and 5.57m), horizontal distance, from the subplot center. (This will vary by region and landowner.)

Total cover of all vegetation foliage in four height layers (0 – 2, > 2 – 6, > 6 – 16, and >16 feet) is estimated on each subplot prior to recording species. Ground variable cover estimates are also recorded on the 24.0-foot radius subplot. Each quadrat is assigned to the dominant condition class on the quadrat, and trampling is assessed.

A species matrix is compiled for each plot as the vegetation specialist visits each sample unit – both quadrats and subplots – on the plot. A species code is recorded when a species is first encountered. When discovered on subsequent sample units within the plot, information is added to the original species record.

On the quadrats where the dominant condition class is accessible forest, species presence/absence data are collected for vascular plants rooted in the quadrat or with overhanging foliage or live material within 6 feet above the ground above the quadrat.

After the quadrats are assessed, a time-constrained search of all species on the subplot is conducted. Total canopy cover of each individual species is estimated, and then canopy cover within each of three height layers (0-6, > 6-16, and >16) are estimated on each subplot. There are no height limits for vegetation overhanging the subplot boundary; trees and shrubs that are rooted outside the subplot are included in the record if they overhang the subplot. Most species will have canopy cover in one layer only, in which case the total canopy cover and layer canopy cover will be the same. Species and canopy cover estimates are only made for the area of the subplot in accessible forest condition(s). Boundaries between multiple accessible forest conditions on a subplot are ignored during data collection.

Specimens of all measured plants that cannot be confidently identified to the species level are collected off-plot and submitted to herbaria for subsequent identification. Data are collected by certified vegetation specialists with regional knowledge to provide optimum field identification of plant species at each site.

When time restrictions limit the completeness of plot data collection, the vegetation specialist should prioritize to complete the entire suite of records for as many subplots as time allows. Quality assurance measurements should be made within 2 weeks of the original plot visit. At the time of next plot measurement cycle, plots should be revisited within 2 weeks of the calendar date of the previous measurement cycle, if at all possible.

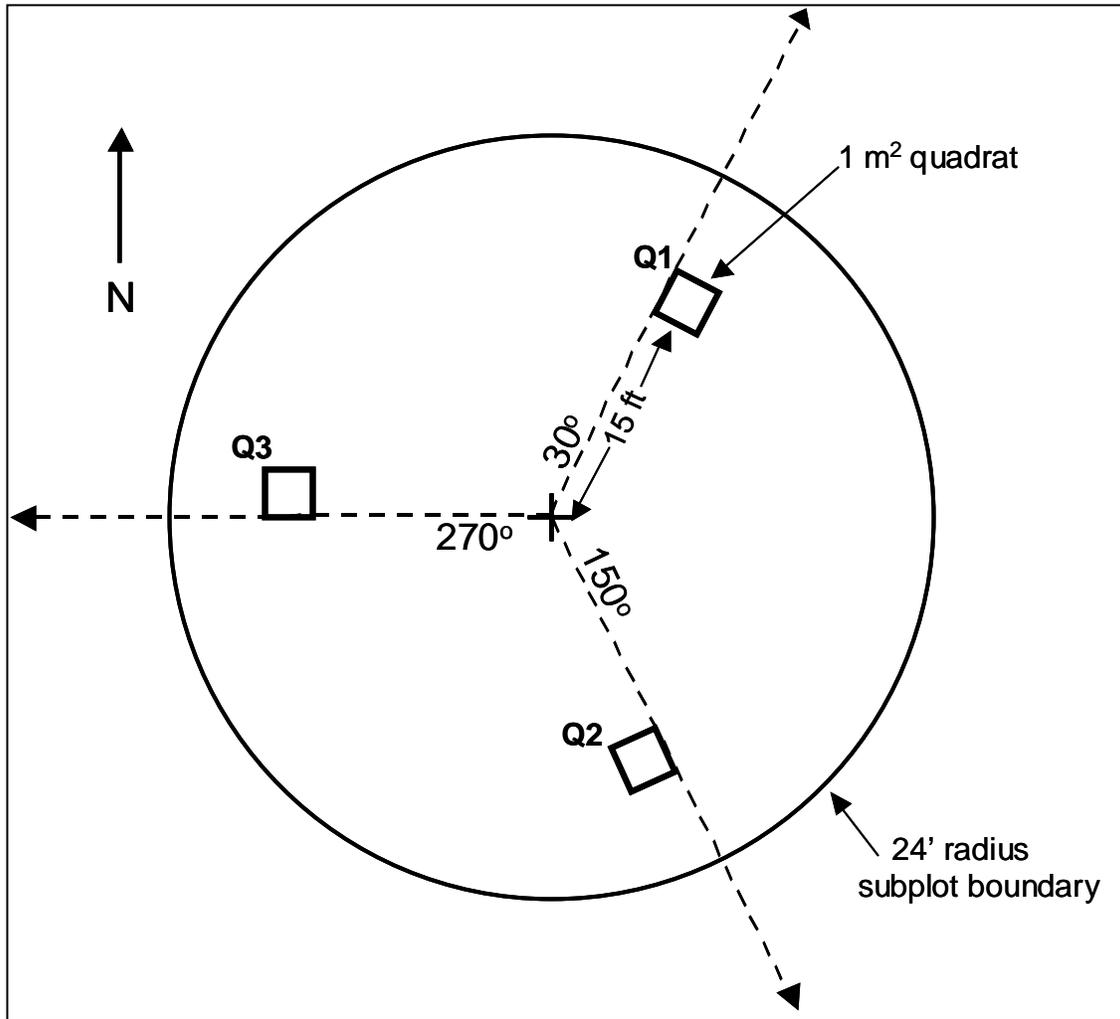


Figure 13-1. Layout of P3 subplot showing location of quadrats and subplot boundary

13.2 SUGGESTED FIELD GEAR UNIQUE TO VEGETATION INDICATOR

- 1-gal plastic bags for unknown plant specimens
- 1-m² quadrat frame
- Permanent pins/stakes to mark quadrat where allowed, or temporary pin flags
- Carpenters ruler (for height measurements)
- Hand lens
- Pre-numbered labels for unknown plant specimens (provided)
- Envelopes for bulky fruits or nuts
- Local flora keys and species lists
- Digging tool
- Large boxes to store and ship samples
- Newspaper and cardboard
- Plant press
- Access to dissecting scope with illuminator
- Mailing instructions for samples (Region specific)
- Diskettes for sending unknown sample information to herbaria
- PLANTS code dictionary with cross-walk plant names to accepted codes

13.3 PLOT AND VISIT REFERENCE INFORMATION

13.3.1 STATE

Record the unique FIPS (Federal Information Processing Standard) code identifying the State where the plot center is located.

When collected: All plots currently having at least one accessible forest condition

Field width: 2 digits

Tolerance: No errors

MQO: At least 99% of the time

Values: See Appendix 1 in the P2 field guide

13.3.2 COUNTY

Record the unique FIPS (Federal Information Processing Standard) code identifying the County where the plot center is located.

When collected: All plots currently having at least one accessible forest condition

Field width: 3 digits

Tolerance: No errors

MQO: At least 99% of the time

Values: See Appendix 1 in the P2 field guide

13.3.3 PLOT NUMBER

Record the identification number, unique within a county, parish, or borough (survey unit in AK), for each plot. If SAMPLE KIND = 3, the plot number will be assigned by the National Information Management System (NIMS). Use 99999 while in the field for replacement plots.

When collected: All plots currently having at least one accessible forest condition

Field width: 4 digits

Tolerance: No errors

MQO: At least 99% of the time

Values: 0000(0) – 9999(9)

13.3.4 QA STATUS

Record the code corresponding to the type of vegetation measurement conducted.

When collected: All plots currently having at least one accessible forest condition

Field width: 1 digit

Tolerance: No errors

MQO: 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)

**3.0 Phase 3 Field Guide – Vegetation Diversity and Structure
October, 2005**

13.3.5 VEG CREW TYPE

Record the code corresponding to the type of crew measuring the vegetation diversity and structure.

When collected: All plots currently having at least one accessible forest condition

Field width: 1 digit

Tolerance: No errors

MQO: At least 99% of the time

Values:

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

13.3.6 VEG SAMPLE KIND

Record sample kind.

When collected: All plots

Field width: 1 digit

Tolerance: No errors

MQO: At least 99% of the time

Values:

- 1 Initial P3 VEG plot establishment
- 2 Remeasure of previously established P3 VEG plot
- 3 Replacement P3 VEG plot

13.3.7 VEG VISIT DATE

Record the year, month, and day that the current plot visit was completed as follows:

13.3.7.1 YEAR

Record the year that the plot was completed.

When collected: All plots

Field width: 4 digits

Tolerance: No errors

MQO: At least 99% of the time

Values: \geq 2005

13.3.7.2 MONTH

Record the month that the plot was completed.

When collected: All plots

Field width: 2 digits

Tolerance: No errors

MQO: At least 99% of the time

Values:

- | | | | | | |
|----|----------|----|--------|----|-----------|
| 01 | January | 05 | May | 09 | September |
| 02 | February | 06 | June | 10 | October |
| 03 | March | 07 | July | 11 | November |
| 04 | April | 08 | August | 12 | December |

13.3.7.3 DAY

Record the day of the month that the plot was completed.

When collected: All plots
Field width: 2 digits
Tolerance: No errors
MQO: At least 99% of the time
Values: 01 to 31

13.3.8 VEGETATION SPECIALIST CREW NAME

Record the name of the crew member measuring vegetation diversity and structure.

When collected: All plots
Field width: 20 digits
Tolerance: No errors
MQO: At least 99% of the time
Values: *Lastname, firstname*

13.3.9 VEG PLOT NOTES

Use these fields to record notes pertaining to the entire plot. If the notes apply only to a specific subplot or other specific aspect of the plot, then make that clear in the notes.

When collected: All plots
Field width: 160 alphanumeric characters
Tolerance: N/A
MQO: N/A
Values: English language words, phrases and numbers

13.4 SUBPLOT INFORMATION

13.4.1 SUBPLOT NUMBER

Record the code corresponding to the number of the subplot.

When collected: Every subplot on all plots with at least one accessible forest condition
Field width: 1 digit
Tolerance: No errors
MQO: At least 99% of the time
Values:

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

13.4.2 VEG SUBPLOT STATUS

Record the code corresponding to how the subplot was sampled, and if not, why not.

When collected: Each subplot
Field width: 1 digit
Tolerance: No errors
MQO: At least 99% of the time

**3.0 Phase 3 Field Guide – Vegetation Diversity and Structure
October, 2005**

Values:

- 1 Sampled – at least one accessible forest land condition present
- 2 Sampled – no accessible forest land condition present on subplot
- 3 Nonsampled

13.4.3 VEG SUBPLOT NONSAMPLED REASON

For subplots that cannot be sampled, and are wholly or partially within the FIA sampling population (U.S. boundary), record one of the following reasons. Codes 1-4 can be assigned to entire plots or portions of plots that are not sampled. Code 5 is assigned only when the entire plot is affected.

When collected: When SUBPLOT STATUS=3

Field width: 2 digits

Tolerance: No errors

MQO: At least 99% of the time

Values:

- 01 Outside U.S. boundary
- 02 Denied access area
- 03 Hazardous situation
- 04 Time Limitation
- 05 Lost data (office use only)
- 10 Other

13.4.4 PERCENT SUBPLOT AREA ACCESSIBLE FOREST LAND

Record the percent area of the subplot in an accessible forested condition.

When collected: When SUBPLOT STATUS=1

Field width: 3 digits

Tolerance: +/- 1 class based on the following canopy cover classes: 1-5%, 6-10%, 11-20%, 21-40%, 41-60%, 61-80%, and 81-100%

MQO: 90% of the time

Values: 001-100.

13.4.5 DETAILED NONFOREST LAND USE

Record the code corresponding to the NONFOREST land use of the portion of the subplot that is not forest. If more than one nonforest land use is present, record the code that best describes the land use occurring closest to subplot center.

When collected: SUBPLOT STATUS = 1, and PERCENT SUBPLOT AREA ACCESSIBLE FOREST LAND < 100%

Field width: 2 digits

Tolerance: No errors

MQO: At least 99% of the time

3.0 Phase 3 Field Guide – Vegetation Diversity and Structure
October, 2005

Values:

- 10 Agriculture
 - 11 Cropland
 - 12 Pasture
 - 13 Idle farmland
 - 14 Orchard
 - 15 Christmas tree plantation
- 20 Rangeland
- 30 Developed
 - 31 Cultural (business, residential, urban buildup)
 - 32 Rights-of-way (improved roads, railway, power lines, canals)
 - 33 Recreation (parks, ski areas, golf courses, etc.)
- 40 Other (beach, desert, noncensus water, marsh, bog)

13.4.6 COMMUNITY DESCRIPTION FOR SPECIMEN LABELS (CORE OPTIONAL)

To fully automate Specimen Label, enter a brief description of the community type to aid the taxonomist in the identification of any specimens collected from this subplot. Community descriptions often describe the dominant overstory species (i.e., Open mixed conifer, closed paper birch, pinyon juniper woodland).

When collected: Optional
Field width: 40 characters
Tolerance: No errors
MQO: At least 99% of the time
Values: English words or phrases that describe plant community

13.4.7 VEG SUBPLOT NOTES

Use these fields to record notes pertaining to the subplot.

When collected: As needed
Field width: 40 alphanumeric characters
Tolerance: N/A
MQO: N/A
Values: English language words, phrases, and numbers

13.5 SUBPLOT TOTAL CANOPY COVER BY LAYER

Estimate the total canopy cover of the foliage of all vascular plants by layer above the ground surface within the accessible forested conditions on the subplot. A rapid canopy cover estimate is made, ignoring overlap among species. It may help to visualize canopy cover by collapsing each layer into a 2-dimension space and using the polygon method. Canopy cover is based on a vertically-projected polygon described by the outline of the foliage, ignoring any normal spaces occurring between the leaves of plants (Daubenmire 1959). If there is no foliage in a layer, enter 0% for that layer. Canopy cover estimates are only made for the area within accessible forest condition(s) and should not include foliage on non-forested portions of the subplot. However, record the percent cover on the forested portion as if the subplot was 100% accessible forest. For example, if cover in a layer is about equal to a circle with a radius of 5.3 ft, enter 5%, as you would for a fully forested subplot, on any partially forested subplot.

**3.0 Phase 3 Field Guide – Vegetation Diversity and Structure
October, 2005**

13.5.1 SUBPLOT CANOPY COVER LAYER 1 (0 – 2 feet above ground)

Estimate the total canopy cover of the foliage of all vascular plants in Layer 1 within the accessible forested conditions on the subplot. A rapid canopy cover estimate is made, ignoring overlap among species.

When collected: All subplots where SUBPLOT STATUS = 1

Field width: 3 digits

Tolerance: +/- 1 class based on the following canopy cover classes: 1-5%, 6-10%, 11-20%, 21-40%, 41-60%, 61-80%, and 81-100%

MQO: At least 90% of the time

Values: 000-100

13.5.2 SUBPLOT CANOPY COVER LAYER 2 (>2 – 6 ft)

Estimate the total canopy cover of the foliage of all vascular plants in Layer 2 within the accessible forested conditions on the subplot. A rapid canopy cover estimate is made, ignoring overlap among species.

When collected: All subplots where SUBPLOT STATUS = 1

Field width: 3 digits

Tolerance: +/- 1 class based on the following canopy cover classes: 1-5%, 6-10%, 11-20%, 21-40%, 41-60%, 61-80%, and 81-100%

MQO: At least 90% of the time

Values: 000-100

13.5.3 SUBPLOT CANOPY COVER LAYER 3 (>6 – 16 ft)

Estimate the total canopy cover of the foliage of all vascular plants in Layer 3 surface within the accessible forested conditions on the subplot. A rapid canopy cover estimate is made, ignoring overlap among species.

When collected: All subplots where SUBPLOT STATUS = 1

Field width: 3 digits

Tolerance: +/- 1 class based on the following canopy cover classes: 1-5%, 6-10%, 11-20%, 21-40%, 41-60%, 61-80%, and 81-100%

MQO: At least 90% of the time

Values: 000-100

13.5.4 SUBPLOT CANOPY COVER LAYER 4 (> 16 ft)

Estimate the total canopy cover of the foliage of all vascular plants in Layer 4 within the accessible forested conditions on the subplot. A rapid canopy cover estimate is made, ignoring overlap among species.

When collected: All subplots where SUBPLOT STATUS = 1

Field width: 3 digits

Tolerance: +/- 1 class based on the following canopy cover classes: 1-5%, 6-10%, 11-20%, 21-40%, 41-60%, 61-80%, and 81-100%

MQO: At least 90% of the time

Values: 000-100

13.6 SUBPLOT GROUND VARIABLE RECORDS

Assess the cover of ground variables found on the accessible forest portion of the subplot. In areas with thick vegetation, you may opt to complete this section after you have collected the species data and have a better perspective on the ground cover. These describe things in contact with the ground surface and not occupied by tree boles

**3.0 Phase 3 Field Guide – Vegetation Diversity and Structure
October, 2005**

or other vegetation basal area. Multiple ground variables often occur on a subplot. Items must be visible from above. For example, a large rock completely covered with moss would not be coded, but the moss would be. Estimate the cover of each ground variable. Cover is estimated to the nearest 1% for each ground variable. The sum of all ground variable covers must equal the percentage entered for variable 13.4.4 PERCENT SUBPLOT AREA ACCESSIBLE FOREST LAND, above.

13.6.1 PERCENT CRYPTOBIOTIC CRUST COVER

Record the PERCENT CRYPTOBIOTIC CRUST COVER in the subplot. Cryptobiotic crust is a layer of symbiotic lichens and algae on the soil surface (common in arid regions).

When collected: All sampled subplots with SUBPLOT STATUS = 1

Field width: 3 digits

Tolerance: +/- 1 class based on the following cover classes: 1-5%, 6-10%, 11-20%, 21-40%, 41-60%, 61-80%, and 81-100%

MQO: At least 90% of the time

Values: 000-100

13.6.2 PERCENT LICHEN COVER

Record the PERCENT LICHEN COVER in the subplot.

When collected: All sampled subplots with SUBPLOT STATUS = 1

Field width: 3 digits

Tolerance: +/- 1 class based on the following cover classes: 1-5%, 6-10%, 11-20%, 21-40%, 41-60%, 61-80%, and 81-100%

MQO: At least 90% of the time

Values: 000-100

13.6.3 PERCENT LITTER/DUFF COVER

Record the PERCENT LITTER/DUFF COVER in the subplot. This is a continuous layer of accumulated organic matter over forest mineral soil (e.g., scattered leaves over mineral soil is coded mineral soil).

When collected: All sampled subplots with SUBPLOT STATUS = 1

Field width: 3 digits

Tolerance: +/- 1 class based on the following cover classes: 1-5%, 6-10%, 11-20%, 21-40%, 41-60%, 61-80%, and 81-100%

MQO: At least 90% of the time

Values: 000-100

13.6.4 PERCENT MINERAL SOIL COVER

Record the PERCENT MINERAL SOIL COVER in the subplot. This is physically weathered soil parent material that may or may not also be chemically and biologically altered.

When collected: All sampled subplots with SUBPLOT STATUS = 1

Field width: 3 digits

Tolerance: +/- 1 class based on the following cover classes: 1-5%, 6-10%, 11-20%, 21-40%, 41-60%, 61-80%, and 81-100%

MQO: At least 90% of the time

Values: 000-100

13.6.5 PERCENT MOSS COVER

Record the PERCENT MOSS COVER in the subplot. If liverworts occur on the subplot, include them here with mosses.

When collected: All sampled subplots with SUBPLOT STATUS = 1

Field width: 3 digits

Tolerance: +/- 1 class based on the following cover classes: 1-5%, 6-10%, 11-20%, 21-40%, 41-60%, 61-80%, and 81-100%

MQO: At least 90% of the time

Values: 000-100

13.6.6 PERCENT ROAD/TRAIL COVER

Record the PERCENT ROAD/TRAIL COVER in the portions of the subplot designated as accessible forest condition. Include any areas compacted and unvegetated from regular use by foot travel or small motorized vehicles.

When collected: All sampled subplots with SUBPLOT STATUS = 1

Field width: 3 digits

Tolerance: +/- 1 class based on the following cover classes: 1-5%, 6-10%, 11-20%, 21-40%, 41-60%, 61-80%, and 81-100%

MQO: At least 90% of the time

Values: 000-100

13.6.7 PERCENT ROCK COVER

Record the PERCENT ROCK COVER in the subplot. Include any rocks, boulders, or accumulations of gravel (> 1/4 inch diameter) or pebbles.

When collected: All sampled subplots with SUBPLOT STATUS = 1

Field width: 3 digits

Tolerance: +/- 1 class based on the following cover classes: 1-5%, 6-10%, 11-20%, 21-40%, 41-60%, 61-80%, and 81-100%

MQO: At least 90% of the time

Values: 000-100

13.6.8 PERCENT STANDING WATER/FLOODED COVER

Record the PERCENT STANDING WATER/FLOODED COVER in the subplot. Include any ponding or flowing water that is not contained within banks.

When collected: All sampled subplots with SUBPLOT STATUS = 1

Field width: 3 digits

Tolerance: +/- 1 class based on the following cover classes: 1-5%, 6-10%, 11-20%, 21-40%, 41-60%, 61-80%, and 81-100%

MQO: At least 90% of the time

Values: 000-100

13.6.9 PERCENT STREAM/LAKE COVER

Record the PERCENT STREAM/LAKE COVER in the subplot. Include any body of water contained within banks that is within a forested condition.

When collected: All sampled subplots with SUBPLOT STATUS = 1

**3.0 Phase 3 Field Guide – Vegetation Diversity and Structure
October, 2005**

Field width: 3 digits
Tolerance: +/- 1 class based on the following cover classes: 1-5%, 6-10%, 11-20%, 21-40%, 41-60%, 61-80%, and 81-100%
MQO: At least 90% of the time
Values: 000-100

13.6.10 PERCENT TRASH/JUNK/OTHER COVER

Record the PERCENT TRASH/JUNK/OTHER COVER in the subplot.

When collected: All sampled subplots with SUBPLOT STATUS = 1
Field width: 3 digits
Tolerance: +/- 1 class based on the following cover classes: 1-5%, 6-10%, 11-20%, 21-40%, 41-60%, 61-80%, and 81-100%
MQO: At least 90% of the time
Values: 000-100

13.6.11 PERCENT WOOD COVER

Record the PERCENT WOOD COVER in the subplot. Wood pieces included should average greater than 3 inches in diameter and be in contact with the ground; smaller pieces should be included in Litter/ Duff Cover. Stumps, live trunks, and roots are included.

When collected: All sampled subplots with SUBPLOT STATUS = 1
Field width: 3 digits
Tolerance: +/- 1 class based on the following cover classes: 1-5%, 6-10%, 11-20%, 21-40%, 41-60%, 61-80%, and 81-100%
MQO: At least 90% of the time
Values: 000-100

13.7 QUADRAT DATA

Place the quadrat frame to the right side of the transect line and make sure the corners are lined up at 15 and 18.3 feet from subplot center. Level the quadrat, if necessary, by propping up the quadrat corners. When a quadrat is located on a steep slope the vegetation specialist should be positioned next to or downhill from the quadrat to prevent sliding or falling into the quadrat. In areas of thick vegetation, slide the quadrat sides through the vegetation. Quadrat frames can be made with hinging corners or detachable sections to improve maneuverability.

13.7.1 SUBPLOT NUMBER

Record the code corresponding to the number of the subplot.

When collected: All sampled subplots with SUBPLOT STATUS = 1
Field width: 1 digit
Tolerance: No errors
MQO: At least 99% of the time
Values:

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

13.7.2 QUADRAT NUMBER

Record the code corresponding to the number of the quadrat.

When collected: Each quadrat
Field width: 1 digits
Tolerance: No errors
MQO: At least 99% of the time
Values:

- 1 Quadrat on 30°
- 2 Quadrat on 150°
- 3 Quadrat on 270°

13.7.3 QUADRAT CONDITION CLASS NUMBER

A CONDITION CLASS number is assigned to each quadrat. If the quadrat straddles a CONDITION CLASS boundary, assign the number for the CONDITION CLASS that occupies the greatest area in the quadrat. Use the CONDITION CLASS number assigned during plot mapping by the mensuration crew (FIA National Core Field Guide, Ver. 3.0, section 2.4.1).

When collected: Each Quadrat on a sampled subplot with SUBPLOT STATUS = 1
Field width: 1 digit
Tolerance: No errors
MQO: At least 99% of the time
Values: 1-9

13.7.4 QUADRAT STATUS

Record the code corresponding to how the quadrat was sampled. If QUADRAT STATUS is 1 or 3, continue to enter data for the quadrat. If the value entered is 2, 4, or 5, leave the remaining quadrat items blank.

When collected: Each quadrat on a sampled subplot with SUBPLOT STATUS = 1
Field width: 1 digit
Tolerance: No errors
MQO: At least 99% of the time
Values:

- 1 Quadrat sampled (most of the quadrat is in an accessible forest condition)
- 2 Quadrat not sampled because most or all of it does not fall in an accessible forested condition class
- 3 Quadrat sampled, no vascular plants rooted in or overhanging within 6 feet of the ground surface
- 4 Quadrat not sampled, hazard present on quadrat
- 5 Quadrat not sampled, other reason – enter in plot notes

13.7.5 TRAMPLING

A trampling code is assigned to each quadrat at the start of vegetation diversity measurements. Trampling is defined as damage to plants or disturbance of the ground layer by humans, livestock, or wildlife.

When collected: QUADRAT STATUS = 1 or 3
Field width: 1 digit

**3.0 Phase 3 Field Guide – Vegetation Diversity and Structure
October, 2005**

Tolerance: +/- one code
MQO: At least 90% of the time
Values:

- 1 Low: 0-10% of quadrat trampled: pristine to relatively undisturbed.
- 2 Moderate: 10-50% of quadrat trampled: trampling by animals or field crew
- 3 Heavy: >50% of quadrat trampled: hiking trail or heavily grazed.

13.7.6 VEG QUADRAT NOTES

Use these fields to record notes pertaining to the quadrat.

When collected: As needed
Field width: 40 alphanumeric characters
Tolerance: N/A
MQO: N/A
Values: English words, phrases, and numbers

13.8 SPECIES RECORDS

Species data are collected at both the subplot level and the quadrat level for each subplot. A single species list is maintained for the entire plot and updated for specific attributes at each level (quadrat and subplot). Species codes are recorded as each species is discovered for the first time on a given plot. Data are added to the original species' record when the species is encountered on subsequent sample units within the plot. This section describes the data required to uniquely identify each recorded species. *Note: It is typically easier to collect quadrat data and quadrat species first, and then return to subplot species.* **WARNING: changing or deleting a species code will change it or delete it for the entire plot.**

13.8.1 Plot Species List

13.8.1.1 SPECIES CODE

Record a code for each vascular plant species found rooted in or overhanging within 6 feet above the quadrat. Species codes must be the standardized codes in the Natural Resource Conservation Service (NRCS) PLANTS database January 2000 version*. Identification to species only is expected. However, if subspecies information is known, enter the appropriate NRCS code.

If a plant cannot be identified quickly and confidently, assign a NRCS PLANTS genus or unknown code appropriate to the species. Collect a specimen away from the quadrat unless the species is locally sparse or another SPECIMEN NOT COLLECTED REASON CODE (13.8.1.5) applies. A species is "locally sparse" if 5 or fewer plants are present in the entire plot (4 subplots) and immediate surrounding area.

When collected: First time each unique species is discovered on plot
Field width: 10 digits
Tolerance: No errors
MQO: At least 99% of the time
Values: Accepted NRCS species when the species is known, or an accepted NRCS genus or unknown code when the species is not known

**3.0 Phase 3 Field Guide – Vegetation Diversity and Structure
October, 2005**

*For more information about the species, genus, and unknown codes contact the indicator advisor. The list of unknown codes (NRCS "Symbols for unknown plants") is given in section 13.12.

13.8.1.2 UNIQUE SPECIES NUMBER

When any code is entered for the first time on a plot, the UNIQUE SPECIES NUMBER is "1". If more than one unidentified species is discovered that is described by the same genus or unknown code, the next sequential number is assigned. If a recorded unidentified species is encountered again elsewhere on the plot, the vegetation specialist adds information to the species' original record.

When collected: All species records
Field width: 2 digits
Tolerance: No errors
MQO: At least 99% of the time
Values: 1-99, assigned in sequential numbers

13.8.1.3 SPECIMEN OFFICIALLY COLLECTED

Record if a specimen was collected or not for each species, genus or unknown code entered as a new unique species.

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

0	No, a specimen was not collected
1	Yes, a specimen was collected

13.8.1.4 SPECIMEN LABEL NUMBER

Record the label number for the collected specimen. Pre-numbered labels are provided to each vegetation specialist by the regional coordinator.

When collected: SPECIMEN OFFICIALLY COLLECTED = 1 (yes)
Field width: 5 digits
Tolerance: No errors
MQO: At least 99% of the time
Values: 1 to 99999, as pre-printed and assigned by region

13.8.1.5 SPECIMEN NOT COLLECTED REASON CODE

Record the code that describes why a specimen has not been collected.

When collected: An unknown code or genus code is entered and SPECIMEN OFFICIALLY COLLECTED = 0 (no)
Field width: 2 digits
Tolerance: No errors
MQO: At least 99% of the time

**3.0 Phase 3 Field Guide – Vegetation Diversity and Structure
October, 2005**

Values:

- 01 Species is locally sparse
- 02 Species has < 1% canopy cover on the subplot and no mature foliage or reproductive parts are present
- 03 Hazardous situation
- 04 Time limitation
- 05 Already collected with previous entry of genus or unknown code with the same unique species number
- 06 Specimen collected for immediate/local identification
- 10 Other (explain in notes)

13.8.1.6 PLOT SPECIES NOTES

Notes may be entered for any species encountered, but are required for each new species that is not identified. Enter text that describes the species. This text may be used in the specimen label and unknown report.

When collected: Required for any new unidentified species encountered on a plot and when SPECIMEN NOT COLLECTED REASON = 10

Field width: Unlimited alphanumeric character field

Tolerance: N/A

MQO: N/A

Values: English language words, phrases, and numbers

13.8.2 Quadrat Species Data Collection

13.8.2.1 SPECIES PRESENCE/ABSENCE ON QUADRAT

At each new sampled quadrat (QUADRAT STATUS = 1), record species presence or absence. When a new species is encountered, enter it using the fields described in section 13.8.1.

When collected: For each unique species present on a quadrat with QUADRAT STATUS = 1

Field width: 1 digit

Tolerance: No errors

MQO: At least 90% of the time

Values: Blank or 0 (not present) or 1 (present)

13.8.3 Subplot Species Data Collection

After completing the three quadrats on a sampled subplot, the vegetation specialist does a search of the entire accessible forest condition area of the subplot, ignoring any condition class boundaries within the accessible forest. **Only** species rooted in or overhanging accessible forest condition(s) are included. All species recorded on the current subplot's quadrats must be included in canopy cover assessments. The vegetation specialist records abundance for all species, searching for no more than an average of 45 minutes per subplot. Some vegetation specialists find they spend more time on the first subplot, but less time on other subplots because most plants have been identified and coded. Only emergent plants are recorded in wetland forest situations. Epiphytes (Spanish moss, ferns, orchids, mistletoes) are recorded as well as possible as seen from the ground level. Two types of canopy cover estimates are made for each species: total canopy cover and canopy cover within each of three layers. The majority of plants will have canopy cover in only one layer, in which case the total and layer canopy covers will be identical.

13.8.3.1 SUBPLOT SPECIES TOTAL PERCENT CANOPY COVER

A rapid canopy cover estimate is made for each species occurring within the 24-foot radius subplot. Estimate SUBPLOT SPECIES TOTAL PERCENT CANOPY COVER over the entire forested condition portion of the subplot, ignoring any boundaries between forested condition(s). Canopy cover is based on a vertically-projected polygon described by the outline of the foliage, ignoring any normal spaces occurring between the leaves of plants (Daubenmire 1959). Canopy cover estimates are only made for the area within accessible forest condition(s) and should not include foliage on non-forested portions of the subplot. However, record the percent cover on the forested portion as if the subplot was 100% accessible forest. That is, if total cover for a given species is about equal to a circle with a radius of 5.3 ft, enter 5%, as you would for a fully forested subplot.

For species of moderate cover, it may be easiest to divide the subplots into quarters, estimate canopy cover of each quarter separately, and then add them together. Record a trace (less than 1%) of canopy cover as "t". The following area-cover sizes may be useful in developing estimates for an entirely forested subplot:

Subplot radius = 24.0 feet, Subplot area = 1809 ft ²			
Cover	Area (ft ²)	Length of a side of a square(ft)	Radius of circular area(ft)
1%	18	4.3	2.4
3%	54	7.4	4.1
5%	90	9.5	5.3
10%	181	13.4	7.6
20%	362	19	10.7

For any species: total cover must be less than or equal to the sum of cover assigned for all layers, but greater than or equal to the greatest cover assigned for any one layer. (Greatest Single Layer Cover ≤ Total Cover ≤ Sum of All Layers).

When collected: Each unique species present on current subplot with SUBPLOT STATUS = 1

Field width: 3 digits

Tolerance: +/- 1 class based on the following canopy cover classes: t, 1-5%, 6-10%, 11-20%, 21-40%, 41-60%, 61-80%, and 81-100%

MQO: At least 90% of the time

Values: t, 001 to 100

13.8.3.2 SUBPLOT SPECIES PERCENT CANOPY COVER LAYER 1 AND 2

A rapid canopy cover estimate is made for each species in a combined Layer 1 and 2. Estimate SUBPLOT SPECIES PERCENT CANOPY COVER LAYER 1 AND 2 over the entire 24-foot radius subplot, ignoring any forested condition class boundaries present, from ground level to 6 feet above the ground. For plants rooted in the subplot, but with no foliage in the combined Layer 1 and 2, enter 0. Cover assigned to any one layer cannot be greater than the value assigned for total cover for that species. Canopy cover is based on a vertically-projected polygon described by the outline of the foliage, ignoring any normal spaces occurring between the leaves of plants (Daubenmire 1959). Canopy cover estimates are only made for the area within accessible forest condition(s) and should not include foliage on non-forested portions of the subplot. However, record the percent cover on the forested portion as if the subplot was 100% accessible forest. That is, if total cover for a given species is about equal to a circle with a radius of 5.3 ft, enter 5%, as you would for a fully forested subplot.

When collected: Each unique species present on current subplot with SUBPLOT STATUS = 1

**3.0 Phase 3 Field Guide – Vegetation Diversity and Structure
October, 2005**

Field width: 3 digits

Tolerance: +/- 1 class based on the following canopy cover classes: 0, t, 1-5%, 6-10%, 11-20%, 21-40%, 41-60%, 61-80%, and 81-100%

MQO: At least 90% of the time

Values: 000, t, 001 to 100

13.8.3.3 SUBPLOT SPECIES PERCENT CANOPY COVER LAYER 3

A rapid canopy cover estimate is made for each species in Layer 3. Estimate SUBPLOT SPECIES PERCENT CANOPY COVER LAYER 3 (from >6-16 feet above the ground) over the entire 24-foot radius subplot, ignoring any forested condition class boundaries present. For plants rooted in the subplot, but with no foliage in layer 3, enter 0. Cover assigned to any one layer cannot be greater than the value assigned for total cover for that species. Canopy cover is based on a vertically-projected polygon described by the outline of the foliage, ignoring any normal spaces occurring between the leaves of plants (Daubenmire 1959). Canopy cover estimates are only made for the area within accessible forest condition(s) and should not include foliage on non-forested portions of the subplot. However, record the percent cover on the forested portion as if the subplot was 100% accessible forest. That is, if total cover for a given species is about equal to a circle with a radius of 5.3 ft, enter 5%, as you would for a fully forested subplot.

When collected: Each unique species present on current subplot with SUBPLOT STATUS = 1

Field width: 3 digits

Tolerance: +/- 1 class based on the following canopy cover classes: 0, t, 1-5%, 6-10%, 11-20%, 21-40%, 41-60%, 61-80%, and 81-100%

MQO: At least 90% of the time

Values: 000, t, 001 to 100

13.8.3.4 SUBPLOT SPECIES PERCENT CANOPY COVER LAYER 4

A rapid canopy cover estimate is made for each species in Layer 4. Estimate SUBPLOT SPECIES PERCENT CANOPY COVER LAYER 4 (>16 feet above the ground) over the entire 24-foot radius subplot, ignoring any forested condition class boundaries present. For plants rooted in the subplot, but with no foliage in layer 4, enter 0. Cover assigned to any one layer cannot be greater than the value assigned for total cover for that species. Canopy cover is based on a vertically-projected polygon described by the outline of the foliage, ignoring any normal spaces occurring between the leaves of plants (Daubenmire 1959). Canopy cover estimates are only made for the area within accessible forest condition(s) and should not include foliage on non-forested portions of the subplot. However, record the percent cover on the forested portion as if the subplot was 100% accessible forest. That is, if total cover for a given species is about equal to a circle with a radius of 5.3 ft, enter 5%, as you would for a fully forested subplot.

When collected: Each unique species present on current subplot with SUBPLOT STATUS = 1

Field width: 3 digits

Tolerance: +/- 1 class based on the following canopy cover classes: 0, t, 1-5%, 6-10%, 11-20%, 21-40%, 41-60%, 61-80%, and 81-100%

MQO: At least 90% of the time

Values: 000, t, 001 to 100

13.9 UNKNOWN SPECIES AND VOUCHER SPECIMEN COLLECTION

When you encounter a species you cannot identify quickly and confidently using field guides, follow these basic steps:

1. Assign a valid NRCS PLANTS Genus or Unknown CODE and appropriate UNIQUE SPECIES NUMBER.
2. Record if a specimen was collected or not in SPECIMEN COLLECTED.
3. When a specimen is collected, enter a SPECIMEN LABEL NUMBER. Place the pre-printed label with the corresponding label number in the bag with the specimen.
4. If no specimen is collected, record a NOT COLLECTED REASON CODE.
5. Describe any newly encountered unknown species in SPECIES NOTES.
6. Record the quadrat occurrence or canopy cover estimate for the sample unit where the plant was encountered, as for any identified species. (see sections 13.8 or 13.9 for more detailed instructions).

Specimen labels with complete information can be generated automatically from downloaded data if a printer is available. Documentation of the unknown on Specimen Labels and Unknown Reports (replacing Unknown spreadsheets) is explained below, along with instructions for handling specimens.

13.9.1 Field Specimen Label

Each vegetation specialist will be issued a set of printed, pre-numbered labels to track unknown specimens (Figure 13-2). Information to be completed by hand in the field is optional, but may include date, unknown code, unique species number and crew name.

Label Number:1 Date: 8/06/03 Unknown Code: ACANT2 Unique Species Nbr: 1 Veg Spec. crew: John Doe
--

Figure 13-2. Example of field label for unknown specimen.

13.9.2 Official Specimen Label

Official specimen labels are printed from plot data and accompany the unknown (or voucher) specimen as it is pressed, dried, and submitted for further identification (Figure 13.3). Information and variables included on Official Specimen Labels are listed in Table 13.1. Labels will not include sensitive plot identification data – the unique specimen label number is sufficient identification for each specimen.

<h1>Specimen Voucher</h1>			
Label Number:	21	Resolved Species Code:	
Resolved scientific name:			
Resolved by (name):			
Date Collected:	6/22/2005		
Unknown Code:	2GRAM	Unique Species Nbr:	7
Field collected scientific name:			
Collected by:	John Doe		
State:	State name	County:	County name
Community type(s) where found:			bottomland, old stripmine
	ridgetop with atv trl, stripped yrs ago		moist bottom
Species Notes:	delicate, hairy joints		

Figure 13-3. Example of official specimen label for unknown specimen.

13.9.2 Unknown Reports

For any unknown plant species encountered, the species is recorded in an **Unknown Report** (replacing the separately maintained Unknown Spreadsheet). The Unknown Report is generated from downloaded plot data. Each Region must train the vegetation specialists if they opt for maintaining unknown spreadsheets as Excel¹ files. The Unknown Spreadsheet contains the fields for variables listed in Table 13.1:

¹ The use of trade or firm names in this publication is for reader information only and does not imply endorsement by the U.S. Department of Agriculture of any product or service.

**3.0 Phase 3 Field Guide – Vegetation Diversity and Structure
October, 2005**

Table 13.1 Summary of Variables for Official Specimen labels and Unknown Reports

Variable	Official Specimen Label	Unknown Report	Source
SPECIMEN Label NBR	X	X	13.8.1.4; Preprinted by Region for each VEG crew
Genus or Unknown code	X	X	13.8.1.1 (As assigned by VEG crew)
UNIQUE SPECIES NBR	X	X	13.8.1.2
VEG spec. crew name	X	X	13.3.8
Field collected scientific name	X	X	Scientific name of species as collected
P2 Plot Number	-	X	13.3.3
State name	(descriptor*)	(descriptor)	13.3.1
County name	(descriptor)	(descriptor)	13.3.2
Community type(s) where found	X	X	13.4.6 or text entered by VEG crew
Date (Collected)	X	X	13.3.7
Description (of plant)	X	X	13.8.1.6; PLOT SPECIES NOTES
Resolved Species Code	X	X	NRCS code entered by identifier
Resolved Scientific Name	X	X	Scientific Name of corresponding NRCS code
Resolved by name	X	X	Name of person identifying the species

*Descriptor used, i.e., State and County NAMES, rather than FIPS code so that information has meaning to independent botanist or herbarium making the identification.

** NRCS PLANTS CODE and scientific name entry to label is highly recommended if specimen is kept for future reference.

13.9.3 Specimen Collection and Handling

A good rule of thumb for when to collect unknown specimens is “when in doubt, **collect!**” Specimens of all plants present in the quadrats and subplots that cannot be quickly and confidently identified to species should be collected **away from quadrats** and **off of the subplot**, if possible. If fewer than 5 of the unknown plants are present DO NOT COLLECT (see section 13.8.1).

Use a digging tool to extract the entire plant, including any underground portions, flowers, fruits, and leaves. If the plant is abundant, collection of two samples will increase the likelihood of a good specimen. All specimens must be labeled, pressed, and dried for shipping and subsequent identification by the vegetation specialist, cooperating herbarium or specialist.

Collected unknown specimens should be transported in the field and from the field in the 1 and/or 2 gallon zip-lock bags provided. Only one species and label may be placed in a single bag. Acceptable methods of transporting collected specimens include:

- Use a 3-hole-punch to punch holes in the bottom of your bags prior to traveling in the field. Place the punched bags into a 2-inch 3-ring binder with the zip-lock portion facing outward. Plants can then be placed with pre-printed, numbered labels into the bag directly in the binder. This method prevents crumpling, tearing, and destroying the specimen during transportation.

3.0 Phase 3 Field Guide – Vegetation Diversity and Structure October, 2005

- Use a 1-hole-punch to punch a hole in the one upper corner of each bag. The hole should be placed in such a manner that it cannot easily be torn. Place the bags on an aluminum carabineer (available at drug stores) or on heavy twine and fasten to your field vest or backpack. Be careful to seal the plants and labels securely inside the bags to prevent accidental loss.

Pressing specimens

1. Each specimen representing a unique species should be placed individually inside a single layer of folded newsprint. Each specimen is to be accompanied by its corresponding unknown specimen label. Even small plant specimens are to be pressed individually. Large plant specimens may be folded in a “v”, “z”, or “w” arrangement to fit on a single newsprint page. Arrange the specimen so that at least one upper and one lower leaf surface is exposed. Plants may be trimmed to reduce bulk, so long as all diagnostic parts are included. Diagnostic portions include stem sections, petioles, leaves, roots, flowers, and fruits. Bulky fruits or nuts may be stored separately in a paper envelope that is taped to the newsprint and is accompanied by an identical copy of the specimen’s unknown label. Unknown codes can be written on the outside of the folded newspaper to aid sorting as specimens are processed.
2. Stack the specimens in their individual newsprint sleeves between two pieces of cardboard. Bind the cardboard and plants together using a piece of twine or flat cloth ribbon wrapped around the length and width of the cardboard bundle. For mailing numerous specimens, several bundles may be used. Place all bundles inside a cardboard box for shipping.

Unknown specimens are to be packaged and shipped at the end of every work week. Exceptions will be made when extended field excursions prevent the vegetation specialist from reaching a post office.

All packaged specimens are to be accompanied by the following:

- Name and address to which final identifications are to be mailed
- One paper and one digital copy of the Unknown Spreadsheet

13.10 REFERENCES

Barbour, M.G., J.H. Burk, and W.D. Pitts. 1987. *Terrestrial plant ecology*. Menlo Park, CA; Benjamin/Cummings Pub. Co.

Daubenmire, R. 1959. A canopy-coverage method of vegetational analysis. *Northwest Science* 33(1): 43-64.

Mueller-Dombois, D.; Ellenberg, H. 1974. *Aims and methods of vegetation ecology*. New York: Wiley & Sons.

Stapanian, M.A.; Sundberg, S.D.; Baumgardner, G.A.; Liston, A. 1998. Alien species composition and associations with anthropogenic disturbance in North American forests. *Plant Ecology* 139: 49-62.

Stohlgren, T.J.; Falkner, M.B.; Schell, L.D. 1995. A modified-Whittaker nested vegetation sampling method. *Vegetatio* 117: 113-121.

3.0 Phase 3 Field Guide – Vegetation Diversity and Structure October, 2005

Stohlgren, T.J.; Rimar, K.A.; Stolte, K.W. *submitted*. Monitoring native and exotic plant diversity in the national forests of the United States. Biodiversity and Conservation XX: xx-xx.

13.11 ACKNOWLEDGEMENTS

Thanks go to the many individuals who were instrumental in the preparation and revision of this chapter over time including, Andrew Gray¹, Colleen Grenz¹, Kevin Dobelbower¹, Lisa Mahal¹, Rick Shory², Kelly Rimar², Tom Stohlgren², Barbara Conkling³, Sharon King⁴, Sonja Oswald⁴, Ken Stolte⁴, Cassandra Olson⁵, Katherine Johnson⁶, Darin Toone⁷, Cyndi Herbert⁷ and all the field crew vegetation specialists who have taken the time to give us the most valuable feedback and comments. Many thanks to Mark Rubey⁷, Chuck Venekase¹, and Jane Reid¹ for programming and IM support.

Contact information for the National Advisor for this indicator is: Beth Schulz, USDA Forest Service PNW Anchorage Forest Science Laboratory, 3301 C Street, Suite 200, Anchorage, AK 99503 or email bschulz@fs.fed.us .

¹USDA Forest Service Pacific Northwest Research Station

²National Biological Service, Natural Resource Ecology Lab, Colorado State University

³North Carolina State University

⁴USDA Forest Service Southern Research Station

⁵USDA Forest Service North Central Research Station

⁶USDA Forest Service Northeast Research Station

⁷USDA Forest Service Interior West Research Station

**3.0 Phase 3 Field Guide – Vegetation Diversity and Structure
October, 2005**

13.12 CODES FOR UNKNOWN PLANTS

Code	Common Name
2FERN	Fern or Fern Ally
2FORB	Forb (herbaceous, not grass nor grasslike)
2FA	Forb, annual
2FB	Forb, biennial
2FD	Forb, dicot
2FDA	Forb, dicot, annual
2FDB	Forb, dicot, biennial
2FDP	Forb, dicot, perennial
2FM	Forb, monocot
2FMA	Forb, monocot, annual
2FMB	Forb, monocot, biennial
2FMP	Forb, monocot, perennial
2FP	Forb, perennial
2FS	Forb, succulent
2FSA	Forb, succulent, annual
2FSB	Forb, succulent, biennial
2FSP	Forb, succulent, perennial
2GRAM	Graminoid (grass or grasslike)
2GA	Grass, annual
2GB	Grass, biennial
2GP	Grass, perennial
2GW	Grass, woody (bamboo, etc.)
2GL	Grasslike (not a true grass)
2GLA	Grasslike, annual
2GLB	Grasslike, biennial
2GLP	Grasslike, perennial
2PLANT	Plant
2SHRUB	Shrub (>.5m)
2SB	Shrub, broadleaf
2SD	Shrub, deciduous
2SDB	Shrub, deciduous, broadleaf
2SDBD	Shrub, deciduous, broadleaf, dicot
2SDBM	Shrub, deciduous, broadleaf, monocot
2SDN	Shrub, deciduous, needleleaf
2SE	Shrub, evergreen
2SEB	Shrub, evergreen, broadleaf
2SEBD	Shrub, evergreen, broadleaf, dicot
2SEBM	Shrub, evergreen, broadleaf, monocot
2SEN	Shrub, evergreen, needleleaf
2SN	Shrub, needleleaf (coniferous)
2SS	Shrub, succulent
2SSL	Shrub, succulent, leaf
2SSS	Shrub, succulent, stem
2SUBS	Subshrub (<.5m)
2SSB	Subshrub, broadleaf
2SSD	Subshrub, deciduous
2SSDB	Subshrub, deciduous, broadleaf

2SSDBD	Subshrub, deciduous, broadleaf, dicot
2SSDBM	Subshrub, deciduous, broadleaf, monocot
2SSDN	Subshrub, deciduous, needleleaf
2SSE	Subshrub, evergreen
2SSEB	Subshrub, evergreen, broadleaf
2SSEBD	Subshrub, evergreen, broadleaf, dicot
2SSEBM	Subshrub, evergreen, broadleaf, monocot
2SSEN	Subshrub, evergreen, needleleaf
2SSN	Subshrub, needleleaf (coniferous)
2SSS2	Subshrub, succulent
2SSSL	Subshrub, succulent, leaf
2SSSS	Subshrub, succulent, stem
2TREE	Tree
2TB	Tree, broadleaf
2TD	Tree, deciduous
2TDB	Tree, deciduous, broadleaf
2TDBD	Tree, deciduous, broadleaf, dicot
2TDBM	Tree, deciduous, broadleaf, monocot
2TDN	Tree, deciduous, needleleaf
2TE	Tree, evergreen
2TEB	Tree, evergreen, broadleaf
2TEBD	Tree, evergreen, broadleaf, dicot
2TEBM	Tree, evergreen, broadleaf, monocot
2TEN	Tree, evergreen, needleleaf
2TN	Tree, needleleaf (coniferous)
2TS	Tree, succulent
2TSL	Tree, succulent, leaf
2TSS	Tree, succulent, stem
2VH	Vine, herbaceous
2VHA	Vine, herbaceous, annual
2VHD	Vine, herbaceous, dicot
2VHDA	Vine, herbaceous, dicot, annual
2VHDP	Vine, herbaceous, dicot, perennial
2VHM	Vine, herbaceous, monocot
2VHMA	Vine, herbaceous, monocot, annual
2VHMP	Vine, herbaceous, monocot, perennial
2VHP	Vine, herbaceous, perennial
2VHS	Vine, herbaceous, succulent
2VHSA	Vine, herbaceous, succulent, annual
2VHSP	Vine, herbaceous, succulent, perennial
2VW	Vine, woody
2VWD	Vine, woody, deciduous
2VWDD	Vine, woody, deciduous, dicot
2VWDM	Vine, woody, deciduous, monocot
2VWE	Vine, woody, evergreen
2VWED	Vine, woody, evergreen, dicot
2VWEM	Vine, woody, evergreen, monocot

P3 VEG DATA SHEETS: Plot and Subplot Information

State:	Year:	VEG Plot Notes:		
County:	Month			
Plot Number:	Day:			
VEG Sample Kind:				
VEG Crew Name:				
VEG QA Status:				
VEG Crew Type:				
	Subplot 1	Subplot 2	Subplot 3	Subplot 4
VEG Subplot status				
VEG Subplot Non-sample reason				
Percent Subplot Area in Accessible Forest Condition(s)				
Nonforest Land Use				
Total Canopy Cover by Layer in Accessible Forest Condition(s)				
1 (0-2)				
2 (>2-6)				
3 (>6-16)				
4 (>16+)				
Subplot Ground Variable Cover in Accessible Forest Condition(s)				
Cryptobiotic crust				
Lichen				
Litter/Duff				
Mineral Soil				
Moss				
Road/Trail				
Rock				
Water				
Stream/Lake				
Trash/Junk/Other				
Wood				

Section 14. Down Woody Materials

14.0 INTRODUCTION 3

14.1 DEFINITION OF DOWN WOODY MATERIALS 3

14.2 LOCATING AND ESTABLISHING LINE TRANSECTS 4

 14.2.1 CWD transects 4

 14.2.2 FWD transects 4

14.3 TRANSECT LINE SEGMENTING 5

 14.3.1 SUBPLOT NUMBER 6

 14.3.2 TRANSECT 6

 14.3.3 CONDITION CLASS NUMBER 7

 14.3.4 BEGINNING DISTANCE 7

 14.3.5 SLOPE PERCENT 7

 14.3.6 ENDING DISTANCE 7

14.4 Sampling Methods for COARSE WOODY DEBRIS (CWD)..... 8

 14.4.1 Tally Rules for Coarse Woody Debris (CWD)..... 8

 14.4.2 Marking CWD..... 10

 14.4.3 Recording Procedures for CWD 10

 14.4.3.1 SUBPLOT NUMBER 10

 14.4.3.2 TRANSECT 11

 14.4.3.3 CWD SLOPE DISTANCE..... 11

 14.4.3.4 CWD DECAY CLASS..... 11

 14.4.3.5 SPECIES 12

 14.4.3.6 Diameters 13

 14.4.3.6.1 DIAMETER AT POINT OF INTERSECTION 14

 14.4.3.6.2 DIAMETER AT THE SMALL END..... 14

 14.4.3.6.3 DIAMETER AT THE LARGE END 14

 14.4.3.7 CWD TOTAL LENGTH..... 15

 14.4.3.8 IS THE PIECE HOLLOW? 15

 14.4.3.9 CWD HISTORY 16

14.5 SAMPLING METHODS FOR FINE WOODY DEBRIS (FWD)..... 16

 14.5.1 SUBPLOT NUMBER 17

 14.5.2 CONDITION CLASS NUMBER 18

 14.5.3 SMALL FWD COUNT 18

 14.5.4 MEDIUM FWD COUNT..... 18

 14.5.5 LARGE FWD COUNT 18

 14.5.6 HIGH COUNT REASON 18

 14.5.7 RESIDUE PILE ON TRANSECT..... 19

14.6 DUFF, LITTER, AND FUELBED DEPTH MEASUREMENTS 19

 14.6.1 Definitions..... 19

 14.6.2 Overview of Measurements 20

 14.6.2.1 Duff and Litter 20

 14.6.2.2 Fuelbed..... 21

 14.6.3 SUBPLOT NUMBER 21

 14.6.4 TRANSECT 21

 14.6.5 DUFF, LITTER, AND FUELBED SAMPLE 21

 14.6.6 DUFF DEPTH..... 22

 14.6.7 LITTER DEPTH..... 22

 14.6.8 FUELBED DEPTH 22

14.7 FUEL LOADING ON THE MICROPLOT..... 22

 14.7.1 SUBPLOT NUMBER 23

 14.7.2 LIVE SHRUB PERCENT COVER..... 23

 14.7.3 LIVE SHRUB HEIGHT 24

 14.7.4 DEAD SHRUBS PERCENT COVER 24

 14.7.5 DEAD SHRUB HEIGHT 24

14.7.6 LIVE HERBS PERCENT COVER.....	24
14.7.7 LIVE HERBS HEIGHT	25
14.7.8 DEAD HERBS PERCENT COVER.....	25
14.7.9 DEAD HERBS HEIGHT	25
14.7.10 LITTER PERCENT COVER.....	26
14.8 SAMPLING RESIDUE PILES.....	26
14.8.1 SUBPLOT NUMBER.....	27
14.8.2 CONDITION CLASS	27
14.8.3 PILE AZIMUTH.....	27
14.8.4 PILE SHAPE	28
14.8.5 PILE LENGTH 1	28
14.8.6 PILE LENGTH 2.....	28
14.8.7 PILE WIDTH 1.....	28
14.8.8 PILE WIDTH 2.....	29
14.8.9 PILE HEIGHT 1	29
14.8.10 PILE HEIGHT 2.....	29
14.8.11 PILE DENSITY.....	29
14.9 ACKNOWLEDGEMENTS	30
APPENDIX. DATA SHEETS	31

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 \geq 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 \pm 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.

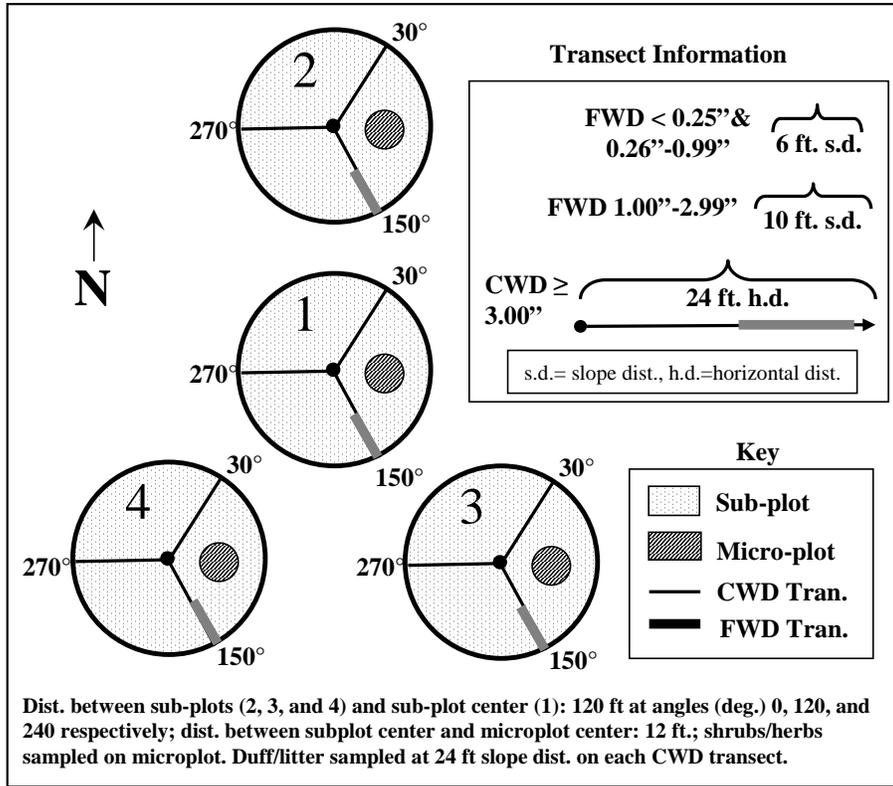


Figure 14-1. Plot layout for sampling CWD, FWD, and fuels.

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.

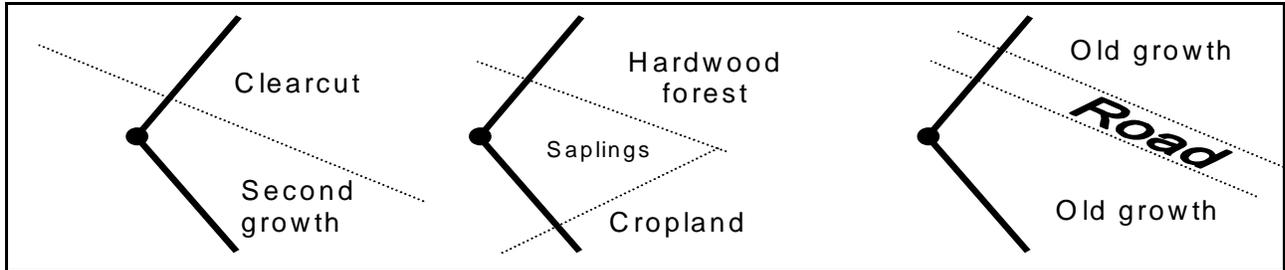


Figure 14-2. Transects are installed across condition class boundaries.

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.

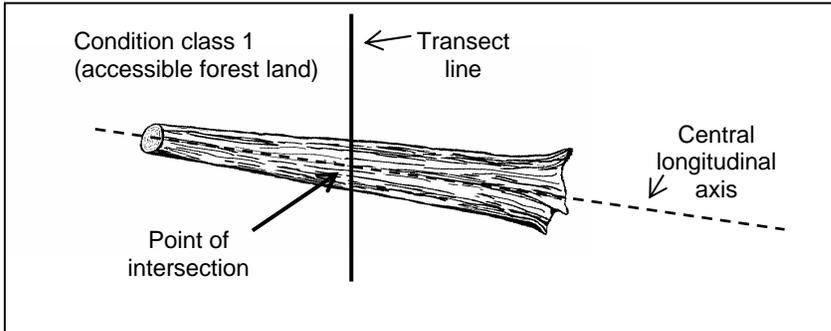


Figure 14-3. Tally rules for CWD.

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).

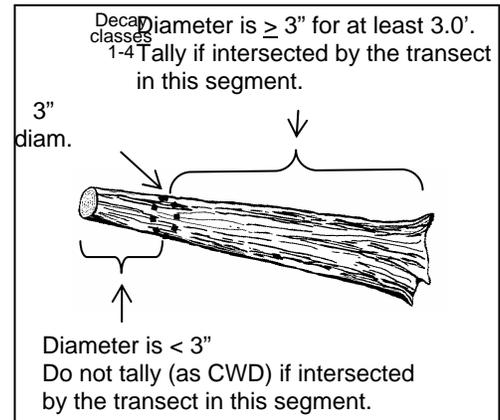


Figure 14-4. CWD tally rules for decay classes 1-4.

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 breakage or uprooting) or by human activities such as cutting only if not systematically machine-piled. Do not record pieces that are part of machine-piled slash piles or windrows, or that are part of a log "jumble" at the bottom of a steep-sided ravine in which individual pieces are impractical to tally separately. Instead, sample these piles

according to instructions in section 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).

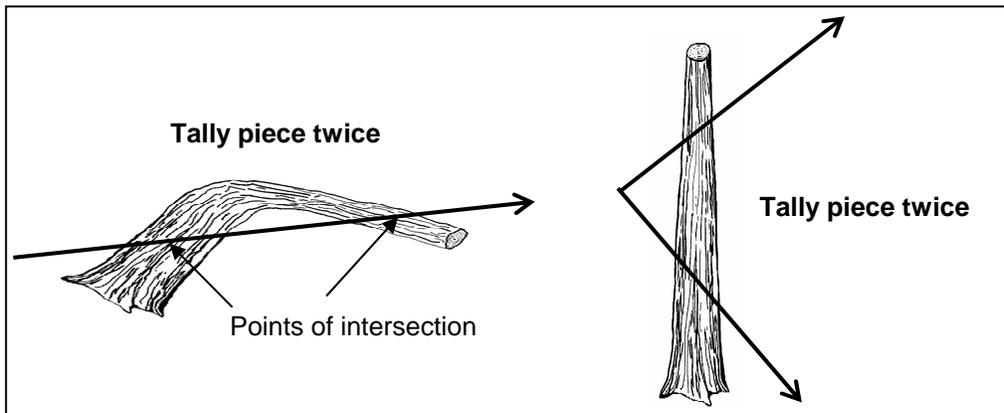


Figure 14-5. CWD tally rules: intersections.

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.

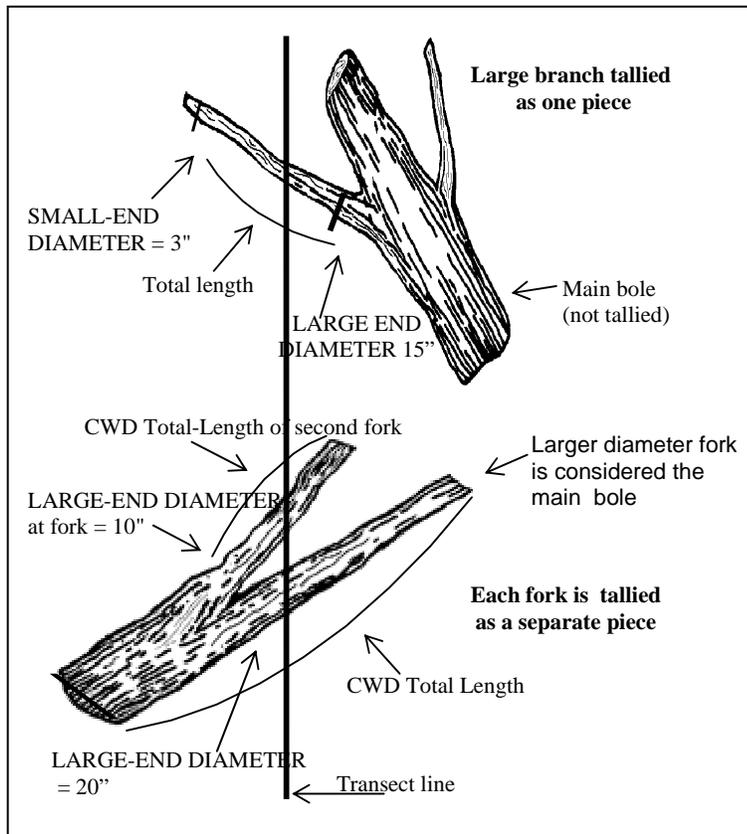


Figure 14-6. CWD tally rules for forked trees.

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

**3.0 Phase 3 Field Guide – Down Woody Materials
October, 2005**

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	Throughout	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	Throughout	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.

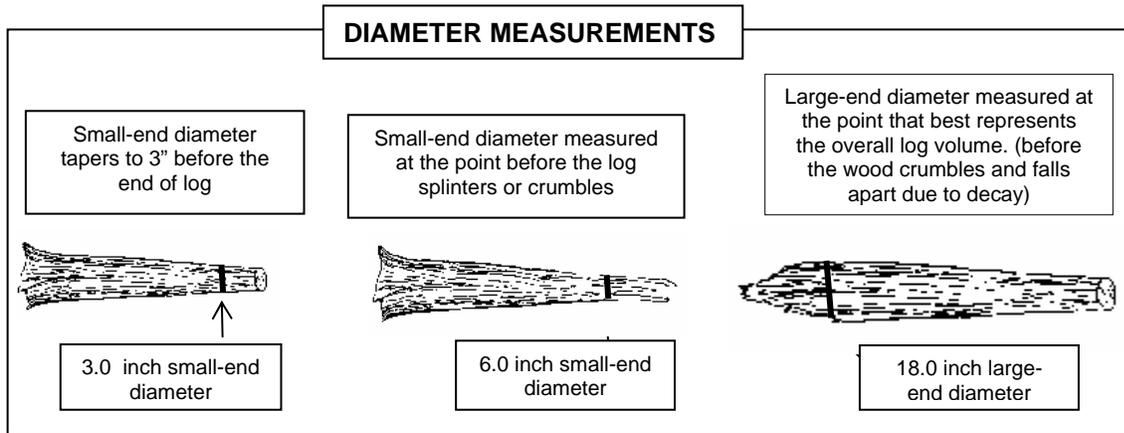


Figure 14-7. Diameter measurements

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.

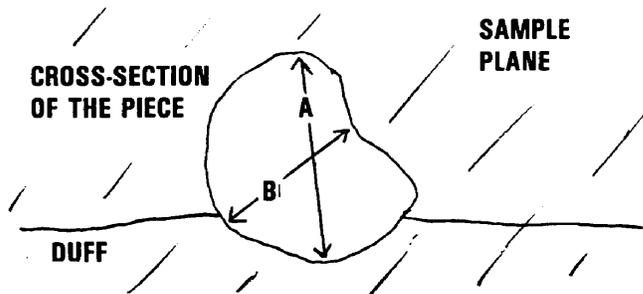


Figure 14-8. Estimating the diameter of pieces that are not round in cross-section.

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.

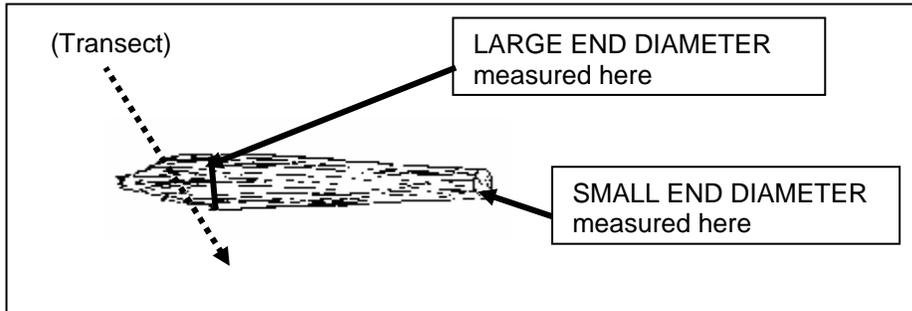


Figure 14-9. Example of decayed end intersecting the transect

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 \geq 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 \geq 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).

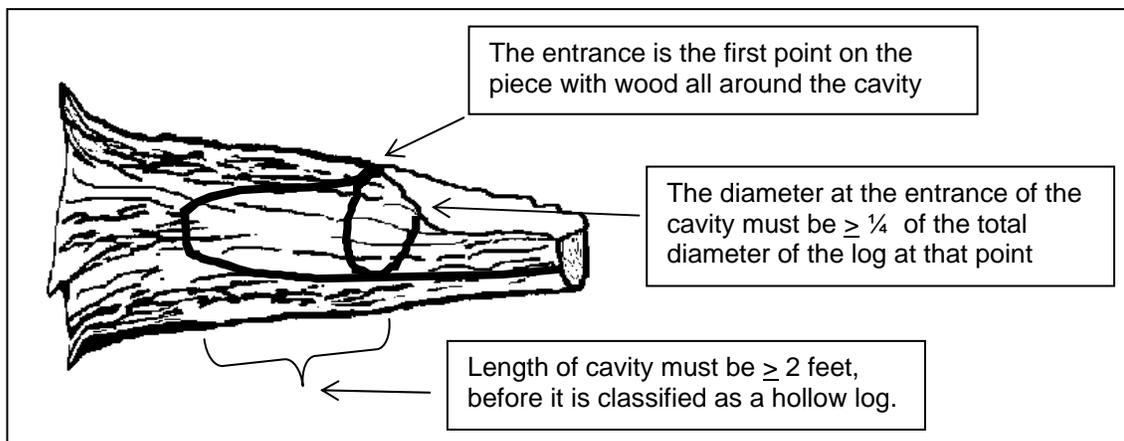


Figure 14-10. Determining if the piece is hollow.

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

**3.0 Phase 3 Field Guide – Down Woody Materials
October, 2005**

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 \geq 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 \geq 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 \geq 3 inches diameter that would be impossible to tally separately.

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

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

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

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

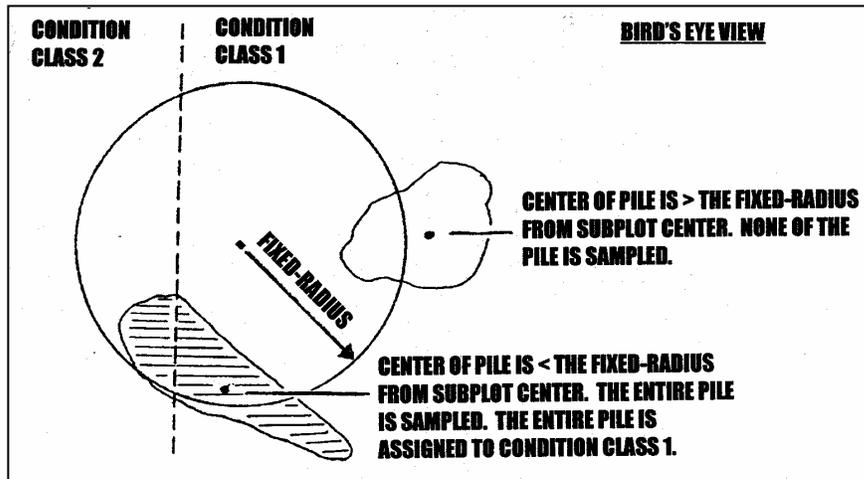


Figure 14-11. Residue pile selection examples.

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

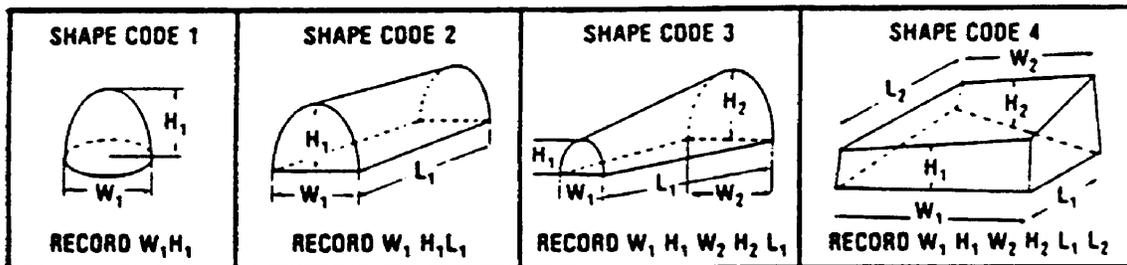


Figure 14-12. PILE SHAPE codes.

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> .

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									

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

**3.0 Phase 3 Field Guide – Down Woody Materials
October, 2005**

FWD Form		0.00 - .25	.25 - 1.00	1.00 - 3.00	H. Count	Residue	History		Microplot Cover	
Sub Plot	Condition	Small	Med	Large	Reason	Pile				
	x	xxx	xxx	xxx	x	x				
1							1	Natural	0	None
2							2	<=15 yrs.	1	Trace
3							3	>15 yrs.	10	1-10
4							4	Firewood	20	11 - 20
							5	Unknown	99	91 - 100

Microplot Fuel Loading									
Sub Plot	Live Shrub	Height	Dead Shrub	Height	Live Herb	Height	Dead Herb	Height	Litter %
	xx (%)	xx.y (ft)	xx (%)	xx.y (ft)	xx (%)	xx.y (ft)	xx (%)	xx.y (ft)	xx (%)
1									
2									
3									
4									

Residue Pile										
Sub Plot	Condition	Azimuth	PILE Shape	Length 1	Length 2	Width 1	Width 2	Height 1	Height 2	Density
xx	xx (%)	xxx (deg)	x	xx (ft)	xx (ft)	xx (ft)	xx (ft)	xx (ft)	xx (ft)	xx (%)