SUPPLEMENT W

SPECIAL DATA COLLECTION PROCEDURES IN WEST OKLAHOMA AND WEST TEXAS

SPECIAL DATA COLLECTION PROCEDURES IN WEST OKLAHOMA AND WEST TEXAS

This section describes special procedures required when measuring western woodlands in Oklahoma and Texas.

1.0 PLOT LEVEL DATA

No differences in plot level data.

2.0 CONDITION CLASS

The following condition level items and descriptions have special requirements for western woodland forest types:

2.3.1 ACCESSIBLE FOREST LAND
ITEM 2404 STAND SIZE CLASS
ITEM 2410 STAND AGE

2.3.1 ACCESSIBLE FOREST LAND

Land that is within the population of interest, is accessible, is on a subplot that can be occupied at subplot center, can safely be visited, and meets (a) **or** (b) **and** (c) from the following criteria:

(a) the condition is at least 10-percent stocked by trees of any size (Appendix 2) or has been at least 10-percent stocked in the past. Additionally, the condition is not subject to nonforest use(s) that prevent normal tree regeneration and succession such as regular mowing, intensive grazing, or recreation activities;

or

(b) in several western woodland types (see Appendix 2) where stocking cannot be determined, and the condition has at least 5 percent crown cover by trees of any size, or has had at least 5 percent cover in the past. Additionally, the condition is not subject to nonforest use that prevents normal regeneration and succession such as regular mowing, chaining, or recreation activities.

and

(c) the prospective condition must be at least 1.0 ac in size and 120.0 ft wide measured stem-to-stem. Forested strips must be 120.0 ft wide for a continuous length of at least 363.0 ft in order to meet the acre threshold. Forested strips that do not meet these requirements are classified as part of the adjacent nonforest land.

ITEM 2404 STAND SIZE CLASS (CORE2.4.4)

Record the code that best describes the predominant size class of all live trees in the condition class that are not overtopped.

When collected: If SIMILAR CONDITION CLASS = 0 and PRESENT CONDITION STATUS = 1
Field width: 1 digit
Values:

0 Nonstocked:
Meeting the definition of accessible forest land, and one of the following applies:

(a) less than 10 percent stocked by trees of any size, and not classified as cover trees, or

(b) for forest types where stocking standards are not available, less than 5 percent **crown cover** of trees of any size.

1 < 4.9 in (seedlings / saplings)
At least 10 percent stocking (or 5 percent crown cover if stocking tables are not available) in trees of any size; and at least 2/3 of the crown cover is in trees less than 5.0 in DBH/DRC.

2 5.0 – 8.9 in (softwoods) / 5.0 – 10.9 in (hardwoods)
At least 10 percent stocking (or 5 percent crown cover if stocking tables are not available) in trees of any size; and at least 1/3 of the crown cover is in trees greater than 5.0 in DBH/DRC and the plurality of the crown cover is in softwoods between 5.0 – 8.9 in diameter and/or hardwoods between 5.0 – 10.9 in DBH, and/or western woodland trees 5.0 – 8.9 in DRC.

3 9.0 – 19.9 in (softwoods) / 11.0 – 19.9 in (hardwoods)
At least 10 percent stocking (or 5 percent crown cover if stocking tables are not available) in trees of any size; and at least 1/3 of the crown cover is in trees greater than 5.0 in DBH/DRC and the plurality of the crown cover is in softwoods between 9.0 – 19.9 in diameter and/or hardwoods between 11.0 – 19.9 in DBH, and for western woodland trees 9.0 – 19.9 in DRC.

4 20.0 – 39.9 in
At least 10 percent stocking (or 5 percent crown cover if stocking tables are not available) in trees of any size; and at least 1/3 of the crown cover is in trees greater than 5.0 in DBH/DRC and the plurality of the crown cover is in trees between 20.0 – 39.9 in DBH.

5 40.0 + in
At least 10 percent stocking (or 5 percent crown cover if stocking tables are not available) in trees of any size; and at least 1/3 of the crown cover is in trees greater than 5.0 in DBH/DRC **and** the plurality of the crown cover is in trees ≥ 40.0 in DBH.

6 Cover trees (non-tallied):
Less than 10 percent stocking by trees of any size, and greater than 5 percent crown cover of species that comprise cover trees.

The instructions in Sections 2.1 and 2.3 apply when delineating, on accessible forest land, contrasting conditions based on differences in STAND SIZE CLASS.

Within the sampled area on microplot, subplot, or annular plot, recognize only very obvious contrasting stands of different mean diameter with an abrupt boundary. Example: an obvious abrupt boundary exists within the sampled (fixed-radius) area of a subplot and demarcates a large diameter stand from a small diameter stand. Use tree stocking of all live trees that are not overtopped to differentiate between stand-size classes; for most western woodland forest types (e.g., pinyon, juniper, gambel oak) where stocking values are not readily available, use percent tree cover to represent stocking.

Use crown cover as the surrogate for stocking to determine STAND SIZE CLASS. View the plot from the top down and examine crown cover. The stand must have at least 5% of the crown cover in STAND SIZE CLASSES of 1,2,3,4, and 5 or any combination of these STAND SIZE CLASSES; otherwise the STAND SIZE CLASS is either 0 or 6 depending on the characteristics of the stand. If at least 1/3 of crown cover is made up of STAND SIZE CLASSES = 2, 3, 4, and 5 (combined), the accessible forested condition will be classified in one of these STAND SIZE CLASSES based on which of these STAND SIZE CLASSES has the most crown cover. If less than 1/3 of the crown cover is made up of STAND SIZE CLASSES = 2, 3, 4, and 5 (combined), classify the accessible forested condition as a STAND SIZE CLASS = 1, if adequate cover is present.

If no other condition class defining variables are different between accessible forest conditions, delineate on differences in STAND SIZE CLASS only for the following combinations:

Between Nonstocked (STAND SIZE CLASS = 0) or cover trees (STAND SIZE CLASS = 6) and any stocked forest land (STAND SIZE CLASS = 1, 2, 3, 4, or 5);
Between STAND SIZE CLASS = 1 and STAND SIZE CLASS = 3, 4, and 5;
Between STAND SIZE CLASS = 2 and STAND SIZE CLASS = 4 and 5; or
Between STAND SIZE CLASS = 3 and STAND SIZE CLASS = 5.

Note: Differing stand size classes can be used to describe separate condition classes, while at the same time not be used to delineate separate condition classes. Example: Two adjacent forested stands of the same forest type, one with a STAND SIZE CLASS = 1 and the other with a STAND SIZE CLASS = 2 could be delineated as separated CONDITION CLASS if one of the other condition class delineation variables differs (based on the rules), i.e. OWNER GROUP differs between the two condition classes. In addition, the STAND SIZE CLASS variables for the two condition classes would be recorded and treated as an ANCILLARY variable.

ITEM 2410 STAND AGE (CORE 2.4.10)

Record the average total age, to the nearest year, of the trees (plurality of all live trees not overtopped) in the predominant STAND SIZE CLASS of the condition, determined using local procedures. Record 000 for non-stocked stands.

An estimate of STAND AGE is required for every forest land condition class defined on a plot. Stand age is usually highly correlated with stand size and should reflect the average age of all trees that are not overtopped. Unlike the procedure for Site tree age, estimates of stand age should estimate the time of tree establishment (e.g., not age at the point of diameter measurement). Note: For planted stands, estimate age based on the year the stand was planted (e.g., do not add in the age of the planting stock).

To estimate STAND AGE, select two or three dominant or codominant trees from the overstory. If the overstory covers a wide range of tree sizes and species, try to select the trees accordingly, but it is not necessary to core additional trees in such stands. The variance associated with mean stand age increases with stand heterogeneity, and additional cores are not likely to improve the estimate. Core each tree at the point of diameter measurement and count the rings between the outside edge and the core to the pith. Add in the number of years that passed from germination until the tree reached the point of core extraction to determine the total age of the tree. Add : longleaf — 7 years; other pines— 3 years; eastern hardwoods— 2 years, 5 years to western hardwoods, and 10 years to western softwoods. Assign a weight to each core by visually estimating the percentage of total overstory trees it represents. Make sure the weights from all cores add up to 1.0, compute the weighted average age, and record. For example, if three trees aged 34, 62, and 59 years represent 25 percent, 60 percent, and 15 percent of the overstory, respectively, the weighted stand age should be:

(34 x 0.25) + (62 x 0.60) + (59 x 0.15) = 55 years.

In some cases, it may be possible to avoid coring trees to determine age. If a stand has not been seriously disturbed since the previous survey, simply add the number of years since the previous inventory to the previous STAND AGE. In other situations, cores collected from site trees can be used to estimate STAND AGE.

If a condition class is nonstocked, assign a STAND AGE of 000.

If all of the trees in a condition class are not suitable to be bored for age (e.g. rotten cores, unable to read growth rings), then record 998. This code should be used in these cases only.

When collected: If SIMILAR IDENTIFIED CONDITION = 0 and PRESENT CONDITION STATUS = 1
Field width: 3 digits
Values: 000 to 997, 998, 999

3.0 BOUNDARY REFERENCES

No differences in boundary references.

4.0 SUBPLOT INFORMATION

No differences in subplot information.

5.0 TREE AND SAPLING DATA

The following tree and sapling data have special requirements for western woodland species:

Standing dead definition
ITEM 5040 AZIMUTH
ITEM 5050 HORIZONTAL DISTANCE
ITEM 5092 DIAMETER AT ROOT COLLAR (DRC)
ITEM 5230 LENGTH TO DIAMETER MEASUREMENT POINT
ITEM 5170 COMPACTED CROWN RATIO
ITEM 5110 ROTTEN/MISSING CULL

STANDING DEAD

To qualify as a standing dead tally tree, dead trees must be standing (LEAN ANGLE = 0) at least 4.5 ft tall and be at least 5.0 inches in diameter. Broken portions of trees that are completely separated from their base are not treated as separate trees. For western woodland species (Appendix 3) with multiple stems, a tree is considered down if more than 2/3 of the volume is no longer attached or upright; do not consider cut and removed volume.

ITEM 5040 AZIMUTH (CORE 5.04)

Record the AZIMUTH from the subplot center (for trees ≥ 5.0 in DBH/DRC) or the microplot center (for saplings 1.0 in and < 5.0 in DBH/DRC), sight the center of the base of each tree with a compass. Sight to the geographic center for multi-stemmed western woodland species. The geographic center is a point of equal distance between all tallied stems for a given woodland tree. Record AZIMUTH to the nearest degree. Use 360 for north.

Note: When SAMPLE KIND = 2, for microplot saplings that become subplot trees, crews must collect new azimuth and distance information from the subplot center.

When Collected: All live and standing dead tally trees ≥ 1.0 in DBH/DRC
Field width: 3 digits
Values: 001 to 360

ITEM 5050 HORIZONTAL DISTANCE (CORE 5.05)

Record the measured HORIZONTAL DISTANCE, to the nearest 0.1 ft, from the subplot center (for trees ≥ 5.0 in DBH/DRC) or microplot center (for saplings 1.0 in and < 5.0 in DBH/DRC) to the pith of the tree at the base. For all multi-stemmed western woodland trees (woodland species indicated in Appendix 3), the HORIZONTAL DISTANCE is measured from subplot or

microplot center to the "geographic center" of the tree. The geographic center is a point of equal distance between all tallied stems for a given woodland tree.

Note: When SAMPLE KIND = 2, for microplot saplings that become subplot trees, crews must collect new azimuth and distance information from the subplot center.

When Collected: All live and standing dead tally trees ≥ 1.0 in DBH/DRC
Field width: 3 digits (xx.y)
Values: Microplot: 001 to 068
Subplot: 001 to 240

DIAMETER

Diameters are measured at either breast height (DBH) or at the root collar (DRC). Species requiring DRC, referred to as woodland species, are denoted with a “w” in Appendix 3. Trees with diameters between 1.0- and 4.9-inches are measured on the 6.8-ft radius microplot, those with diameters of 5.0-inches and larger are measured on the 24-ft radius subplots.

ITEM 5092 DIAMETER AT ROOT COLLAR (DRC) (CORE 5.09.4)

For species requiring diameter at the root collar (refer to Appendix 3), measure the diameter at the ground line or at the stem root collar, whichever is higher. For these trees, treat clumps of stems having a unified crown and common root stock as a single tree; examples include mesquite, juniper, and mountain mahogany. Treat stems of woodland species such as Gambel oak and Rocky Mountain maple as individual trees if they originate below the ground. For multi-stemmed trees, compute and record a cumulative DRC (see below); record individual stem diameters and a stem status (live or dead) on a separate form or menu as required.

1 Measuring DRC: Before measuring DRC, remove the loose material on the ground (e.g., litter) but not mineral soil. Measure just above any swells present, and in a location so that the diameter measurements are reflective of the volume above the stems (especially when trees are extremely deformed at the base).

Stems must be at least 1.0 ft in length and 1.0 inch in diameter to qualify for measurement; stems that are missing due to cutting or damage must have previously been at least 1.0 ft in length.

Whenever DRC is impossible or extremely difficult to measure with a diameter tape (e.g., due to thorns, extreme number of limbs), stems may be estimated and recorded to the nearest 1.0-in class.

Additional instructions for DRC measurements are illustrated in Figure 23.

2 Computing and Recording DRC: For all tally trees requiring DRC, with at least one stem 1.0 inch in diameter or larger at the root collar, DRC is computed as the square root of the sum of the squared stem diameters. For a single-stemmed DRC tree, the computed DRC is equal to the single diameter measured.

Use the following formula to compute DRC:

$$DRC = SQRT [SUM (stem\ diameter^2)]$$

Round the result to the nearest 0.1 in. For example, a multi-stemmed woodland tree with stems of 12.2, 13.2, 3.8, and 22.1 would be calculated as:

$$DRC = SQRT (12.2^2 + 13.2^2 + 3.8^2 + 22.1^2)$$
$$= SQRT (825.93)$$
$$= 28.74$$
$$= 28.7$$

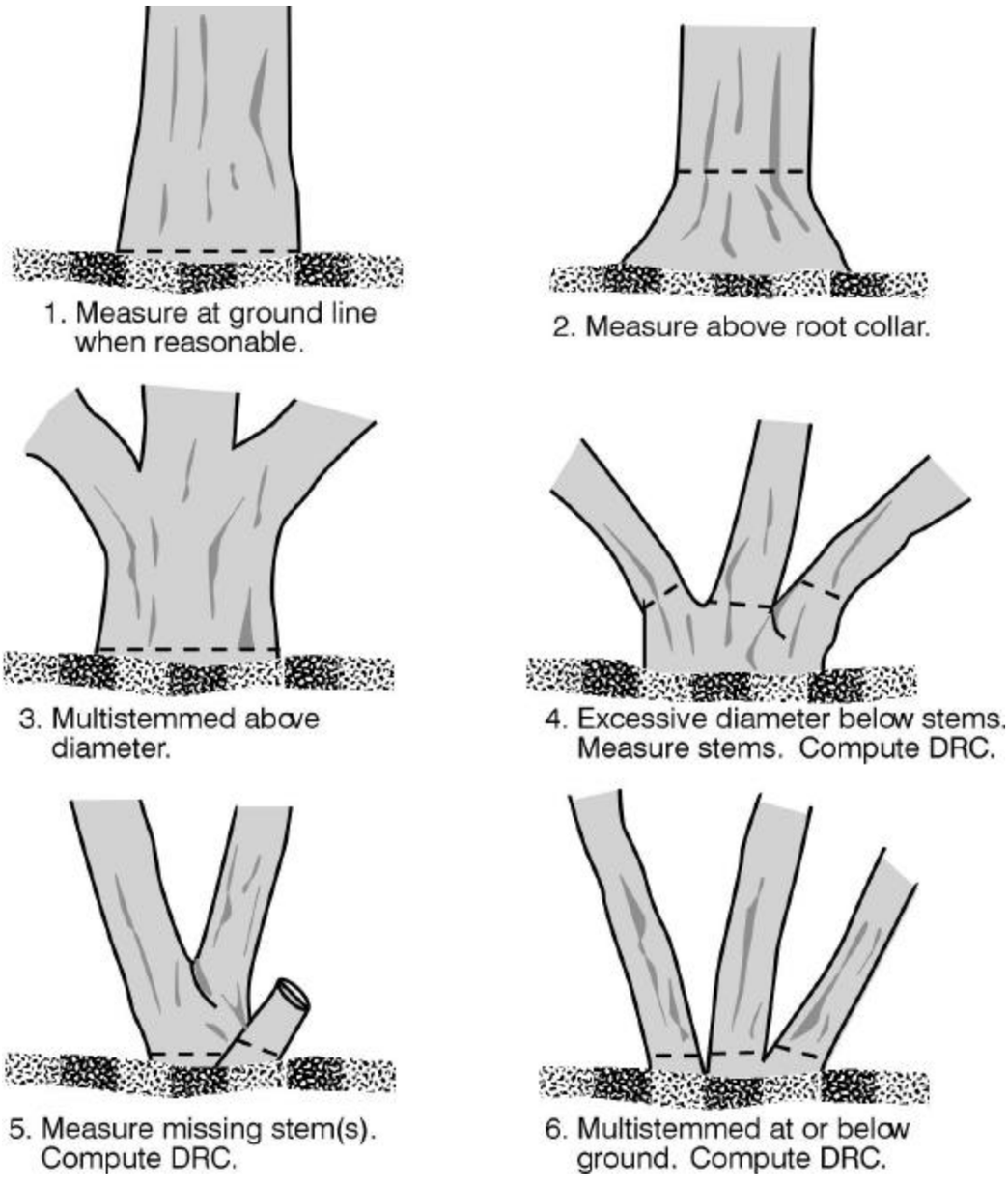

Figure 23. How to measure DRC in a variety of situations.

ITEM 5230 LENGTH TO DIAMETER MEASUREMENT POINT (CORE 5.23)

For those trees measured directly at 4.5 ft above the ground, leave this item blank. If the diameter is not measured at 4.5 ft, record the actual length from the ground, to the nearest 0.1 in, at which the diameter was measured for each tally tree, 1.0 in DBH and larger. Leave this item blank for western woodland species measured for diameter at root collar.

When Collected: All live and dead tally trees (except western woodland species)
Field width: 3 digits
Values: 001 – 150

ITEM 5170 COMPACTED CROWN RATIO (CORE 5.17)

Record the COMPACTED CROWN RATIO for each live tally tree, 1.0 in and larger to the nearest 1%. COMPACTED CROWN RATIO is that portion of the tree supporting live foliage and is expressed as a percentage of the actual tree length. To determine COMPACTED CROWN RATIO, ocularly transfer lower live branches to fill in large holes in the upper portion of the tree until a full, even crown is visualized.

Do not over-compact trees beyond their typical full crown situation. For example, if tree branches tend to average 2-feet between whorls, do not compact crowns any tighter than the 2-foot spacing (Figure 28).

When Collected: All live tally trees 1.0 in DBH/DRC
Field width: 2 digits
Values: 00 to 99

For multi-stemmed western woodland species, ocularly transfer lower live foliage to fill large holes on all stems and form an even crown across the tree (Figure 28).

ITEM 5110 ROTTEN/MISSING CULL (CORE 5.11)

Record the percentage of rotten and missing cubic-foot volume, to the nearest 1 percent. When estimating volume loss (tree cull), only consider the cull on the merchantable bole/portion of the tree, from a 1-ft stump to a 4-inch top. Do not include any cull estimate above actual length. For western woodland species, the merchantable portion is between the point of DRC measurement to a 1.5-inch DOB top. See Appendix 3 for complete procedures and cubic foot volume table.

When Collected: All live tally trees $\geq$ 5.0 in DBH; all mortality trees $\geq$ 5.0 in DBH and TREE CLASS = 2
Field width: 2 digits
Values: 00 to 99

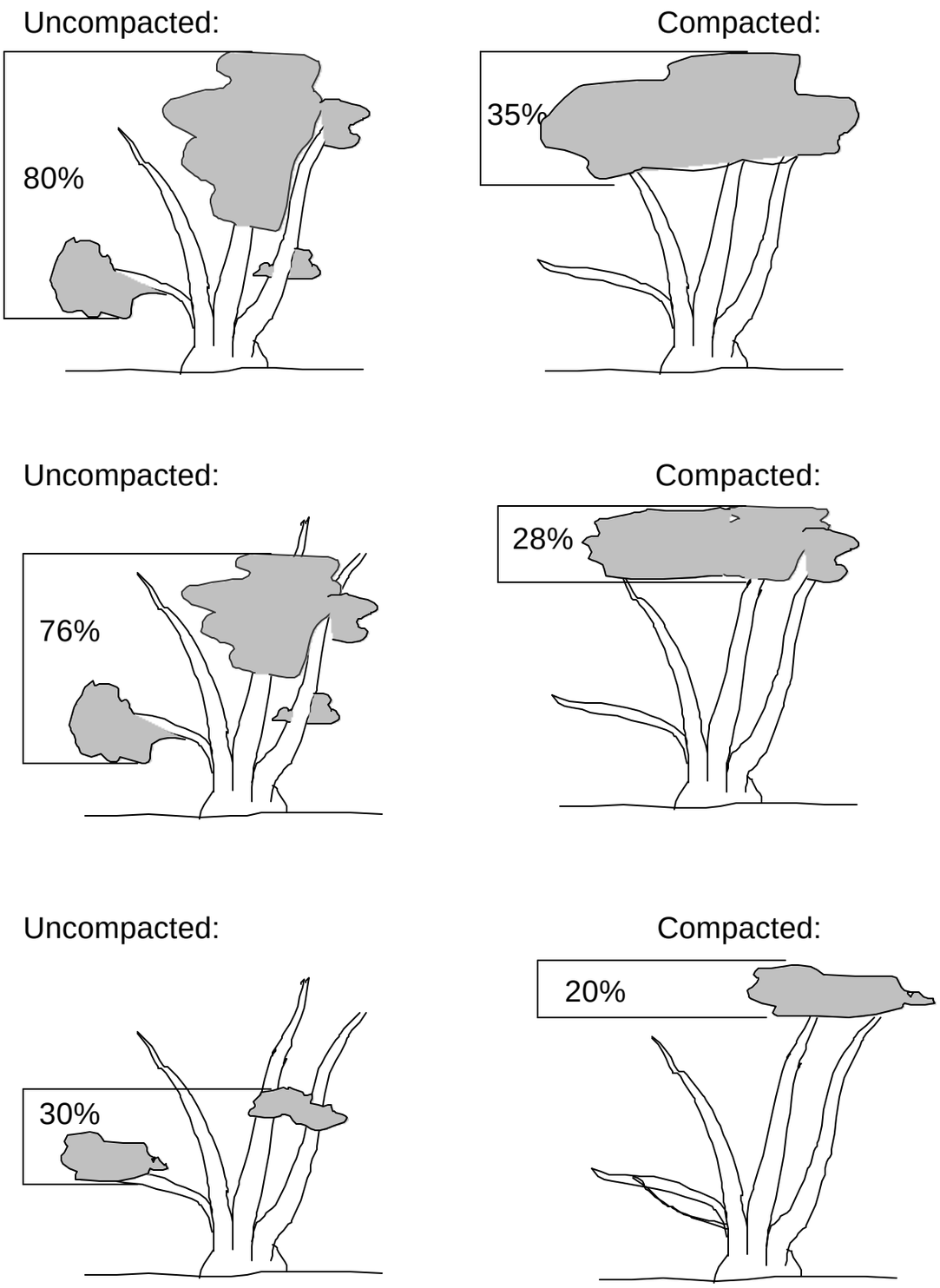

Figure 28. Examples of COMPACTED CROWN RATIO of western woodland species.

6.0 SEEDLING DATA

Stocking and regeneration information are obtained by counting seedlings within the 6.8 ft radius microplot located 90 degrees and 12.0 ft from each subplot center within each of the four subplots. Conifer seedlings must be at least 6.0 inches in length and less than 1.0 in at DBH/DRC in order to qualify for tallying. Hardwood seedlings must be at least 12.0 inches in length and less than 1.0 in at DBH/DRC in order to qualify for tallying. For western woodland species, each stem on a single tree must be less than 1.0 inch in DRC. Seedlings are counted in groups by species and condition class, up to 5 individuals per species. Counts beyond 5 are coded as 6. Species are coded in order from most abundant to least abundant when SEEDLING COUNT is coded as 6. Only count seedlings occurring in accessible forest land condition classes.

7.0 SITE TREE INFORMATION

Reject woodland species when selecting site tree species. See Appendix 4 for site tree selection criteria.

8.0 NONFOREST/DENIED ACCESS/HAZARDOUS/ INTENSIFICATION PLOTS

No differences in nonforest/denied access/hazardous/intensification plots.

NOTE: See Section 2.3.1 Accessible Forest Land in this supplement for a definition of forest land in western woodland forest types.

Section 9. Ozone Bioindicator Plants (West)

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9.0 QUICK REFERENCE FOR THE OZONE INDICATOR

9.0.1 QUICK REFERENCE ON 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.

9.0.2 QUICK REFERENCE ON PDR SCREENS

Ozone indicator data are recorded on portable data recorders (PDR's) including Paravant, Husky, Handspring and Palm. Each of the tables below corresponds to a PDR data screen or portion of a screen that includes ozone measurement variables. The tables serve as a quick reference for the PDR application screens by indexing the Subsections in this chapter where the variables on each screen are defined. An "x" in one of these tables means that the variable is prompted for on the FIA Ozone Grid, and the field crew is required to complete that field. For a written summary of the data entry procedures, definitions, and codes for the ozone measurement variables refer to subsections 9.1.3 and 9.2 through 9.5. There is a PDR Field Manual and a User's Guide for the Palm that provide a self-guided tour of the data entry screens for the ozone indicator.

Table 9-1. Bioindicator Plot Identification Screen(Subsection 9.2 and 9.6)

Measurement Variables	PDR Prompt	SAMPLE KIND 1,2, and 3	FG Subsection
STATE	State	X	9.2.1
COUNTY	Cnty	X	9.2.2
OZONE HEXAGON NUMBER	Hex Num	X	9.2.3
PLOT NUMBER	PlotNum	Set to1	9.2.4
QA STATUS	QA Stat	X	9.2.5
CREW TYPE	CrewTyp	X	9.2.6
OZONE SAMPLE KIND	SampKnd	X	9.2.7
MONTH	Month	X	9.2.8.1
DAY	Day	X	9.2.8.2
YEAR	Year	Set to current year	9.2.8.3
OZONE GRID DENSITY	GridDen	X	9.2.9
PLOT SIZE	PlotSiz	X	9.2.10
ELEVATION	Elev	X	9.3.4
ASPECT	Aspct	X	9.2.11
TERRAIN POSITION	TerrPos	X	9.2.12
SOIL DEPTH	SoilDep	X	9.2.13
SOIL DRAINAGE	SoilDrn	X	9.2.14
PLOT WETNESS	PlotWet	X	9.2.15
DISTURBANCE	Distrb	X	9.2.16
INJURY CHECK	InjChk	X	9.2.17

Table 9-2. Plot Notes Screen (Subsection 9.5.1 and 9.6)

Measurement Variables	PDR Prompt	SAMPLE KIND 1,2, and 3	FG Subsection
REMARKS1	Rem1	X	9.5.1
REMARKS2	Rem2	X	9.5.1

Table 9-3. Bio Species Screen (Symptom Scoring, Subsection 9.4, 9.6.4 and 9.6.6)

Measurement Variables	PDR Prompt	SAMPLE KIND 1,2, and 3	FG Subsection
SPECIES	Species	X	9.4.1 and 9.6.4
AMOUNT	Amount	X	9.4.2 and 9.6.6
NUMBER OF PLANTS	NbrPlnt	X	9.4.3
SEVERITY	Severity	x	9.4.4 and 9.6.6

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). In the enhanced FIA Program, 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 / 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 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. Estimated errors for the ozone indicator measurements are kept below 10%; and

5. 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 our national forests. In cleaner regions, the emphasis must be on establishing a baseline for the ozone indicator. In this regard, field crews collecting mostly zeros for the ozone injury variables are making a significant contribution to the national FIA database.

9.1.2 SUMMARY OF METHOD

Crew procedures include the selection of a suitable site for symptom evaluation, identification of one to three 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 field work for the ozone indicator.

9.1.3 SUMMARY OF TALLY PROCEDURES, DEFINITIONS, AND CODES

All of the ozone bioindicator data are entered under Option 07 on the Tally main menu. For each biomonitoring site, you must select Option 07 from the Tally main menu and complete the three data entry screens for ozone data. The Bioindicator Plot Identification Screen (Table 9-1) includes a record of plot status and detail on site characteristics that influence ozone injury expression. The Plot Notes Screen (Table 9-2) prompts crews to add additional information that will help interpret the injury results and/or assist subsequent crews collecting data at the same location. The Bio Species Screen (Table 9-3 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 3 screens presented under the Tally, Bioindicator Plants Option 07.

Ozone applications other than Tally also use three data entry screens as described above.

9.1.4 EQUIPMENT AND SUPPLIES

- X A large diameter, 10X hand lens for close examination of plant leaves for ozone injury.
- X Reference photographs and laminated leaf samples to aid in symptom identification.
- X A small plant press with cardboard inserts to store leaf vouchers collected in the field.
- X Stamped, addressed envelopes for mailing the leaf vouchers to the National Ozone Advisor.
- X Stiff paper or cardboard for protecting the leaf vouchers in the mailing envelopes.
- X Flagging: for temporary marking of sites or sample plants.
- X 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. Although field crews are certified during the regular preseason training session, they must also participate in a refresher session held 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 session 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. Field crew supervisors audit the field crews and assist Regional Advisors and QA staff with remeasurement activities as needed.

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).

9.1.5.1 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 9.6.7. 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.

9.1.6 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 (978) 544-7186 (< 7am + > 7pm)
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 92506
e-mail: ptemple@fs.fed.us
or: temple_p@msn.com

Regional Advisor for the North Central Region:

Ed Jepsen Phone: (608) 266-3538
Wisconsin Department of Natural Resources
101 South Webster Street
Madison, WI 53707
e-mail: jepsee@dnr.state.wi.us

Regional Advisor for the South:

Dan Stratton Phone: (828) 257-4350
USDA Forest Service
P.O. Box 2680
Asheville, NC 28802
e-mail: dstratton@fs.fed.us

9.2 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 (Paravant or Husky) or a personal data assistant (Handspring or Palm).

Ozone plots vary in size and do not have set boundaries. When describing plot-level characteristics, use the predominant characteristics where most of the plant species are located. If conditions vary markedly across the site, or by species, then describe this in the plot notes or on the site map. Specify the elevation, aspect, terrain position, soil depth, soil drainage, and disturbance for the highest priority species (Subsection 9.6.4) found on the site. For a complete explanation of the procedures associated with these measurement codes, refer to Subsection 9.6.

9.2.1 STATE

Record the unique FIPS 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

9.2.2 COUNTY

Record the unique FIPS code identifying the county 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

9.2.3 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:

9.2.4 PLOT NUMBER

This variable is preset to “1” and may not be visible on your PDR screen.

9.2.5 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 7

1 Standard ozone plot
2 Cold check
3 Not used
4 Training/practice plot (off grid)
5 Botched plot file
6 Blind check
7 Production plot (hot check)

9.2.6 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 crew collecting remeasurement data)

9.2.7 OZONE SAMPLE KIND

Record the code that describes the kind of plot being visited.

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.
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.

9.2.8 CURRENT DATE

Record the MONTH (2-digits), DAY (2 digits), and YEAR (4-digits) that the current plot was completed.

9.2.8.1 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

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

9.2.8.2 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

9.2.8.3 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

9.2.9 OZONE GRID DENSITY

Record the code that identifies whether the plot is on the base ozone grid or on an intensified ozone grid.

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:1 polygon)
2 One of two or more ozone plots within the same polygon.

9.2.10 PLOT SIZE

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

When collected: All plots
Field width: 1 digit
Tolerance:
MQO: Repeatable estimate
Values: 1 to 3

1 Greater than three acres (1.2 hectares).
2 Greater than one acre, but less than three acres (0.2 to 1.2 hectares).
3 Not used.
4 Not used.

9.2.11 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: 0 to 360°

9.2.12 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

9.2.13 SOIL DEPTH

Record the code that indicates the 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.

9.2.14 SOIL DRAINAGE

Record the code that identifies the 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

9.2.15 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.

9.2.16 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.

9.2.17 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.

9.3 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 1.6. 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.

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.

9.3.1 GPS UNIT

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

When collected: All 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 Trimble GeoExplorer or Pathfinder Pro
4 Recreational GPS (Garmin, Magellan, etc.)

9.3.2 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

9.3.3 GPS LATITUDE

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

When collected: When GPS UNIT = 1, 2, 3 or 4
Field width: 8 digits
Tolerance: +/- 140 ft
MQO: At least 99% of the time
Values:

9.3.4 GPS LONGITUDE

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

When collected: When GPS UNIT = 1, 2, 3 or 4
Field width: 9 digits
Tolerance: +/- 140 ft
MQO: At least 99% of the time
Values:

9.3.5 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 = 0,1, 2 or 4
Field width: 6 digits
Tolerance:
MQO: At least 99% of the time
Values: -00100 to 20000

9.3.6 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: 0 to 70 if possible; 71 to 999 if an error of less than 70 cannot be obtained

9.3.7 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: 1 to 999

9.3.8 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

9.4 FOLIAR INJURY DATA

All measurement codes for the BioSpecies screen (e.g., foliar injury data) are defined below. The codes and definitions are the same whether the crew is entering data on a PDR or personal data assistant (Palm). 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 Subsection 9.6.6). 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 after 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.

9.4.1 SPECIES

Record the three-digit code that identifies each species on the plot. Codes for the bioindicator species are listed on the help screen for this variable. 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: 3 digits
Tolerance: No error
MQO: At least 90% of the time
Values:

9.4.2 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 9.6.6.

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

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.

9.4.3 NUMBER OF PLANTS

Record the number of plants you have tallied so far with no injury. When 0 is entered for AMOUNT, the PDR prompts you for the NUMBER OF PLANTS with no injury. When a number greater than zero is entered for AMOUNT, the PDR prompts you for the associated SEVERITY value. You can enter zero and non-zero values for any species as they are encountered on the plot. The pop-up menu keeps track of plant counts by species so that you do not have to.

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

9.4.4 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 9.6.6.

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

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.

9.5 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

9.5.1 Rem1 and Rem2

Record any information on site characteristics, 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

9.6 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. Some plots or biosites will be new, established for the first time in 2002 on the new FIA ozone grid. Other plots have been established for many years as part of the FIA-P3 or FHM plot system. Both old and new plots have equal importance to the FIA program and are part of the national database for ozone biomonitoring.

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 2002 ozone grid**. 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 known ozone-sensitive species** at the site, symptom identification and scoring on the foliage of **30 plants of each** of three 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 evaluation window, **all ozone sites on the ozone grid are**

evaluated for ozone injury. The same sites are evaluated **every year**.

Site selection procedures depend on whether crews are establishing new ozone sites or revisiting established plots. However, procedures for species and plant selection, symptom identification and scoring, and collection of leaf samples for verification of the ozone symptom are the same for all crews.

9.6.1 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 8 July and extends through 23 August. In the West Coast States, the window is open from 15 July through 23 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. If possible, 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.

9.6.2 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
Size of Opening:	>3 acres (1.2h); wide open area <50% crown closure	Between 1-3 acres; long narrow or irregularly sized opening
Plant Numbers:	More than 30 plants of more than 3 species	More than 30 plants of 2 or 3 species
Site Moisture:	Wet or damp area; riparian zone, meadow, bottom land.	Moderately dry area; grassland or Northeast facing slope.
Site Conditions:	Good to adequate fertility; No recent disturbance or obvous soil compaction.	Exposed or rocky area; Little or no disturnbance.

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. Nearby sites are combined under the same hexagon number. If site characteristics vary significantly, note this on the field data mapping sheet and on the Plot Notes screen of the PDR. Use your best judgment as to what constitutes a nearby site. Ozone is a regional pollutant, affecting large geographic areas, and sites within 3 miles of each other generally have the same ozone exposure regime.

States in the Interior and West Coast Regions, that are establishing ozone sites for the first time, complete the site selection procedures described below and map the best site that can be found within the confines of each grid polygon visited by the crews during the field season. The subsequent procedures for species and plant selection, and symptom quantification are completed only if the evaluation window is open at the time of site selection and establishment. Generally, crews are expected to complete two ozone sites in a ten-hour workday.

The best ozone sites are often associated with wildlife preserves on public land. 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. Private landowners are often eager to participate in the ozone program. State and county parks and wildlife openings also provide good ozone sites. Avoid open areas where plants are obviously stressed by some other factor that could mimic the ozone response. Do not select a site under a high-tension power line or on or near an active or reclaimed landfill. No more than **one half day** should be spent locating a new bioindicator evaluation site.

FIA crews and State Cooperators that have an established network of ozone sites are strongly encouraged to select and map new sites as needed throughout the field season, but the focus of the field activities should be on symptom quantification during the injury evaluation period. Once the evaluation window opens, crews complete the bioindicator measurements on all ozone sites on the grid. The logistics of completing the bioindicator measurements may vary from State to State depending on the numbers of plots and crews. Crews must provide **geographic coordinates (i.e., latitude and longitude)** for all newly established ozone sites.

9.6.3 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 Subsection 9.6.5) **and approximate location of plant groupings** used for evaluation (see Subsection 9.6.6) 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). This bioindicator site map must be kept with the appropriate state or federal cooperator so that it is readily available to whoever needs it.

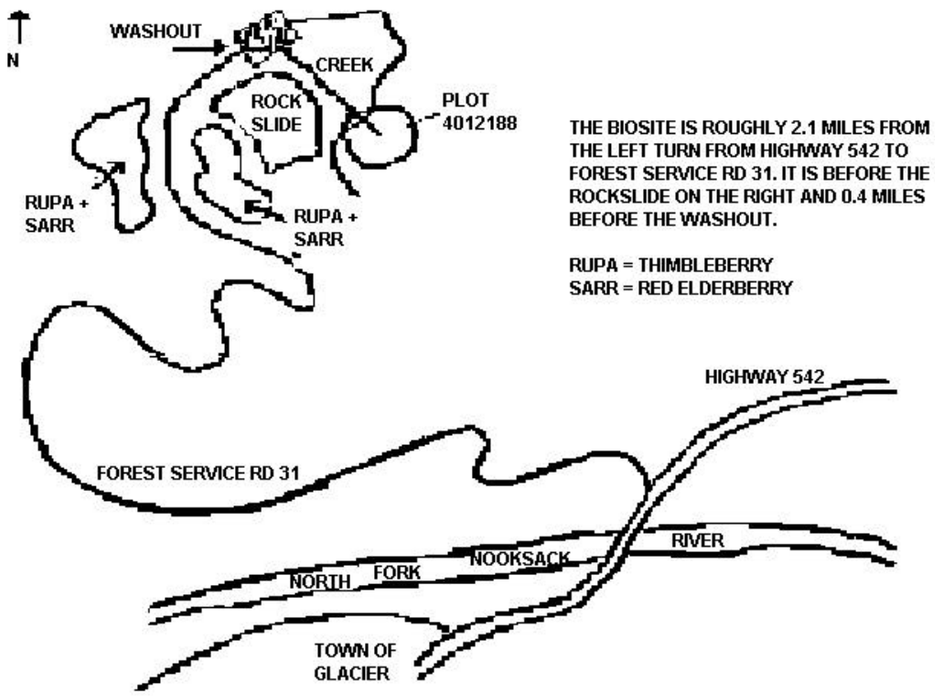

Figure 9-1. Example of a well-drawn map showing the location of the biosite and the approximate location of the bioindicator species and other key landmarks. Road names and North arrow are also included.

9.6.4 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
122	Ponderosa pine[1]	*Pinus ponderosa*
746	Quaking aspen	*Populus tremuloides*
924	Scouler=s willow	*Salix scouleriana*
116	Jeffrey pine[2]	*Pinus jeffreyi*
351	Red alder[2]	*Alnus rubra*
905	Ninebark	*Physocarpus malvaceus*
965	Huckleberry	*Vaccinium membranaceum*
960	Blue elderberry	*Sambucus cerulea*
961	Red elderberry	*Sambucus racemosa*
909	Skunk bush	*Rhus trilobata*
907	Western wormwood	*Artemesia ludoviciana*
968	Evening Primrose	*Oenothera elata*
969	Mountain snowberry	*Symphoricarpos oreaphilus*

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

West Coast Region

Code	Definition	Scientific Names
122	Ponderosa pine[1]	*Pinus ponderosa*
746	Quaking aspen	*Populus tremuloides*
924	Scouler's willow	*Salix scouleriana*
818	California black oak[2]	*Quercus kellogii*
116	Jeffrey pine	*Pinus jeffreyi*
351	Red alder	*Alnus rubra*
905	Ninebark	*Physocarpus malvaceus*
906	Pacific Ninebark (WC)[3]	*Physocarpus capitatus*
965	Huckleberry	*Vaccinium membranaceum*
960	Blue elderberry	*Sambucus cerulea*
961	Red elderberry	*Sambucus racemosa*
909	Skunk bush	*Rhus trilobata*
907	Western wormwood	*Artemesia ludoviciana*
908	Mugwort	*Artemesia douglasiana*
968	Evening primrose	*Oenothera elata*
969	Mountain snowberry	*Symphoricarpos oreaphilus*

[1] *Pinus ponderosa* var. *ponderosa*
[2] This species is only found in southern Oregon (and south).
[3] WC = This species is only found west of the Cascades.

9.6.5 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, 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 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 or data sheet.

NOTE: A pop-up menu keeps track of the **plant counts** by species. You can tabulate more than three species and a limited sample number of 30 plants per species. Stop when the pop-up display indicates you have tabulated 30 plants of at least 3 species, or when no additional plants can be found on site.

NOTE: 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 two 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.

9.6.6 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 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).

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

- Symptoms are more severe on mid-aged and older leaves. New leaves will have no or very little injury.

- Symptoms are most likely confined to the upper leaf surface, and are typically visible as tiny purple-red to black spots (stippling).

- Check leaves covering each other. Overlapped leaves will have no injury on the bottom leaf.

- There will be some uniformity to size and shape of the lesions (stippling) on a leaf.

- Later in the growing season, stippling may be associated with leaf yellowing or premature senescence. Check the ground for fallen leaves.

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

- Symptoms are visible as diffuse yellow areas (chlorotic mottle) without sharp borders between green and yellow zones, on older needles. Not

all needles in a fascicle will be uniformly affected.

- Chlorotic mottle is rarely seen on current-year needles except in high-ozone areas. On young needles it may appear more olive than yellow.

- Older needles that are directly exposed to sunlight may show the most severe chlorotic mottle. However, almost all exposed branches on a plant will be affected to some degree.
- Premature needle drop frequently occurs on ozone-injured pines, even on trees that do not show other ozone injury symptoms. Check for missing older annual whorls and for large numbers of needles on the ground. Live crowns may appear small and thin.

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

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

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

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

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

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

	leaves/needles have ozone symptoms.
4	On average, 51 to 75 percent of the leaf area of injured leaves/needles have ozone symptoms.
5	On average, >75 percent of the leaf area of injured leaves/needles have ozone symptoms.

NOTE: Red and blue elderberry have compound leaves. Use the whole leaf, not each leaflet, to estimate injury amount and 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 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 Western Regional Trainer using the guidelines presented in Subsection 9.6.7.

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 you are experiencing below average rainfall for your area, please note this in the PDR or on the data sheet.

9.6.7 COLLECTION OF LEAF SAMPLES

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. Crew data that do not include a voucher leaf sample are removed from the FIA database. A voucher leaf sample must be collected for each injured species evaluated on the bioindicator site. For example, 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.

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.

9.6.7.1 FIELD COLLECTION

For each injured, **broad-leaved species**, the voucher consists of three leaves that clearly show the ozone injury symptom. Ideally, these are three leaves with high amounts of foliar injury symptoms. If this is not possible, send whatever leaf sample is available even if it is only one leaf with faint symptoms. Cut the leaf at the petiole with hand clippers or a sharp knife.

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 this is not possible, collect whatever needle sample(s) are available.

If the leaves/needles are wet when you cut them, shake off any excess moisture and pat dry. The samples do not have to be completely dry at this point. Place the samples into the **plant press** you were provided at training. Each leaf or branch sample is placed in the press so that it does not overlap another leaf. (Ozone symptoms become indistinguishable on leaves that overlap each other in the press so that the vouchers become useless.) Include a small **label** with each leaf sample you place into the plant press that identifies which plot the sample came from and the date. Labels are provided for this purpose. Record the information on the labels with indelible ink and then wrap them around the petiole (or stem) of one leaf per sample so that the backsides stick together and will not slip off the leaf. If you forget to take the plant press with you into the field, then place the leaves and accompanying label between pages of a notebook, or otherwise keep as flat as possible.

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

9.6.7.2 DATA COLLECTION

The plants from which the leaf vouchers are selected must be evaluated by the field crews for **INJURY LOCATION and INJURY TYPE**. This information, together with the visible injury symptoms on the leaf samples, will be used to validate the ozone injury data observed and recorded in the field by the field crews. Injury location and type are not specific to a particular plant but are, rather, representative codes of the sampled population. The injury location and 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.

9.6.7.3 MAILING PROCEDURE

Vouchers may be mailed in bulk at the end of the field season, or earlier, depending on your work schedule. It is very important to **mail only dry, pressed leaf samples**. Before mailing, make sure you have filled out the upper half of the voucher data sheet. 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.

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.

9.6.8 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.

9.6.9 SITE INTENSIFICATION

In addition to the unique ozone plots that are identified by the base FIA 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 above. Voucher leaf samples must be collected, according to procedures described in Subsection 9.6.7 and mailed to the National Indicator Advisor.

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

1. ***Ponderosa Pine*** is a large tree, up to 70 meters 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, 12-26 cm 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, 12-25 cm 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 36 meters 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 10 meters in height. Leaf blade is 3-10 cm 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. ***California Black Oak*** is a deciduous tree up to 25 meters in height. Bark becoming deeply furrowed, dark gray-brown to black. Leaves bright green and smooth on the upper surface, dull green and finely hairy on the lower surface, deeply lobed, tips of lobes with 1-4 teeth. Fruit is an acorn with the cup hairy on the inside. May be confused with Oregon white oak which differs by having rounded lobes and the acorn cap without hair inside.

6. ***Pacific Ninebark*** is a deciduous shrub 2-4 meters in height. Leaves alternate, 3 or 5 lobed (maple-like), 4-8 cm 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.

7. ***Ninebark*** is an erect, loosely branched shrub with maple-like leaves and shreddy bark. May be up to 2 meters 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.

8. ***Huckleberry*** is an erect shrub 0.9 to 1.5 m high. Leaves 2.5 to 5.0 cm 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.

9. ***Blue Elderberry*** is a tall deciduous shrub, sometimes tree-like, up to 6 meters 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.

10. ***Red Elderberry*** is a tall deciduous shrub, sometimes tree-like, up to 6 meters 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.

11. ***Western Wormwood*** is an aromatic perennial herb, 0.3 to 1.0 meter in height. Leaves mostly 3-11 cm 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, 5-30 cm 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.

12. ***Mugwort*** is a large perennial herb 0.5 to 1.5 meters tall, usually found in large colonies in wet areas, ditches, or drainages. Leaves are evenly-spaced, 1 to 10 cm long, the upper leaves are narrowly elliptical, the lower widely oblanceolate, often coarsely 3 to 5 lobed near the leaf tip, 2 to 3 cm wide, green above, covered with dense white hair beneath. Differs from western wormwood in having wider lower leaves and in its generally damp habitat.

13. ***Evening Primrose*** is a large biennial with elliptical leaves up to 25 cm 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.

14. ***Mountain Snowberry*** is a shrub, 0.5 to 1.5 meters in height with a solid brown pith. Bark: shreddy, brownish. Young twigs: hairy. Leaves opposite, elliptical, 1.0 to 3.5 cm 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.

15. ***Red Alder*** is a deciduous tree up to 20 meters tall with dark green leaves 6 to 12 cm 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.

16. **Skunkbush** is a small, diffusively-branched shrub, 0.5 to 1 meter 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

Site Characteristics - West

To be filled out by the FIELD CREW or Cooperator:

State	County	Hexagon No. or Site ID	Month	Day	Year	Crew ID

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

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

Plot size:		**Terrain position:**	
	> 1.2 hectares (3.0 acres)		Ridge top or upper slope
	0.2 – 1.2 hectares (<1/2 – 3 acres)		Bench or level area along a slope
	Other: please describe		Lower slope
			Flat land unrelated to slope
			Bottom land with occasional flooding

Aspect: record aspect to nearest degree; code 000° = no aspect; code 360° = north aspect

Elevation: record elevation in feet or meters; estimate if necessary.	
Feet =	Meters =

Plot Wetness:		**Soil Drainage:**		**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.

Ozone Sample Kind:	
	Initial plot establishment on the 2002 FIA ozone grid.
	Remeasurement of a previously established plot.
	Replacement of a previously established plot that was replaced to meet new site selection guidelines (or lost site).

Geographic Coordinates:

Latitude:		Longitude:	
Easting:	Northing:	+/-Error(ft.):	Grid Zone:

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

File this completed data sheet with the bioindicator site map in the ozone plot file.

OZONE BIOINDICATOR PLANTS - 2002

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

State	Cty	Hexagon No. or Site ID	Month	Day	Measurement Type (check one):
					___ Regular crew ___ QA crew

Record species code number (choose up to 3; use additional sheets for >3 species at one site): **122** Ponderosa Pine **116** Jeffrey Pine **746** Quaking Aspen **924** Scouler's Willow **818** California Black Oak **351** Red Alder **906** Pacific Ninebark **905** Ninebark **965** Huckleberry **960** Blue Elderberry **961** Red Elderberry **907** Western Wormwood **908** Mugwort **968** Evening Primrose **969** Mountain Snowberry **909** 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).
0 = No injury; **1** = 1-6%; **2** = 7-25%; **3** = 26-50%; **4** = 51-75%; **5** = >75% [Add notes on back of sheet as needed.]

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

OZONE BIOINDICATOR PLANTS

Data Sheet for Mapping the Bioindicator Site Location

To be filled out by the FIELD CREW or Cooperator:

State	County	Hexagon No. or Site ID	Month	Day	Year	Crew ID

PLGR Information: (Please fill in this information, if available)

Easting	Northing	+/- Error (ft.)	Grid Zone

Please include the following information on the map: (1) Location of the site relative to some obvious and permanent marker; (2) road names and distances as needed; (3) North arrow; (4) starting point for plant selection; (5) approximate location of plant groupings used for the ozone injury evaluations.

Attach the original of this map to the corresponding plot data sheet 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.

For sites that lack a standard 7-digit hex number, please provide approximate latitude and longitude.

Latitude:	Longitude:

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.

CODE	DEFINITION
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.

CODE	DEFINITION
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

122 Ponderosa Pine
116 Jeffrey Pine
746 Quaking Aspen
351 Red alder
924 Scouler's Willow
818 California Black Oak
960 Blue Elderberry
961 Red Elderberry
965 Huckleberry
905 Ninebark
906 Pacific Ninebark
907 Western Wormwood
908 Mugwort
909 Skunkbush
968 Evening Primrose
969 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:

State	County	Hexagon No. or Site ID	Month	Day	Year	Tally No. or Crew ID

To be filled out by the Cooperator (only needed when the hex number and tally numbers are not known).

Ozone plot name or identification number	Name and e-mail address of data collector

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

Bioindicator Species	Injury Location	Injury Type	Is the leaf sample injury close to 100% ozone stipple or chlorotic mottle or is some other leaf surface injury also present?
			Close to 100% _____ Estimated percent other _____

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

Species codes: 122 Ponderosa pine 116 Jeffrey pine 746 Quaking aspen 924 Scouler's willow 351 Red alder 818 California black oak 960 Blue elderberry 961 Red elderberry 965 Huckleberry 905 Ninebark 906 Pacific ninebark 907 Western wormwood 908 Mugwort 909 Skunkbush 968 Evening primrose 969 Mountain snowberry. *Injury Location codes:* 1 = greater than 50% of the injured leaves are younger leaves (broadleaf) or current whorl (pine); 2 = greater than 50% of the injured leaves are mid-aged or older (broadleaf) or on whorls 1 year and older (pine); 3 = injured leaves are all ages. *Injury type codes:* 1 = greater than 50% of the injury is upper-leaf-surface stipple (broadleaf) or chlorotic mottle (pine); 2 = greater than 50% is not stipple

Questions? Call your Regional Advisor. **West: Pat Temple (909) 680-1583**; North Central:Teague Prichard (608) 264-8883; South: Dan Stratton (828) 257-4350; National: Gretchen Smith (413) 545-1680 [gcsmith@forwild.umass.edu];

Mail this sheet with the leaf samples to :
[Note: One sheet for each species.]

Pat Temple
USDA FS, PSW Experiment Station
4955 Canyon Crest Drive
Riverside, CA 92506

QA/QC PERSON: To be filled out by the regional ozone expert.

Positive for ozone	Negative for ozone	Date validated	Date rechecked	Sample condition

Notes: Explanation of symptoms or questions for the data collector.