Establishment of Monitoring Plots and Evaluation of Trees Injured By Ozone

Daniel Duriscoe, Kenneth Stolte, and John Pronos[1]

By establishing long–term monitoring plots, it is possible to record environmental and biological conditions of the plot and individual trees, evaluate the condition of crowns of trees in the plot, and determine the extent of ozone injury to western conifers. This chapter recommends various methods for recording data and selecting plots, and provides information for improved efficiency and safety of field work in studies on ozone injury to ponderosa pine (*Pinus ponderosa*) and Jeffrey pine (*P. jeffreyi*).

Data Recording

To record field data for most site and tree variables, data sheets may be used (*figs. 1* and *2*) or a field data recorder (FDR), such as the Corvallis MC–V™ with Mbase™ using appropriate custom programs[2] (*appendix A*). Tree, branch, and whorl–level data recorded on data sheets (*fig. 2*) can be entered electronically on a PC computer using customized programs in dBase IV™ or other database management software to facilitate efficiency (*appendix B*). However, some factors should be considered before using an FDR. For instance, the level of computer training and familiarity with the hardware and software of the field personnel should be sufficient to recognize and solve problems. At least two persons should conduct the field measurements (one to examine the branches and call out data and another to type it in). When working alone the extra task of managing the FDR is too cumbersome and time–consuming. In addition, paper data sheets should be carried to the field to provide a back–up in case a problem develops with the use of the FDR. And finally, data files should be downloaded daily to a PC from the FDR to avoid the possibility of losing large amounts of data by accidentally writing over an existing file, or if the battery in the FDR fails.

Plot Location and Number

The placement and number of plots for any given study will depend mainly on two factors: objectives of the study and availability of resources to complete the effort. Design should not be compromised so that differences of biological significance cannot be detected, even if resources are limited. If resources are not available to describe the entire population of the species of interest with sufficient confidence, we recommend that the level of effort be reduced by defining a sub–population of particular interest and adequately sampling that sub–population. An important step in the sampling design is to define the target population. This may be accomplished by stratifying the entire geographic extent of the species of interest, and progressively eliminating strata that meet rejection criteria. These criteria may be defined by the intersection of map themes. For example, an investigator may wish to eliminate slopes greater than 60 percent, closed–canopy forest stands, and Jeffrey pine type from the sample. The overlay of these themes and the area defined by their union would constitute the area to be eliminated from potential sampling. The area remaining would constitute the target population. This process may be quickly accomplished with a geographic information system (GIS), if it contains the appropriate data on all the themes of interest.

[1] Biological Technician, Resources Management, Sequoia and Kings Canyon National Parks, USDI National Park Service, Three Rivers, CA 93271; Deputy Director, Forest Health Monitoring, Southern Experiment Station, USDA Forest Service, 3041 Cornwallis Rd., Research Triangle Park, NC 27709; Plant Pathologist, Forest Pest Management, Stanislaus National Forest, USDA Forest Service, 19777 Greenley Rd., Sonora, CA 95370

[2] Trade names and commercial products or enterprise are mentioned solely for information. No endorsement by the U.S. Department of Agriculture is implied.

MANAGEMENT UNIT/SITE:__________ PLOT NAME/NUMBER:__________ CREW:__________

TOPO MAP:__________ LANDUSE:__________ DATE:__________

PLOT LOCATOR TREE (SPECIES, DBH, CHARACTERISTICS):__________

ELEVATION:__________ LATITUDE:__________ LONGITUDE:__________

COMPASS BEARING AT STARTING POINT:__________ %SLOPE:__________ ASPECT:__________

FOREST TYPE/COMMUNITY (3 MAIN TREE SPECIES):__________ SITE INDEX__________

UNDERSTORY VEGETATION:__________

SLOPE POSITION: summit shoulder backslope footslope terrace bottom

LANDFORM: ridgetop spur-ridge noseslope headslope sideslope cove draw

SKETCH IN LOCATION OF EACH TREE (WITH TREE NUMBER), AS ACCURATELY AS POSSIBLE.

SKETCH IN SECTION OF ROAD, TRAIL, OR PROMINENT GEOGRAPHIC FEATURE TO FACILITATE RELOCATING PLOT IN FUTURE.

ATTACH APPROACH LOGS AND PHOTOS OF PLOTS IF AVAILABLE

Figure 1—Site data sheet.

FOREST:	SITE:	PLOT:	TAG:
CREW:	COMMUNITY:		
	ASPECT:	SLOPE:	ELEVATION:
DATE:	LANDFORM:	SLOPE POSITION:	

			WHORL						
SP	#	FOL LEN	#	CM	FR	NL	BIOTIC	ABIOTIC	COMMENT
	1		1						
AGE			2						
			3						
SNDX			4						
			5						
			6						
POS			7						
			8						
HT	2		1						
			2						
			3						
DBH			4						
			5						
MREL			6						
			7						
			8						
ROCK	3		1						
			2						
MIST			3						
			4						
			5						
CONK			6						
			7						
BEET			8						
	4		1						
			2						
FIRE			3						
			4						
MECH			5						
			6						
			7						
LIGT			8						
	5		1						
BROM			2						
			3						
			4						
%LC			5						
			6						
LCR			7						
			8						

UNITS USED:
DBH ________
HT ________
FOL LEN________
NL ________

FR = FAS RET
(WHOLE WHORL)
0 = NONE
1 = 1 - 33%
2 = 34 - 66%
3 = 67 - 100%

CHL. MOTTLE
0 = NONE
1 = 1 - 6%
2 = 7 - 25%
3 = 26 - 50%
4 = 51 - 75%
5 = 76 - 100%

ABIOTIC INJURY
0 = NONE
1 = < 25%
2 = > 25%

BIOTIC INJURY
0 = NONE
1 = < 25%
2 = > 25%

MREL
PL = PLANAR
CC = CONCAVE
CX = CONVEX

BOLE INJ
0 = ABSENT
1 = PRESENT
2 = SEVERE

MIST: 0 - 6

%LC = % LIVE CROWN

LCR = LIVE CROWN RATIO (FILL-IN)

ROCK = % ROCK IN 20X TREE DIA AREA

SNDX = SITE INDEX

Figure 2—Tree and whorl data sheet.

The main objective of a study may be *estimation* of the true population parameters or *testing* hypotheses relating to spatial variation, temporal variation, or relationships between air pollution effects and other environmental factors, such as air pollution exposure. Long–term monitoring plots can be used for both purposes. Plots can be distributed throughout the range of the species (Duriscoe and Stolte 1989), or plots can be co–located with an ambient ozone monitor to test ozone exposure–response. No single recommended sampling design can ideally satisfy both objectives. In any case, results should always be presented with confidence intervals and confidence coefficients of estimates, or the probability and alpha–values for tests.

Plot Selection Criteria

For long–term monitoring studies in which the temporal trends in crown condition are of primary interest, the target population is restricted to trees that will provide a long–term data base; can be readily assessed for ozone injury to the lower crown; are not located in unusual microhabitats; are not infested with foliar insects and diseases that would confound the evaluation of air pollution injury; and are accessible and relocatable so that they have a reasonable chance of being re–visited on a regular basis. The spatial distribution of the species population should be defined by using the best available vegetation maps. Such maps are usually not available at the individual species level. If practical, an initial reconnaissance of the area may be made to verify the extent of the species of interest.

To minimize the within–plot variance, confounding factors should be stratified. For instance, the entire extent of the plot should be within the same general landform type (*fig. 3*). Transects (direction of the long dimension of the plot) should generally run along the elevational contour, and in a straight line for mapping convenience. Plot length should be 250 m and 80 m should be allowed for plot width. This effectively eliminates severely dissected landform types less than 250 m in size. Some sophisticated programming may be required to define these areas on a GIS. Selecting a uniform landform may sometimes be difficult in the field, but some degree of minor violation may be tolerated for practical reasons.

Another method to eliminate within–plot variance is to select a stand density that contains at least 50 trees from a 1 ha plot. Trees with crown positions including codominant, dominant or open–grown are those of primary interest. At least 30 trees should be as tall as the general forest canopy.

In addition, severe needle cast fungus infections (e.g. *Elytroderma deformans*) or dwarf mistletoe infections should be avoided. Large groups of bark beetle–killed trees should also be avoided as beetles may spread to nearby living trees the following year (recent aerial photographs may reveal these areas). Sites with high levels of bark beetle–caused mortality may also indicate that soil moisture holding capacity is low or a root disease center is present, thus making nearby trees susceptible to bark beetle attack during subsequent drought years.

Trees growing in serpentine soils, near quarries or mine tailings, or in disturbed soils (roadcuts or old roadbeds) should be avoided unless there is a specific purpose to study how these variables may influence response to ozone exposure. However, stands of open–grown Jeffrey pine growing on bare rock

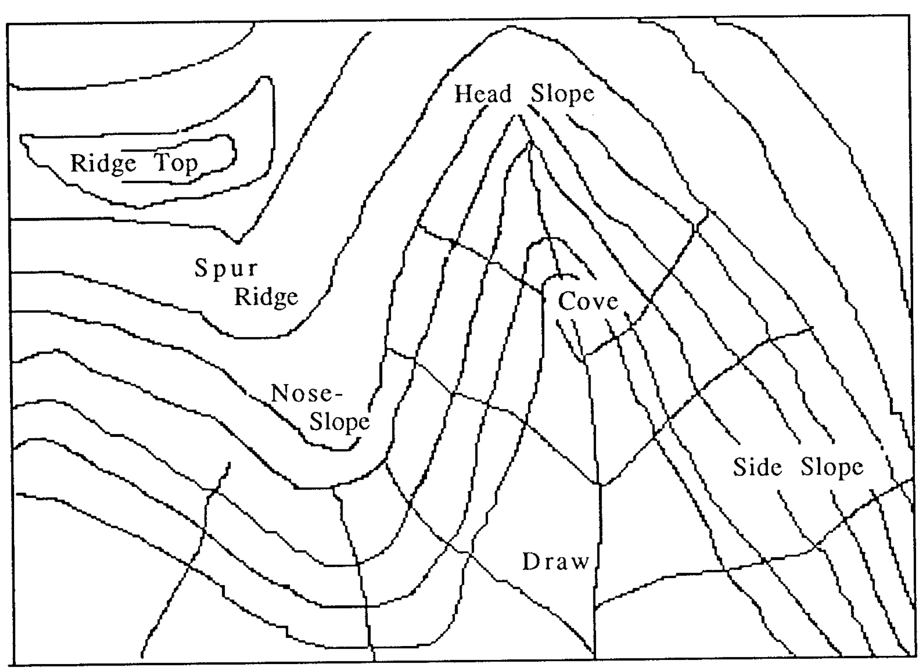


Figure 3—Seven types of landforms: ridgetop, spur–ridge, noseslope, headslope, sideslope, cove, and draw.

are common in the Sierra Nevada, and should not be eliminated from the target population. If dose–response relationships are part of the investigation, these environments should be stratified from other more mesic areas with little or no exposed rock, if correlative or predictive models are developed.

After the target population is defined, it may be further stratified into smaller sampling units as a means of increasing sampling efficiency. A simple areal and/or elevational stratification is recommended. The first level of areal stratification is usually defined by major drainage basins. Further strata may be defined systematically using a square grid (Duriscoe and Stolte 1989) or a design that produces equal areas of the target population only (Duriscoe and Graban 1992). In areas with large topographic relief, elevational stratification (into 300 m belts) may be appropriate. In any case, smaller sampling units will almost always contain less within–unit variability in crown condition than larger units. Other factors which may be considered for defining strata are species (e.g., ponderosa or Jeffrey pine) or variety (e.g., *scopulorum* or *arizonica* varieties of ponderosa pine in the southwest), site class, landform type, and soil moisture holding capacity (which may be modeled from an estimate of soil depth, slope position, slope angle, and/or aspect). Within each sampling unit, simple random sampling should be employed to locate potential plot sites.

A system of plot rejection criteria (required stand density, pathogen infection levels) and a procedure for selecting an alternate site if the sample point fails (another random point in the unit, a random offset from the failed point, or simply the nearest point to the failed point where a viable plot can be established) should be determined before venturing into all potential sampling points in the field. In general, plots should be rejected if the trees show obvious stresses from natural or human–caused factors that would mask any observable effect from ozone pollution.

Establishment of Plots

A belt transect 80 m wide and 250 m long (2 hectare) is the recommended size and shape for relatively dry and open western pine forests. For species that sometimes grow in small isolated stands, such as Jeffrey pine, western white pine (*Pinus monticola*) or coulter pine (*P. coulteri*), the entire stand may be sampled rather than using a belt transect (see below).

Certain methods for plot establishment are recommended following repeated trials in the field (*fig. 4*). First, a compass direction must be selected that will include a suitable number of sample trees. On a slope the compass direction is usually parallel with the contour of the slope. On flat areas it is possible to select a random compass direction. This becomes the long axis of the plot and also represents the center line. The long axis of the plot should be within the same landform type. Use a steel or fiberglass tape to measure distances and if the slope in either the long or the short dimensions of the plot exceeds 10 percent, add or subtract distance using the actual slope (percent) and a reference table.

The plot should be identified for re–location with a locator tree (a large conspicuous, or uniquely–shaped tree) within or near the plot. The distance and compass direction from the plot locator tree to the beginning point of the long axis of the plot should be measured and recorded. The diameter–at–breast–height (DBH) of the locator tree should be measured and a small aluminum plate should be nailed at breast height on the uphill side of the tree. Plot information should be etched on the plate, including plot name, agency, and date established.

The locator tree should be photographed from a known point (roadside turnout, mile marker, prominent ridgetop located on topo map, etc.) to facilitate

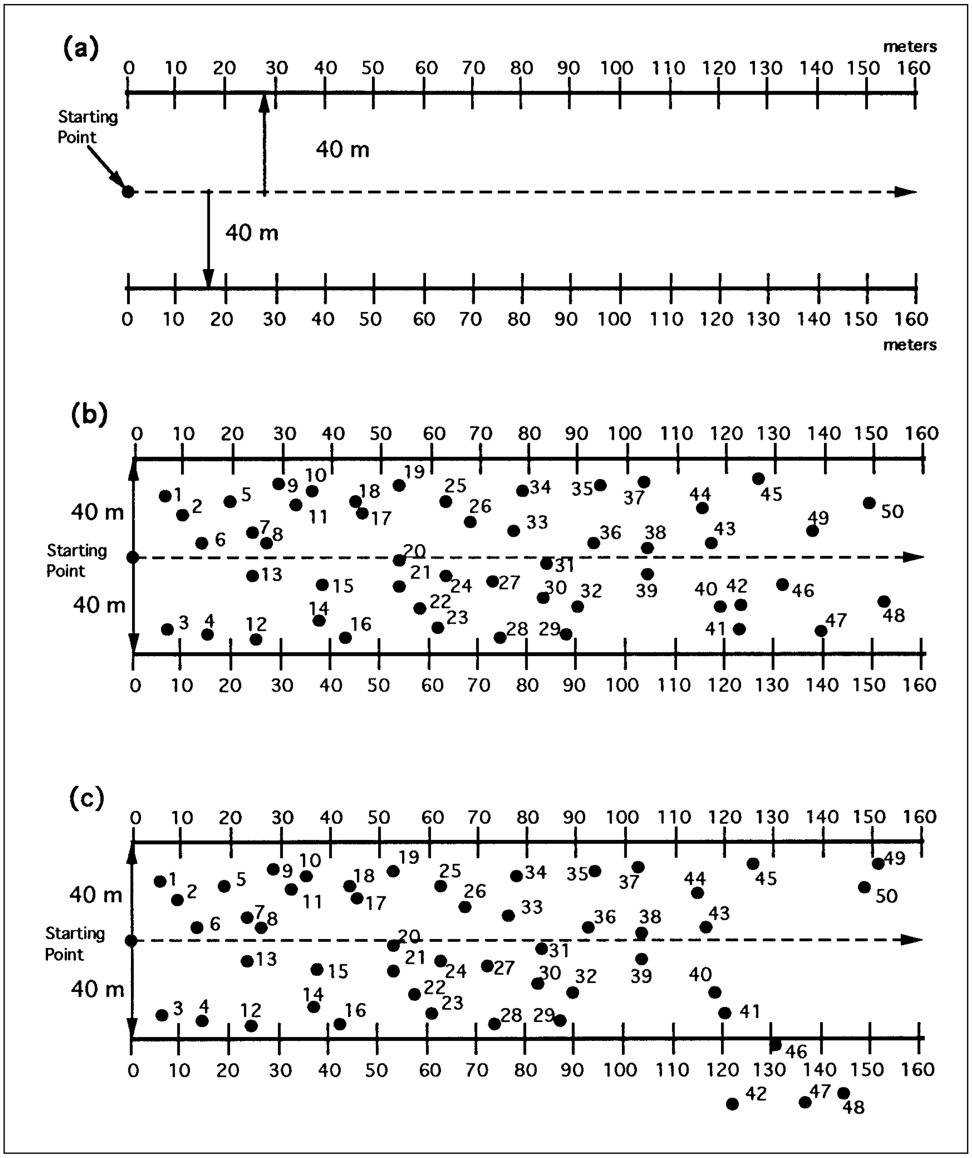


Figure 4—Establishment of a plot containing 50 trees. (a) Plots are 80 meters wide (40 meters on each side of the transect line). Length of the transect line is indeterminate; it is extended until 50 trees meeting specifications are found. (b) Mapping 50 trees within plot bounds and relevant to plot outline. (c) Mapping 50 trees in the plot; 46 are within the plot perimeter, with 4 trees mapped outside the plot perimeter.

relocation. We also recommend that if bedrock outcrops are evident in the vicinity, a stainless steel or brass tag should be imbedded in the rock with a concrete nail and epoxy, and the position of this tag geo–referenced with a global positioning system (GPS) to within 5 meters. If all plot features are then mapped from this reference point accurately, the location of the plot and its originally selected trees may be reconstructed for many future decades regardless of changes in the appearance of the vegetation. A descriptive log of how to find the locator tree or rock monument should also be included.

Trees for monitoring should be surveyed and selected by recording and mapping all trees of the species of interest with DBH > 10 cm (*fig. 5*) within 40 m (map distance) of each side of the center line (total width of transect = 80 meters). Trees should be tallied and classified by crown position (dominant, codominant, intermediate, and suppressed) and DBH (estimate or caliper)

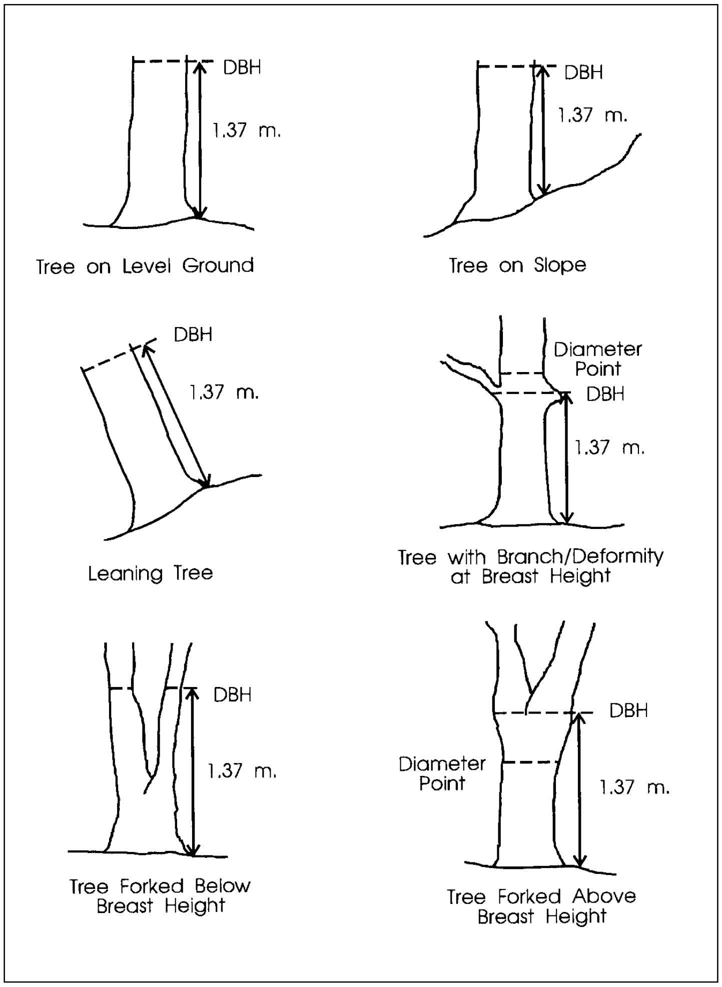


Figure 5—Proper method for measurement of diameter–at–breast–height (DBH) of the tree bole.

recorded on a Tally Sheet (*table 1*). If time allows, tree stems should be mapped by measuring distance out from start point along the transect center line and distance left or right of the center line. Whether the tree is suitable for long–term monitoring should also be noted. We recommend screening out trees for long–term monitoring with the following conditions: severe mechanical wounds, unpruneable crown (lowest branches > 10 m above ground), crown too small to stand repeated pruning, root disease, excessive lean, bark beetles, severe dwarf mistletoe, severe needle cast disease. This process should continue along transect from origin point until one of the following conditions is met: 50 dominant or codominant pines suitable for long term monitoring are obtained; a different landform type is encountered; the transect extends out of the pine vegetation type; or the transect is extended to 250 m from the origin point. If at least 30 dominant and codominant trees of the species of interest are not found, the transect could be extended beyond 250 m if the landform type does not change. If this is not possible the placement of the plot upslope or downslope could be adjusted. As a last resort, widening the transect may be necessary. In any case, the plot should be no wider than 80 meters. If an open– grown discrete stand is encountered that is irregular in shape with well–defined boundaries, is less than about 2 hectares in size, and contains less than about 100 canopy trees, it may be more efficient to enumerate the entire stand and map the stand boundaries rather than to try to fit a rectangle to nature. The objective is to

Table 1—*Tree selection work sheet for tallying trees to be labeled with tags. (See* **fig. 8** *for crown class descriptions.)* [1]

DBH		Crown Class				
inch	cm	Open Grown	Dominant	Codominant	Intermediate	Suppressed
4	10					
6	15					
8	20					
10	25					
12	30					
14	35					
16	40					
18	45					
20	50					
22	55					
24	60					
26	65					
28	70					
30	75					
32	80					
34	85					
36	90					
38	95					
40	100					
42	105					
44	110					
46	115					
48	120					
50	125					
50+	(Specify)					
Totals						
Sum		Canopy (Open Grown, Dom. CoDom.)			Subcanopy (Int., Sup.)	

[1]Note unpruneable trees with asterisk (*).

include at least 30 canopy trees > 10 cm DBH. Ideally, 50 dominant and codominant trees will be found in less than 250 m. If more than 29 but less than 50 can be included within the plot boundaries, the remainder (intermediate and suppressed) may be selected randomly from all those found within the plot, so that each tree has a probability of being selected. The remainder (between 0 and 20) should not exceed the total number of trees selected for monitoring (50). Selected trees should be identified with a numbered tag attached by an aluminum nail (#7 siding nail) at breast height on the uphill side of the tree (*fig. 5*). Tree diameter should be measured with a tape at a point just above the nail. Tree locations should be mapped as accurately as possible relative to each other, as well as the plot corners or the monument in rock. A hand–held compass and tape should be the minimum tools used. Information on forest dynamics may be obtained by mapping every tree stem of all species, if the resources are available to accomplish this task (Miller and others 1991).

Mortality of selected trees subsequent to plot establishment may be observed in long–term monitoring. The selection of replacement trees is not recommended, unless the number of surviving trees falls below 15 or 20. At that level, the useful life of the plot may be over, and a new set of 50 trees should be established, if necessary. Data from the old plot trees should *not* be directly compared to data from the newly established trees because the natural tree–to–tree variability in sensitivity to air pollution is high. The statistical power of long–term comparisons of *adjacent* groups of trees is very much less than a comparison of the *same* group of trees. And lastly, the site class for each plot should be calculated by selecting three open–grown or dominant trees. Trees should not have any obvious stress from competition, and should be measured for height and cored for a count of the number of radial rings. These measurements are then evaluated by the use of a site–class table (*appendix C*).

Collection of Site, Stand and Tree–Level Data

After locating, tagging, and mapping 50 acceptable trees, management data should be recorded on a site data sheet (*fig. 1*). Landform categories are illustrated in *fig. 3*.

Tree–level data should be collected by evaluating the crown and bole condition of each tree including whole crown, branch variables, and whorl variables. These evaluations are performed by visual estimates and by using simple instruments, both on the whole tree and on branch samples extracted from the lower crown. The approved methods for measuring DBH (*fig. 5*), selecting the category of slope position (*fig. 6*), and category of microrelief (*fig. 7*) should become familiar to the field crew (Zedaker and Nicholas 1990).

Whole tree and crown evaluations may be recorded on a data sheet (*fig. 2*), or in the FDR. Instructions are provided for judging the crown position (*fig. 8*), measuring tree height (*fig. 9*), and rating the severity of dwarf mistletoe infection (*fig. 10*). A visual estimate should be used to record further tree injury observations using these classes: 0=none; 1=present; 2=severe for the following: conks (identify species if possible); bark beetles (identify species if possible); witches brooms (with or without presence of dwarf mistletoe plants); fire scars (the rating refers to the percent of the circumference affected); mechanical injury (specify type); and lightning scars.

Collection of Branch and Whorl–Level Data

Branches must be cut from the lower crown of each tree so that foliage may be examined in hand. On steep slopes this may be a labor–intensive portion of the field work. It is important to obtain representative branches of the lower crown.

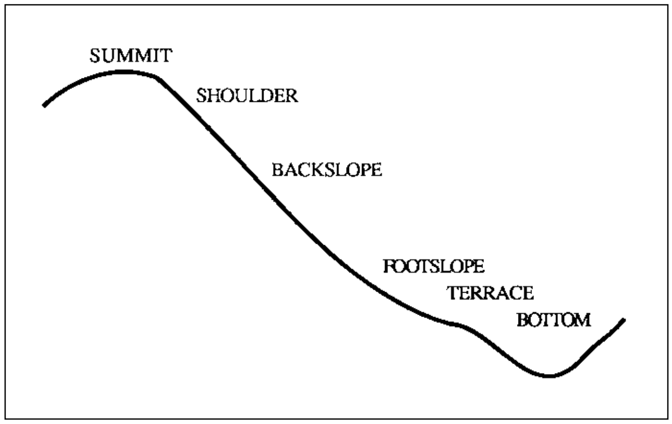


Figure 6—Slope positions that are available for establishment of pine monitoring plots. Six slope positions: summit, shoulder, backslope, footslope, terrace, and bottom (floodplain). Plots should fall within any slope position without overlap between slope positions.

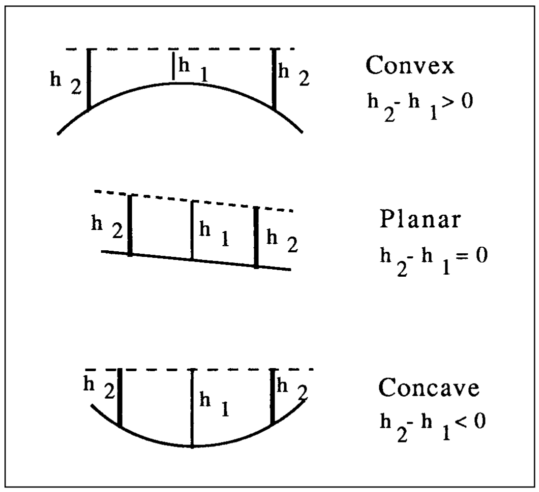


Figure 7—Microrelief types to be evaluated under the drip lines of each tree. Types are planar, concave, and convex.

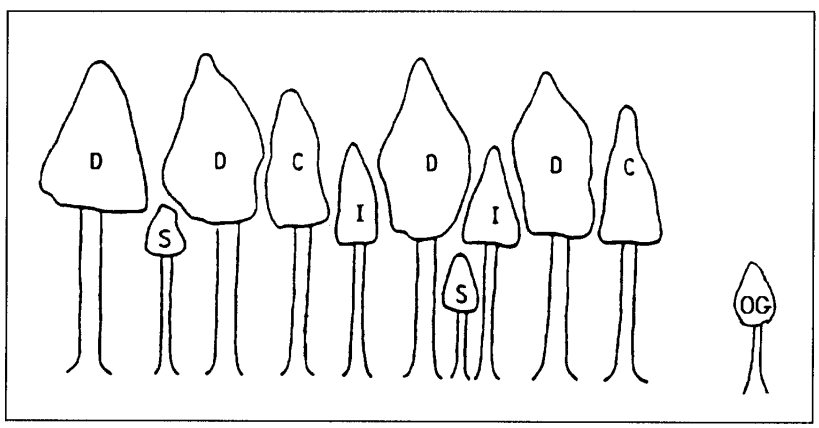
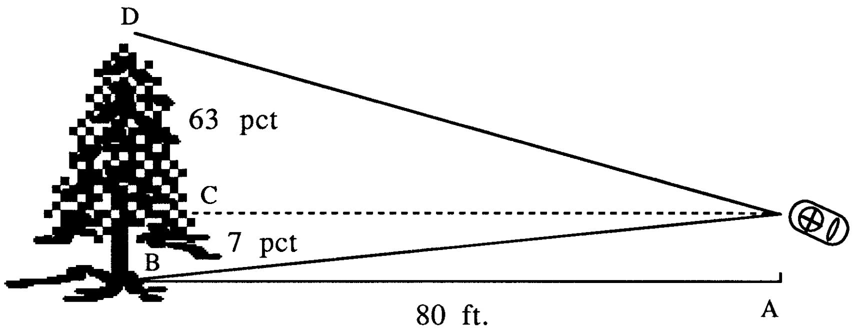


Figure 8—Crown Position Classes: D = dominant, C = codominant, I = intermediate, S = suppressed, OG = open–grown.

However, factors that may confound the evaluation of chlorotic mottle and needle retention that occur on specific branches should be avoided if they are not present on the majority of all branches in the lower crown. Branches with dead terminal buds, severe needle cast fungi, severe scale infestations, or that have obviously been severely chewed by insects or squirrels should therefore be rejected. Branches with cones or those which bifurcate (split) within the foliated length should be accepted, although their evaluation may be more time–consuming. "Branchlets" (the smallest side branch with a full complement of needle whorls) should be cut from near the crown edge (*fig. 11A*) without pruning the branch leader of major branches (*fig. 11B*); the middle of the lower



Using the percent scale, stand a proper baseline distance from the tree, in this example 80 ft. Sight the top of the tree (D) and read the percent scale (63 percent = C to D). Sight the bottom of the tree (B) and read the percent scale (C to B = 7 percent). Add the readings to get a total reading of 70 percent. Multiply the total reading by the baseline distance to get the tree height (70 percent × 80 ft. = 56 ft.). When the base of the tree is below eye level, the two readings are added. When the base of the tree is above eye level, the second reading is subtracted from the first.

Figure 9—Forest inventory method for determining tree heights.

crown should be sampled on all sides of the tree. The very lowest branch on mature trees should be avoided because it may soon die as the tree self–prunes with age; its overall vigor is probably less than the rest of the lower crown. Small trees should not be over–pruned.

Five branchlet measurements are required for adequate within–tree replication:

- Foliated length—The length of the woody stem should be measured from the base node of the oldest whorl with green foliage (even if younger whorls are missing) to the base of the terminal bud. This is a general measure of overall vigor of the tree and potential growth rate.
- Number of whorls—The whorls of needles retained should be counted. This is a measure of the age of the oldest foliage retained on the branch in years minus one. If a whorl is missing between older and younger foliage, it is tallied on the data sheet as a "0" (*fig. 12*). Whorls with short needles must also be included (*fig. 13*)
- Chlorotic mottle—The severity of chlorotic mottle resulting from ozone injury should be estimated as a visual estimate of the surface area of each whorl covered with mottle using the following classes (*fig. 14*):

  0 = no mottle observed

  1 = 1–6 pct

  2 = 7–25 pct

  3 = 26–50 pct

  4 = 51–75 pct

  5 = > 75 pct.
- Fascicle retention in whorls—The portion of the full complement of needle fascicles that remain (*fig. 12*), should be estimated by using the following classes:

  1 = 1–33 pct

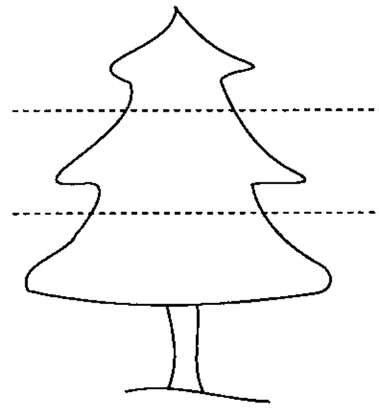
  2 = 34–66 pct

Step 1: Divide live crown into thirds

Step 2: Rate each third separately

Assign each third either 0, 1, or 2:
0 - No visible infection
1 - Light, less the 1/2 of branches have mistletoe plants
2 - Heavy, more than 1/2 of branches have mistletoe plants and/or brooms

Step 3: Add ratings of each third to obtain total tree rating



EEE

Total rating	Infection level
0	none
1 or 2	light
3 or 4	moderate
5 or 6	heavy

Example

This third has no visible infection	0
Less than half this third is infected	1
More than half this third is infected	2
Total rating for this tree	3

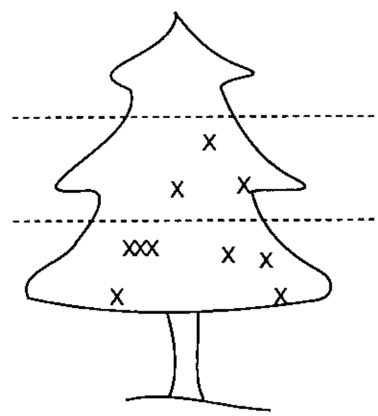


Figure 10—Description and example of Hawksworth Six–class method for evaluating dwarf mistletoe infection (Hawksworth 1977).

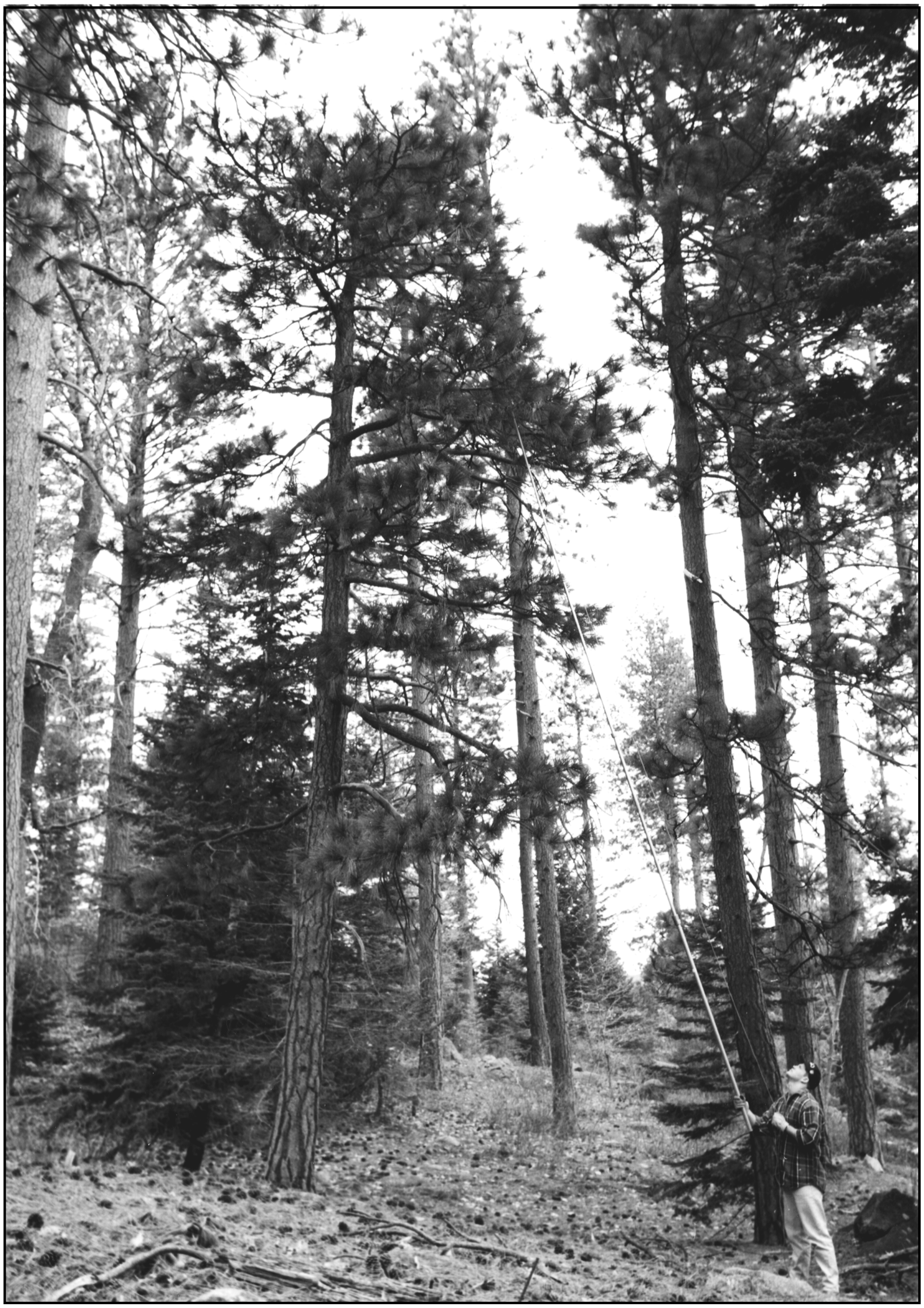


Figure 11A—Five sample branches should be cut around the tree at the mid to lower crown of each plot tree.

Figure 11B—Lateral branches should be selected for cutting, not the terminal portion of the branch.

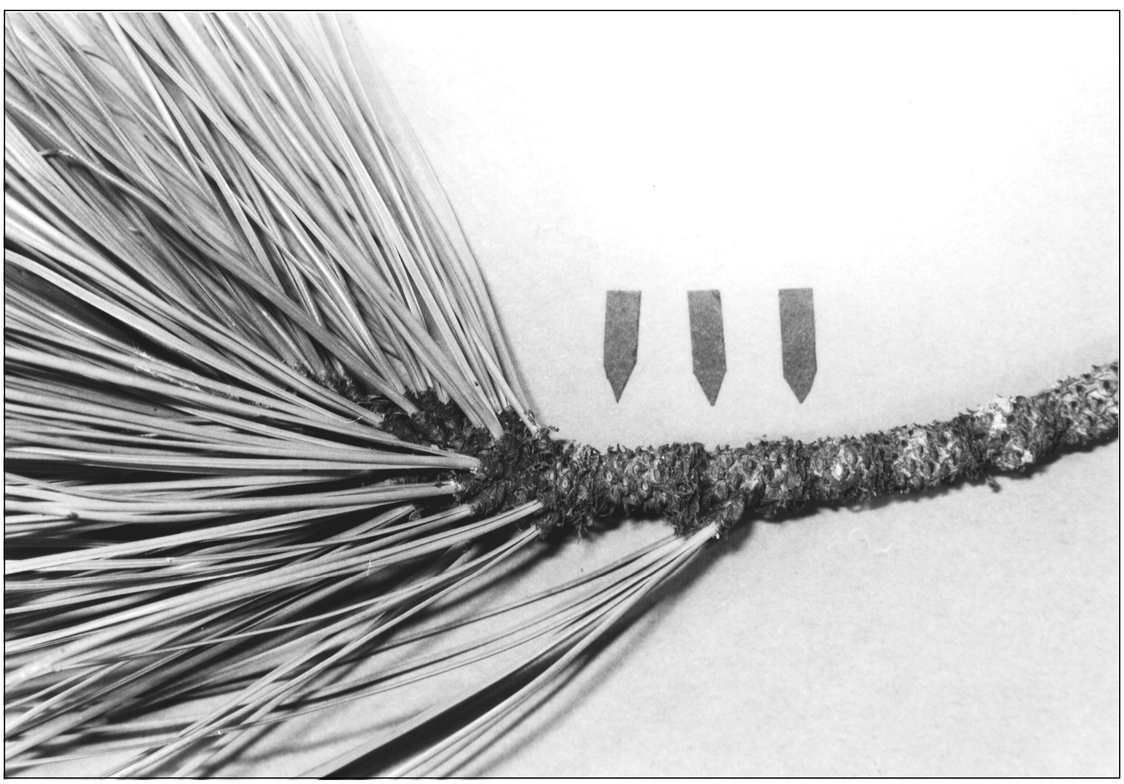


Figure 12—A branch with partially or completely missing whorls. Pointers mark the nodes that separate needle whorls. Nodes can be identified by residual bud scales that form a raised, darker ring around the stem. Scars where needles were once attached appear as small pits.

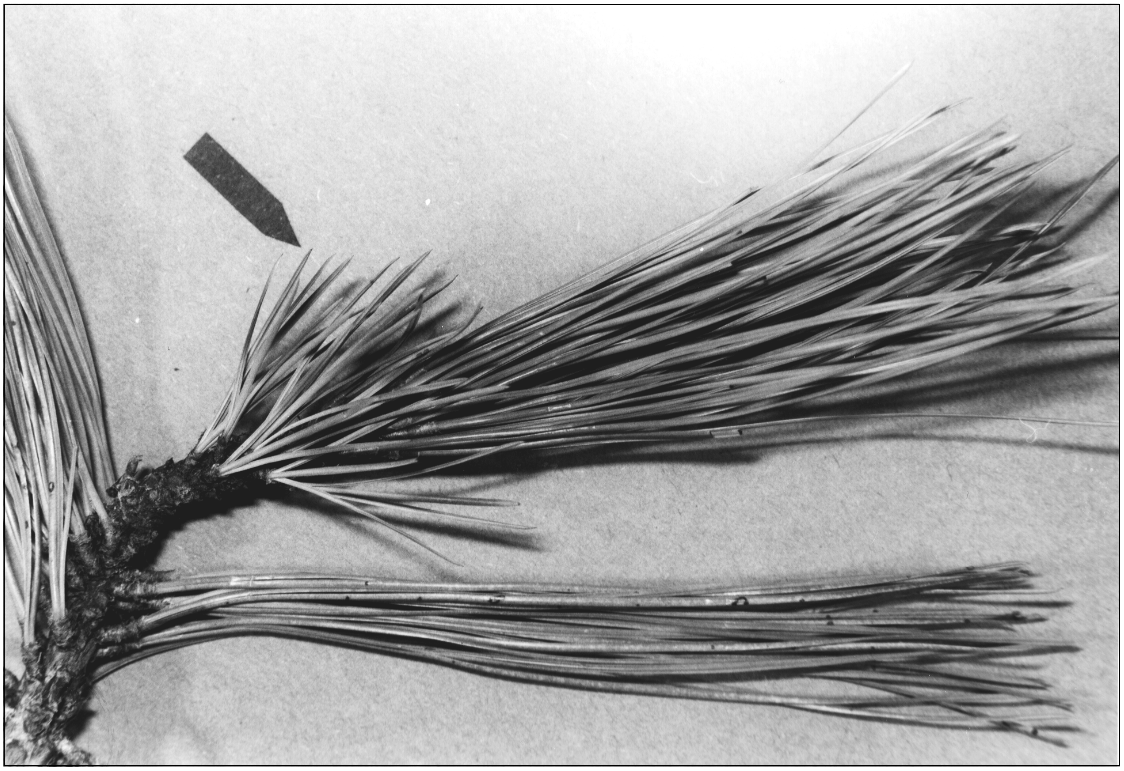


Figure 13—Needle whorl with extremely short needles formed during a drought year may be obscured by longer needles of adjacent whorls. Care must be taken to identify and include whorls with short needles.

3 = 67–100 pct

To estimate fascicle retention, abscission scars (small pits in the scaly branch surface) should be noted between the whorl nodes (*fig. 12*). Most often on younger needle whorls none will be present, and the retention class will be 3 (100 pct). It is not necessary to actually count all abscission scars and retained fascicles; a visual estimate is sufficient.

- Common needle length—The common needle length in each whorl should be measured with a ruler to the nearest centimeter in the center portion of the whorl (*fig. 15*). The needle tips should not be chewed off at the same point by insects, but if they have been, a "missing" data value should be recorded or another branch selected.

Biotic and Other Abiotic Injury to Needles

This category is a visual estimate of needle damage by biotic agents such as: CI = chewing insects, SI = sucking insects, FI = fungal injury, and OTH = other, (read as pct of needles affected), and other abiotic (WF = winter fleck, OTH = other) injuries observed on the needle surfaces (read as pct of needle surface affected) and should use the following classes:

0 = none

1 = 1–25 pct

2 = >25 pct

Procedural Tips

When possible, work should be done in pairs or a crew of three. An efficient crew includes a pruner, an observer, and a data recorder. Pruned branches

0

1

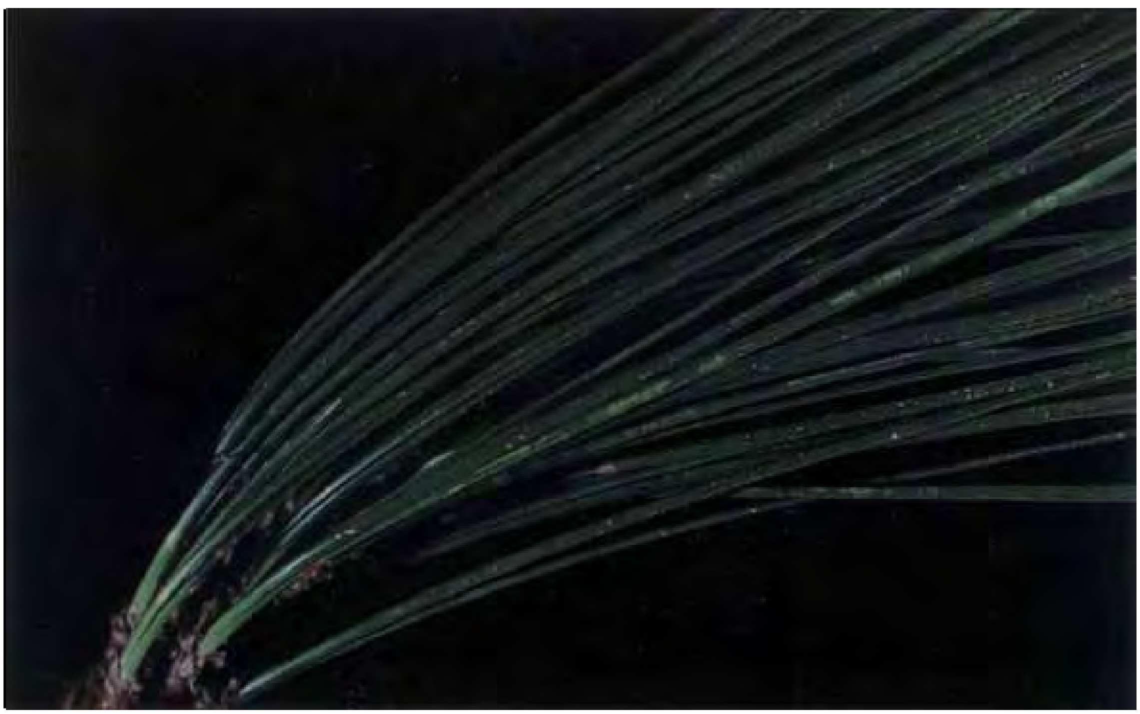
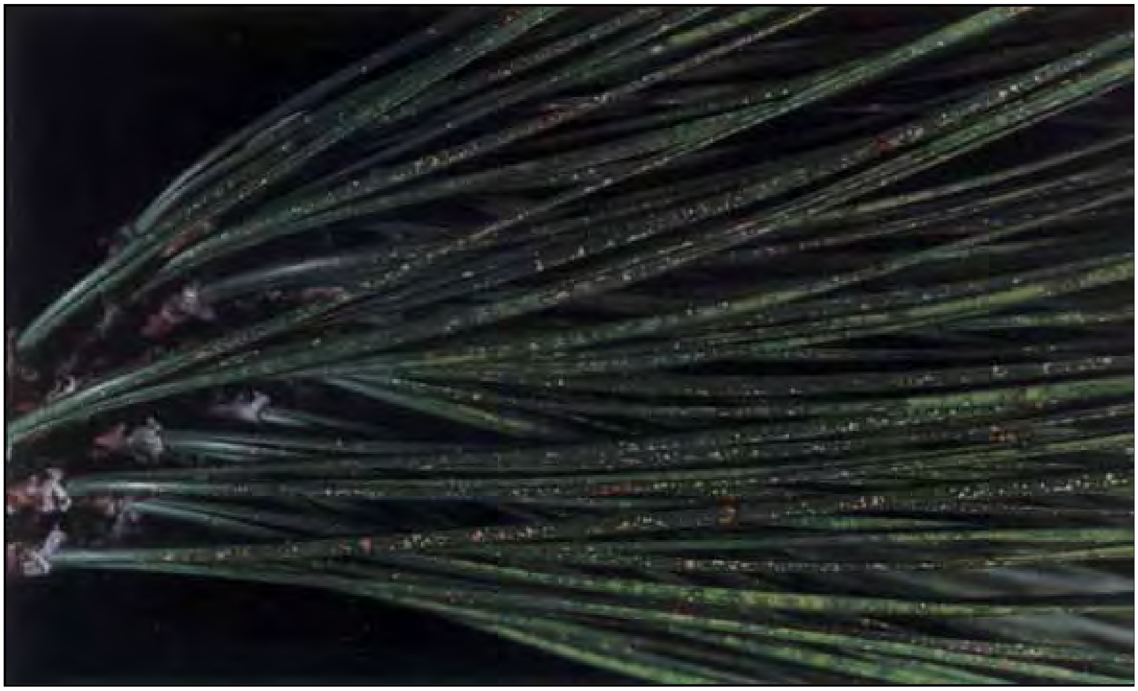
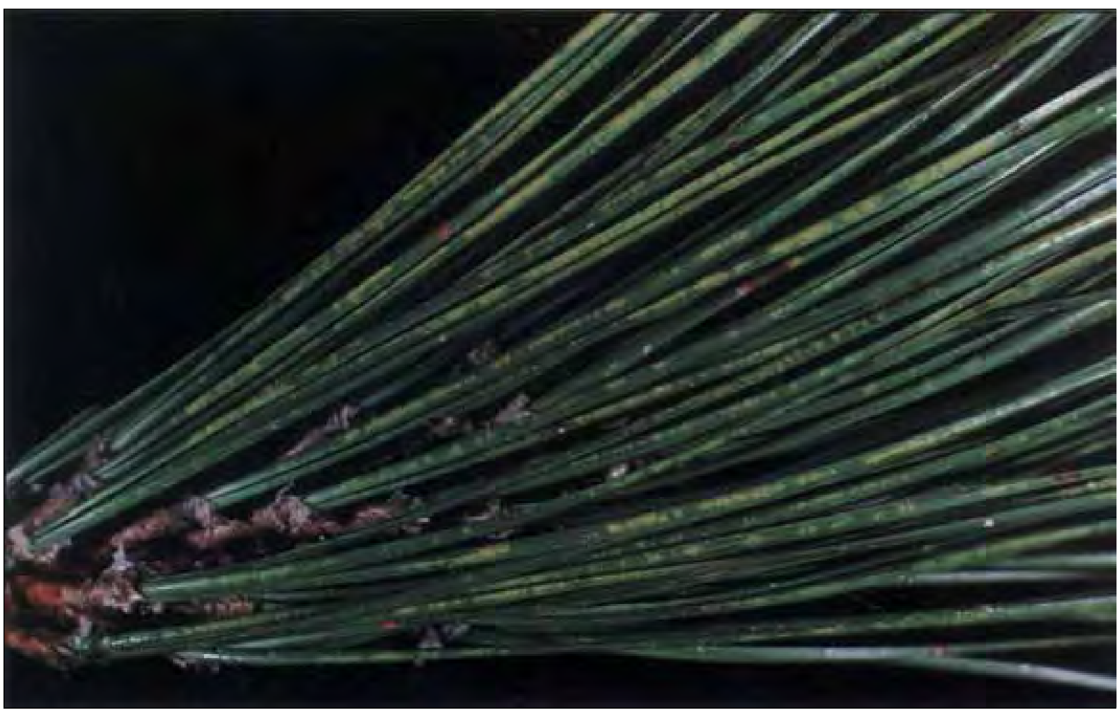


Figure 14—Examples of the different categories of chlorotic mottle used to estimate intensity of ozone injury to needles: 0 = No Mottle, 1 = 1–6 pct, 2 = 7–25 pct, 3 = 26–50 pct, 4 = 51–75 pct and 5 = > 75 pct.

2



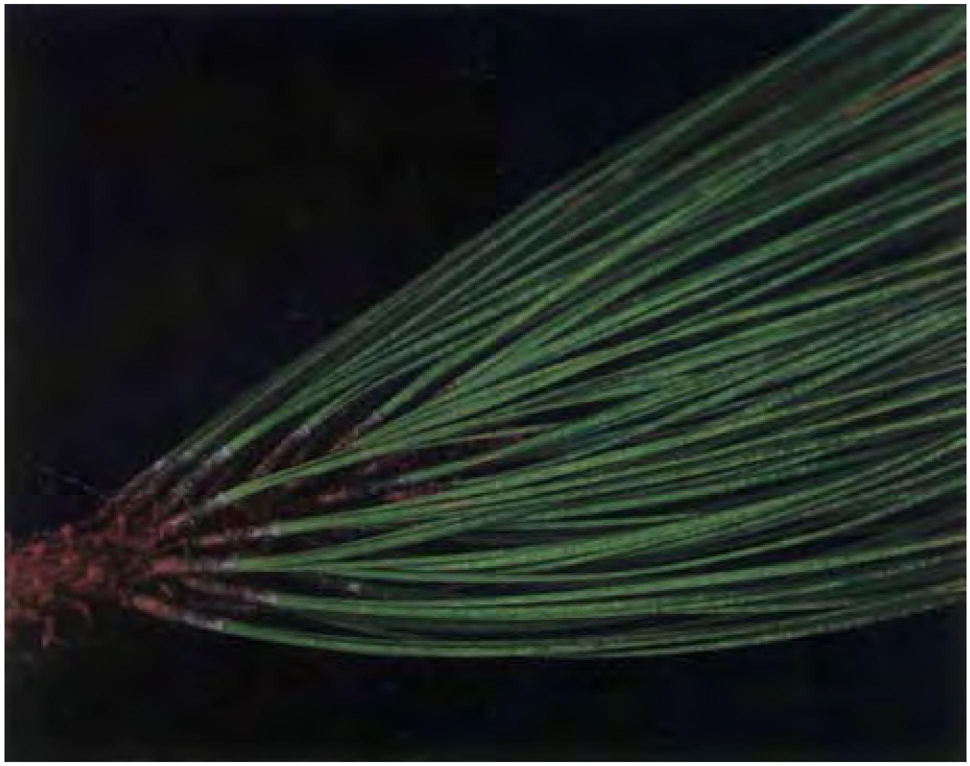
3



(Fig. 14, continued)

(Fig. 14, continued)

4



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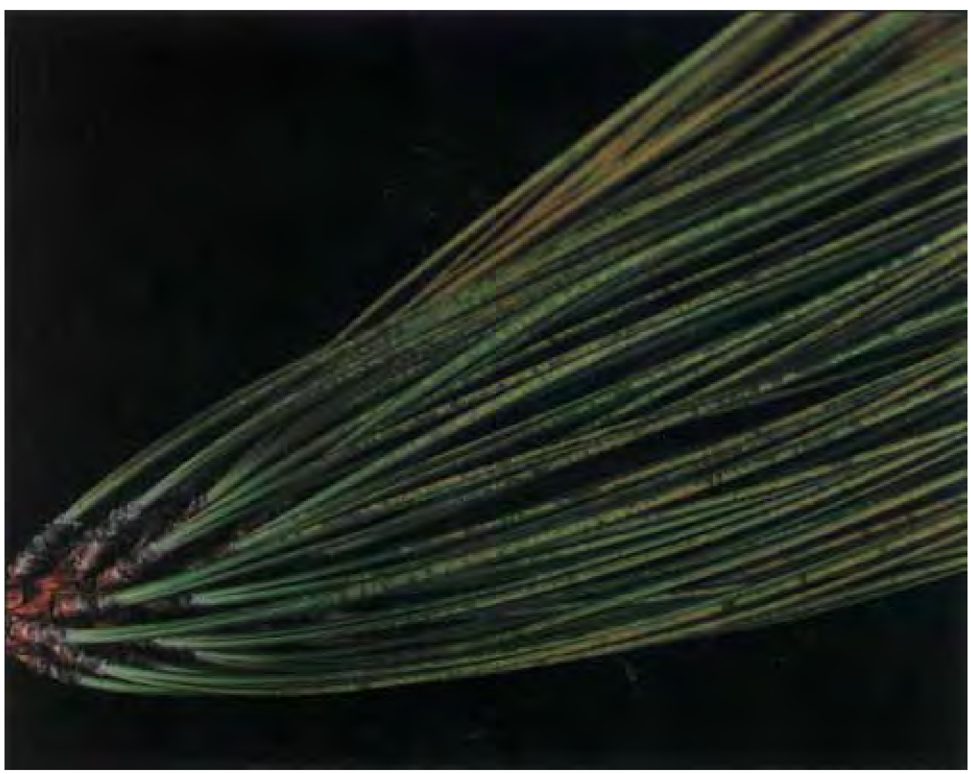


Figure 15—The method for measuring needle length of each whorl present.

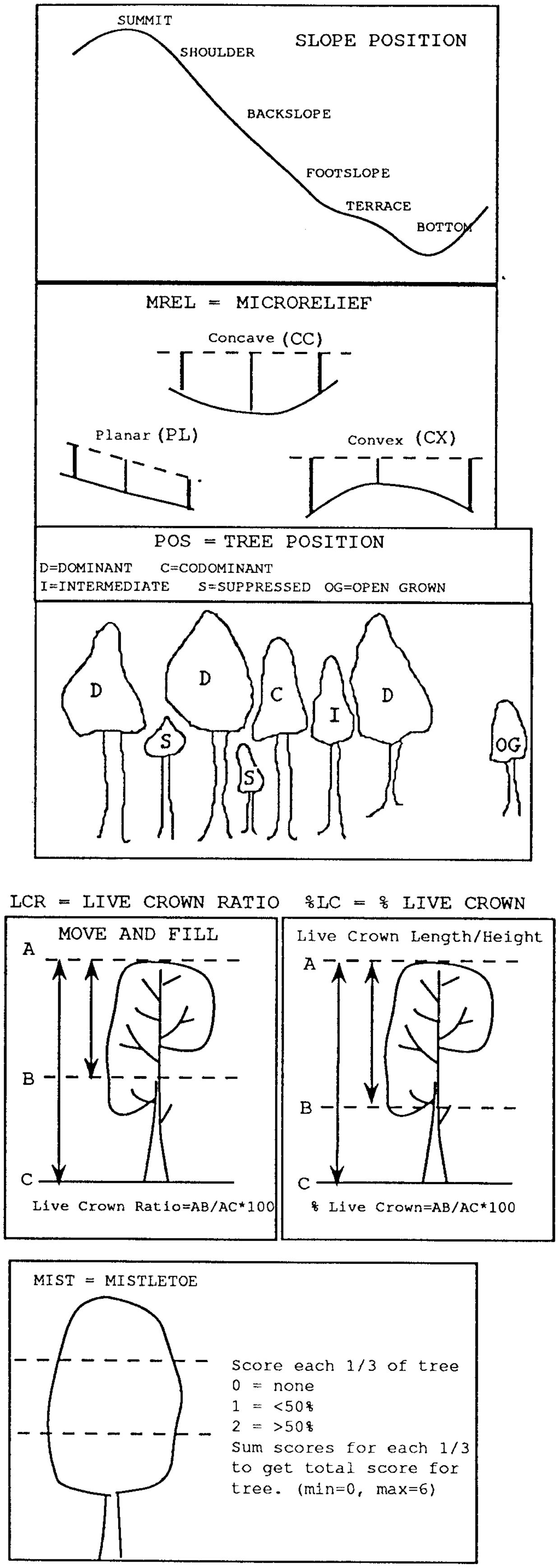
should be organized at the base of each tree in the shade. If branches cannot be evaluated within 1–2 hours they should be placed in labeled plastic bags and in a cooler or ice chest.

A ball point pen or permanent fine–tipped marker (Sharpie extra fine) should be used to write the number of each branch on the cut surface or, if resin is too heavy, a 1 to 2 cm strip of bark should be sliced off with a pocket knife and the branch number (1 through 5) written on the surface of the wood. This is important for quality assurance checks and for re–checking foliage before leaving the field. A copy of the code sheet and illustrations should be used for quick reference in the field (*fig. 16*).

It is usually faster to observe all whorl–level variables in a sequence (e.g. mottle, biotic, abiotic, retention, length)—beginners find it easier to concentrate on one variable and complete the necessary estimates or measurements on all whorls. Because this requires repeated separation or isolation of whorls it is not efficient in terms of hand motions required. As soon as the observer is confident about the estimation or measurement of individual variables, we recommend that all variables are measured one whorl at a time. Visual estimates do not require prolonged scrutiny: experience has shown that the first impression is usually the most accurate. If working alone, the observer can use an audio tape recorder to read data into and keep both hands on the branch and ruler. Data can be entered into the computer later.

Safety

The primary safety concerns are those typical of work in the lower elevations of western mountains (climate, topography, poisonous flora and fauna). In



CODE	DEFINITION	POSSIBLE VALUES			
		ABSENT	PRESENT	SEVERE	
CONK	Conk	0	1	2	
BEET	Bark beetles	0	1	2	
FIRE	Fire scar	0	1	2	
LIGH	Lightning	0	1	2	
BROM	Witches broom	0	1	2	
MECH	Mechanical inj to lower bole	0	1	2	
MREL	Microrelief	PLANAR (PL)	CONCAVE (CC)		CONVEX (CX)
POS	Tree position	Dominant	D		
		Co-dominant	C		
		Intermediate	I		
		Suppressed	S		
		Open grown	OG		
LCR	Live Crown Ratio (move and fill) est to nearest 5%				
%LC	Percent Live Crown (% of bole with live branches) est to nearest 5%				
ROCK	% rock cover in 20Xtree dia. area				
FR	% Fascicle Retention		0. No fascicles retained		
			1 (1-33)		
			2 (34-66)		
			3 (67-100)		
CM	CHL Mottle		0 (0)	1 (1-6)	2 (7-25)
			3 (26-50)	4 (51-75)	5 (76-100)
BIOTIC INJURY		0 (none)	1 (< 25%)	2 (> 25%)	
SC	Scale				
SI	Sucking Insects				
CI	Chewing Insects				
W	Weevils				
FI	Fungus(needle cast)				
ABIOTIC INJURY		0 (none)	1 (< 25%)	2 (> 25%)	
WF	Weather Fleck				

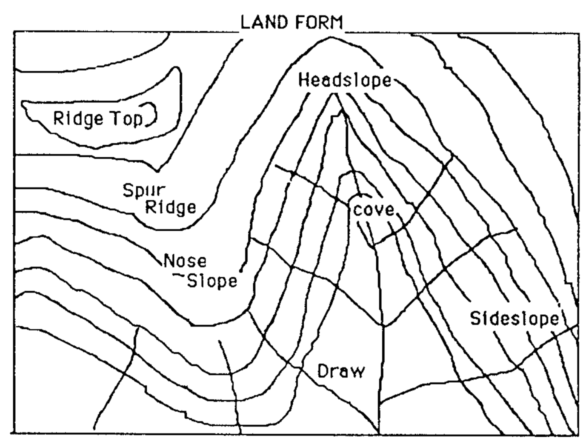


Figure 16—Quick reference sheet of site, tree and branch variables to be taken to the field.

addition, the use of a 30–ft telescoping pole–pruner can be hazardous under adverse conditions of slope, inclement weather (lightning), and fatigue. Power lines should be avoided when using a pole pruner. The pruner should be stable if it is leaning against a tree in an extended position. Back injury can result from hoisting the pole pruner from ground to vertical when fully extended. When extended or collapsed in a vertical position, pole segments in some designs can collapse rapidly causing injury to fingers and hands if they are between locking ferrules. Wearing leather gloves, such as baseball batting gloves, improves grip and may help prevent injury.

A hard hat should be worn because dead branch stubs, cones or the pruned branches themselves constantly fall from the tree. Safety glasses are also advised to prevent direct injury from a heavy falling object and also to protect eyes from the accumulation of fine debris that is dislodged from bark and needles.

Steep slopes are more hazardous because the pruner's attention is less focused on immediate surroundings while trying to get positioned to prune a branch. The field crew should be alert to poison oak and rattlesnakes. They should avoid working alone and if possible carry a hand–held radio or cellular phone so that assistance can be requested if needed.