How To…

Guide

Duncan C. Lutes
Robert E. Keane
John F. Caratti
Carl H. Key
Nathan C. Benson

HOW TO CONSTRUCT A UNIQUE PLOT IDENTIFIER

This is probably the most critical phase of FIREMON sampling because this plot ID must be unique across all plots that will be entered in the FIREMON database. The plot identifier is made up of three parts: Registration Code, Project Code, and Plot Number.

The FIREMON Analysis Tools program will allow summarization and comparison of plots only if they have the same Registration and Project Codes. This restriction is set because typically each monitoring project has unique objectives with the sample size and monitoring methods developed for specific reasons intimately related to each project. Comparisons made between projects with dissimilar methods may not be appropriate.

Registration Code ID—The Registration Code is a four-character code determined by you or assigned to you. The Registration Code should be used to identify a large group of people, such as all the people at one District of a National Forest or a number of people working under one monitoring leader. You are required to use all four characters. Chose your Registration Code so that the letters and numbers are related to your business or organization. For example:

MFSL = Missoula Fire Sciences Lab
MTSW = Montana DNRC, Southwest Land Office
CHRC = Chippewa National Forest, Revegetation Crew
RMJD = Rocky Mountain Research Station, John Doe

Project Code—The Project Code is an eight-charcter code used to identify project work that is done within the group. You are not required to use all eight characters. Some examples of Project Codes are:

TCRESTOR = Tenderfoot Creek Restoration
BurntFk = Burnt Fork Project
SCF1 = Swan Creek Prescribed Fire, Monitoring Crew 1
BoxCkDem = Box Creek Demonstration Project

It will be easier to read the sorted results if you do not include digits in the left-most position of the project code. For instance, if two of your projects are 22Lolo and 9Lolo, then when sorted 22Lolo will come before 9Lolo. The preferred option would be to name the projects Lolo09 and Lolo22, although Lolo9 and Lolo22 will sort in the proper order, also.

Plot Number—Identifier that corresponds to the site where sampling methods are applied. Integer value.

HOW TO LOCATE A FIREMON PLOT

The FIREMON plot describes the area where the FIREMON methods are applied. Each plot location is determined by the sampling approach—relevé or statistical—then its location is identified with written directions to the plot center and, finally, monumented with a permanent marker.

Identifying the Appropriate Place for a FIREMON Plot

FIREMON plot location procedures differ by sampling approach. If a relevé approach is used, then FIREMON plots are located by traversing the stand or strata to be sampled to find the range of vegetation and biophysical conditions that exist within the strata. When a location is found that has the conditions that comprehensively represent conditions across the entire strata, the crew boss will identify the plot center. Representative conditions should be assessed from a wide range of ecological attributes with the most important decision criteria keyed to the project objectives. First, the macroplot should represent the vegetation conditions of the strata. This includes species composition, vertical stand structure (canopy layers), plant size (such as, diameter and height), and plant health. Next, use the biophysical environment to judge representativeness of the macroplot. The macroplot should represent modal topography conditions or average slope, aspect, slope position, and elevation attributes. The disturbance history should then be taken into account by making sure that the disturbance evidence (insect, disease, fire, browsing, and so forth) on the macroplot represents the entire strata. Lastly, make sure the fuel characteristics are representative of the macroplot. Be sure to judge fuels individually (fine woody debris, coarse woody debris, and vegetation) and as a group (fire behavior fuel model) to make sure the macroplot is not located in an atypical fuel condition.

Being able to locate a plot in a representative portion of the stand without preconceived bias is somewhat unrealistic. Most plot locations will contain some element of sampler bias. However, in complex ecosystems with high spatial and temporal variability when many attributes must be measured, relevé appears to be the most simple, efficient, and tenable sampling approach available. One way to minimize bias and subjectivity is to mark a plot location, then randomly choose a direction (you can use the second hand on a watch) and place the plot center 100 ft (30 m) away along the randomly selected direction.

There are a few rules that should be followed for relevé plot location. First, establish the plot at least 150 ft (50 m) from any major change in vegetation or ecosystem conditions, such as a roadway, ecotone, or watercourse, and 150 ft (50 m) from the edge of the strata. Next, be sure the macroplot does not contain any atypical features such as brush piles, trails, or camp spots.

If a statistical approach is used, you must randomly locate the plots within the strata or across the landscape using one of three distribution techniques: systematic, random, or cluster. The systematic method is usually preferred because most of the FIREMON plots are located a set distance and azimuth from one another, making them easier to relocate. The random method uses some process that allows plots to be located at any point within the strata with equal probability. This means that two or more plots may be directly adjacent to one another. Plot locations can be picked by overlaying a map of the strata with a clear plastic sheet marked with random points or using randomly determined x- and y-coordinates. Clustered sampling is used to randomly locate plots around a point of origin. In FIREMON we suggest placing the point of origin near the intersection of multiple strata. This will reduce travel and sampling times and may allow you to increase the number of plots per strata. Unfortunately, cluster sampling this way usually involves some sort of bias because areas near the point of origin are more likely to be sampled than parts farther away. Also, the plots are, more often than not, near the boundary edges and may not be located to give the best description of typical conditions. These biases may lead to debate over the validity of statistical results when using clustered plots. There is a more extensive description of the statistical, random, and clumped plot location techniques in the **Integrated Sampling Strategy** chapter.

Once the plots have been marked on a map, the distance and azimuth to each one must be calculated. This can be done using the map scale and plotter or, more easily, using a GIS.

FIREMON Plot Center

The center of the FIREMON macroplot is a marked, discreet point around which the sampling methods are applied. FIREMON plots that will be resampled must have this point permanently identified. The plot center should be identified by two means: 1) written directions including, at least, latitude/longitude or UTM coordinates, and 2) a physical monument. Additionally, plot photos can be quite useful in relocating the FIREMON plot center.

Written Directions to the FIREMON Plot

Directions should be kept in the FIREMON notebook and/or the Metadata Table in the FIREMON database. They should carefully describe the directions to the plot from some well-known location that is not likely to change. Instead of "Travel 2 miles from the big boulder in Pat Firemon's pasture…" use "Turn right at the junction of Highway 87 and Forest Service Road 829, then travel 2 miles…". Give more specific directions as you get closer to the plot. The final leg should include distance and azimuth to the plot center. For instance, "…travel 2 miles up FS Rd 829. At Orion Park turn left on FS Rd 73 and go 3.1 miles. On left (north) side of road are two blazed DF (10.3" and 14.4")—if you go over culvert for Johnson's Springs you've gone 0.1 mile too far. Trees should also be marked with flagging. Between the two trees is a red stake. The first plot is 245 ft at 330 degrees true north (17.5 degrees E declination) from the stake. Plot center is marked with flagging and 1-ft tall, 2" x 2" red wood stake. The plot stake is 18.2 ft@155 degrees from a 12.4" DF (tag number #33), 25.8 ft@200 degrees from a 9.0" DF (#34), and 23.0 ft@050 degrees from a 18.1" PP (#35). Tags are at 1-ft height facing plot center. The other five plots are in a line spaced two chains apart on an azimuth of 330 true north, starting from the first plot, and marked with red stakes and flagging." The written directions should always include latitude/longitude or UTM coordinates for plot locations, averaged over 200 readings along with the associated location error.

The directions should be accompanied by a USGS 7.5 minute quadrangle map or aerial photo showing all of the plot locations and, if needed, a hand drawn map showing features not on the quad map such as side roads and log landings. Be sure to record any unique characteristics that might help locate the plot such as a group of blow down trees or a spring.

Monumenting the FIREMON Plot

The actual method of marking the plot center depends on the land use, distance from roads, vegetation, and the type of treatment that will be applied at the plot. We suggest using the most permanent marker possible for the situation. In areas not frequented by the public, domestic livestock, or hoofed wildlife, or in areas that will not see the use of rubber tired skidders, brightly painted steel fence posts or reinforcing bar (rebar) that extend above the understory vegetation make good choices. Rebar is heavy so you don't want to use it if you are traveling long distances on foot. In such cases, metal electrical conduit might be a better choice. If the unit is going to be burned, the best identification is by stamping plot markers or using casket tags. At the other end of the spectrum, a short wooden 2 x 2 inch (5 x 5 cm) post pounded down to ground level may be best. Relocation of wooden stakes can be made more easily if two or three bridge spikes are pounded around the stake, below ground level, so that the plot center can be relocated with a metal detector. Generally, spikes below ground level are not disturbed by or do damage to rubber tired skidders. Identify the plot center marker in some way (paint color, tag, stamped identification) so that it is not confused with other markers on the plot such as the ones used to identify the fuels transects or the vegetation baseline. Each project is unique, and it is up to the crew boss to determine the best method for permanently marking the plot center. When used in combination—good written directions, GPS locations, flagging, and tree tags—you should be able to locate all plot centers with minimal effort.

HOW TO PERMANENTLY ESTABLISH A FIREMON PLOT

FIREMON macroplots can be located permanently by driving a 3-ft (1-m) long 1-inch (2.5 cm) diameter piece of concrete reinforcement steel bar (rebar) down 1 to 2 ft (0.3 to 0.5 m) into the ground. Use a heavy hammer if possible. Sometimes it's not possible to drive the rebar into the ground because of rocks or hard soil. If so, drive the rebar in as deep as possible and then hacksaw off the top leaving about 6 inches (15 cm) of rebar showing. Tie a tag around the rebar about 4 inches (10 cm) from the top. As aluminum tags may melt, tags should be hard gauge steel (casket steel) if the plot will be burned in the near future. Use aluminum tags if the plot has already been burned. This tag should have an ID number stamped on it. Write the ID tag down in your notebook. Try to make the ID number part of the plot number. It is highly recommended that an orange or colorful cap be put on the exposed rebar for two reasons. First, it will be easy to relocate and find on the ground. And, more important, it will be highly visible so that no one gets hurt by tripping or falling on it.

The location of the plot must be documented using three methods. First, stand over the rebar and estimate the longitude and latitude of the plot location using a GPS unit. Average at least 200 instantaneous readings to get the most accurate geo-position. Second, take photos of the plot by following the recommendations in **How To Take Plot Photos.** Third, the rebar should be benchmarked by referencing it to at least three semipermanent monuments. A monument can be a large (greater than 8 inches diameter breast height), healthy tree, large rock (greater than 6 ft diameter), or stump. Don't use logs, snags, or objects that can easily be moved. Measure the distance and direction (degrees azimuth) from the plot center to the monument and write in a field notebook. Be sure to describe the monument in detail including unique attributes of the monument. For example, record the approximate species, diameter breast height, and height of a tree monument, or describe the type and size of a rock monument. If possible, permanently mark a monument so that it is more easily identified. For example, blaze a tree monument or scar a rock monument.

HOW TO DEFINE THE BOUNDARIES OF A MACROPLOT

The boundaries of a macroplot are defined by tying flagging on branches or vegetation at a fixed distance away from the plot monuments accounting for slope of the plot. For circular plots a spring loaded logger's tape makes flagging the plot boundaries easier because it automatically rewinds itself as you walk back toward plot center to get around trees. Tie or hook a cloth or logger's tape to the plot center monument, walk out a distance equal to the plot radius, and tie a flag to a semipermanent structure such as a branch, grass bunch, or downed log (fig. HT-1). Flagging should be placed near eye level along the boundary of the macroplot at intervals that allow the field crew accurate measures of plant cover or tree measurement. We suggest that at least eight points along the plot perimeter be flagged, but dense undergrowth, high tree densities, or severe topography might require additional flagging. Err on the conservative side and put more flag perimeter points when in doubt. It is important that the distances be adjusted for the slope of the ground by multiplying the fixed distances by a slope correction factor. See **How to Adjust for Slope** for the correction factors. The flagging should clearly identify which plants are inside or outside the macroplot boundaries.

If the macroplot is rectangular, then cloth tapes are stretched to form the boundaries with all of the corners marked with stakes or rebar. Tie flagging on branches that cross over the tape. The tape may not be visible from all parts of the plot, and the flags will make it easier to identify the plot boundaries.

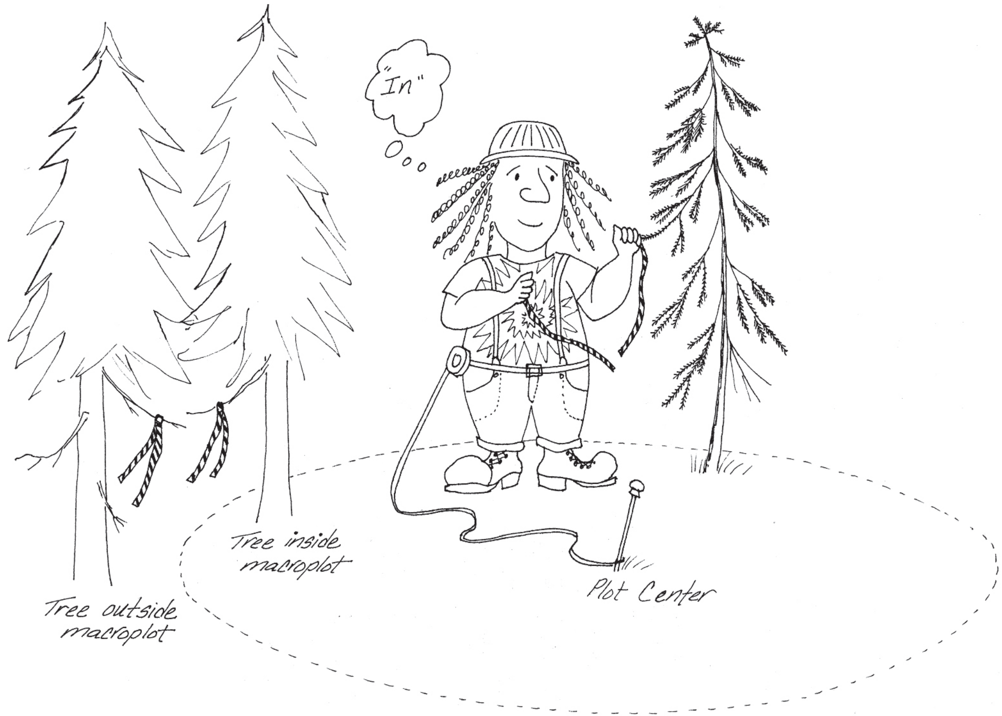


Figure HT-1—Mark the macroplot boundary with flagging.

While selection of flag color may seem trivial, it can be an important phase in the sampling effort. Select a color that is easy to see and different from what other resource groups at your agency or district office may be using. For monitoring plots, it is often helpful if the flags stay up for at least 3 to 5 years so that the same boundaries can possibly be used for the second measurement. It is also good practice to write the plot number on the flagging.

HOW TO ESTABLISH PLOTS WITH MULTIPLE METHODS

Plot Layout

Typically, the FIREMON sampling will be done using more than one method. If so, this may mean more than one plot type will be used to gather all of the data. In FIREMON there are four general recommended plot types used for sampling: 1) a 0.1 acre (0.04 ha) circular plot for the Plot Description (PD), Species Composition (SC), and Tree Data (TD) methods; 2) a 66 x 66 ft (20 x 20 m) vegetation sampling plot for the Cover/Frequency (CF), Point Intercept (PO), Line Intercept (LI), Density (DE), and Rare Species (RS) methods; 3) a hexagonal path defined by the 75-ft (25-m) Fuel Loading (FL) sampling planes; and 4) a 50-ft (0.18-acre) or 15-m radius (0.07-ha) sampling plot for the Composite Burn Index (CB) method. FIREMON allows you to use almost any plot size and shape, but the point is that when you lay out the different plot types they should, as much as possible, cover the same area (fig. HT-2).

The FIREMON plot center coincides with the start of the first sampling plane of the FL method as well as the center of the PD, SC, TD, and CBI methods so it is not difficult to lay them out. The CF, PO, LI, DE, and RS methods use transects and quadrats oriented perpendicular to a baseline, and it may not be clear where to start the baseline in order for the vegetation plot to be positioned appropriately. If you are using the recommended plot size for the CF, PO, LI, DE, or RS methods, then from the FIREMON

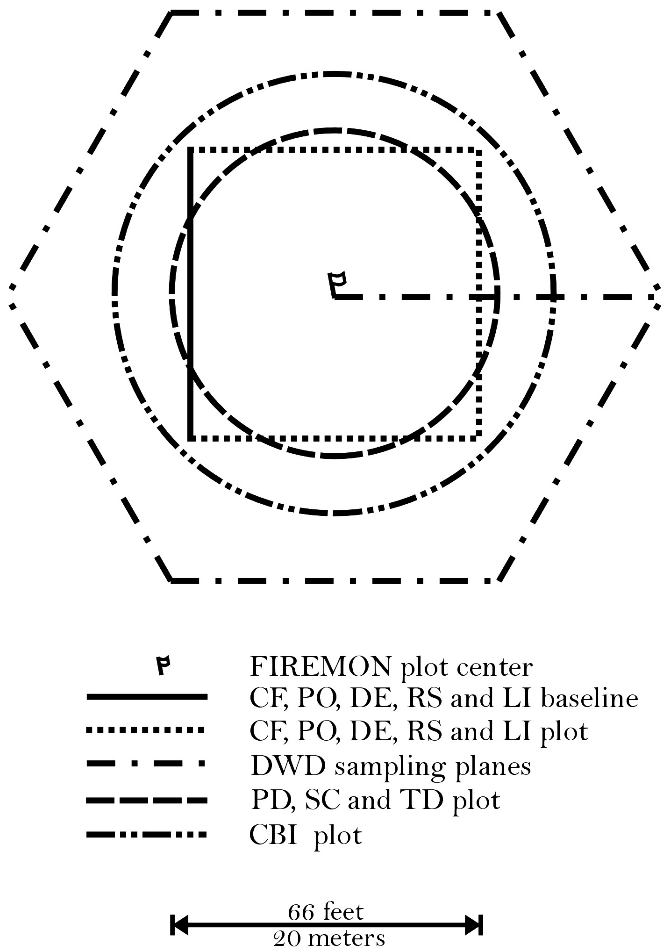


Figure HT-2—Four general plot shapes are used when sampling with the recommended protocols. Often more than one of these plots will be used. If so, the different plots should be laid out so they overlay each other as much as possible.

plot center measure 33 ft (10 m) down slope, then 33 ft (10 m) across slope to the right, and locate the start of the baseline at that point. If the plot is located on flat ground, the starting point for the baseline is located 33 ft (10 m) true south and 33 ft (10 m) due west from the plot center. To locate the baseline when using a different plot size, measure one-half the plot width down slope from plot center, then one-half the plot height across the slope, and locate the start of the transect there. If you are using a rectangular plot the longer dimension will generally go across the slope.

Sampling Order

Each sampling method will impact the sampling area to some extent, and the impact from one method may negatively influence the ability to sample with another method. For instance, tree sampling often leads to lots of trampling because the samplers are moving back and forth across the plot to mark the boundary, then sampling small and mature trees. If you try to measure herbaceous vegetation heights after tree sampling you won't get a true representation because of the trampling.

Use table HT-1 to order the sampling on your plot. Look for the method(s) that you will be using on each FIREMON plot and sample them in the order you find them in the table. For example, if you are using the TD and CF methods, complete the CF protocol before moving on to the TD protocol. The first three methods are equally sensitive to plot disturbance. However, rarely would more than one be used on a particular plot. Modify the order if needed so that plot measurements reflect the actual plot condition, not the condition caused by sampling (such as trampling).

Table HT-1—Suggested order for sampling when using multiple methods. Modify as necessary for your project.

Order	Method
1	RS
2	SC
3	PO
4	CF
5	DE
6	LI
7	TD
8	FL
9	CB
10	PD

HOW TO DETERMINE SAMPLE SIZE

Plotting Graphs of Mean Values for Varying Sample Sizes

It may be necessary to sample more than the recommended number of transects or quadrats in order to sufficiently capture the plant species variation within the macroplot. The FIREMON Line Intercept, Point Intercept-Transect, and Density-Belt Transect sampling methods are transect-based methods that may require adding more transects or making the existing transect length longer in order to capture the variability of the attribute of interest. The FIREMON Cover/Frequency (CF), Point Intercept-Frame, and Density-Quadrat methods are quadrat-based sampling methods that may require installing more quadrats on longer transects or installing more quadrats on additional transects in order to capture the variability of the attribute of interest.

The following example uses the FIREMON CF method to determine a sufficient sample size for estimating plant species canopy cover. Begin by laying out the minimum number of transects and quadrats. See **How to Locate Transects and Quadrats** for more details. Then record plant species canopy cover for each quadrat. Using a calculator and graph paper or a spreadsheet program such as Microsoft® Excel, plot the average canopy cover of selected plant species for varying number of quadrats (table HT-2). Start with averaging canopy cover for the first quadrat and end with averaging canopy cover over all quadrats. It may be necessary to plot average plant species cover values on more than one plot if some plant species have low cover values and some plant species have high cover values. Plotting cover values at different scales will allow you to see fluctuations in the graphs for all species, regardless of the absolute cover values. In this example, four species with high relative cover values were plotted on one graph (fig. HT-3), and two species with low relative cover values were plotted on a second graph (fig. HT-4).

Fluctuations in the graph will level out at a sufficient number of quadrats for sampling the attribute plotted—canopy cover, in this example. More quadrats should be sampled if the line graphs do not level out. If more quadrats need to be sampled, add more transects with the same number of quadrats as the other transects, or make the existing quadrats longer and add more quadrats. A third option would be to place additional quadrats on the existing transects. However, this can lead to questions about the spatial correlation of some attributes, so we recommend using this option only if the first two are not feasible. Record plant species canopy cover for the new quadrats and then plot the graphs again with the additional cover values. These graphs can be plotted for other attributes such as frequency, density, and height. The basic idea is to plot a graph for the attribute you are interested in measuring and adjust the sample size appropriately. This method can be used to plot mean attribute values by transect for the transect sampling methods. The number of transects sampled may be adjusted accordingly.

Table HT-2—Average canopy cover values for selected plant species. Average values are calculated for successively larger numbers of quadrats.

Agropyron spicatum	Agropyron smithii	Bromus japonicus	Achillea millefolium	Koelaria cristata
0	0	0	0	0
20.5	20.4	0.5	0	0
23.3	23.3	1.3	0	1
23.4	23.3	6	0.25	1.5
18.4	18.5	5.4	0.2	1.2
15.2	14.9	5	0.17	1
13.6	14.5	5.7	0.14	1
11.1	14.4	5.4	0.25	1
10.7	13.4	5.1	0.22	1.22
9.5	12.5	5.6	0.3	1.1
9.1	12.5	4.5	0.27	1
8.4	11.2	5.2	0.25	0.92
7.4	10	5	0.46	1.1
7.3	9.2	4.8	0.5	1.2
7.2	9.2	4.5	0.47	1.1
6.3	9.2	4.4	0.63	1.06
6.3	7.8	4.3	0.59	1.06
6.3	7.8	4.1	0.56	1.17
5.6	7.1	4	0.68	1.26
5.4	7.1	4	0.65	1.35
5.3	7.1	3.8	0.67	1.29
5.4	7.1	3.8	0.64	1.3
4.3	6.2	3.5	0.62	1.3
4.3	6.2	3.5	0.62	1.3
4.3	6.2	3.5	0.62	1.3

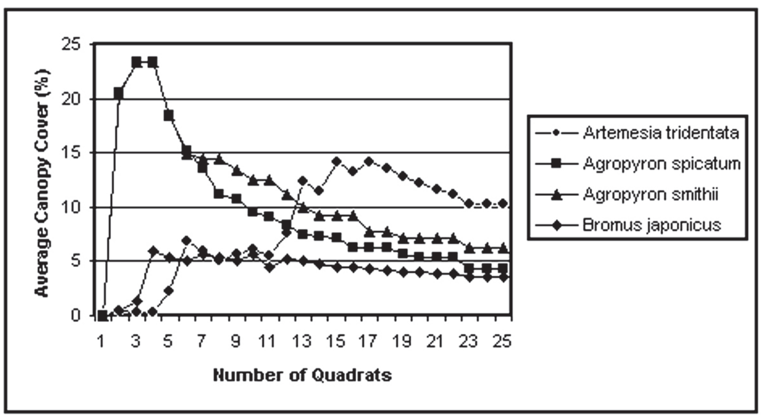


Figure HT-3—Plot of average canopy cover versus number of quadrats for four plant species on a plot having approximately 5 percent or more cover.

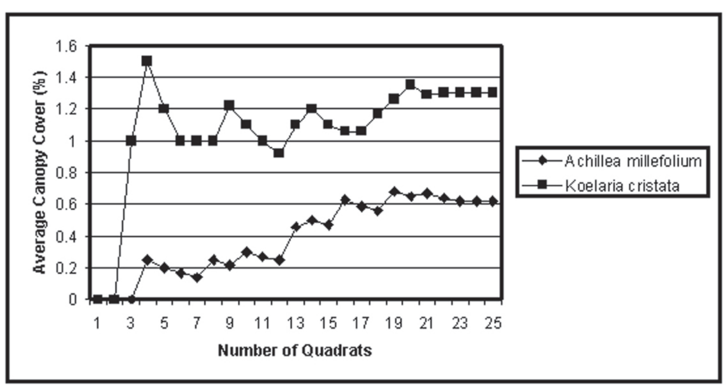


Figure HT-4—Plot of average canopy cover versus number of quadrats for two plant species on a plot having approximately 1 percent or less cover.

HOW TO ESTIMATE COVER

General Cover Estimation Techniques

Depending on the objectives of your monitoring project you may be estimating cover using the Plot Description (PD), Fuel Load (FL), Cover/Frequency (CF), and Species Composition (SC) methods. In FIREMON cover estimation is usually made at one of two general scales. The cover estimation is made over the entire macroplot with the PD and SC methods and, usually, on a 20 inch (0.50 cm) square or 6-ft (2-m) diameter plot with the CF and FL methods, respectively. Cover estimation is much more straightforward with the LI method and is described in the LI documentation.

Cover is usually defined one of two ways. First, cover may be the outside edge or drip line of the plant crown being assessed, with all of the spaces within the crown included in the estimate. Although there is no standard definition, this cover assessment is sometimes called canopy cover, or if tree cover is being estimated, crown cover. Second, cover may be estimated as the vertical projection of the plant foliage and supporting parts with all of the spaces within the crown excluded from the estimate. Again, there is no standard definition; however, this cover assessment is sometimes called foliar cover. Since the foliage of overstory trees is dense, the two assessments are nearly synonymous for that component. Apart from FIREMON, it is common for cover of overstory trees to be estimated using the canopy cover definition, and the cover of other components to be estimated using foliar cover definition.

In FIREMON, all the methods suggest using foliar cover for the cover estimates. Some figures in this section were developed to help users estimate foliar cover.Other figures are presented to help users visualize concepts, such as subdividing and grouping, to make better cover estimations. If users want to estimate canopy cover using a method that is different than foliar cover, it should be noted in the Metadata table.

Of the two types, foliar cover is a better measure of vegetation change over time. If you estimate cover based on plant perimeter you are purposely disregarding the open spaces in the canopy. These spaces are likely locations for new growth to occur so it would be possible for foliar cover to increase over time without any associated increase in canopy cover. Changes in foliar cover are often important to fire monitoring projects, so we suggest sampling that characteristic rather than just canopy cover.

The biomass equations used in the FIREMON Analysis Tools package are based on foliar cover, but this is not always the case. If you are collecting species-specific cover data to derive biomass outside of the FIREMON Analysis Tools, be sure that you sample cover the same way that it was sampled when the equations were developed or your biomass estimations will be incorrect.

You may need to make cover estimates for a number of ecosystem components. The most common estimates are for living vegetation, such as individual species, structural layer, or life form. Other components include cover of dead vegetation such as fine and coarse woody debris and dead herbaceous material. Finally, bare ground, rocks, and ash are examples of nonvegetation components that may be sampled.

In FIREMON, “cover” is the vertically projected cover of the component being sampled. Vertically projected cover is best described as the cover of the sampling entity if it were compressed straight to the ground. To make good estimations of cover, field samplers will need to visualize this compression for each component. This might not be hard to visualize if samplers are estimating the cover of logs, lichen, or some other low entity, but as the vegetation gets taller and occupies more layers, the task becomes more difficult. Experience will help samplers be less intimidated by this task. Sometimes a plant that is rooted outside the sampling area has vegetation—branches and leaves primarily—growing within the sampling area. This vegetation should be included in the cover estimates you make.

If a particular species was sampled sufficiently early or late in the season that you believe its cover at peak phonological development would be one cover class greater or lower, enter the estimated peak cover. For example, if leaves have fallen off the plant and are on the ground, mentally reconstruct the plant with leaves attached and estimate its cover.

The cover classes used in FIREMON are relatively broad, typically 10 percent (table HT-3), so the precision of cover estimates are secondary to accuracy.

Table HT-3—Cover classes used in FIREMON.

Code	Cover
	percent
0	Zero
0.5	0–1
3	>1–5
10	>5–15
20	>15–25
30	>25–35
40	>35–45
50	>45–55
60	>55–65
70	>65–75
80	>75–85
90	>85–95
98	>95–100

The easiest way to get a cover estimate in the field is through an iterative process where you first note that cover is between two cover classes, then use the midpoint of those two classes and try to determine which half the cover is in. Continue this until you have narrowed cover down to one class. For instance, say you are looking at a sampling area where you know for certain that cover is between 15 and 55 percent (cover classes 20 and 60). Next, try and determine if cover is between 15 and 35 percent or between 35 and 55 percent. If you think cover is lower than 35 percent, then try to determine if cover is between 15 and 25 percent or of it is between 25 and 35 percent. Cover class will be 20 if you choose the lower half or 30 if you choose the upper half.

Experienced field samplers usually get accurate estimations of cover using two methods: grouping or subdividing. On smaller plots many samplers mentally group the plants to one corner of the sampling area and then estimate the cover. Cover estimates are easier when you group using a marked quadrat such as the one described in the CF methods. The subdivision method uses our natural ability to estimate cover better on small areas than large areas. It is typically used on large plots, such as the FIREMON macroplot. Subdivision also helps get accurate cover estimates when the entire plot cannot be seen from one location.

When using the subdivision method, divide the sampling area into quadrants or some other easily determined area, and estimate the cover in each part. It may be useful to use the grouping technique on each quadrant also. In figure HT-5, A, illustrates how plants, represented by the circles, might be distributed across a plot. B shows the plot divided into quadrants and plants being mentally combined within the quadrant with the combined cover shown using circles in C or as squares in D. The areas of all the circles in A make up 10 percent cover. In C, percent cover for quadrants 1, 2, 3, and 4 is 12, 4, 16, and 8 percent, respectively. Percent cover, then, is (12 + 4 + 16 + 8)/4 = 10 percent. Usually you will also be developing a species list for the plot, so as you walk around the perimeter looking at the cover within each quadrant you can record the species at the same time.

The dimensions of the imaginary item groups can be used by the field sampler to estimate cover on the entire plot. For instance, if you visually group all of the herbaceous cover on the macroplot and find that it would fit in a circle about 24 ft across, that group would constitute a cover of about 10 percent on the typical 0.10 acre macroplot (table HT-4). This method can be used at the individual species level for estimating cover in layers or for a composite estimation of cover.

Regardless of the technique used for estimating cover, samplers will need to calibrate their eye in order to make an accurate assessment of cover. Field crews should develop a plan so that samplers can calibrate their eyes periodically throughout the field season. The best way to do this is by visually estimating cover on a FIREMON plot-sized area where the “true” value has been verified using either PO for ground cover, CF for herbaceous cover, and/or LI for shrub cover. Below are some illustrations that are designed to help samplers as they begin to calibrate their eyes.

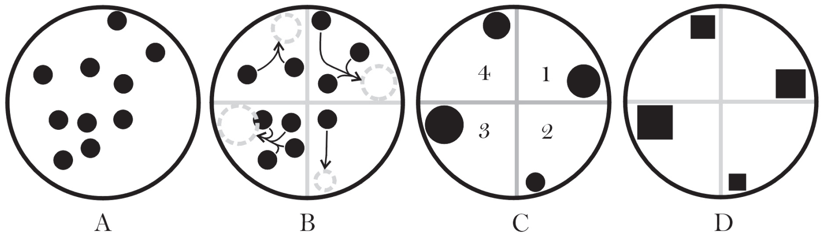


Figure HT-5—The subdivision and grouping technique for estimating cover. Average the cover in quadrants to get the cover class estimation.

Table HT-4—Percent cover for different radius areas on a 0.10 acre (400 m²) circular macroplot.

Radius	Radius	Percent of 0.10 acre (400 m²) macroplot
	ft	*m*
37.2	11.28	100
26.3	7.98	50
18.6	5.64	25
11.8	3.57	10
8.3	2.52	5
3.7	1.13	1

The illustrations in figure HT-6 represent a circular plot of any size. Before reading the figure caption try to estimate the area inside each large circle that is covered by the smaller circles. As a hint, people tend to overestimate.

The illustrations in figure HT-7 represent a 6-ft diameter sampling area with 1 inch and 0.25 inch diameter pieces scattered inside. Try to estimate the percent of vertically projected cover before reading the caption.

Notice that in figure HT-7 the illustrations of branches are two-dimensional representations of three-dimensional entities—that is each illustration shows how much ground the dead branches would cover if they were compressed straight to the ground. In the field, samplers will need to get comfortable with imagining all of the suspended pieces moved to the ground in order to estimate vertically projected cover.

The illustrations in figure HT-8 represent live cover on a 6-ft diameter sample plot. This cover estimate includes both the branches and leaves together. The percent cover is listed below each illustration. Remember, some of the vegetation in the sampling area might be rooted outside the sampling area; however, it is included in your cover estimate.

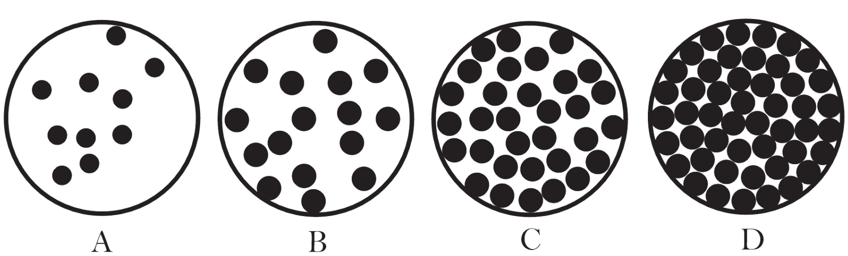


Figure HT-6—Cover illustrations showing different levels of cover. Cover in A, B, C, and D is 10, 25, 50, and 75 percent, respectively.

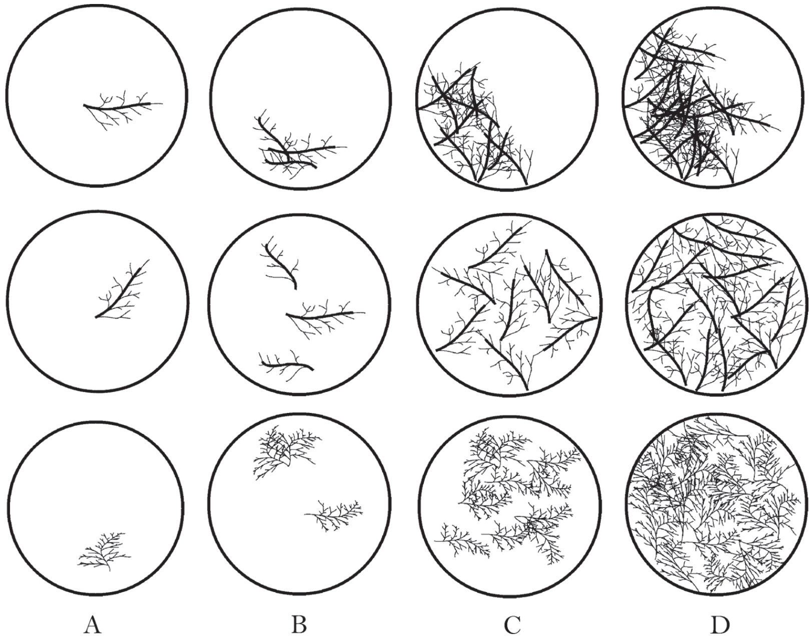


Figure HT-7—Cover illustrations showing levels of dead vegetation. Each circle represents a 6-ft diameter sampling area. Thick lines represent pieces 1 inch diameter and thin lines 0.25 inch diameter. The cover in columns A, B, C, and D is 1, 3, 10, and 20 percent, respectively.

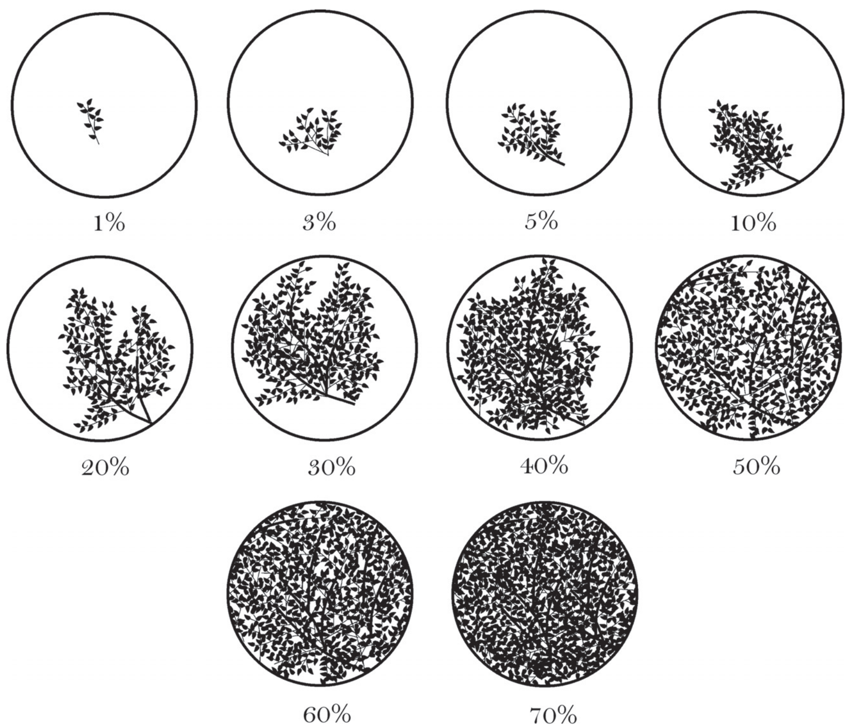


Figure HT-8—Cover of live vegetation on a 6-ft diameter sampling area. Percent cover is indicated below each illustration.

Estimating the cover of multiple entities makes the estimation task more difficult because you have to mentally separate each entity. It is easiest to first make an estimate of the total vertically projected cover on the sampling area, and then estimate cover of the entities from greatest cover to least cover. Figure HT-9 shows two entities, woody and nonwoody vegetation, being sampled on the same sampling area. First, the total cover (A) would be estimated, then nonwoody cover (B), and finally, woody cover (C). Because of overlap between entities, the sum of the entities may be greater than the total cover and may sum to be greater than 100 percent.

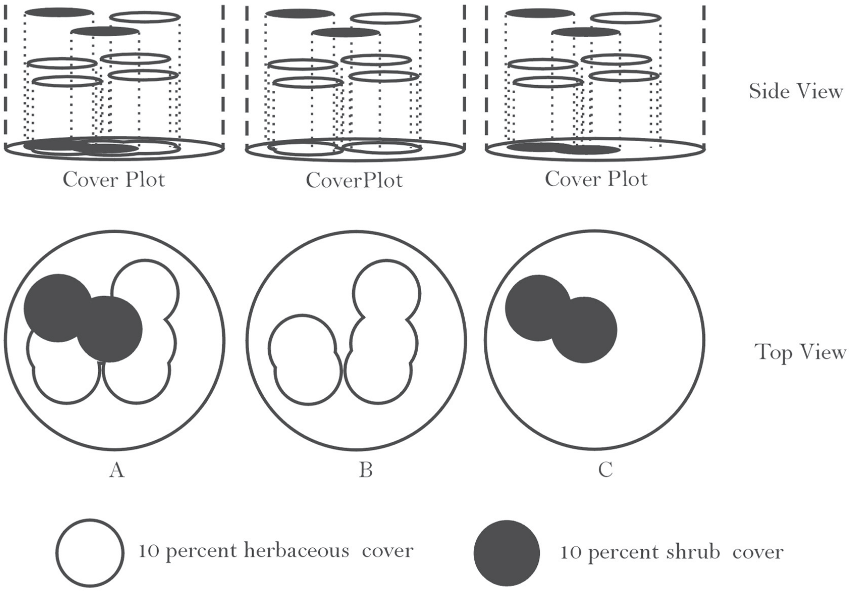


Figure HT-9—In these illustrations each circle, individually, represents 10 percent cover. A) Total cover within the sampling area is about 40 percent. B) Cover of nonwoody vegetation is about 30 percent. C) Cover of woody vegetation is about 15 percent. Note that, because of overlap, the sum of cover for the entities will always be greater than or equal to the total cover, and may sum to greater than 100 percent cover. In terms of field data, cover in A, B, and C would be recorded as 40, 30, and 20, respectively.

Additional Hints for Estimating Cover When Using the Species Composition (SC) Method

Use the techniques provided above to estimate cover on the SC sampling area. Both the subdivision and grouping techniques may be helpful on a large macroplot. If you are sampling species cover, do not include overlap between canopies of the same plant species (fig. HT-10). If cover is measured by size class for a plant species, estimate the cover for each size class and include canopy overlap between different size classes (fig. HT-11).

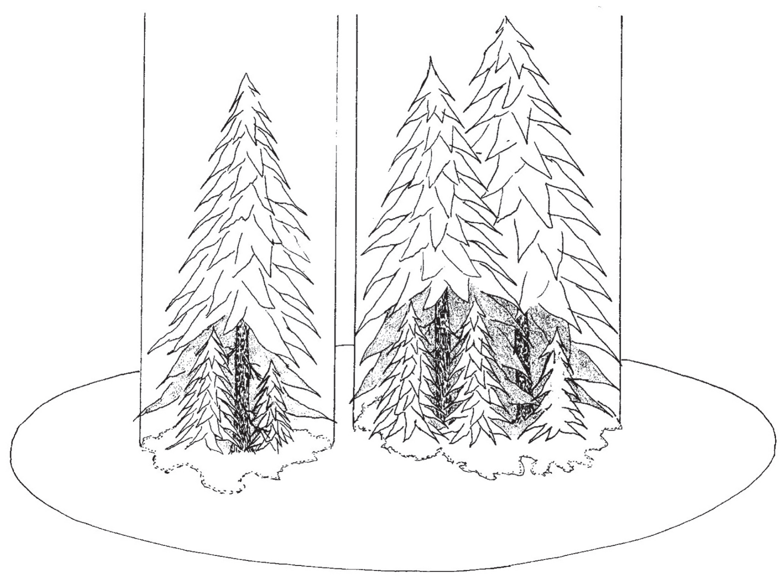


Figure HT-10—In this figure, the small trees underneath the canopy of the larger trees are the same plant species. If cover estimates are being made for total cover by species then cover is estimated as the projection of the large tree canopy onto the ground, which overlaps the canopy of the smaller trees.

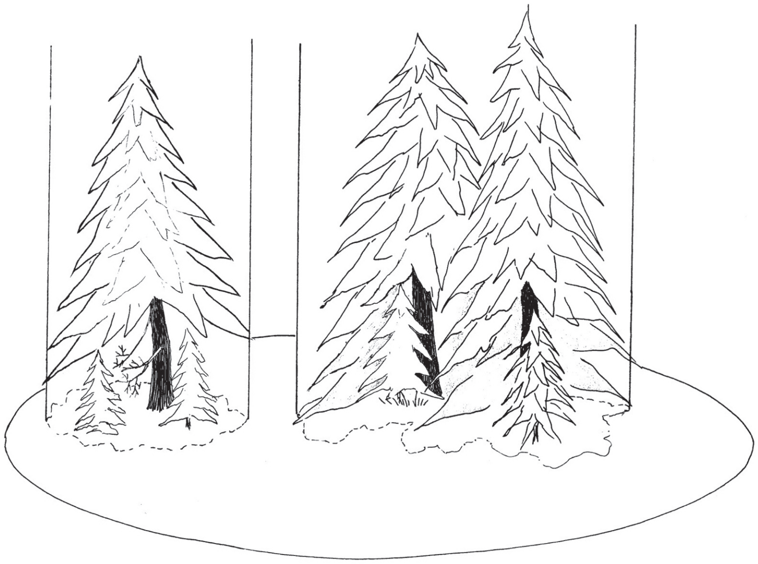


Figure HT-11—In this figure the small trees underneath the canopy of the larger trees are the same plant species but a different size class (seedlings versus saplings). If cover estimates are being made by species and size class, then one cover estimate should be made for the seedlings and one estimate for the saplings.

Additional Hints for Estimating Cover When Using Quadrats

Estimating cover within quadrats is made easier by marking the quadrat frame to indicate subplot sizes and knowing the percent of quadrat area each subplot represents (fig. HT-12). Subplots are used to estimate cover for a plant species by mentally grouping cover for all individuals of a plant species into one of the subplots. The percent size of that subplot, in relation to the size of the quadrat being sampled, is used to make a cover class estimate for the species. Cover estimates should include plant cover over the plot even if a plant is rooted outside the plot (fig. HT-13).

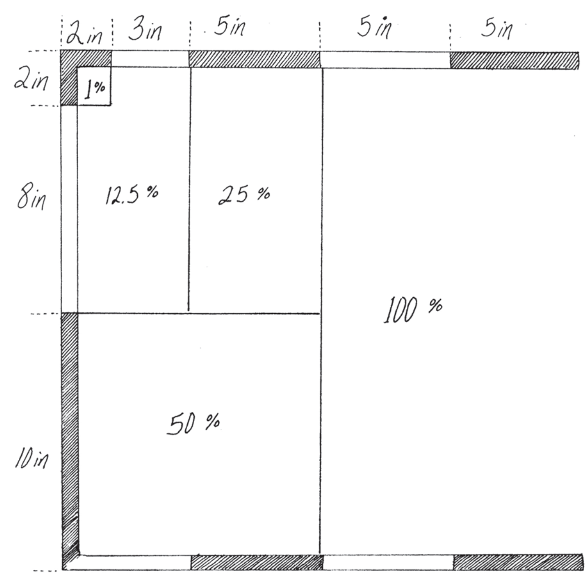


Figure HT-12—Subplot dimensions for the standard 20 x 20 inch (50 x 50 cm) quadrat used for cover/frequency sampling.

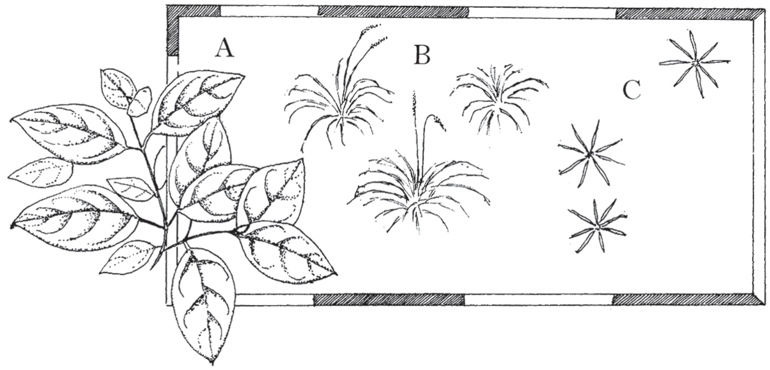


Figure HT-13—Cover from species A is estimated even though this species is not actually rooted within the quadrat.

HOW TO USE A COMPASS—SIGHTING AND SETTING DECLINATION

Compass headings are used to navigate to plots, determine plot aspect, orient sampling transects, and other field tasks. In FIREMON we call the compass heading the *azimuth*. It is extremely important that the field crews are familiar with using a compass so they can walk a course with a known azimuth and find the azimuth of a course where the azimuth is unknown. For example, when describing the directions to a new FIREMON plot, the crew will have to determine what distances and azimuth to record so that sampling crews will be able to find the plot at the next sampling time. For subsequent sampling visits, the crew will follow the directions provided by the crew that sampled the plot initially. When you are determining a course, compass use is different than when you are following a course. We recommend that you use a compass that has a sighting mirror and declination adjustment. The parts of a compass are shown in figure HT-14.

If you want to determine a course between two points, say a flagged tree and a sample plot, stand at the tree, set up your compass so that you can see the compass face in the mirror, with the sighting line in the mirror and the sight on the compass lined up. Now, with the compass level, hold it out in front of you at eye level so that you can see the plot center in the sight on top of the compass. If the compass is not held level, the compass needle will not rotate freely and the azimuth will be wrong. Sometimes there are bubbles in the compass and you can use the bubble's reflection in the mirror to let you know if the compass is not level. With the plot center in the sight and the scribed line on the mirror lined up with the sighting marks on the compass face, hold the compass still and while looking at the compass needle in the mirror, use your free hand to turn the compass housing until the compass needle is parallel to the orienting arrow. Make sure that the north end of the compass needle (usually marked red) is pointing the same direction as the orienting arrow or your azimuth will be off 180 degrees. Now, lower the compass and record the azimuth from the sighting mark closest to the mirror. If the declination is set to zero, you will be recording the azimuth in magnetic degrees. If the declination is set to the declination for your sampling area, then you will be recording the azimuth in degrees true north.

If the bearing between two points is known and you want to follow that course, then set the known azimuth at the sighting mark closest to the mirror. Next, hold the compass out in front of you, level and at eye level. Keep the compass in the same position relative to your eye and rotate your body until you see in the mirror that the compass needle is parallel with the orienting needle. Make sure the scribed line on the mirror is lined up with the sights marks or you will be going the wrong direction. With the needles parallel, use the sight on the mirror to pick an obvious object, such as a rock or tree, that falls in line with the direction you want to go. Pick something distinct that you will be able to see for the entire distance as you are walking. For example, don't pick just any tree as many look alike. Instead, pick a tree with a forked crown or other distinctive feature. Once you get to the object you will repeat the procedure. For long distances or in dense vegetation you may have to repeat this sight-and-walk procedure many times before you get to your destination. When laying out the sampling planes for the FL method you use this technique to guide the sampler pulling the tape. For instance, for the first

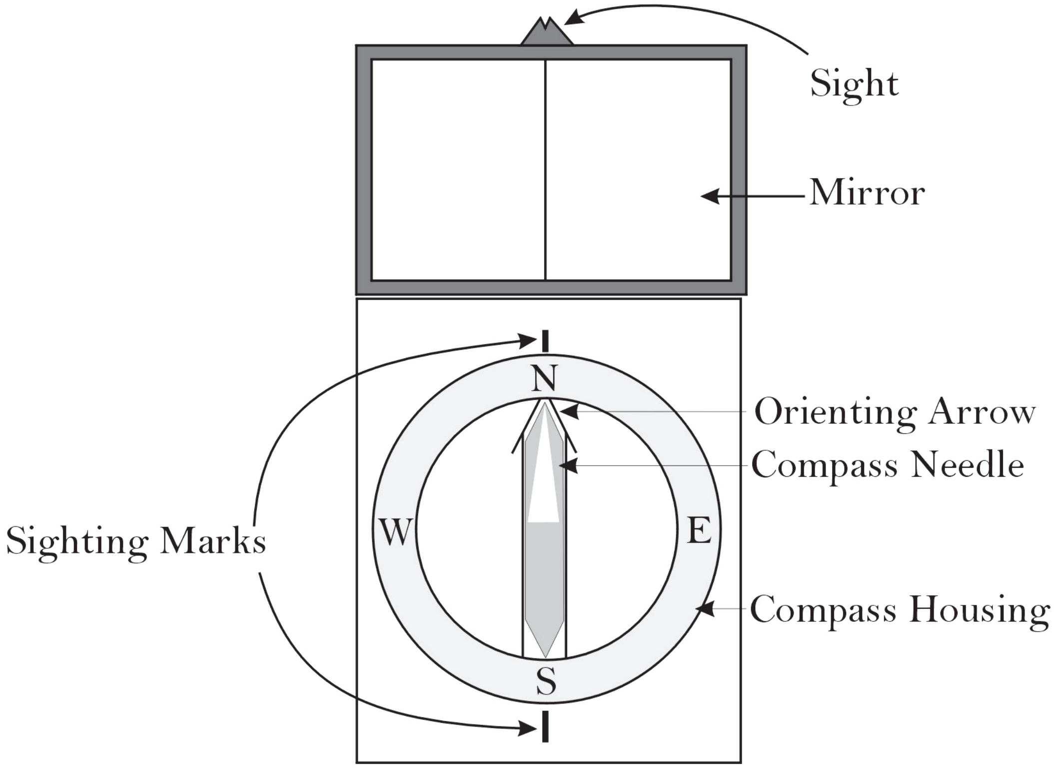


Figure HT-14—The parts of a compass. Azimuth numbers have been left off for readability.

sampling plane you set the azimuth 090 degrees at the sighting mark closest to the mirror, then hold the compass in front of you and guide the other sampler along making sure to keep that person on the 090 degree azimuth.

Magnetic declination is the difference between true north (pointing to the North Pole) and magnetic north (the direction the needle on your compass points). We suggest always using true north degrees, which requires that you set the declination on your compass. The declination for the area you are sampling should be set the same on all the compasses in the project and recorded in the Comments field of the Plot Data table or in the Metadata table. Declination can change substantially as you move from place to place, especially in the Northern United States and Canada, so be sure that you look up the declination at each of your sampling sites. Probably the best declination values are available from aircraft sectional charts. However, those maps may not be immediately available. Ask a pilot friend to give you an old sectional chart when it has gone out of date (usually once a year) and keep it on hand for reference. Declination changes over time, so do not use sectional charts or declination maps greater than 10 years old to get the declination value. Other sources for declination information are the World Wide Web or people familiar with the sampling area. For example, the USGS has a coarse scale map of declination on its Web site (http://geomag.usgs.gov/usimages.html).

Different compasses have different mechanisms for changing the declination but most use a small screw on the compass housing. Use a screwdriver (usually supplied with a new compass) and turn the declination screw left or right until the mark in the orienting arrow lines up with the proper declination. Be sure that you use the correct declination direction, east or west. In figure HT-15 declination is set to 6 degrees east declination.

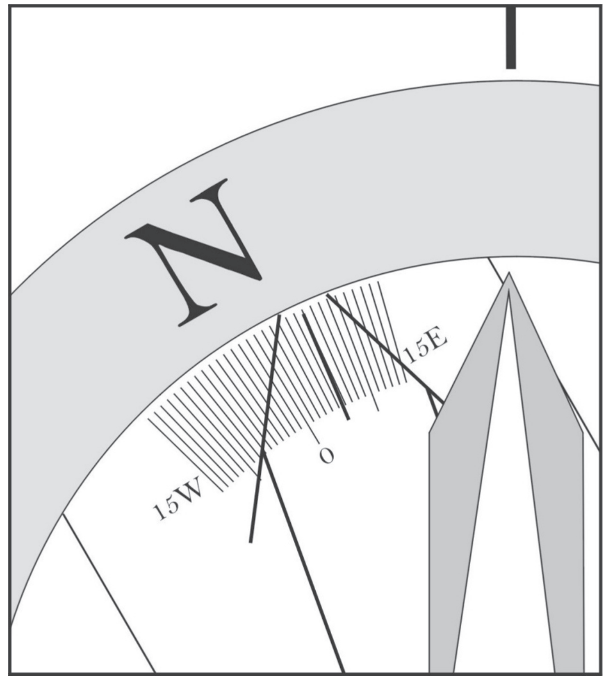


Figure HT-15—The mark in the orienting arrow indicates the compass is set to 6 degrees east declination.

HOW TO ESTABLISH A BASELINE FOR TRANSECTS

The suggested baseline is 66 ft (20 m) long and is oriented upslope with the 0-ft (0-m) mark at the lower point (fig. HT-16). On flat areas, the baseline runs from south to north with the 0-ft (0-m) mark on the south end of the baseline. Transects are placed perpendicular to the baseline (across the slope) and are sampled starting at the baseline. Running transects across the slope will reduce the possibility of erosion along paths taken by samplers as they move along the transect. The greatest concern for erosion is on areas with sparse ground vegetation. On flat areas, transects are located west to east.

The baseline is established by stretching a tape measure the desired distance between two stakes. Permanently mark the baseline with four markers. In the written description of the plot location record the foot (meter) location of each marker along the baseline. For a 66-ft (20-m) baseline markers are placed at 0 ft (0 m), 3 ft (1 m), 63 ft (19 m), and 66 ft (20 m). Locating a transect nearer that 3 ft (1 m) to the end of the baseline may mean that portions of quadrats will lie outside the vegetation plot. It is not always necessary to permanently mark the 3-ft and 63-ft points, but doing so provides a backup in case any markers are disturbed. The markers at the start and end of the baseline should be brightly painted or marked with flagging so that they are easy to relocate for subsequent sampling.

In general you should locate the baseline using the most permanent marker available for the situation. In areas not frequented by the public, domestic livestock, hoofed wildlife, or areas that won't see the use of rubber tired skidders, brightly painted steel fence posts or reinforcing bar (rebar) that extend above the understory vegetation make good choices. Rebar is heavy so you don't want to use it if you are traveling long distances on foot. In these cases, metal electrical conduit might be a better choice. If the unit is going to be burned, the best identification is by stamping the plot marker or using casket tags. At the other end of the spectrum, a short wooden 2 x 2 inch (5 x 5 cm) post pounded down to ground level may be best. Relocation of wooden stakes is easier if two or three bridge spikes are pounded around the stake, below ground level, so that the plot center can be relocated with a metal detector. Generally, spikes below ground level are not disturbed by or do damage to rubber tired skidders. Identify the baseline markers in some way (for example, paint color, tag, or stamped identification) so that they are not confused with other markers on the plot such as the ones used to identify the fuels transects or the plot center. Use a file or other type of permanent marker to display 1, 2, 3, or 4 notches in the appropriate

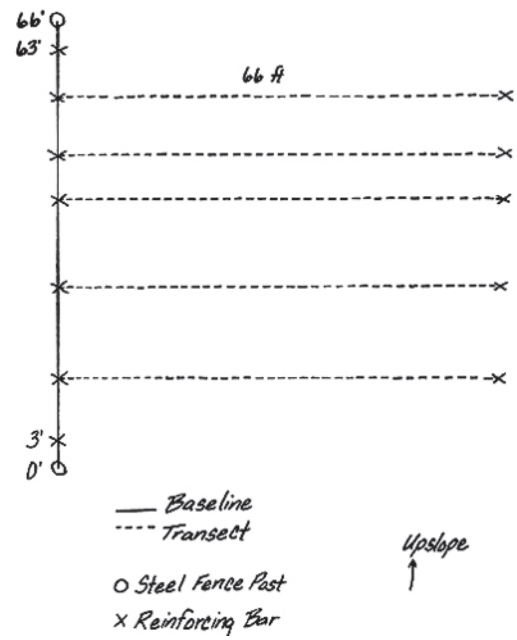


Figure HT-16—Orient the baseline upslope with the zero end positioned at the lower point. Transects are oriented across the slope to limit the opportunity for erosion.

marker with one notch denoting the starting marker and four notches denoting the ending marker along the baseline. Each project is unique, and it is up to the crew boss to determine the best method for permanently marking the baseline.

From the starting and ending markers, take a compass bearing (azimuth) and distance to the plot center and record the information on the plot location. Take a compass bearing from the starting marker to the ending marker and record this on the map and on the plot location description. Determine the compass bearing perpendicular to the baseline for each of the transects and record them on the general description map. If permanent transects are established, mark the beginning and ending of each transect with reinforcing bar.

Transect locations should be recorded on the general description map and in a written description of the plot layout design used in the project. Transects are placed perpendicular to the baseline with a compass and tape to ensure they are parallel to each other and can be relocated.

HOW TO LOCATE TRANSECTS AND QUADRATS

The FIREMON Random Transect and Quadrat Locator program (fig. HT-17) selects random starting points for transects along the macroplot baseline. The program also selects random starting points for systematic placement of quadrats along a transect. The numbers are unit-less, so you can enter them in feet or in meters and the result will be in feet or meters.

Enter a seed number for the random number generator. Then enter the number of transects and the length of the baseline in feet (meters). If two or more transects start at the same point or are too close to each other (less than the quadrat width), press the run button again to generate another set of transect locations. If you are placing quadrats along the transects, you can also generate random starting points for placement of the first quadrat. Enter the maximum distance from the baseline in feet (meters) in which the first quadrat on each transect could be placed. For example, if you are placing five 20 x 20 inch (50 x 50 cm) quadrats along a 66-ft (20-m) transect and placing them 12 ft (4 m) apart, the maximum distance would be 12 ft (4 m). If the random starting point equals 10 ft, your quadrats would start at 10, 22, 34, 46, and 58 ft.

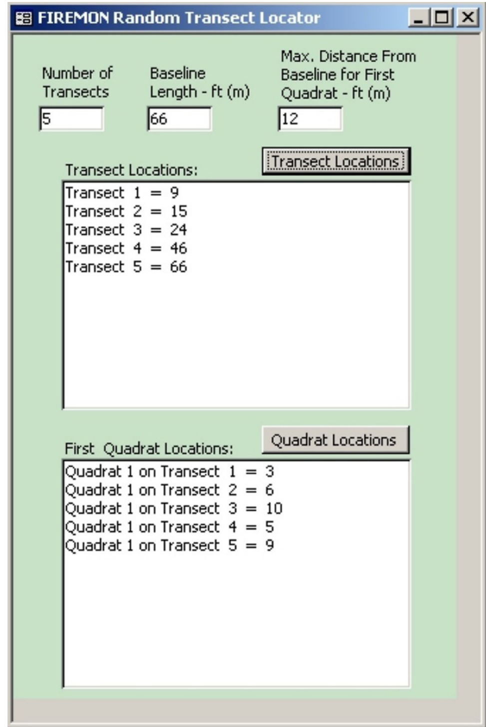


Figure HT-17—FIREMON random transect and quadrat locator.

Press the Transect Locations button to generate random transect starting points along the baseline. Press the Quadrat Placement button to generate random starting points for quadrat placement along each transect. Tables HT-5 and HT-6 present five sampling schemes for randomly locating five transects along a 66-ft (20-m) baseline. If you were using the FIREMON Line Intercept, Point Intercept, or Density method with only three transects along the baseline, you would use transect locations 1, 3, and 5 in tables HT-5 and HT-6.

Figure HT-18 illustrates example transect locations and quadrat placement for the recommended FIREMON Cover/Frequency sampling method. Five transects are located along a 66-ft baseline using sampling scheme 3 from table HT-5. Five quadrats are placed systematically along each transect starting 12 ft from the baseline and placed at 12-ft intervals.

Figure HT-19 illustrates example transect locations, quadrat placement, and belt transect placement for the recommended FIREMON Density sampling method. Five transects are located along a 66-ft baseline using sampling scheme 3 from table HT-5. Five 3 x 3 ft quadrats for sampling herbaceous plants are placed systematically along each transect starting 12 ft from the baseline and placed at 12-ft intervals. Three 6-ft (2-m) belt transects for sampling shrubs and trees are placed along each transect.

Table HT-5—Sample schemes for five randomly placed transects in feet.

Sample scheme	Transect number 1	2	3	4	5
	Distance along baseline				
	ft				
1	3	8	14	49	56
2	3	16	20	22	46
3	8	24	34	45	57
4	12	18	22	34	64
5	17	26	30	42	58

Table HT-6—Sample schemes for five randomly placed transects in meters.

Sample scheme	Transect number 1	2	3	4	5
	Distance along baseline				
	m				
1	2	7	9	16	19
2	1	8	12	16	19
3	4	6	9	16	18
4	2	4	9	15	20
5	1	7	10	14	20

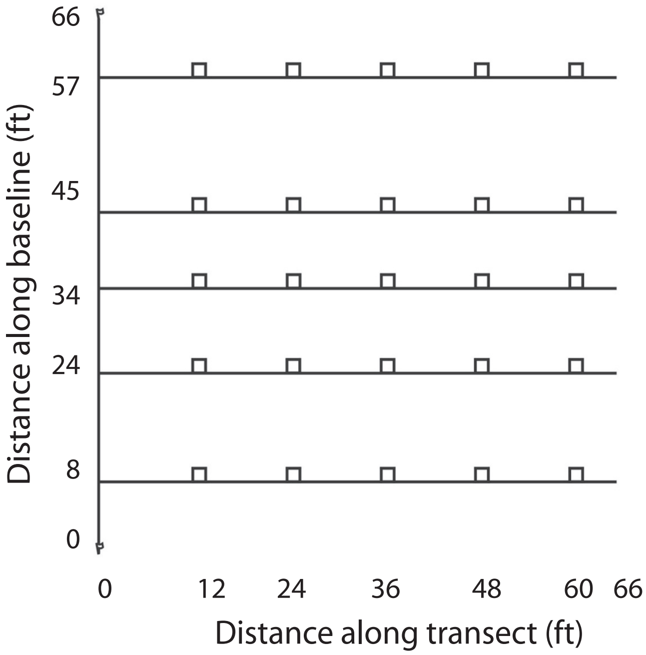


Figure HT-18—Transect and quadrat layout for the recommended FIREMON Cover/Frequency sampling method.

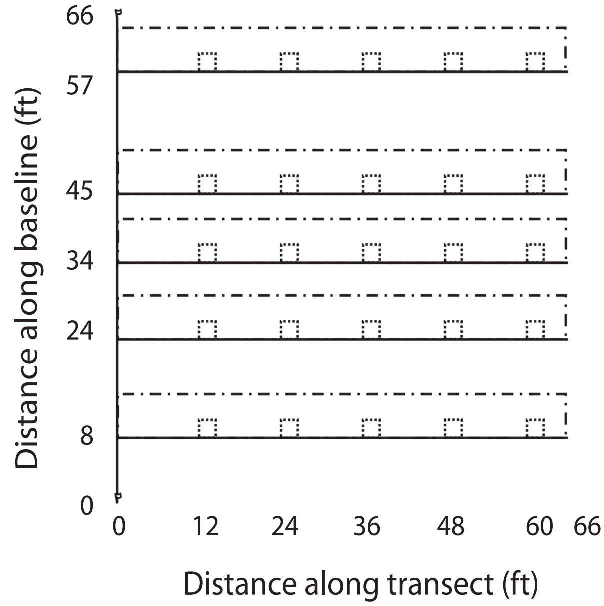
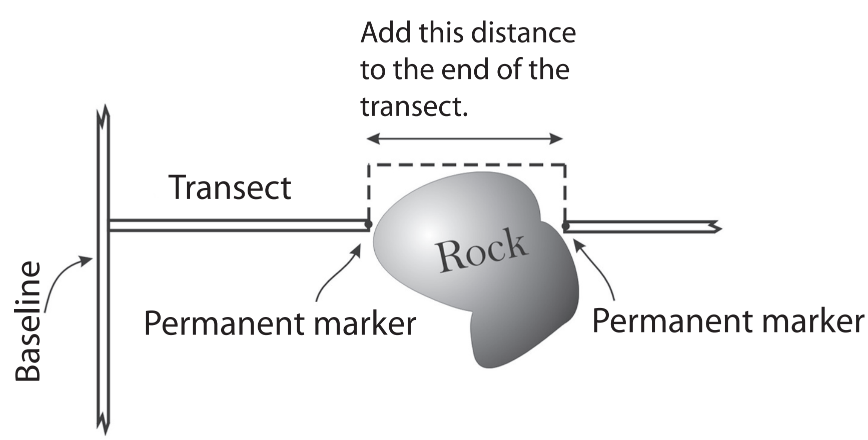


Figure HT-19—Example belt transect (for large shrubs) and quadrat layout for the recommended FIREMON Density sampling method.

HOW TO OFFSET A TRANSECT

If an obstacle, such as a large rock or tree, is encountered along a transect, use the following procedure to lay the transect around it (fig. HT-20). First, run the measuring tape from the baseline to the obstacle and place a permanent marker, such as concrete reinforcing bar (rebar), at this point. Note the distance on the measuring tape. Choose the direction to deviate from the transect, left or right, that gives the shortest offset from the original transect. Next, deviate 90 degrees from the transect until the obstacle is cleared and place a temporary marker at this point. Then run a tape from this point in the same azimuth as the original transect until the obstacle is cleared and place a temporary marker at this point. Next, deviate 90 degrees from this point back to the location of the original transect, and place a permanent marker at this spot. Add the distance between the two temporary markers to the desired

Figure HT-20—If samplers encounter an obstruction, offset the transect line around the obstruction and correct for the lost distance by adding on the appropriate amount of transect to the end of the same transect.



transect length. For example, if you offset 15 ft around a large rock, do not sample on the 15-ft offset; instead, extend the transect out to 81 ft (66 ft +15 ft). Use the Comments field on the Plot Description (PD) form to note the transect modification on the plot.

HOW TO CONSTRUCT A QUADRAT FRAME

Cover/Frequency Frames

Quadrats are used to provide estimates of canopy cover and frequency by plant species. Subplots within a quadrat frame are used to improve estimates of canopy cover and provide multiple quadrat sizes to measure frequency. Frequency estimates based on subplots nested within a quadrat are commonly referred to as Nested Rooted Frequency. Various types of materials (wood, metal, or plastic) are suitable for plot frame construction. Five-eighths inch outside diameter PVC pipe works well. Cement two corners in place but leave the remaining two free so that one side can be removed. This will make it easier to slide the quadrat under plant crowns. Large diameter materials should be avoided because they create greater error in estimates of cover and nested frequency than smaller diameter materials. Construction of the standard 20 x 20 inch (50 x 50 cm) quadrat frame for recording canopy cover and nested rooted frequency is described here. Frames having other dimensions can be constructed in a similar fashion.

The 20 x 20 inch (50 x 50 cm) frame used in Cover/Frequency sampling (fig. HT-21) has painted sections with alternating colors (red and white work well). The alternating colors delineate different sized subplots within the quadrat and are used to help estimate cover. Delineation of these sections is made from the inside of the plot frame. A list of subplot sizes used to estimate cover with the standard 20 x 20 inch (50 x 50 cm) quadrat frame described here is displayed in table HT-7. The four subplots used to record nested rooted frequency are illustrated and described in figure HT-22 and table HT-8.

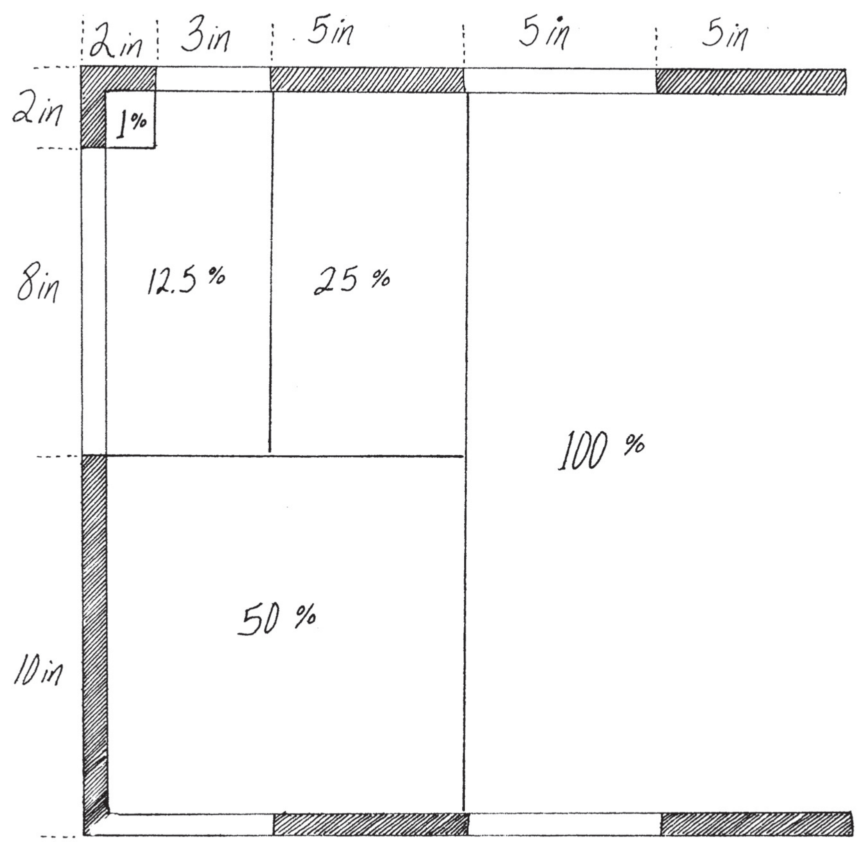


Figure HT-21—Dimensions and color coding conventions for a 20 x 20 inch (50 x 50 cm) quadrat frame. Various subplots are shown with their corresponding percent of the total quadrat.

Table HT-7—Percent of quadrat represented by various subplots within the standard 20 x 20 inch or 50 x 50 cm quadrat.

Size of subplot	Percent of quadrat
inches (cm)	
2 x 2 (5 x 5)	1
5 x 10 (12.5 x 25)	12.5
10 x 10 (25 x 25)	25
10 x 20 (25 x 50)	50
20 x 20 (50 x 50)	100

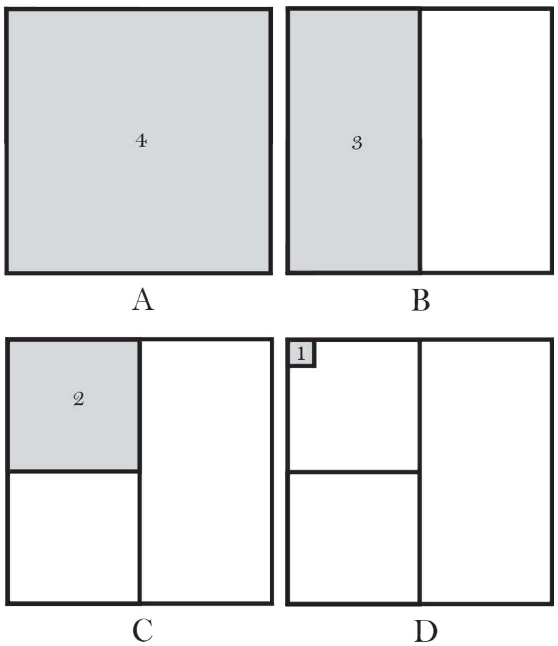


Figure HT-22—The numbers inside the plot frame denote the value recorded if a plant is present in that area of the frame. The number 4 corresponds to the entire quadrat (A). The sampling area for number 3 is the entire top half of the quadrat (B). The sampling areas for the numbers 2 and 1 are the upper left quarter and the upper left corner (1 percent) of the quadrat, respectively (C and D). Each larger subplot contains all smaller subplots. Subplots aid the sampler in estimating canopy cover by mentally grouping canopy cover for all individuals of a plant species into one of the subplots.

Table HT-8—Percent of quadrat represented by the four subplots used to record nested rooted frequency within the standard 20 x 20 inch (50 x 50 cm) quadrat. Each subplot number includes all subplots with smaller numbers. For example, subplot 3 includes subplots 2 and 1 and is 50 percent of the entire quadrat.

Subplot number for rooted frequency	Size of subplot	Percent quadrat
	inches (cm)	
1	2 x 2 (5 x 5)	1
2	10 x 10 (25 x 25)	25
3	10 x 20 (25 x 50)	50
4	20 x 20 (50 x 50)	100

Density Frames and Belt Transects

Quadrats and belt transects are used to provide estimates of density for plant species. Quadrats are commonly used to estimate density for grasses and forbs, while belt transects are commonly used to estimate shrub and small tree density. A belt transect is essentially a quadrat with a long side, bounded along the transect, and a narrow side.

For density quadrats we suggest using three folding rulers 6 ft (2 m) in length. Folding rulers work well for delineating density quadrats because they allow for varying quadrat sizes and are easily carried in the field. Depending on the quadrat size and shape, density quadrats are constructed using one to three rulers. The sampling area can be designated by placing two folding rulers at right angles to the transect tape at a distance equal to the length of the quadrat . The remaining side of the quadrat can be closed with the third folding ruler. If 3 x 3 ft (1 x 1 m) quadrats are used, then one ruler is folded at right angles and a second ruler used to close the open end of the quadrat. If you anticipate constructing density quadrats longer than 6 ft (2 m) in length, a long piece of rope may be used to close the long end of the quadrat (fig. HT-23).

Belt transects can be constructed by placing two measuring tapes along the length of the transect and at a distance apart equal to the width of the belt (fig. HT-24). The width of the belt is measured at both ends with a folding ruler, 6 ft (1 m) in length. Instead of stretching parallel tapes to delineate the belt transect, observers may walk along the transect with a ruler the width of the belt transect. The ruler is oriented perpendicular to the measuring tape with one end adjacent to the tape. Observers can then count individual plants or other items that are within the belt as they walk the length of the transect.

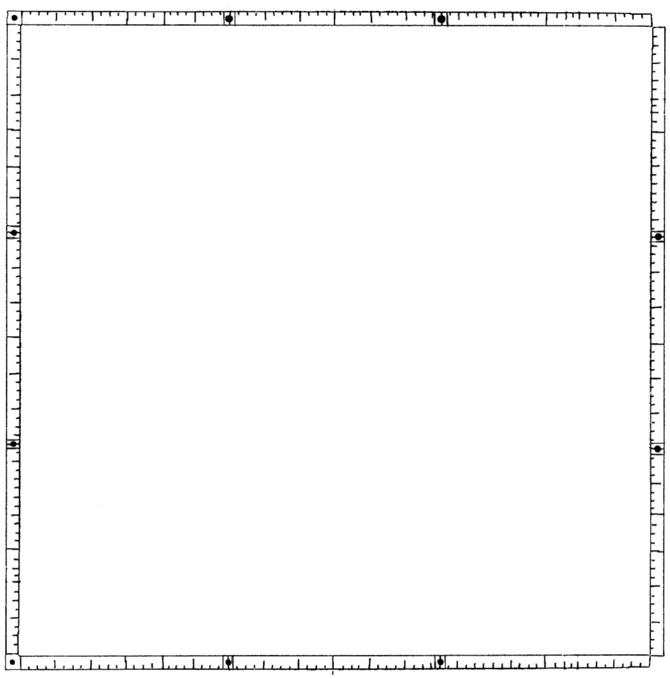


Figure HT-23—Use a folding frame or folding ruler to lay out three sides of the sampling quadrat; slide the ruler under any vegetation and close the quadrat with another yardstick.

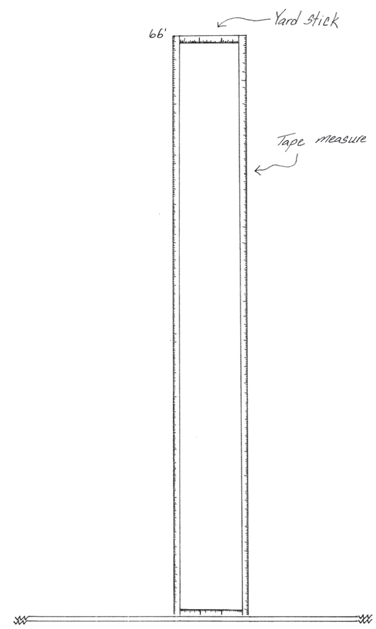


Figure HT-24—Density belt transects can be constructed easily using two measuring tapes and two yardsticks.

HOW TO CONSTRUCT POINT FRAMES AND GRID FRAMES

Point frames are used to provide estimates of plant species cover and ground cover using the Point Intercept (PO) sampling method. Point frames can be constructed out of plastic or metal tubing or wood. The basic concept is to design a free-standing frame with 10 holes so that the pins can be lowered vertically (fig. HT-25). The point frame should stand far enough above the ground to sample vegetation 3 to 4.5 ft (1 to 1.5 m) tall. Pins are commonly placed 3 to 4 inches (7.5 to 10 cm) apart, but spacing is dependent on the size and spacing of the vegetation being sampled.

The PO method may be used in conjunction with the Cover/Frequency (CF) method to sample ground cover by using the CF sampling quadrat as a point frame. A pencil or pen is used to record ground cover "hits" at the four corners and the four midpoints on each side of the quadrat for a total of eight points per quadrat.

Grid frames can be constructed out of metal or plastic tubing or wood. The basic design is to build two square or rectangular frames with wires stretched across the length and width of each frame to form a grid. The grid must have identical spacing for both frames. The frames are placed on top of each other a small distance apart. The entire sighting frame has three to four legs, preferably adjustable type tripod legs (fig. HT-26). The two sets of wire grids allow the observer to always have a vertical line of sight when recording point data. The point frame should stand far enough above the ground to sample the vegetation 3 to 4.5 ft (1 to 1.5 m) tall. Crosshairs are commonly placed 3 to 4 inches (7.5 to 10 cm) apart, but spacing is dependent on the size and spacing of the vegetation being sampled.

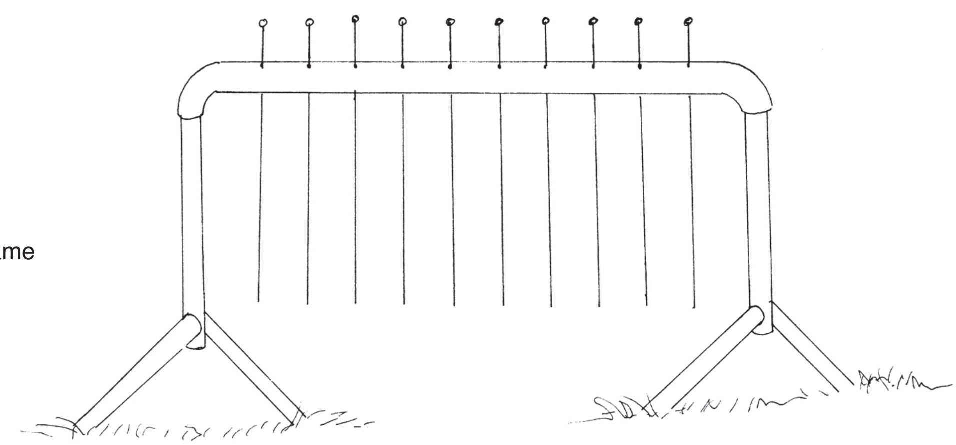


Figure HT-25—Example of a point frame with 10 pins.

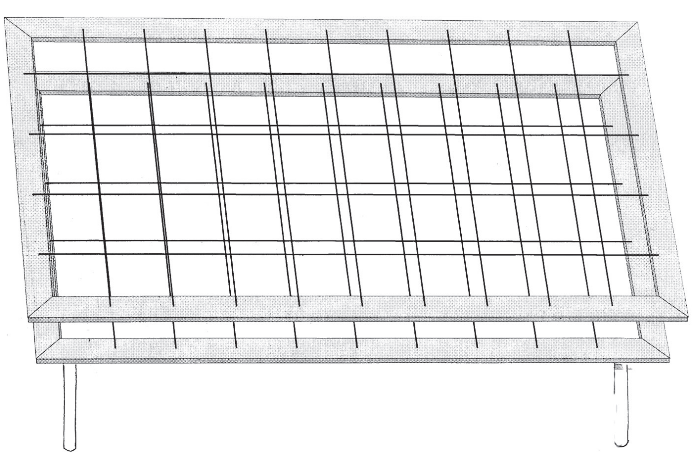


Figure HT-26—Example of a grid frame with 36 points (4 x 9).

HOW TO COUNT BOUNDARY PLANTS

Boundary plants are defined as plants that have a portion of basal vegetation intersecting the sampling boundary. The boundary could be a flagged macroplot such as used in the Tree Density (TD) sampling method but is more likely to be a quadrat like the one used in the Density (DE) method. For different life forms the basal area may be defined differently. For example the basal area of a tree is measured 4.5 ft (1.37 m) above the ground. For shrub species the basal portion is the area beneath the plant where stems grow out of the ground at some predefined density. The basal area of bunchgrasses is where the aerial portions grow out of the ground and is somewhat intuitive (fig. HT-27).

Decisions on which boundary plants to count and which ones to exclude must be consistently applied to each quadrat. For example, it is fairly easy to determine if thin, single-stemmed plants are in or out of the quadrat, but plants with larger basal diameters (such as bunchgrasses) could be partly in and partly out of the quadrat. There are a several ways to count boundary plants, but one easy way to consistently apply boundary decisions is to count all boundary plants "in" on two adjacent sides of a quadrat and "out" on the other two sides. Figure HT-28 is a top view representation of plants around a quadrat. Some of the plants only have their aerial portion overlapping the quadrat so they are not

Figure HT-27—Bunchgrasses (A), shrubs (B), saplings (C) and trees (D) all have their basal area defined differently. Before any sampling, the crew leader should determine how the basal area will be defined for the different life forms.

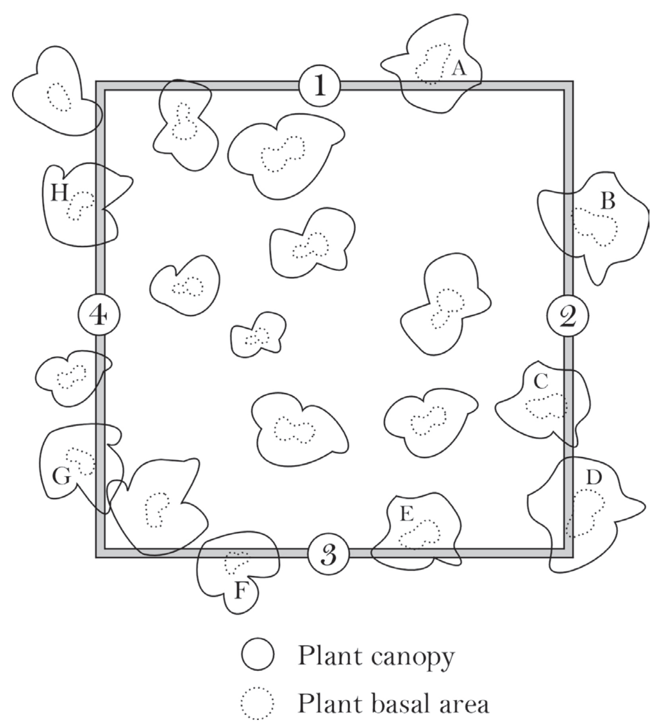


Figure HT-28—Boundary plants are plants with basal portions intercepting the sampling boundary. In this illustration the boundary is a quadrat frame. Using the decision rule to count the boundary plants on sides 1 and 2 as "in" and the plants on sides 3 and 4 as "out" results in plants A through D being included in the survey and plants E through H excluded from the survey.

boundary plants. The plants with their basal portion touching the quadrat are boundary plants. These are the plants that will have the decision rules applied to them. For example, if the rules are that boundary plants on sides 1 and 2 are "in" and the plants on sides 3 and 4 are "out," then four of the boundary plants in figure HT-28 would be "in" (plants A through D) and four would be "out" (plants E through H).

HOW TO DOT TALLY

Instead of counting items in your head or inefficiently tallying items in groups of five using lines, try using a box tally method where you put a dot for each item. Dots and lines are used to record counts as shown in figure HT-29. Each completed box represents 10 items. You will find that this is an efficient and quick method of tallying large numbers of items such as fuel intersects or tree seedlings.

HOW TO MEASURE PLANT HEIGHT

In FIREMON, tree or plant height measurement is accomplished using a clinometer for taller plants, or a yardstick for shorter plants.

Plants Greater Than 20 Feet (6 m)

To measure the height of taller vegetation using a clinometer, first, attach a cloth or logger's tape to the tree or plant at breast height and walk away from the tree, on the slope contour, a distance a little more than the tree is tall. For example, if you think a tree is about 30 ft tall, walk out about 40 ft. Once you are in position, read the angle to the top of the tree from the *percent scale* in the clinometer. Next, take the percent reading from your position to bottom of the tree, where it enters the ground. This angle will usually be negative, which is okay (fig. HT-30).

Calculate height using the equation:

Equation HT-1

$$HT = \theta_1 \left(D/100 \right) - \theta_2 \left(D/100 \right)$$

where,HT is the tree height in the same units as D.

θ_1 is the angle from the sampling position to the top of the tree, measured in percent slope.

θ_2 is the angle from the sampling position to the bottom of the tree, measured in percent slope.

D is the horizontal distance from the tree in feet or meters.

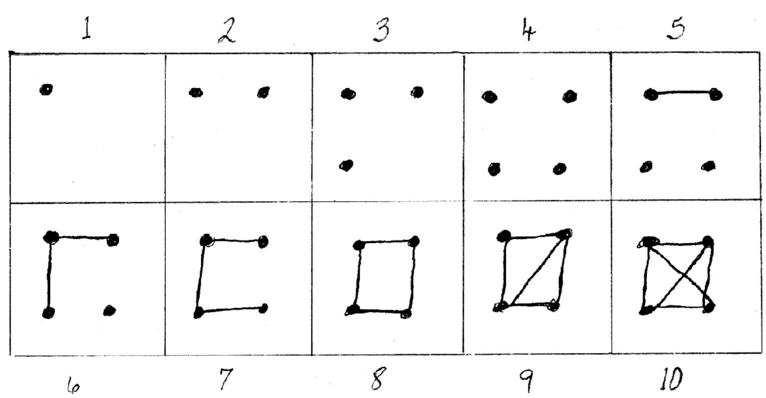


Figure HT-29—Use the dot tally system to record counts quickly and accurately.

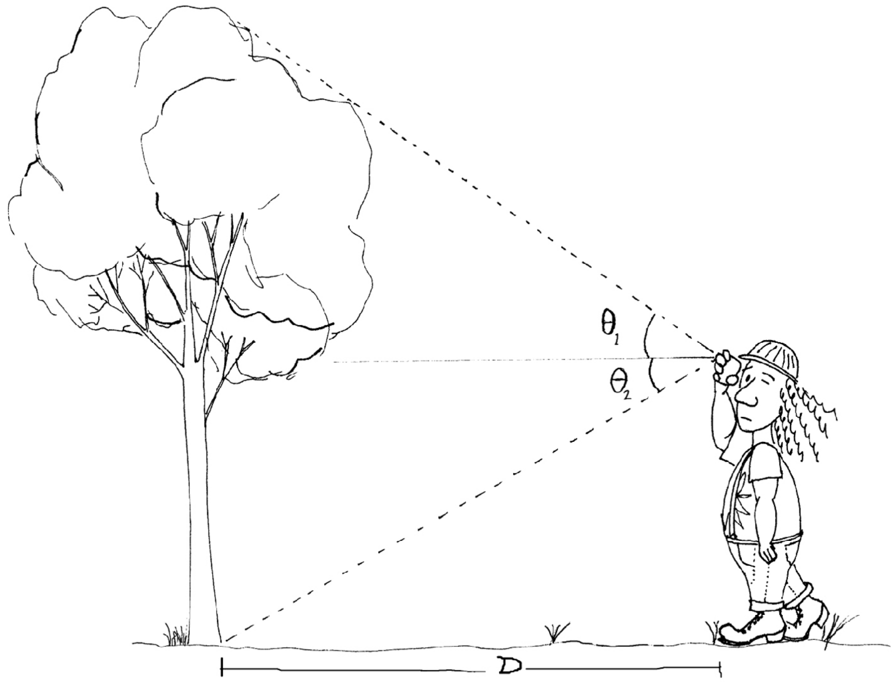


Figure HT-30—Measure the height of tall trees by moving away from the tree a known distance (slope corrected) and measure the percent slope to the top and the bottom of the tree. Use equation HT-1 to calculate height. Units of tree height will be the same as the units of the distance (D) measurement.

Note that when the θ_2 is negative you actually add the two angles. If either θ_1 or θ_2 are greater than 100 percent, go out another 20 ft and recheck the angles. Measuring high angles can cause a lot of error. It may be helpful to make a table of tree height as a function of tree angles (total angle from top to bottom of the tree) and distances, to reduce the time spent making height calculations in the field.

Sometimes it is difficult to see the top of the tree because of obstructions or other tree tops. In these cases, have someone shake the tree at DBH which will cause the top to move and perhaps make it more visible. The sampler also might have to move uphill or downhill one or two paces, making sure the distance from the tree is kept constant, to get a better view of the tree top. If you need to move up or downslope, correct for slope using the correction factors in **How to Adjust for Slope.**

Often, the notetaker on the FIREMON plot will be too busy with other duties to hear or record the tree height measurement. Therefore, we recommend that the sampler measuring tree heights take a field notebook into the field and write down the measured heights along with the tree and plot numbers to make sampling go faster.

Depending on the project objective(s), tree height is recorded to the top of the stem or to the highest live foliage; sometimes dead tops are not considered part of the height of the tree. This subject is discussed in detail in the **Tree Data (TD) Sampling Method** chapter. The highest foliage might not be directly above the tree bole, as in hardwoods, so the sampler must be sure to check all lateral branches to make sure the highest foliage is being measured.

If the tree is leaning at an angle measure tree height using the procedure described above even though the tree would measure taller if it were standing up straight.

Plants Between 10 and 20 Feet (3 to 6 m) Tall

Depending on the precision requirements of the monitoring project, these plants can either be measured using a clinometer, for more precise estimates, or they may be estimated. The clinometer method is described in the section immediately preceding this one. Faster, less precise measurements can be made by looking at a tree and moving your eyes up in increments. Many people are about 6 ft tall so it is easy to think in that scale. Starting at the ground level simply move your eyes up 6 ft at a time, keeping a mental tally. At first, you should check your estimate using a clinometer, but with a little practice you will be able to estimate heights of these plants to between 1 and 2 ft, consistently.

Plants Less Than 10 Feet (3 m) Tall

Measure these plant heights with a yardstick (meterstick) for the highest precision. You can also measure the height of the top of your boots, knees, hips, head, and raised hand, then use those measurements to estimate the plant heights.

Other Height Measuring Tips

Often you will be able to estimate the height of tall trees based on the measured height of another tree that is close by. This can substantially reduce the sampling time because you only need to make four or five height measurements per plot. If the project objectives require high precision, then the height of each tree taller than 20 ft should be measured with a clinometer.

Sometimes the sampling methods call for an average plant height across species or life form. When the plants vary greatly in height, this can be tricky because it is hard to estimate an average. One way is to imagine a piece of plastic draped over the plants you are interested in then estimate what the average height of the plastic sheet would be.

When measuring the height of herbaceous plants, measure only to the point that includes approximately 80 percent of the plant biomass. For example, inflorescence height in graminoids is not typically measured.

HOW TO MEASURE DBH

The diameter of a tree or shrub is conventionally measured at exactly 4.5 ft (1.37 m) above the ground surface, measured on the uphill side of the tree if it is on a slope. Wrap a diameter tape around the bole or stem of the plant, without twists or bends, and without dead or live branches caught between the tape and the stem.

When making the diameter measurement, the diameter tape should always be positioned so that it is perpendicular to the tree stem at the point of measurement. If the tree splits above breast height, record as one tree with the diameter measurement made at a representative area below the swell caused by the separation. If the tree splits below breast height then record two trees with diameter measured as close as possible to breast height while still getting a representative measure. If there is a stem deformity at breast height, measure the diameter at the closest location above or below that will allow the most representative diameter measurement (fig. HT-31).

There may be times when it is necessary to remove problem branches to thread the DBH tape around the tree bole. If so, carefully remove just enough of the unwanted branches so you do not threaten the survival of the tree. Sometimes it is impossible to measure diameter at breast height with a tape because of protruding branches and other trees. In these rare cases, use a plastic ruler to obtain a diameter (see **How To Measure Diameter with a Ruler**).

Some tree species (juniper, for instance) have multiple stems at breast height. If the project objectives for your project indicate, you should measure the stem diameter of these individuals at ground level. This is called the diameter at root crown or DRC. Use the DRC measurement to classify the tree as a mature tree or sapling and mark the Local Code field so you know that DRC was measured. Some studies may indicate it is also important to count the number of stems at breast height. The down side to DRC measurements is that they may not give an accurate representation of mortality (counting the number of stems at breast height can overcome this), and basal diameters may not adequately portray canopy fuels for fire modeling.

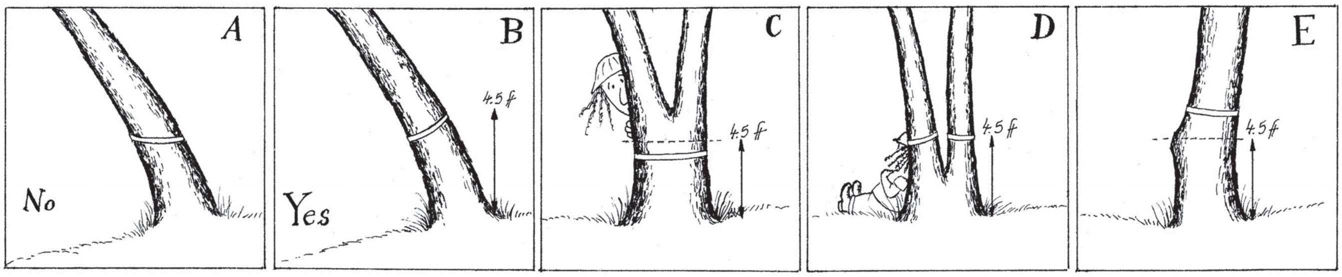


Figure HT-31—DBH measurements. A) Diameter tape is not perpendicular to the tree stem. B) Correct way to measure tree diameter is with tape perpendicular to tree stem. C) If the tree splits above breast height measure tree diameter below any swell cause by the separation. D) If the tree splits below breast height measure as two trees. E) Measure the most representative diameter above or below any deformity.

HOW TO MEASURE DIAMETER WITH A RULER

Using a ruler to measure tree or log diameter can be easier and quicker than with a diameter tape. However, ruler measurements can give biased estimates of diameter if done incorrectly. To measure diameter correctly first, hold one end of the ruler so that it is aligned with the one edge of the tree (at breast height) or log, then, while keeping the ruler in the same position, move your head to the other end of the ruler so that you are looking at the other side of the tree or log at a perpendicular angle to the ruler (fig. HT-32). Estimate the diameter to the appropriate precision. With practice you will only need to use the ruler to measure trees that are on the boundary between two classes.

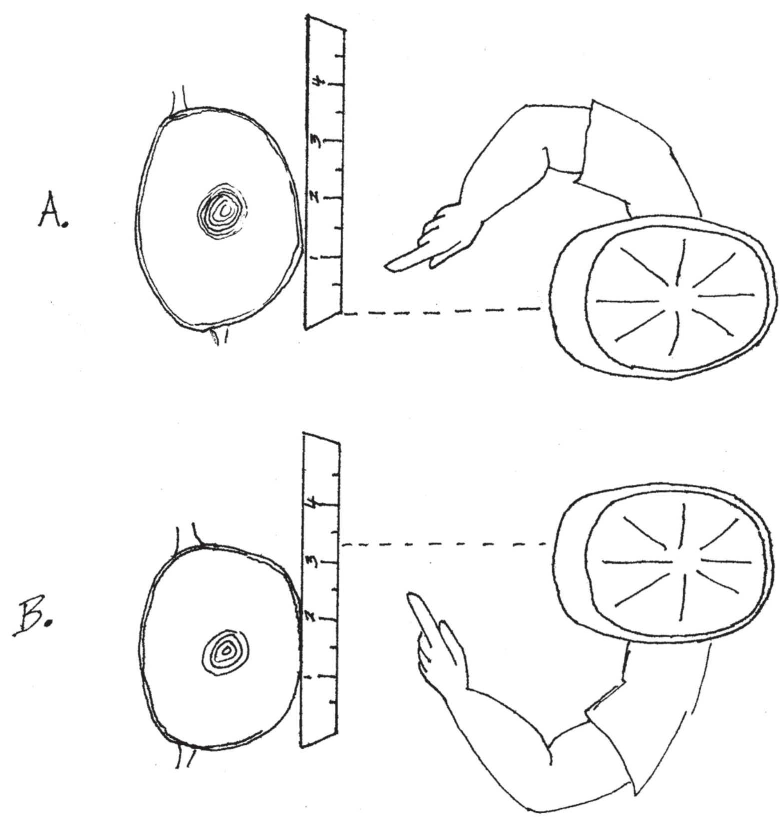


Figure HT-32—To accurately measure tree diameter using a ruler, A) align the left side of the ruler with the left side of the tree, then B) without moving the ruler, move your head so that it is aligned with the right side of the tree. The same method can be used for logs.

HOW TO AGE A TREE

Tree age is estimated by extracting a core from the tree at stump height (about 1 ft above ground line) on the downhill side of the tree using an increment borer. Stump height is used instead of the conventional height at DBH because it is difficult to estimate the time it takes the tree to grow to DBH, especially in severe environments such as the upper subalpine and woodland ecosystems. In fact, the lower down on the tree, the better the estimate of total age. The increment borer is positioned on the downhill side of the tree at an angle that will ensure that the pith of the tree will be struck as the increment core is drilled into the tree. The pith is required to absolutely estimate the age of the tree at stump height. Tree coring requires a certain degree of experience to consistently obtain the pith. To extract a core, screw the increment corer into the tree just deep enough to hit the pith, and then insert the spoon of the corer on the top part of the core (spoon is facing downward). Next, unscrew the borer one-half turn so that the spoon is facing upward. Tug gently on the spoon, and if the planets are in alignment, the core will be extracted in one piece. Be especially careful to collect all of the pieces of broken cores so that the rings can be accurately counted.

Age is not simply the count of the tree rings from cambium to pith. You will have to add an estimate of the number of years it took the tree to grow to stump height to get total tree age. Sometimes this can be done by counting branch whorls on the bole from the ground to stump height, but often branch whorls are difficult to identify and count. Usually you will have make a best-guess estimate on the years it took the tree to grow to the height where the core was taken. Sometimes, the pith is rotten or difficult to extract, so the sampler must also estimate the number of rings it would take to get to the pith. In that case, three counts must be added to obtain true tree age: (total ring count) + (years to stump height) + (years to pith) = Tree Age.

Once the core is extracted, the sampler can either count the age of the core while it is still in the spoon, or store the core for ring counting later in a laboratory or office. If trees are young (<100 years old) and growth rates are not important, then the sampler can probably count the tree rings in the field and record the age estimate in the appropriate field on the forms. A small magnifying glass is often helpful for counting rings. Rings on some cores can be difficult to read because they are tightly packed or difficult to distinguish. It is advisable to take these cores back to the office where the rings can be counted with the proper equipment. Cores that are to be taken back to the office can be stored in drinking straws to reduce breakage, but the straws should be slit so the core can dry and not get moldy. Or cores can be mounted on planks. Wood planks or sections of plywood can be grooved with a router using a diameter that corresponds to the increment corer. Then, in the field, the core can be glued into the groove with wood glue (fig. HT-33). The advantage of using the wood mount is that once the glue has dried, the cores

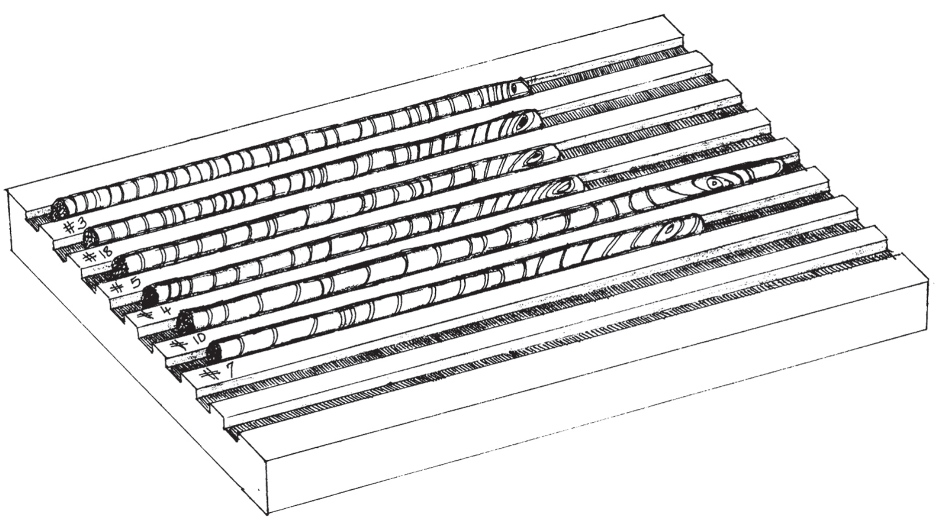


Figure HT-33—A core board is used to permanently store tree cores.

can be sanded. This will heighten the contrast between rings and make the age and growth rate determination easier and more accurate. The disadvantage is that the glue and wood mounts are difficult to transport in the field. It's best to record plot ID, tree tag number, date, years to stump height, and years to pith directly on the mount or straw.

HOW TO MEASURE SLOPE

Slope measurements are made so that a correction factor can be applied to slope distance to get the horizontal distance. To find the percent slope, aim the clinometer at the eye level of sampler at the other end of the line (fig. HT-34). Be sure to read the slope off the percent scale in the clinometer. For slope correction use the absolute value of percent slope. If there is a height difference of the samplers, adjust the height where you are aiming so that the slope reading is accurate.

HOW TO ADJUST FOR SLOPE

Some distance measurements in FIREMON must be corrected to horizontal distance. Examples are macroplot radius and the distance you measure out from a tree when measuring tree height. Table HT-9 shows the correction factor for slope by 10-percent class. Note that the correction factor on slopes less

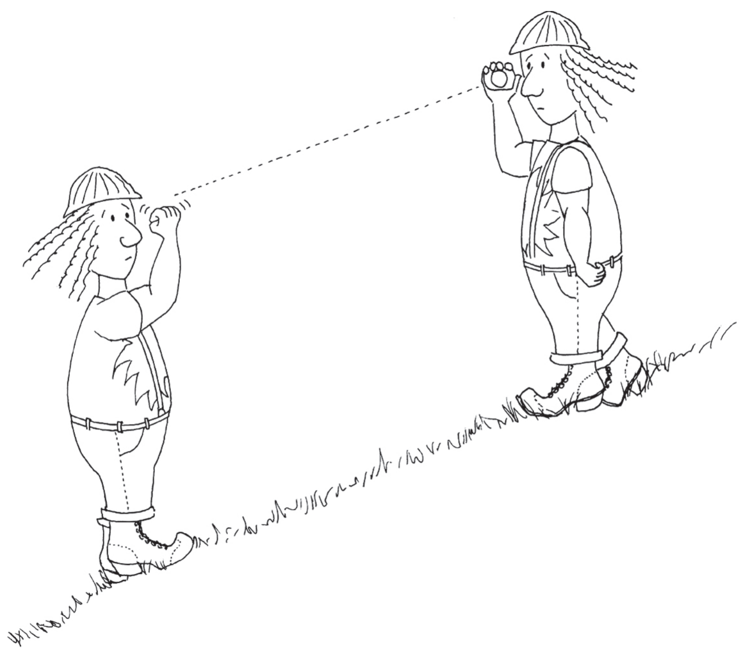


Figure HT-34—Measure the slope of each line by aiming the clinometer at eye level on the sampler at the opposite end of the measuring tape, then reading and recording the percent slope seen on the scale in the instrument.

Table HT-9—Correct for slope by multiplying the horizontal distance you need to travel by the appropriate correction factor listed.

Slope Percent	Slope Degrees	Correction factor	Slope Percent	Slope Degrees	Correction factor
10	5.71	1.00	100	45.00	1.41
20	11.31	1.02	110	47.73	1.49
30	16.70	1.04	120	50.19	1.56
40	21.80	1.08	130	52.43	1.64
50	26.57	1.12	140	54.46	1.72
60	30.96	1.17	150	56.31	1.80
70	34.99	1.22	160	57.99	1.89
80	38.66	1.28	170	59.53	1.97
90	41.99	1.35	180	60.95	2.06

than 30 percent is negligible. To find corrected distance, multiply the horizontal distance you need by the appropriate correction factor. For example, when marking the boundary of a macroplot with a radius of 37.2 ft on a site with 50-percent slope, you would have to measure the upslope and downslope radius out to a distance of 37.2 x 1.12 = 41.67 ft.

HOW TO DOCUMENT PLOT LOCATION AND FIRE EFFECTS WITH PHOTOS

Photographs, conventional or digital, are a useful means to document the FIREMON plot. They provide a unique opportunity to visually assess fire effects and document plot location. Previously established FIREMON plots can be found by orienting the landmarks in photos to visual cues in the field. Photos can be compared to determine important changes after a fire. Photos provide excellent communication tools for describing fire effects to the public and forest professionals.

Document the FIREMON macroplot location using two photographs taken facing north and east. For the north-facing photo move about 10 ft south of the FIREMON macroplot center then take the photo facing north, being sure that the plot center stake or rebar will be visible in the picture (fig. HT-35). Then move west of the plot center about 10 ft and take a photo facing east, again being sure that the plot center stake or rebar will be visible in the picture. For these pictures be sure that the camera is focused on the environment surrounding the plot, not the distance or foreground, and that the camera is set for the correct exposure and aperture for existing light conditions. A flash might be needed in low-light conditions.

Photos taken with conventional film can be identified by assigning a code that integrates the roll number and/or name and the picture number. For example, picture 8 taken on roll John Smith Roll 1 might be called JSR01P08. Use a consistent system so the plot photos do not get mixed up.

You must label the roll so that you will be able to find the correct photos after the film has been developed. One way is to take a picture of a card with the roll information on it, as your first photo. Or, you can write the roll information on the film canister before you load it into the camera. The first method is the most foolproof. For digital cameras, write the plot identification on a whiteboard and place the board in the plot scene or enter the file name of the digital picture on the PD form. Film photos will need to be scanned once they are developed and stored on your computer in digital format.

Figure HT-35—Take your plot photos so that they show the plot center and the general plot conditions.

HOW TO RECORD A GPS LOCATION

Basically, there are a number of options today for GPS receivers and ways to acquire locational data. Here are recommend protocols on only a few issues.

Acceptable Accuracy

The two-dimensional accuracy of X, Y coordinates reported by the GPS should be less that 10 meters, preferably less than 7 meters. There is no procedural requirement on elevation, or the Z coordinate.

Geodetic Datum

The more accurate and more recent NAD83 should be selected, unless there is strong need to use the data predominantly within a local GIS, *and* the local standard is for some other datum. For example, many National Park Service sites still use NAD27 in order to reference data taken from their older base maps. These were some of the first areas mapped with USGS 1:24,000 quadrangles. In any event, it is important to note the datum used for plot location so conversions can be made if necessary.

When Digitizing a Single Point

Y-Code receivers such as Rockwell's PLGR should be set to an averaging mode and allowed to log a number of points until the coordinates stabilize, at which time the plot center is either jotted down or saved in memory. These receivers are only available to approved Federal government employees.

P-Code receivers such as Trimble's Pathfinder or GeoExplorer should be treated similarly *only* if "selective availability" is off. If "selective availability" is on, a differential correction should be used. Set the receiver to log and save a hundred or so points for each plot center. There then are options to do differential correction "on the fly," or later by receiving suitable reference control data from a surveyed base station. You will have to check with GPS-knowledgeable people in your area to find how to access local base station data.