Habitat Measurement Techniques

Paul R Ashley – Regional HEP Team Coordinator

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This document includes the basic techniques and protocols used by the Regional HEP Team to collect habitat variable data for HEP surveys and CHAP verification transects. This publication was developed as a stand-alone, user friendly, hands-on habitat variable measurement technique manual for both novice and experienced field technicians alike. As such, theory and mathematical/statistical discussions are held to a minimum. Funding and/or administrative support was provided by the Bonneville Power Administration and Columbia Basin Fish and Wildlife Authority.

Columbia Basin Fish and Wildlife Authority
851 SW 6th Ave., Ste. 300
Portland, Oregon
97204

Name:____

ORG.:____

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Habitat Measurement Techniques and Protocols

(February 2010)

Introduction

This document was developed to provide consistency with how habitat variable data is collected throughout the Columbia Basin Region in support of the Columbia River Wildlife Mitigation Program funded by Bonneville Power Administration (BPA). This publication is a “stand alone” reference for Habitat Evaluation Procedures (HEP) and Combined Habitat Assessment Protocols (CHAP) transect techniques used by the Regional HEP Team (RHT).

This document is intended to be a “user friendly” habitat variable measurement technique manual for both novice and experienced field technicians alike. As a result, theory and mathematical/statistical discussions are held to a minimum. It is assumed that field technicians will possess the specific measuring devices discussed in this manual. Thus, device descriptions are limited in most cases.

English measurements e. g., inches, feet, etc., are used to accommodate measurements found in many HEP models and because English measurements are better understood by the general public. English measurements can easily be converted to metric equivalents if needed.

General and specific protocols are described in the following sections. General protocols include a brief description of pre HEP survey pilot studies; transect establishment guidelines, and photo documentation parameters. In contrast, specific metrics detail actual habitat variable measurement techniques including diagrams where additional explanation is needed. In cases where more than one measurement technique option is possible, options are assigned an alpha-numeric code. This allows project managers and field technicians to identify specific measurement techniques in report tables and data spreadsheets without lengthy, redundant explanations.

This field techniques manual is intended to be a “living” document and will be modified as needed. The following standardized protocols and measurement techniques are used by the Regional HEP team to measure habitat variables described in HEP models and used in conjunction with CHAP verification transects.

General Protocols

Pilot Studies

Pilot studies are conducted in new habitat types and/or familiar habitat types that are comprised of unique structural conditions/key ecological correlates. Pilot study data is used to estimate the sample size needed for a confidence level ≥ 80% with a ≤20% tolerable error level (Avery 1994) and to determine the most appropriate sampling unit[1] for the habitat variable of interest i.e., a coefficient of variation analysis (BLM 1998). In addition, a power analysis is conducted on pilot study data (and periodically throughout data collection) to ensure that sample sizes are sufficient to identify a minimal detectable change of 20% in the variable of interest with a Type I error rate ≤0.10 and P = 0.9 (BLM 1998, Block et al. 2001). Funding and/or temporal constraints may limit the ability to meet power analysis goals. All field data is recorded on data loggers or field data forms.

Transects

Transects are established based on a stratified random strategy. Project areas are stratified by cover type(s) while random transect start points are selected either by superimposing a grid over cover type maps and then identifying specific X/Y coordinates with the aid of a random numbers table, or through use of a computer generated random number generator point locater program. Occasionally, random transect locations are moved to accommodate cover types missed in the random assignment.

The initial number of transect start points established for each cover type is based on the proportional allocation strategy suggested by Husch et al., (2003). Transects are established at least 300 feet from ecotones, roads, and other anthropogenic influences wherever possible. Transect start, turn, and end point locations are documented with global positioning system (GPS) units and Universal Transverse Mercator (UTM) coordinates using North American Datum 27 (NAD 27) unless another datum is requested.

A random azimuth is selected from a random numbers table to establish the initial transect azimuth (direction). Compass azimuths are magnetic bearings i.e., not corrected for local declination. If cover types change or transect length is greater than 300 feet, another random transect azimuth is selected, or the original azimuth is varied by 45 degrees (the direction, left or right, is determined by the flip of a coin when the 45 degree option is chosen).

Transect start, turn, and end point locations are marked with 14-inch long/ 0.25 inch diameter rebar stakes[2] painted fluorescent orange or red and/or topped with a plastic safety cap. Occasionally, surveyors "ribbon" is used in place of or in addition to rebar stakes.

Unless noted otherwise, transects are divided into 100 foot (~30 m) sample units for statistical purposes. Specific transect information including transect identification, cover type, HEP Team members, global positioning system (GPS) coordinates, and other pertinent information is documented on transect summary forms (Appendix A).

Photo Points

Photo points are established at the start point of each transect. Pictures are recorded from a height of three feet at the beginning of each transect while facing in the direction of the transect azimuth. A

[1] Includes micro-plot quadrat size and shape etc.
[2] Marking transect points with rebar stakes is at the discretion of the project proponent. Therefore, not all transects are marked in this manner.

transect reference board (includes transect number, project name, date, GPS reference number) is placed at the 15 foot interval while a cover board is placed at the 30 foot mark on each transect.

Occasionally, panoramic photographs are also needed e.g., dense vegetation, linear/narrow cover types. Habitat conditions are photographed with a digital camera (with and without magnification). A photo point example is shown in Figure 1.

Figure 1 Photo point example

Specific Metrics

Metrics generally follow those described by Hays et al. (1981) and/or Avery (1994) unless otherwise noted. Some metrics have been modified due to extreme field conditions and/or to better meet Regional HEP Team needs.

Data Logger Input Procedures

Apply the following standard operating procedures (SOPs) when recording data on data logger spreadsheets:

1. Open appropriate data logger template
2. Immediately save template using:
    a. Project name
    b. Transect number

c. Specific measurement(s) including interval
d. Your initials

For example, if "John/Jane Doe" was assigned to measure shrub cover using point intercept at two foot intervals on transect 03 on the Satus project, the file name would be saved as: SS03_shrub2_jd. Crew supervisors will provide project name details.

3. Open specific data logger spreadsheet "page" e.g., "shrub point intercept 2" and enter data in the appropriate columns and rows as follows:
    a. Project alpha numeric designator (for example: SS03)
    b. Transect date
    c. Enter shrub/tree species designators (species name or code) as needed
    d. Enter specific transect data in appropriate columns/rows
    e. Enter either specific data or zero (0) in appropriate column/row for entire length of transect (entering zeros lets data compilers know that the "point" was surveyed and not skipped; likewise, if your intent was to use line intercept to determine shrub cover and no shrubs were detected-record "0" in the appropriate column/row on the data logger line intercept form and write "no shrubs" on the paper transect summary form).
    f. **"Save" data** several times during transect
    g. **If experiencing trouble with data logger, contact RHT supervisor**
    h. **If you save over the data logger template, contact RHT supervisor**

Herbaceous Measurements

Percent Cover

1. Herbaceous percent cover measurements are recorded at 20 or 25-foot intervals on the right side of the transect tape (the right side is determined by standing at 0 feet and facing the line of travel/transect azimuth). RHT members walk on the left side of the transect line to reduce sample disturbance.

A square $0.1m^2$ micro-plot quadrat is used in grasslands to estimate percent cover of herbaceous vegetation while a rectangular $0.5m^2$ quadrat is generally used in shrublands (the $0.5m^2$ quadrat may also be used in grasslands if desired). The near right hand corner of the grid is placed at the sampling interval (rectangle grids are placed with the long axis perpendicular to the tape, and the lower right corner on the sampling interval).

An example of micro-plot quadrat placement is shown in Figure 2. Approximately 20% of the micro plot is covered by vegetation in the example. Quadrat samples are considered independent samples for statistical purposes.

1A: $0.1m^2$ micro-plot quadrat/20' interval

1B: $0.1m^2$ micro-plot quadrat/25' interval

1C: $0.5m^2$ micro-plot quadrat/20' interval

1D: $0.5m^2$ micro-plot quadrat/25' interval

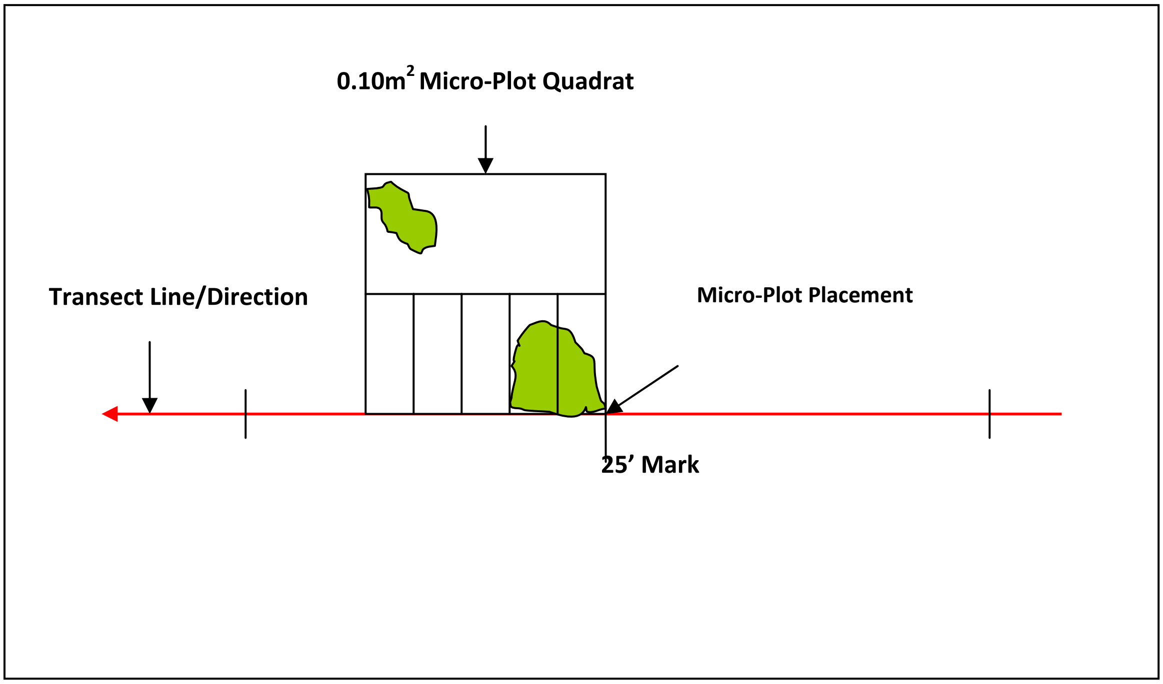

Figure 2 Micro-plot quadrat placement and aerial cover example

Herbaceous Vegetation Height

2. Herbaceous height is measured with a graduated rod or similar device in 10ths of feet (0.10 ft.). Only leaf material is measured (leaves provide the greatest amount of cover). "Leaf material" may include residual cover and/or new growth predicated on HEP model variable requirements. Grass/herbs inflorescences are not included in height measurements. Although there are a number of procedures to estimate the height of herbaceous vegetation, the following technique (2A) is the primary method utilized by the Regional HEP Team.

2A. The height of herbaceous vegetation is measured within the micro-plot quadrat by recording the height of the vegetation occupying the most space within the quadrat (i.e., providing the most cover). Since "plant B" occupies the most space in the micro-plot quadrat displayed in Figure 3, plant "B" herbaceous height is measured and recorded.

Record the height on the data logger or paper data form in 10ths of feet using whole numbers (round up or down as necessary). For measurements less than 1 foot in height, record the actual number (1 through 10); for measurements greater than 1 foot in height, record the 10ths of feet e.g., 1.5 feet is recorded as numeral 15. Record the default height measurement "1" for vegetation less than 1/10th of a foot in height.

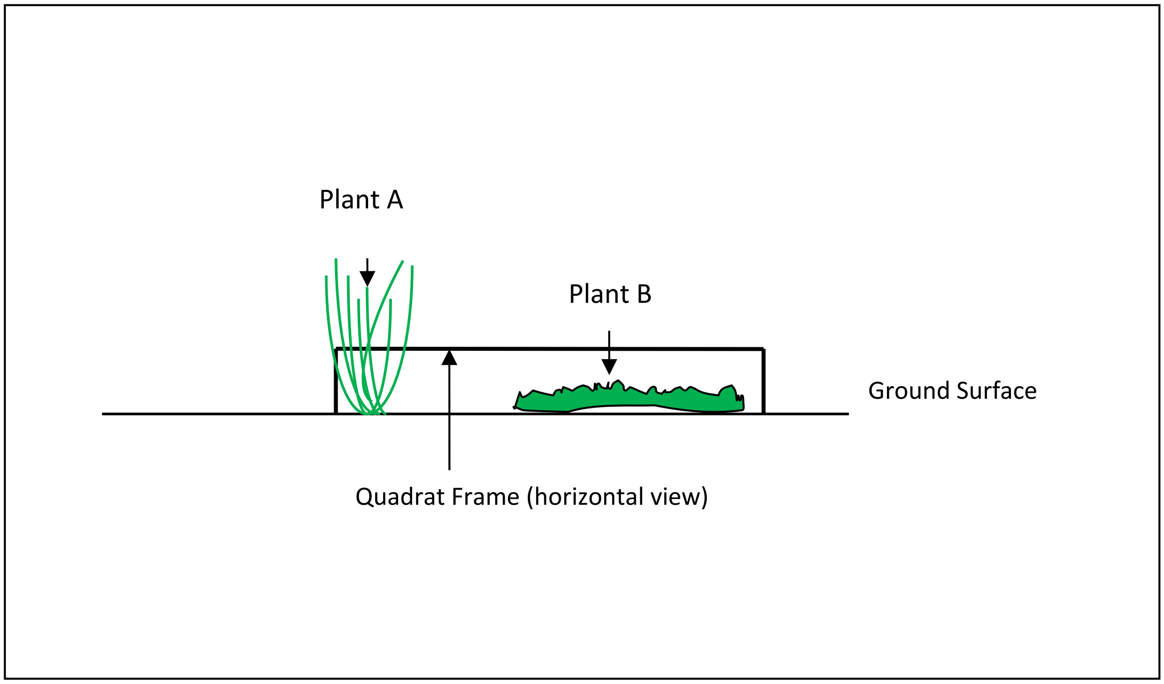

Figure 3 Herbaceous vegetation height measurement example

If herbaceous vegetation within the quadrat is damaged or altered as a result of laying out the transect or placing the quadrat on the ground, measure herbaceous vegetation height in a simulated quadrat sized space immediately adjacent to the quadrat in the direction of the transect azimuth (Figure 4).

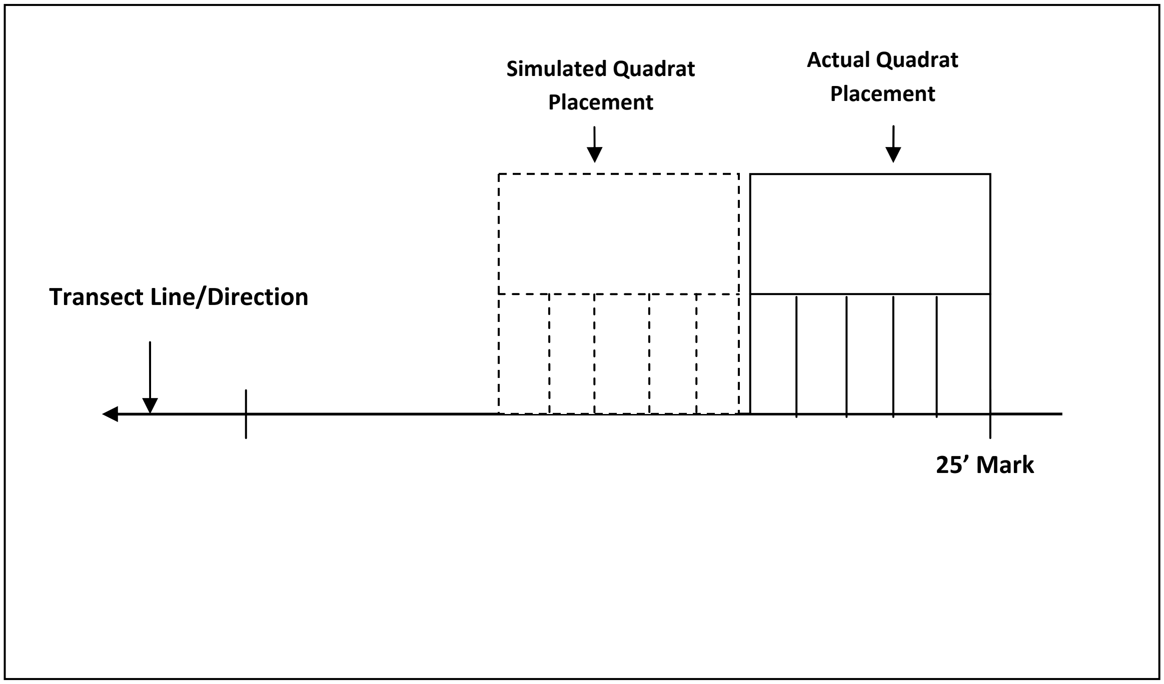

Figure 4 Placement of simulated quadrat (broken lines)

2B. Another method to measure the height of herbaceous vegetation involves measuring plant height at specific intervals along the transect line. Like the previous method (2A), herbaceous vegetation is measured in 10^{ths} of feet rounding as necessary to the nearest whole number.

Herbaceous vegetation height is measured with a measuring rod held in a vertical position immediately adjacent to the transect line at the designated interval. The height of the tallest herbaceous plant contacting the measuring rod is recorded (exclude inflorescences).

This method is effective in grasslands exceeding 90% cover; however, because vegetation must intersect the measuring rod to be counted, landing on bare areas can be problematic when attempting to maintain a constant interval and/or specific sample size. Apply closer intervals as heterogeneity increases. The following intervals are recommended:

2B-1: 3 feet (heterogeneous pastures/grasslands ≥ 90% cover)

2B-2: 5 feet (pastures/grasslands ≥ 95% cover)

2B-3: 10 feet (homogeneous pastures/grasslands-100% herbaceous cover)

Visual Obstruction Readings (VOR)

3. A Robel pole (Robel 1975) is used to document vertical and/or horizontal cover for herbaceous vegetation i.e., visual obstruction readings (VOR). Measurements are recorded at 20, 25, or 50-foot intervals. Intervals are determined by the length of each transect, i.e., a minimum of 12 measurements are required for each transect, or cover type heterogeneity (structurally diverse cover types generally require larger sample sizes).

The Robel pole (Robel 1975) is held in a vertical position on the transect line at the appropriate interval. Four observations are taken from a distance of four meters from the Robel pole and averaged to obtain a single visual obstruction reading or VOR. Observers sight over a one meter pole and record how much of the Robel pole is totally obscured from the ground up (Figure 5). Measurements are reported in 0.25 decimeter increments (this is the only measurement that is recorded in metric units).

Two measurements are taken on the transect line on opposite sides of the Robel pole; two identical measurements are taken from the same point perpendicular to the transect line for a total of four "readings" (Figure 6).

Sample size is determined to be adequate when the "running mean" varies ≤ 10% of the mean. VOR samples are considered independent for statistical purposes.

3A: 20' interval

3B: 25' interval

3C: 50' interval

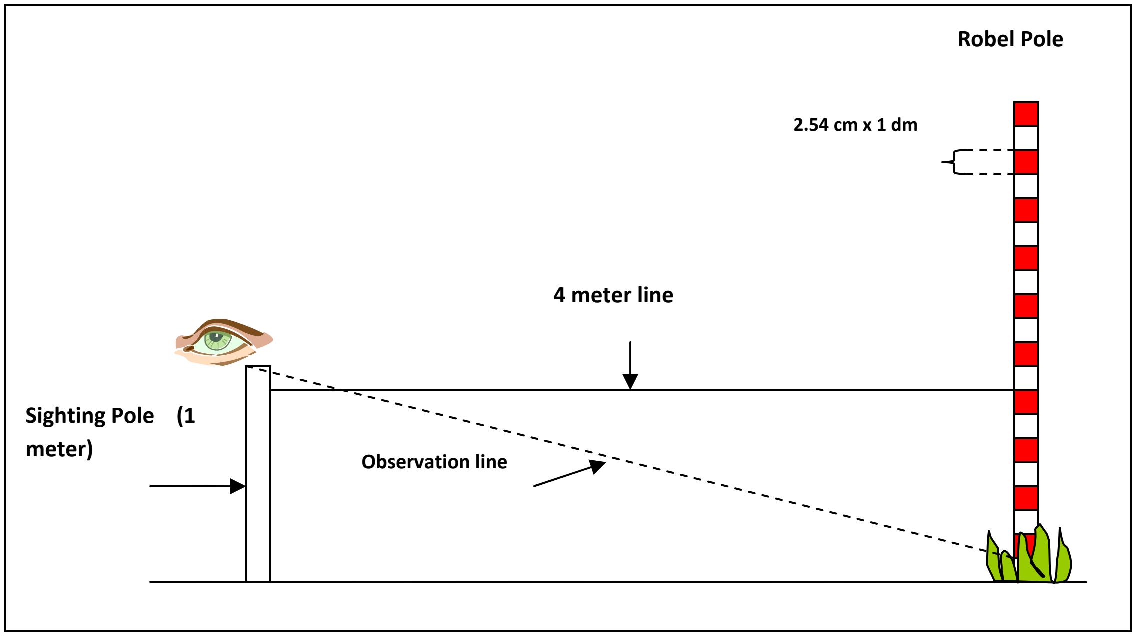

Figure 5 "VOR" sighting diagram

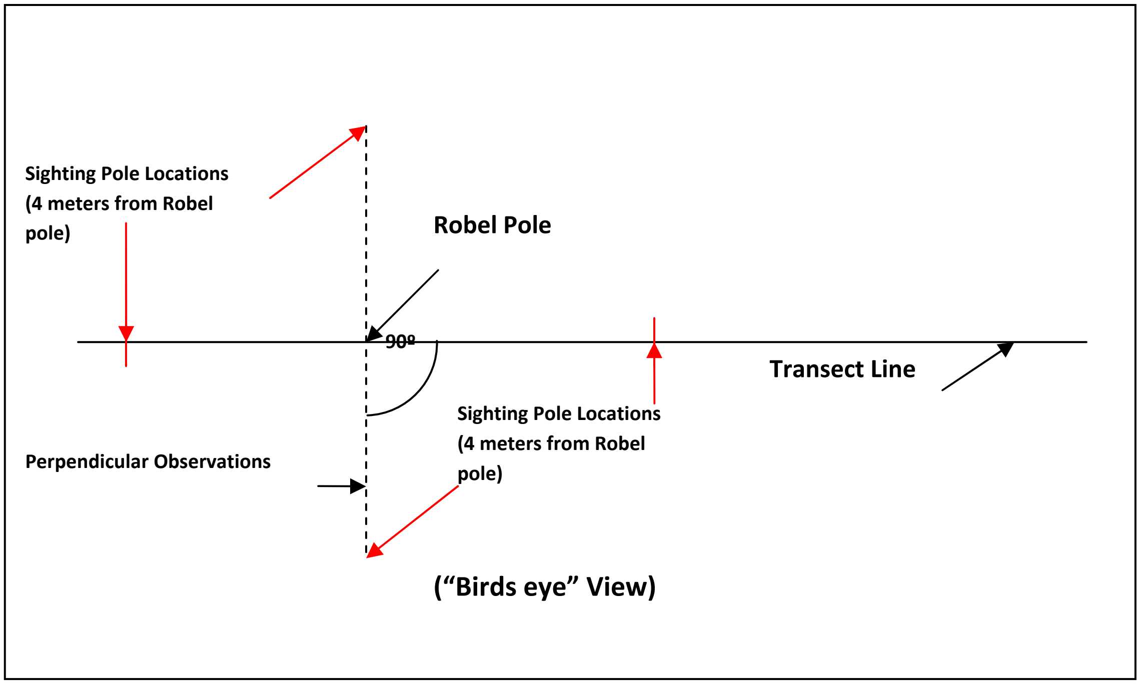

Figure 6 Robel pole (VOR) measurement diagram

Shrub Measurements

Percent Cover

4. Line intercept or point intercept (Hays et. al. 1981) is used to determine shrub cover. Line intercept will always be used when shrub cover is estimated at < 5%. In contrast, the point intercept method is used if shrub cover is estimated at ≥ 5%. Point intercept results (2' intervals) closely resemble those obtained using the line intercept technique (shrub cover ≥5%); however, not all shrub species may be detected when shrub cover is less than 10 percent.

Line Intercept

4A: Line intercept is used to measure the amount of cover that intercepts/crosses the transect line as illustrated by the vertical lines shown in Figure 7. Foliage gaps ≤3 inches wide are generally ignored in contiguous shrub cover. The line intercept method provides the most accurate results and can be used to determine shrub cover at all shrub cover levels/strata.

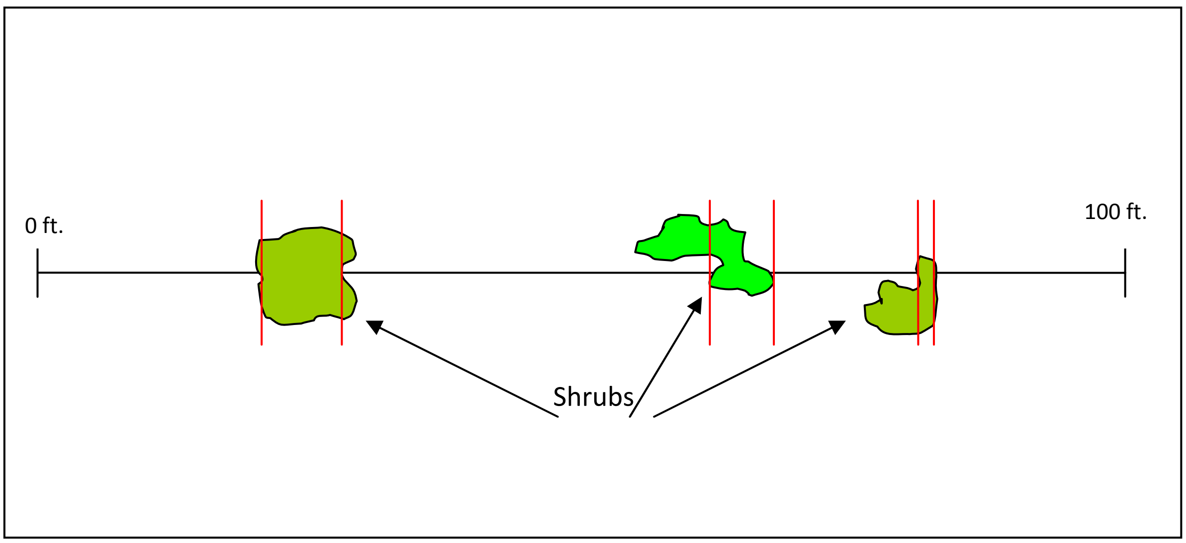

Figure 7 Line intercept measurement example

The amount covered by shrubs is added to determine shrub intercept for each transect. For example, if 7.5 feet of a 100-foot long transect is covered by shrubs, percent cover is 7.5%. Where different shrub species overlap, shrub intercept is recorded for the tallest shrub while lower shrubs are noted as also present.

Point Intercept

4B: Point intercept is used when shrub canopy cover is estimated at ≥5%. Shrub cover is determined by recording the number of "hits" at specific intervals along a transect line. To be counted as a "hit", a portion of the shrub must cross the transect tape's interval number line e.g., 2', 4', 6'…. nth point. If a portion of the shrub does not break the vertical plane at the interval number line, it is reported as a miss (Figure 8).

Shrub "hits" are identified and recorded by species (shrub species are assigned a number on data loggers) while "misses" are recorded as "0" (zero) on either data loggers or paper data forms. Where shrubs overlap, shrub intercept is recorded for the tallest shrub and noted for the lower shrub (see Complex Shrub Section for measuring shrub cover in multi-strata stands). Use the two foot interval unless directed otherwise by the survey crew supervisor.

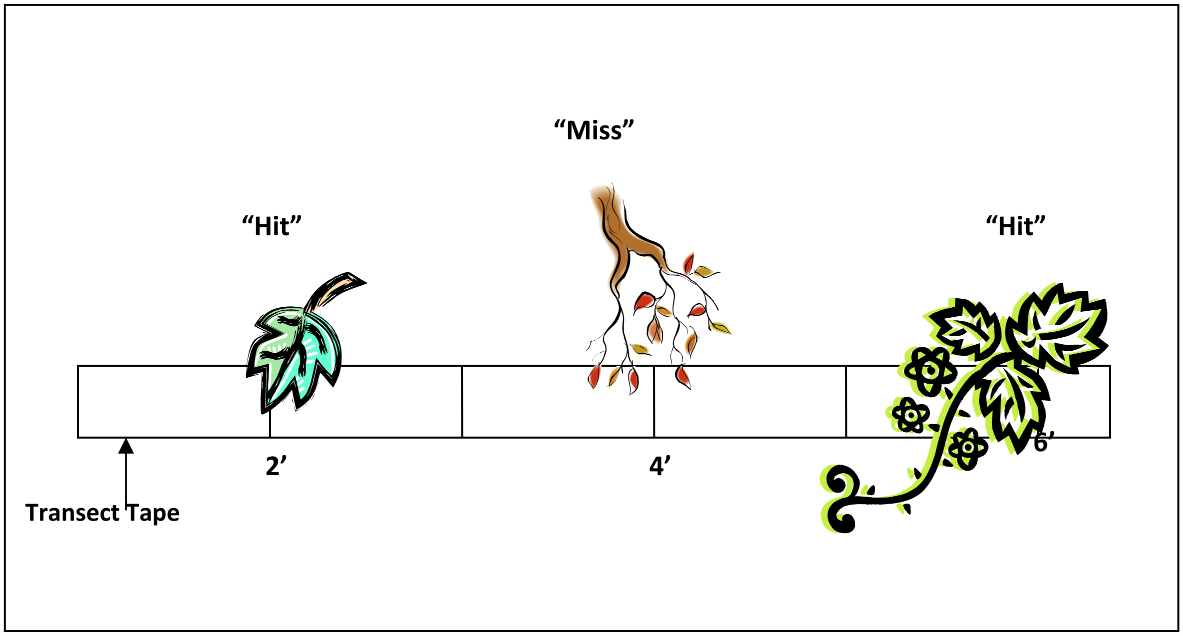

Figure 8 Point intercept method example showing "hits" and "misses"

From 5% to 40% shrub cover, point data is always collected at two-foot intervals (50 possible "hits" per 100 ft. sample unit). If shrub cover is estimated at >40%, shrub point data may be collected at five foot intervals (20 possible "hits" per 100 ft. sample unit) in relatively homogeneous shrub stands (again, check with crew supervisor).

On rare occasions, ten-foot intervals may be used when shrub cover exceeds 50% (10 possible "hits" per 100 ft. sample unit). The ten-foot interval is generally reserved for shrub monocultures (single species), or areas with only a few shrub species that exhibit relatively equal distribution/density.

4B-1: 2' interval

4B-2: 5' interval

4B-3: 10' interval

Modified Point Intercept

4C: Modified point method ("stick-in" method) is used when shrub cover is impenetrable or otherwise inaccessible. A baseline transect is established along the shrub edge. A six-foot measuring rod is then inserted into the shrub cover at right angles to the baseline tape at appropriate intervals. Recorders estimate shrub "hits", species information, and height data where the end of the six-foot measuring rod intercepts the shrub cover (Figure 9). As with point intercept, intervals may vary. Shrubs are identified by species.

4C-1: 2’ interval

4C-2: 5’ interval

4C-3: 10’ interval

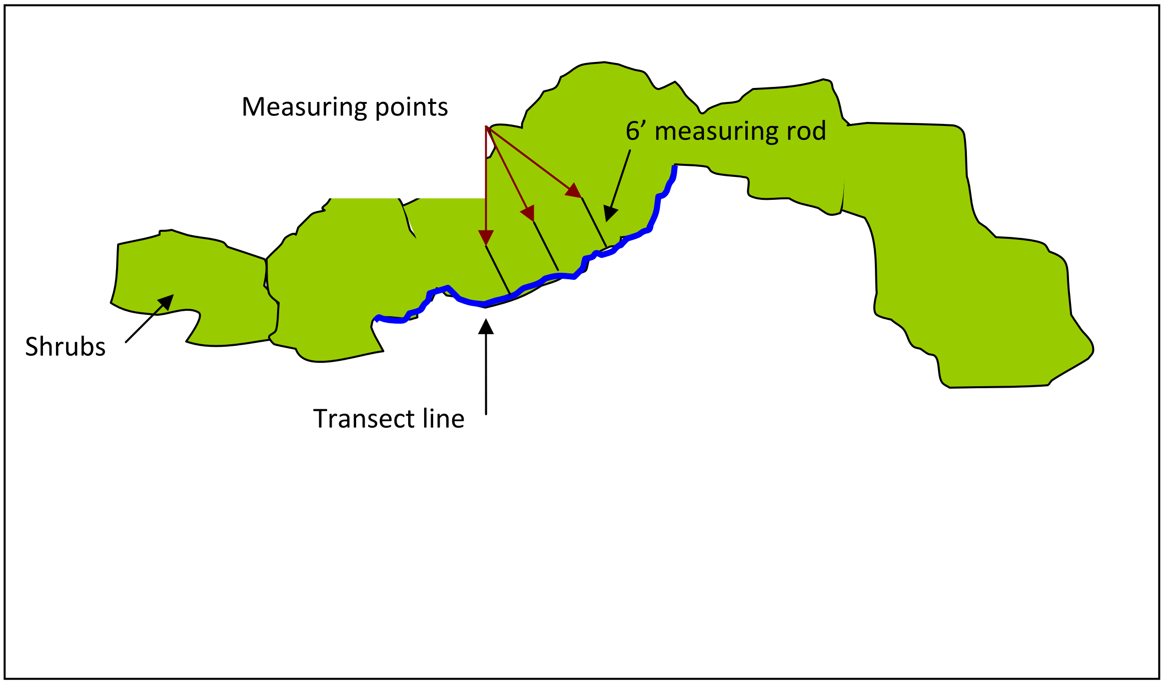

Figure 9 Modified point intercept ("stick-in") method example

In addition to being applied in impenetrable or inaccessible shrub stands, this method is generally reserved for areas ≥ 90% shrub cover; whereas the relative cover of various shrub species is the factor in question. This method should be used with caution and only employed when other more precise/accurate methods are impractical.

Complex Shrub Intercept

4D: Complex shrub intercept is used to determine percent shrub cover in multi strata shrub communities (generally applied to riparian and/or forest cover types). This technique is a point intercept method. Overlapping shrubs are identified for each stratum (Figure 10).

Shrub “hits” are recorded on data loggers/data sheets from lowest to highest stratum at one of three intervals along the transect line i.e., two, five, or ten foot intervals. Record point intercept measurements at five foot intervals in both homogeneous and heterogeneous shrub stands unless otherwise directed by survey crew supervisors.

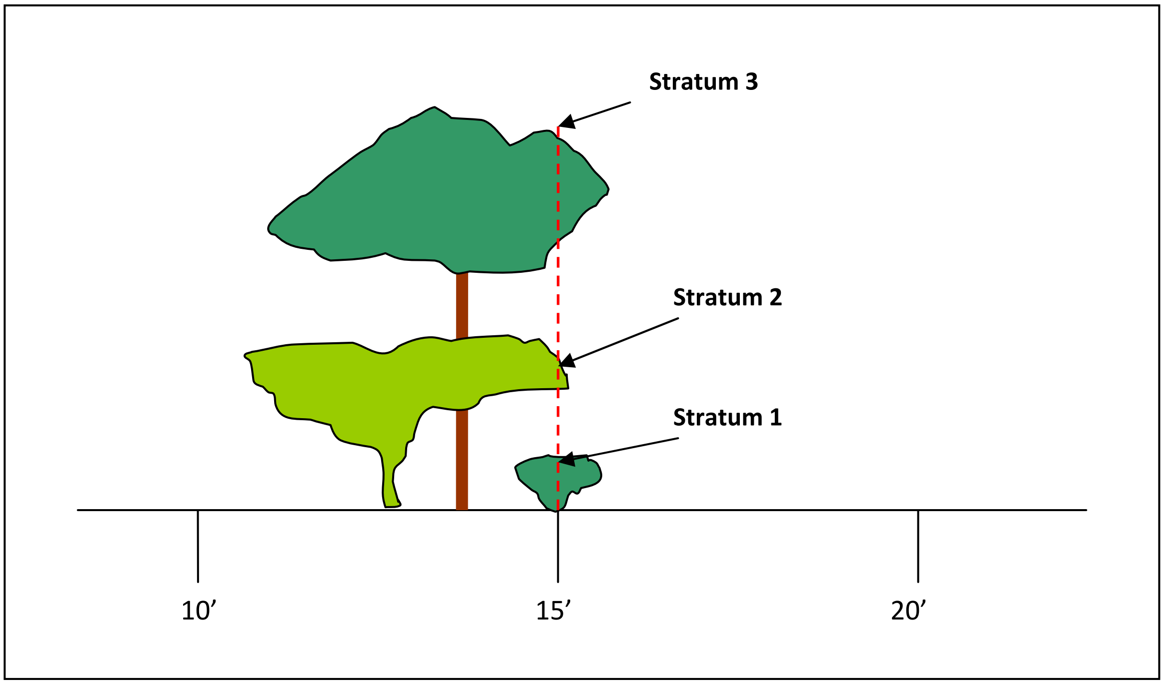

Figure 10 Complex shrub/canopy example at 5 foot intervals

Two foot intervals are recommended if estimated shrub cover is < 30%. Homogenous shrub cover estimated at >75% may be measured at ten foot intervals without impacting precision; however, ten foot intervals should not be used to measure heterogeneous shrub stands regardless of density due to the potential to not detect all shrub species. Percent shrub cover is determined for each of four possible strata as well as total percent shrub cover and overlapping percent cover.

4D-1: 2' interval

4D-2: 5' interval

4D-3: 10' interval

Shrub transect length/sample size is determined as described in the Sample Size Determination Section. Data from short transects (300 ft) can be pooled to meet statistical objectives; however, once initiated the "pooled data" method should be applied to all shrub transects within the cover type.

Shrub Height

5. Shrubs are defined as woody vegetation including trees <16 feet in height unless otherwise defined in HEP models[3]. The Regional HEP Team assumes that trees <16 feet tall function ecologically more like shrubs than trees.

[3] The 16' height restriction generally applies to tree species such as ponderosa pine (*Pinus ponderosa*). If the tree is < 16' tall, it is counted as a shrub; > 16' tall it is counted as a tree. Conversely, most shrub species are always counted as shrubs regardless of height e.g., a chokecherry (*Prunus virginiana*) > 16' in height will always be

Shrub height measurements are recorded relative to the position of the transect line and/or point interval. As a result, the height of the dominant shrub canopy biomass is recorded (maximum shrub height is seldom documented - especially in shrubsteppe habitat). Mean shrub height data results are generally lower than ocular shrub height estimates.

Shrub heights are recorded in 10^{ths} of feet as whole numbers on either data loggers or paper data forms. For example, a shrub height of four feet is recorded as "40". Similarly, a shrub height of two feet six inches is recorded as "26".

Line Intercept Shrub Height

5A. Shrub height is measured in 10^{ths} of feet at the highest point for each uninterrupted line intercept segment as depicted in Figure 11. Height measurements are taken "above" the transect line.

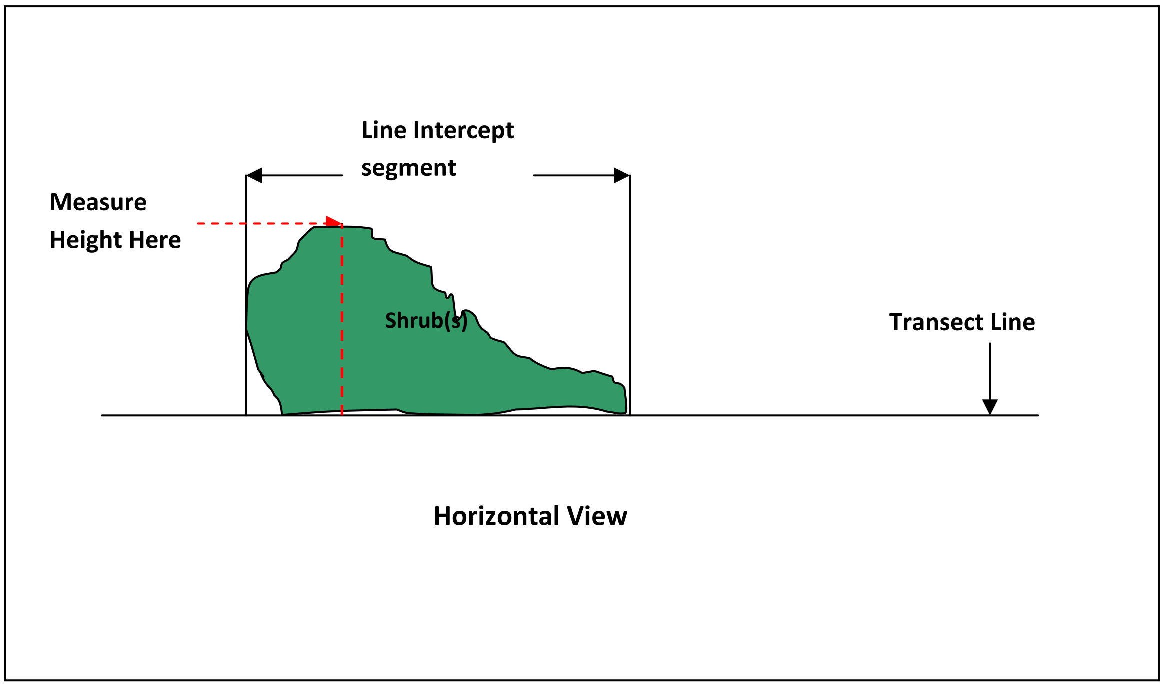

Figure 11 Line intercept shrub height measurement example

Point Intercept Height

5B. Shrub height is measured in 10^{ths} of feet at the highest position directly above the point intercept mark crossed by any part of the shrub (Figure 12). Height measurements are obtained with a "surveyor's rod" or similar device. Shrub height exceeding that which can be measured directly is estimated.

considered a shrub. The project leader will review HEP model requirements and general data needs to identify specific protocols.

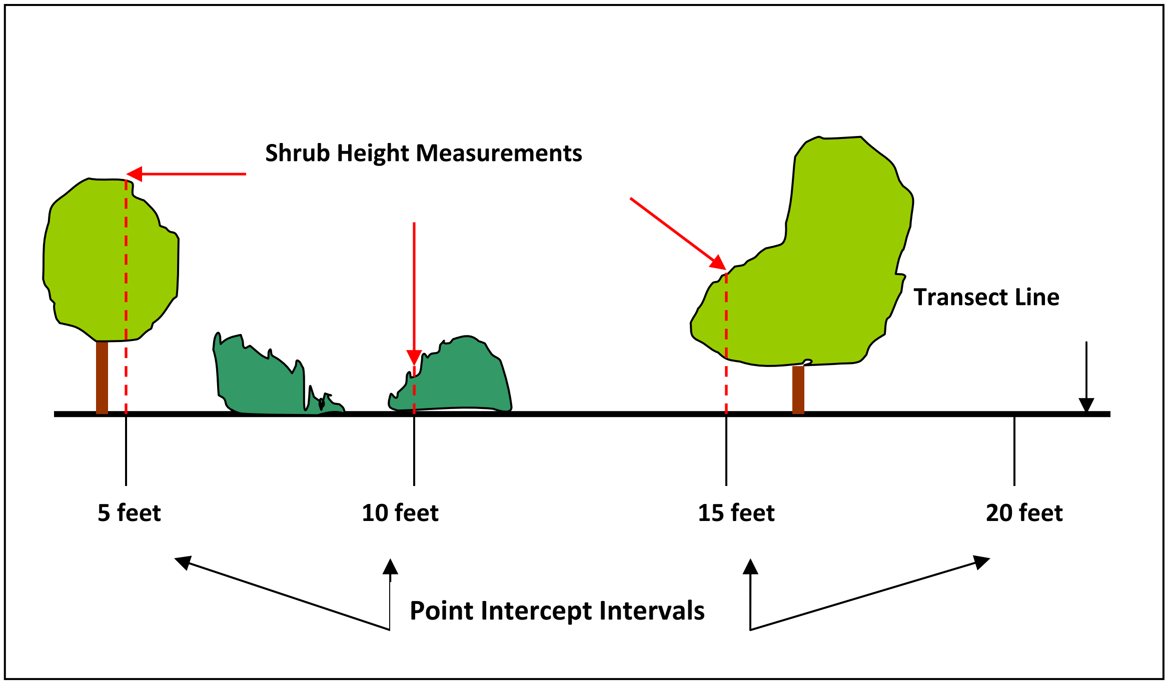

Figure 12 Point intercept shrub height example

Complex Structure Shrub Height

5C. In structurally complex (overlapping) shrub communities, height is measured for each stratum (maximum of four) in 10ths of feet as illustrated in Figure 13. Shrub height is recorded on data loggers/data sheets from lowest to highest strata i.e., begin with stratum 1.

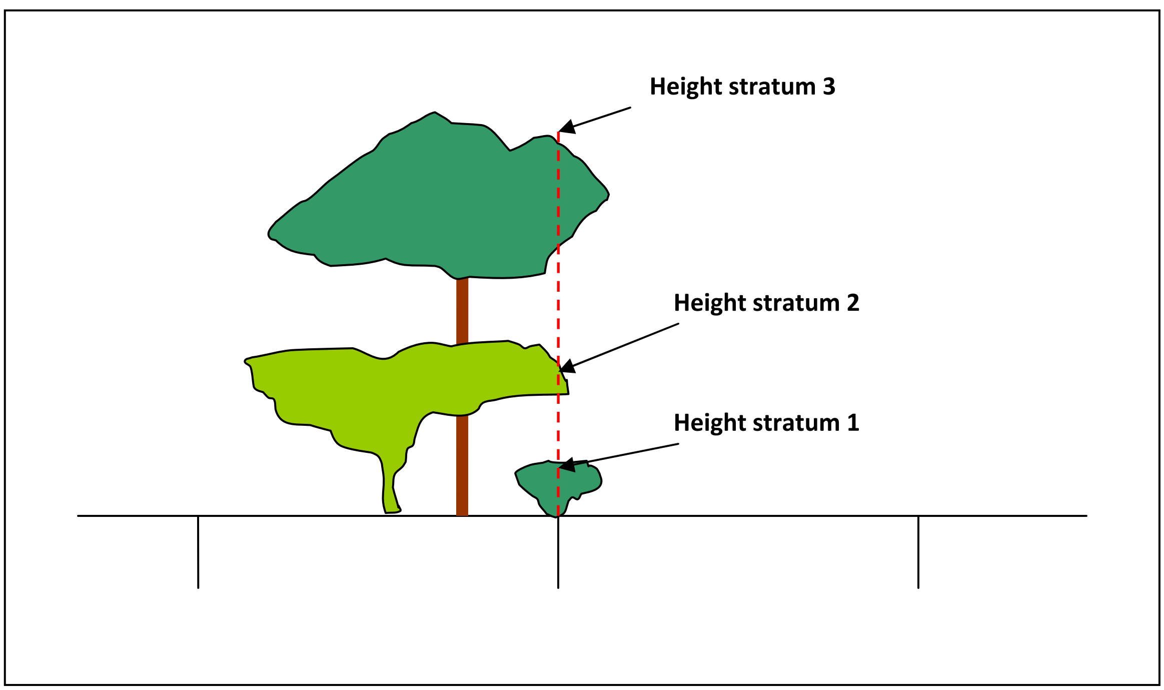

Figure 13 Complex shrub height measurement example

Stratum are not defined/restricted by height, but rather whether or not multiple shrub species overlap at a given point (if only a single species occurs, a single height measurement [highest] is recorded regardless of overlap). Although not generally employed, “fixed height” strata can be defined and data collected accordingly if biological/ecological needs warrant (do not apply “fixed height” protocols unless directed by survey team leaders).

It is assumed that shrub height measurements correspond to the method used to determine percent shrub cover. For example, if percent shrub cover is determined using the line intercept method (Figure 7), then it is assumed that shrub height will be obtained as illustrated in Figure 11.

Recording shrub height at the highest point above the transect line/point interval occasionally leads to underestimating the amount of browse available to mule deer and other ungulates. If a habitat suitability model includes a “percent cover palatable shrubs ≤ 5 feet in height” or similar variable, note shrub species that provide browse at ≤ 5 feet even though the recorded shrub height may exceed five feet. Document notes on data logger note/GPS page and transect summary forms.

Shrub Demographics

Shrub demographics/condition is primarily used to document and track winter deer range trends associated with shrubsteppe habitat; however, this could also be applied to other cover types as well. Shrubs are classified as either seedling, juvenile, mature, decadent, very decadent, or dead and are assigned a number, from 1 to 6, which is recorded on the data logger point intercept spreadsheet or paper data form. Shrub classes are defined in Table 1.

Table 1 Shrub demographics/condition descriptions

Class #	Class Name	Description
1	Juvenile (J)	Single stem, non flowering, generally first year post germination
2	Young (Y)	Branched, non flowering, non seed-bearing
3	Mature (M)	Flowering and/or producing seeds
4	Decadent (D)	25% to 50% of the shrub is dead
5	Very Decadent (VD)	Shrub is alive, however, >50% of the shrub is dead
6	Dead (DD)	Entire shrub is dead

Tree Measurements

Percent Canopy Cover

6. Tree canopy cover measurements are recorded at five foot intervals (point intercept) with a densitometer® (Geographic Resource Solutions)[4]. The densitometer is a tool that uses a mirror to project a view of the sample location point in the tree canopy above the individual holding the densitometer on the ground (Figure 14).

[4] http://www.grsgis.com

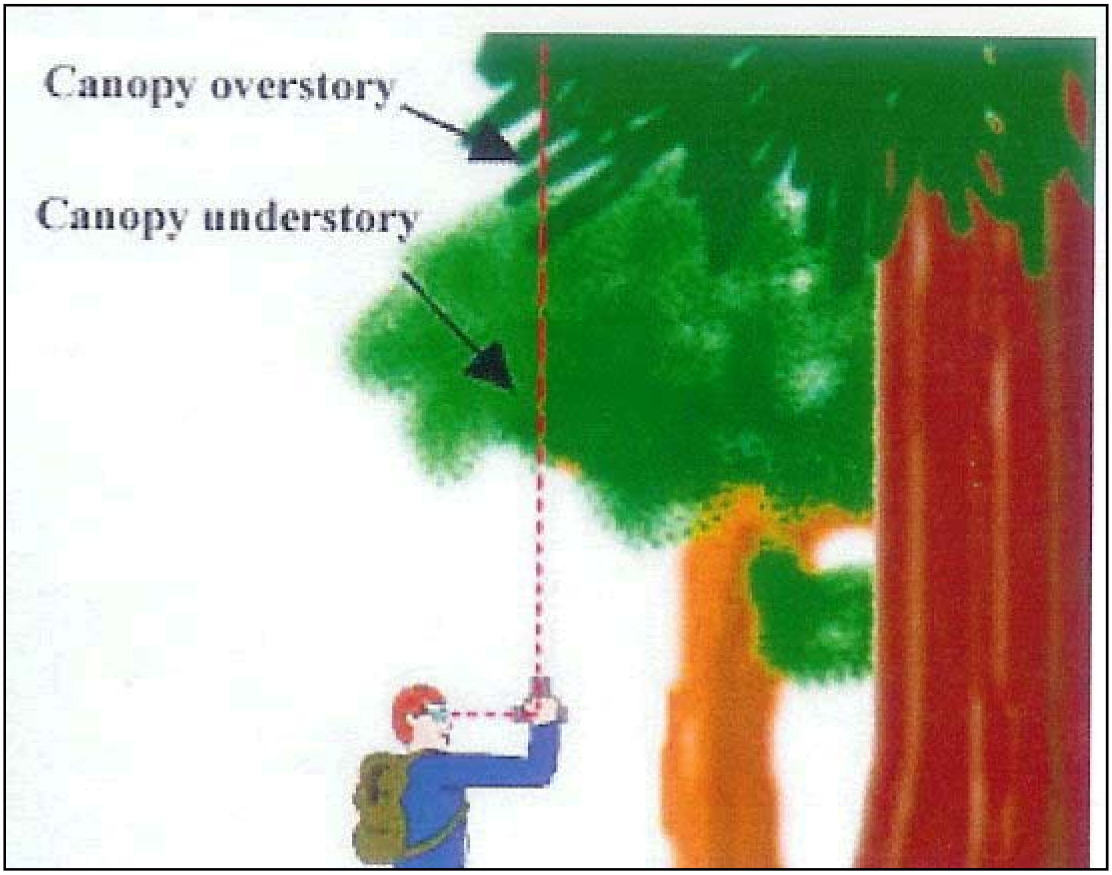

Figure 14 Measuring tree canopy cover with a densitometer

The observer sights through the densitometer tube and aligns the two bubble-line level vials. Once both vials are level, the field technician records only vegetation "hits" (includes twigs, needles, leaves – any part of the tree) that intersect the small "dot" located in the center of the circle as shown in Figure 15 diagram "B". Tree species are assigned a number e. g., ponderosa pine = 1, Douglas fir = 2, etc. Tree "hits" are recorded by species number on data logger spreadsheets or paper data forms.

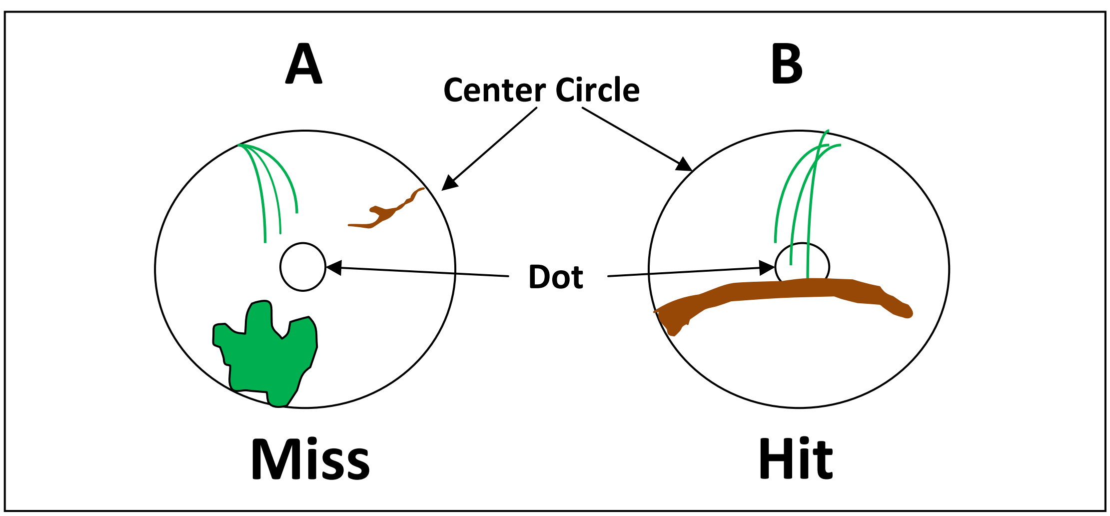

Figure 15 Densitometer "miss" and "hit" examples

If estimated tree canopy closure is ≥ 80%, a 10 foot sample interval can be applied in homogenous stands without significantly compromising the results or statistical validity. The 10 foot interval, however, is seldom used.

The size of the sample area strongly influences transect length. In tree stands limited in size, data from several short (300 foot) transects may be “pooled” in order to determine percent tree canopy cover. When “pooled”, each 300 foot transect is usually considered a sample unit. When data is not pooled, the sample unit is a 100 foot transect segment. Transect length/sample size is determined as described in the Sample Size Determination Section.

6A: 5’ interval

6B: 10’ interval

Tree Height

7. Tree height is determined with a clinometer; however, an electronic height measurement instrument or a “forestry stick” may also be used (only the clinometer tree height method is discussed below). The tree height measurement interval is 100 feet depending upon forest stand homogeneity, tree density, and data needs (HEP model variable/CHAP verification transect requirements determine the extent of tree height measurements e.g., single/multi-canopy, over-story, etc.).

7A. Use the “topographic” or “percent” (%) clinometer scale to determine tree height. Measure the horizontal distance[5] from the base of the tree and multiply the tree height reading (% scale) by the horizontal distance (0 to 1)[6]. If the horizontal distance to the base of the tree is 100 feet (1), tree height is the direct percent scale reading. For example, a clinometer value of 70%, equates to a tree height of 70 feet (70 x 1.0 = 70 feet) at 100 feet horizontal distance. Conversely, if the horizontal distance is 50 feet, a 70% clinometer value indicates the tree height is 35 feet (70 x 0.50 = 35 feet).

Eye level relative to the tree base determines how clinometer percent slope values are determined. When eye level is even (0% or no slope) with the base of a tree (Figure 16), height is determined as described in the previous paragraph without slope correction.

When trees are located “down slope” (Figure 17) from the field technician or the tree base is below eye level, two measurements are taken and added together to determine tree height. Angle 1 measurement is the percent reading from 0% to the top of the tree while the angle 2 measurement is the percent reading from 0% to the base of the tree. For example, if the value of angle 1 is 40% and the value of angle 2 is 50%, add the two values together (disregard +/- signs: use absolute values) and multiple the sum by the horizontal distance (D) e.g., if the horizontal distance is 80 feet, tree height is 72 feet (40 + 50 = 90 x 0.80 = 72 feet).

[5] It is assumed that the horizontal distance is ≤ 100 feet.
[6] Convert distances less than 100 feet to a decimal value e. g., 40 feet = 0.40, 75 feet = 0.75….n^{th}

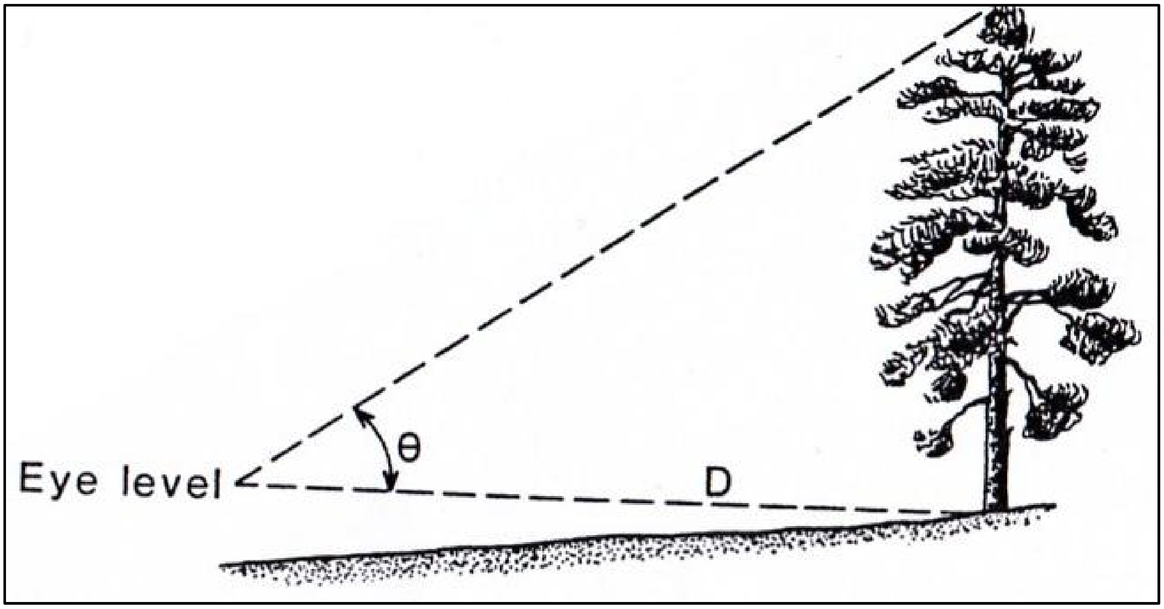

Figure 16 Measuring tree height when "eye level" is even with the tree base

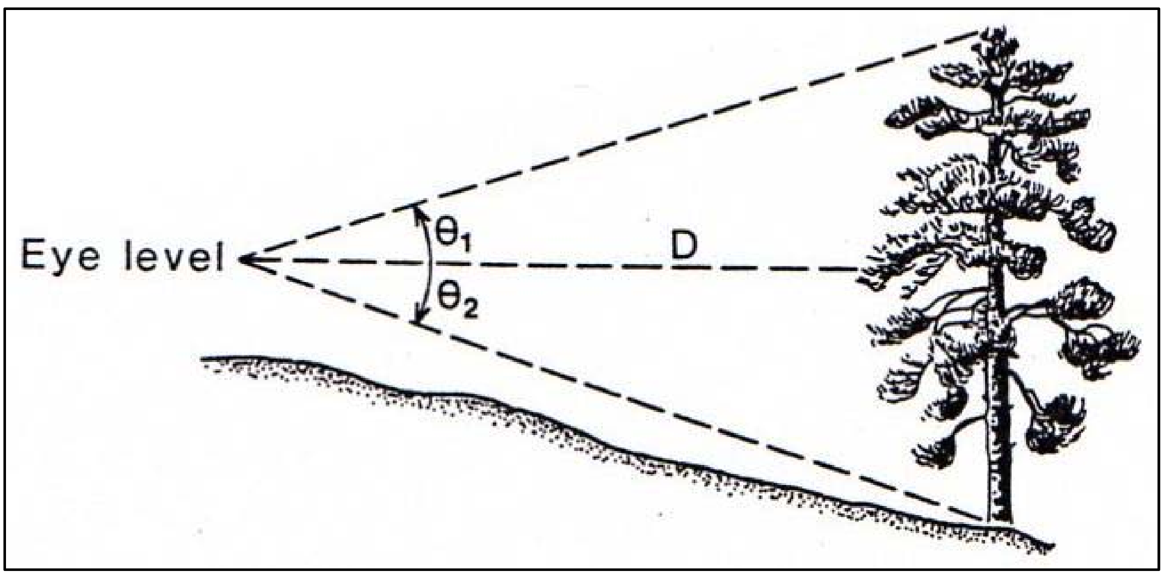

Figure 17 Measuring tree height when "eye level" is above the tree base

When the tree base is above eye level (Figure 18) it is necessary to subtract the angle 2 slope from the angle 1 slope. For example, if the angle 2 slope is 10% and the angle 1 slope is 80%, the difference is 70% (80% - 10% = 70%). Multiple the difference by the horizontal distance (D) to obtain tree height. Another method is to count only the vertical slope from the base of the tree to the top of the tree. If the clinometer value at base of the tree is 30% and the clinometer reading at the top of the tree is 100%, the difference is 70% (100% - 30% = 70%). Again, multiply the difference by the horizontal distance (D) to obtain tree height.

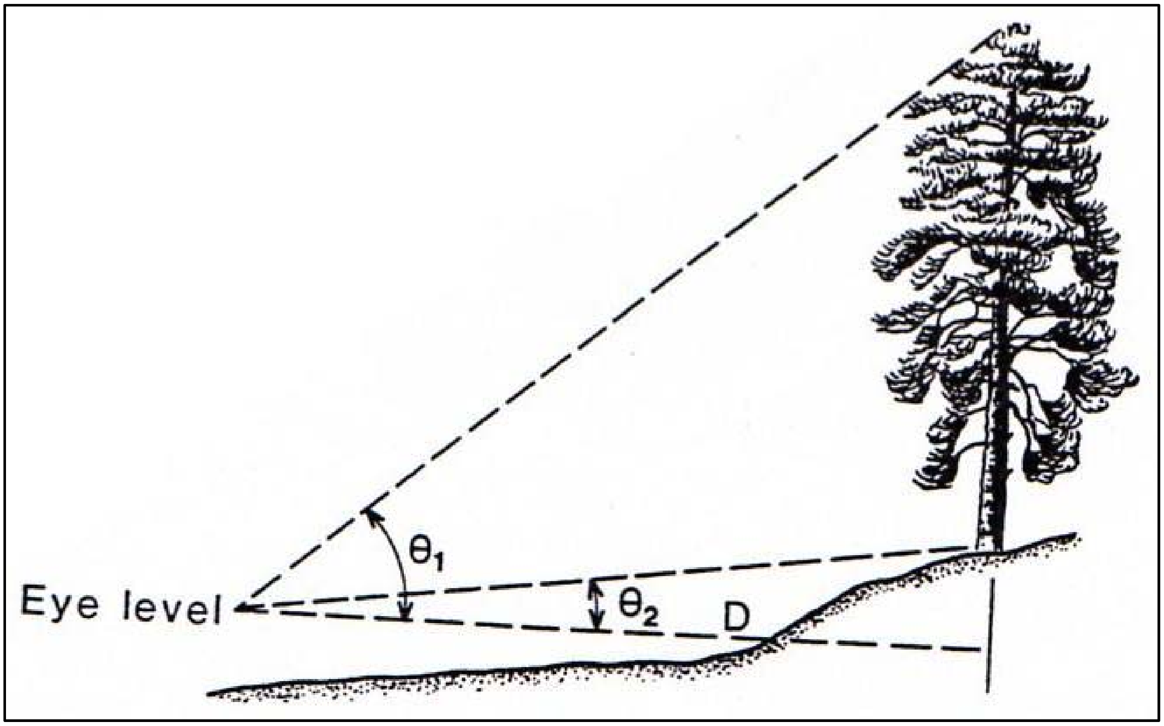

Figure 18 Tree height measurements when the base of the tree is above "eye level"

7A: Clinometer

7B: Forestry Stick

7C: Other

Basal Area

8. Avery and Burkhart (1994) defined basal area as the sum of the cross sectional areas of all tree stems in a stand measured at breast height (4.5 feet) and expressed as per unit of land area i.e., ft^2/acre or m^2/hectare (envision measuring the surface area, including bark, on the top of all tree stumps cut at 4.5 feet above the ground).

Tree basal area data is collected at 50 or 100-foot intervals using a "factor 10" prism. Each 50 or 100-foot interval basal area observation (all tree "hits" at each point) is considered an independent sample. Sample collection points are "plot-less" (no fixed radius).

The prism is held in a horizontal position over the interval point and "live" trees are counted as "in" or "out". The observer holds the prism in a fixed position over the interval point and rotates 360° while looking through the prism held 10 inches from the eye (Husch et. al. 2003)[7]. Trees are viewed at DBH level (4.5 feet above the ground). If the images overlap as illustrated in Figure 19, the tree is counted.

[7] Husch et. al. (2003) stated that 10 inches is the normal viewing distance and that the distance from the eye is immaterial as long as the viewer has a clear picture.

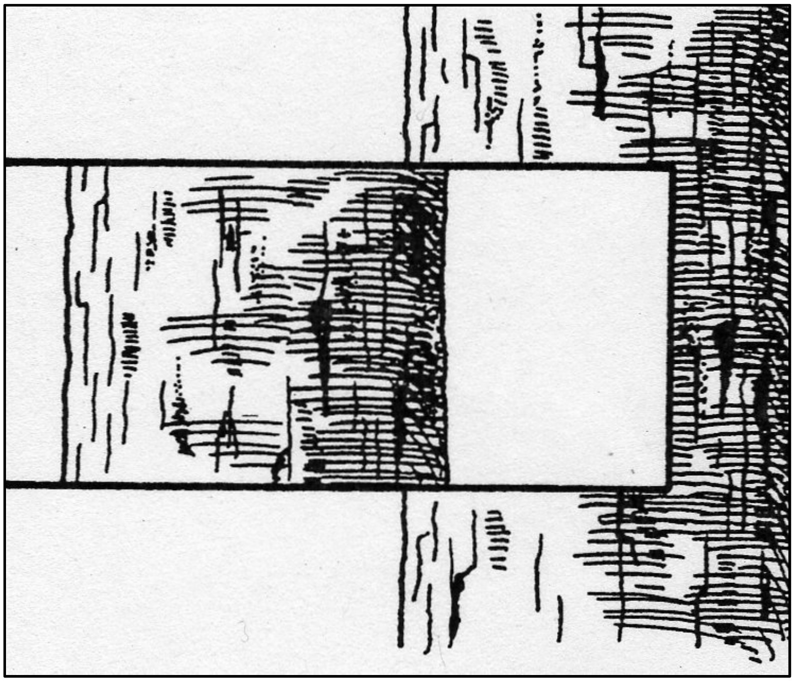

Figure 19 Overlapping images - tree is counted

If the images do not overlap (Figure 20), the tree is not counted. Borderline trees (Figure 21) are counted as one-half.

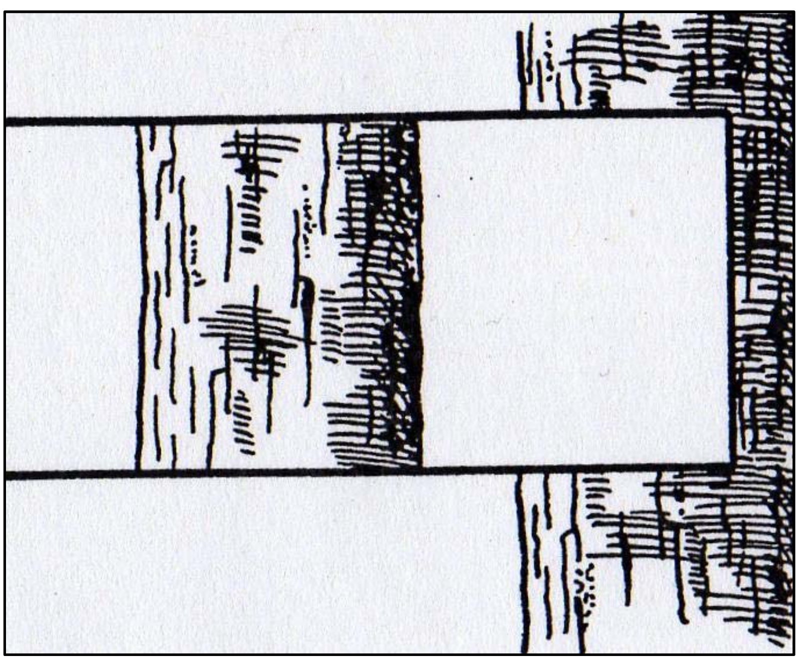

Figure 20 Images not overlapping - tree is not counted

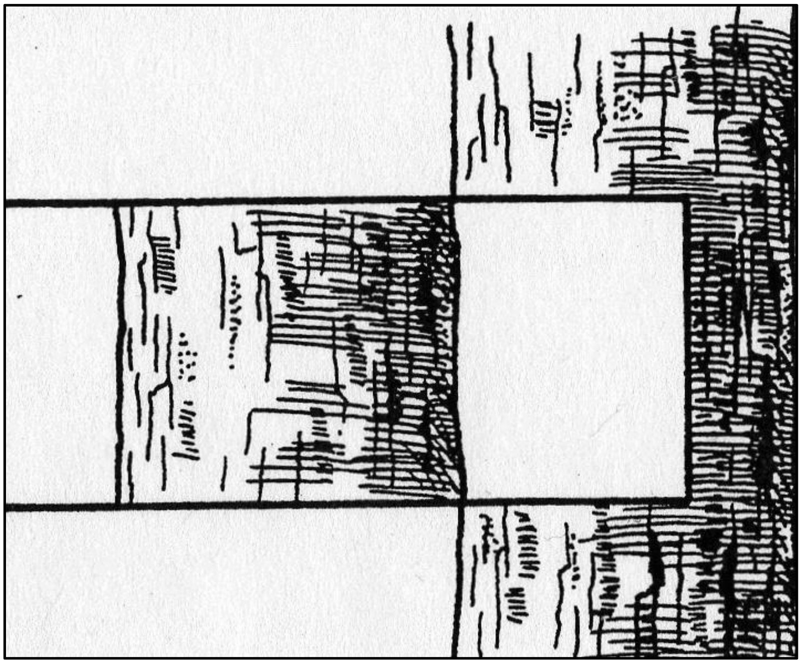

Figure 21 Borderline overlap image - count as one-half

Basal area measurements are recorded at 50 foot intervals if tree dbh is typically ≤12 inches. Conversely, use 100 foot intervals if the majority of trees exceed 12 inches dbh. This reduces the amount of overlap/double counting. Record basal area "hits" on data logger spreadsheet (forest 5' page) or paper data form and document basal area interval on transect summary sheet.

8A. 50 foot interval

8B. 100 foot interval

Hays et. al. (1981) suggested using the following equation to calculate basal area:

$$B = \frac{\sum n}{p}(BAF)$$

Whereas: B = basal area

$\sum n$ = total number trees counted at all sample points

P = number of sample points

BAF = basal area factor (factor 10 prism)

Diameter Breast Height (DBH)

9. The diameter of trees is taken at 4.5 feet above ground level and is referred to as *diameter at breast height* or dbh (Husch et. al. 2003). The most common dbh measurement situations are illustrated in Figure 22.

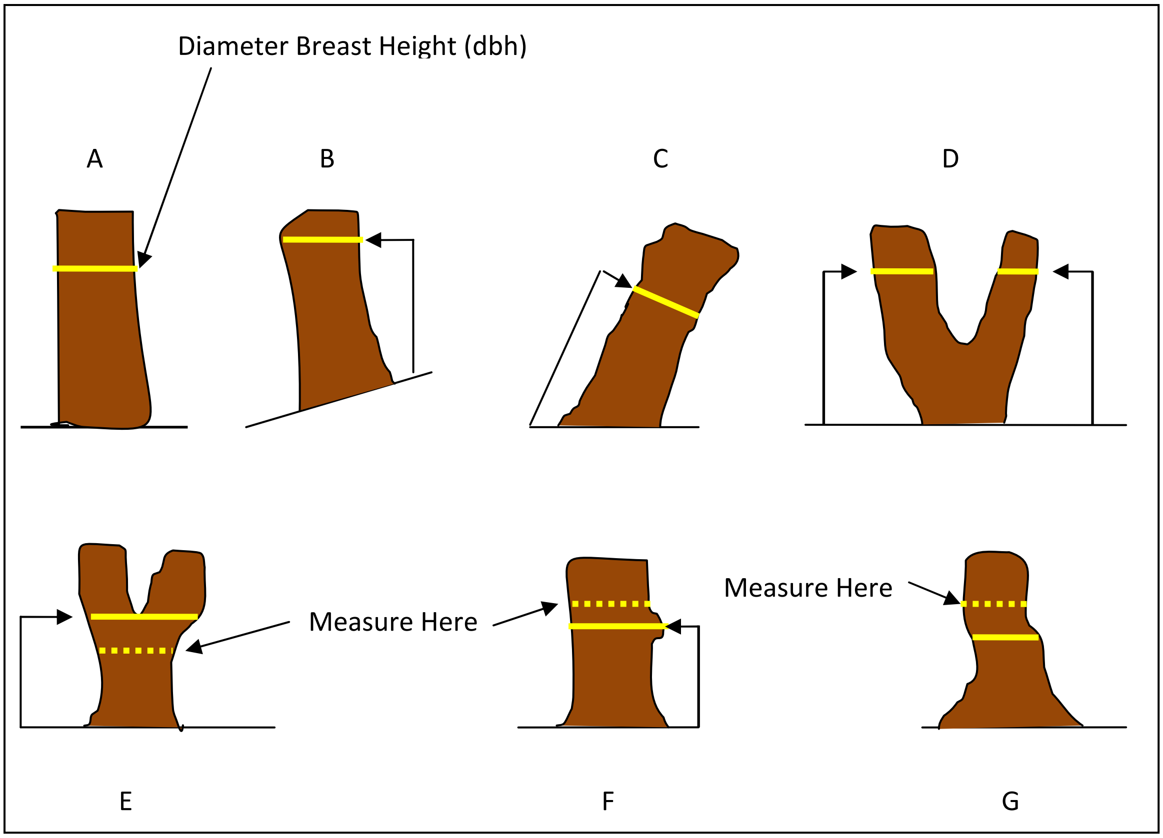

Figure 22 Diameter breast height (dbh) measurement examples

Measuring dbh with a diameter tape is the primary method used by the RHT. Wrap the diameter tape around the tree at 4.5 feet above the ground and read the proper tape scale to obtain dbh. Tree diameter is the point at which the "0" mark crosses the tape when pulled tight around the tree. To obtain accurate dbh measurements, the wrapped tape must be level (except as shown in Figure 22, diagram C), not twisted, and against the tree trunk without interference from branches, vines, etc.; record dbh to the nearest inch.

On level ground, dbh can be measured from any convenient position as shown in Figure 22, diagram A. On slopes and/or uneven ground, dbh must be measured from the uphill side of the tree (Figure 22, diagram B). When a tree is leaning, as illustrated in Figure 22 diagram C, diameter breast height is measured parallel to the lean on the high side of the tree. The diameter is measured perpendicular to the longitudinal axis of the trunk (Husch et. al. 2003).

If a tree consists of two or more stems that fork below breast height (4.5 ft.), measure each tree stem separately (Figure 22, diagram D). If the tree forks at breast height or slightly above, measure it as one tree below the enlargement caused by the fork as illustrated in Figure 22, diagram E.

When a tree has a limb, bulge, or other abnormality at diameter breast height, measure dbh above the abnormality; strive to obtain the diameter the tree would have been had the abnormalites not been present (Figure 22, diagrams F and G) (Husch et. al. 2003).

Diameter breast height can also be measured with a Forestry Stick. Although slightly less accurate and precise, measurements can be obtained in less time. The Forestry Stick is held 25 inches from the body against the tree trunk perpendicular to the stem (Figure 23). The technician looks straight ahead and moves only the eyes to obtain the measurement.

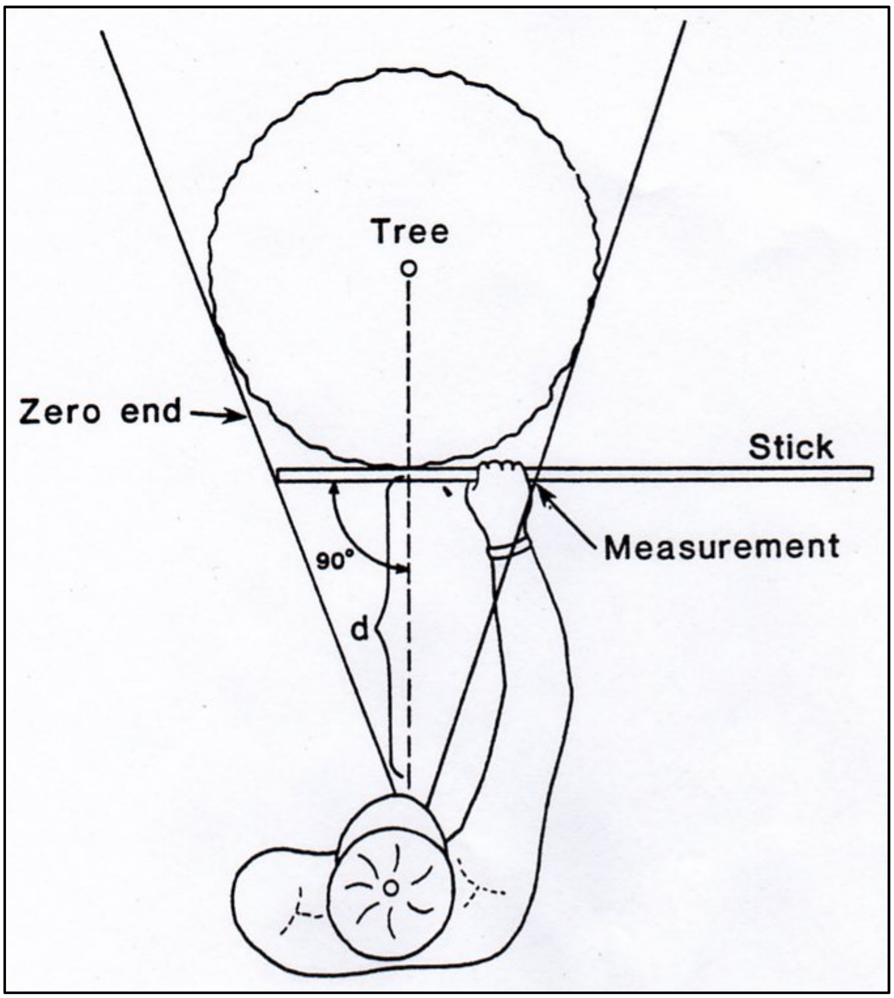

Figure 23 Measuring dbh with a Forestry Stick

The observer moves the left side of the stick until the “zero” (0) end of the stick visually aligns with the left side of the tree by extending the line of sight. Dbh is obtained by extending the line of site over the stick to the right side of the tree. Dbh is the point on the Forestry Stick where the line of site crosses to line up with the right side of the tree (Figure 23).

9A. DBH Tape

9B. Forestry Stick

Belt Transects

Belt Transects

Belt transects are 44 feet wide i.e., 22 feet on each side of the baseline transect. As with shrubs and trees, the sampling unit is a 100-foot segment. Each belt transect sampling unit is approximately one tenth of an acre in area. Belt transect layout is depicted in Figure 24.

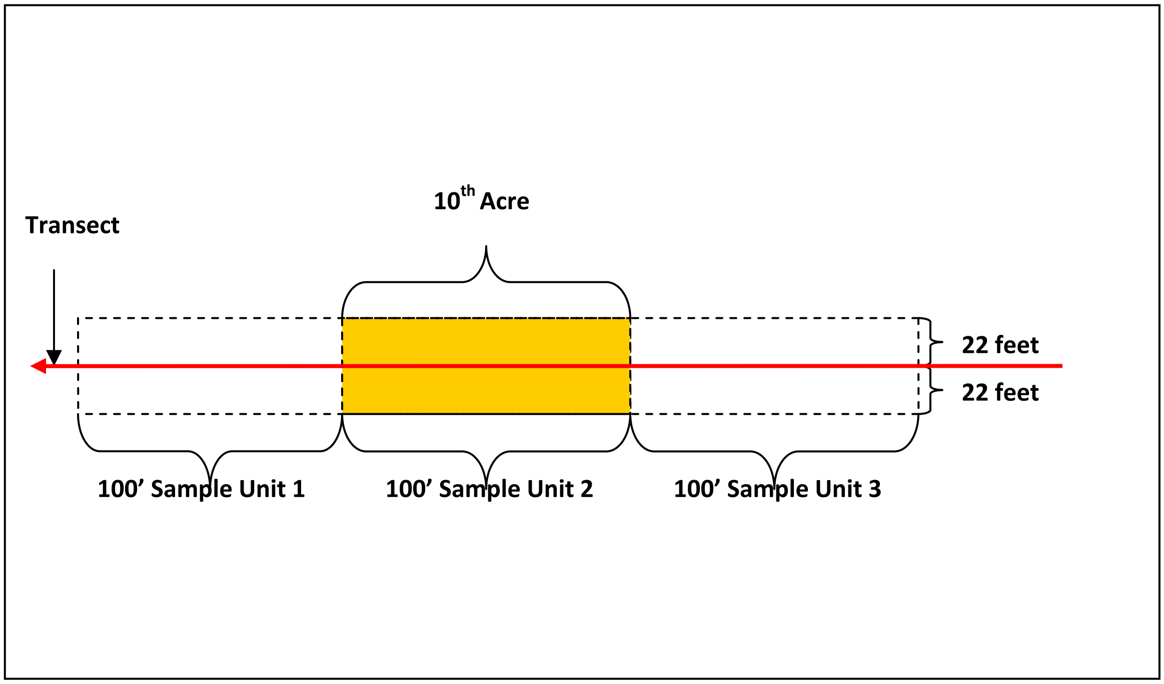

Figure 24 Belt transect layout diagram

Snags

10. Snag data is collected within belt transects . Field technicians collect snag data in conjunction with tree canopy closure measurements. The diameter breast height (dbh) of all snags located within tenth-acre belt transects is measured. Either the actual dbh is recorded, or snag data is reported by class e.g., 5 snags <4" dbh, 2 snags >20" dbh etc., (see dbh section). Crew supervisors will advise whether to collect snag data by class or specific dbh.

Snag dbh classes for CHAP verification transects are listed on the data logger form shown in Table 2. Field technicians record the number of snags observed in each dbh/decay class (Table 3).

Table 2 DBH and decay class example

Snags: Dead trees > 6 feet tall				
BELT 1		**Decay Class**		
DBH Class	#	A	B	C
<1"	1		2	
> 1" - 9.9"	2			
10" - 14.9"	3			
15" - 19.9"	4	3		2
20" - 29.9"	5			
≥ 30"	6			

Table 3 Snag decay class definitions

Decay Class Key
A = Hard: Top, bark, Branches
B = Moderate: Some bark/branches, <solid
C = Soft: No bark & branches

Each 100 foot transect segment is assigned a belt number. For example, belt 1 is the first 100 feet; belt 2 extends from 100 to 200 feet…..n^{th} belt.

The example data in Table 2 indicates that in belt 1 (0' to 100') there were two dbh class 1 snags; both assigned to decay class B. In addition, five dbh class 4 snags were also observed; three snags in the decay class A category and two snags in the decay class C category.

Snag dbh classes for HEP transects are listed in Table 4. Decay class data is generally not recorded for HEP surveys.

Table 4 HEP survey dbh size classes

DBH Class	Designator
No snags	0
<4"	1
> 4" =< 6"	2
> 6" to 10"	3
>10" to 20"	4
> 20"	5

Down Woody Debris

11. Down woody debris includes logs and tree branches lying horizontally on the ground and/or supported by other down woody material that are not attached to a "living" tree. Down woody debris data is recorded primarily in conjunction with CHAP verification transects. Like snags, downed woody debris is identified by size class. To be counted, downed woody debris must be ≥ 1 inch in diameter and ≥3 feet in length and intersect (cross) the transect line as illustrated in Figure 25.

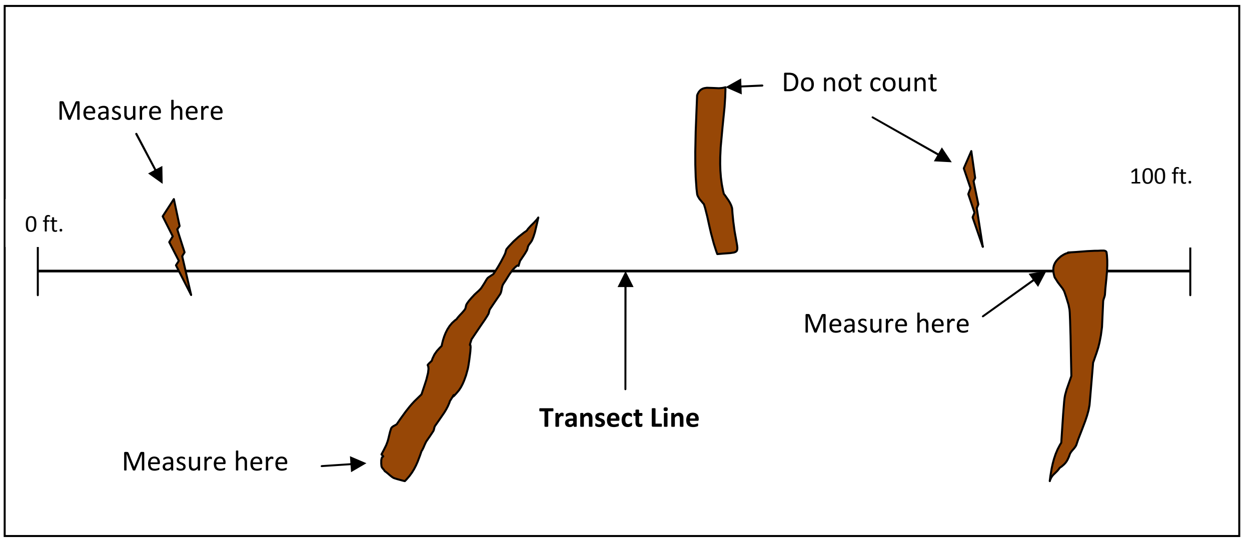

Figure 25 Down woody debris example

Measure the diameter at the widest point of the down woody debris using a dbh tape, Forestry Stick, or other similar device (the Forestry Stick is the most efficient tool). Enter data in the data logger on the down woody debris page (Table 5) or on paper data forms for each 100 foot sample unit.

Table 5 Down wood dbh class example and data logger spreadsheet

Down Wood ≥ 3' long				
Sample Unit: 0' - 100'				
Diameter Class		Number	Number	Number
Small: ≤ 5" large end	A			
Medium: > 5" to < 20" large end	B			
Large: ≥ 20" large end	C			
Total				

In post logging conditions and wind falls where significant amounts of down woody debris is present i.e., more than 50 pieces in a given size class per 100 foot sample unit, count and record 50 in the first cell and estimate and record the remainder in the adjacent cell with the suffix "E" added as shown in Table 6.

Table 6 Down woody debris example showing estimated stems

Down Wood ≥ 3' long				
Sample Unit: 0' - 100'				
DBH Class		Number	Number	Number
Small: ≤ 5" large end	A	50	75E	
Medium: > 5" to < 20" large end	B			
Large: ≥ 20" large end	C	2		
Total				

Stumps

12. Stumps are dead tree stems ≤ 6 feet in height still rooted in the ground. Similar to snags and down woody debris, stumps are assigned diameter classes as illustrated in Table 7.

Table 7 Stump diameter classes as shown on data logger spreadsheet

Stumps: ≤ 6 feet tall			
BELT 1			
Diameter Class	Number	Number	Number
Small: <10" DBH			
Medium: 10" - 19.9" DBH			
Large: ≥ 20" DBH			
Total			

Stumps are counted in conjunction with CHAP verification transects. Count and measure all stumps located within belt transects and record the data in the data logger for each sample unit e.g., belt 1, belt 2….belt n^{th}. Measure stumps > 4.5 feet in height with a dbh tape or Forestry Stick using the procedures discussed in the dbh section. Record the diameter of the top of stumps ≤ 4.5 feet in height using a standard tape measure or Forestry Stick. All stump diameter measurements are in inches. Survey crew supervisors will advise whether to record actual stump measurements or record stump classes.

Density

13. Avery and Burhart (1994) defined stand density as the number of plants or specific plant parts per unit area of ground surface e.g., the number of trees per acre. Density can be determined for herbaceous vegetation, shrubs, or trees; however, density measurements are usually reserved for trees and occasionally shrubs in conjunction with CHAP verification transects.

Like stumps, all trees within belt transects are counted and recorded on the data logger spreadsheet displayed in Table 8. Data is recorded for each sampling unit (belt). Counts can be made based on dbh, species, or other classification predicated on data needs. Crew supervisors will provide specific guidance.

Table 8 Density data logger entry spreadsheet

Project		Transect		
Date				
	Number	Number	Number	Number
BELT 1				0
BELT 2				0
BELT 3				0
BELT 4				0
BELT 5				0
BELT 6				0
BELT 7				0
BELT 8				0
BELT 9				0
BELT 10				0
Total				0

Cover Pole (White-tailed Deer Pole)

14. The white-tailed deer cover pole was developed to estimate screening/hiding cover[8]. The pole measures one inch (2.54 cm) in diameter, is ≈ 50 inches (1.5 m) in height, and is divided into three sections each measuring ≈16.66 inches (0.5 m). Sections are alternately colored red and white as illustrated in Figure 26.

The pole is “read” from bottom to top. Each section is assigned a value of 100%. As a result, each 0.5m section could have a cover value ranging from 0% (no cover) to 100% (total cover). The amount of cover obscuring each section is estimated as shown in Figure 27.

The cover provided by multiple branches, stems, leaves, needles, and abiotic objects including rocks and topography, are combined to obtain a percent cover value for each 0.5m section. For example, two vegetation components that cover section 3 in Figure 27 are added together to obtain an estimated 20% cover for that section.

Cover pole measurements are made at 50 foot intervals on the transect line. Field technicians take four measurements; two on the transect line and two perpendicular to the transect line (Figure 28).

One field technician holds the cover pole in a vertical position at the appropriate interval and records cover estimates provided by one or more technicians. Cover values are estimated from a distance of 45 feet from the cover pole at a height of five feet (the five foot height requirement ensures some level of

[8] The cover pole was developed to measure a white-tailed deer HEP model (Ashley et. al. 1998) habitat variable.

consistency between observers). Technicians use a “stick” or other device as a height/sighting reference. Cover data for each section is recorded in a data logger or on a paper data form (Table 9).

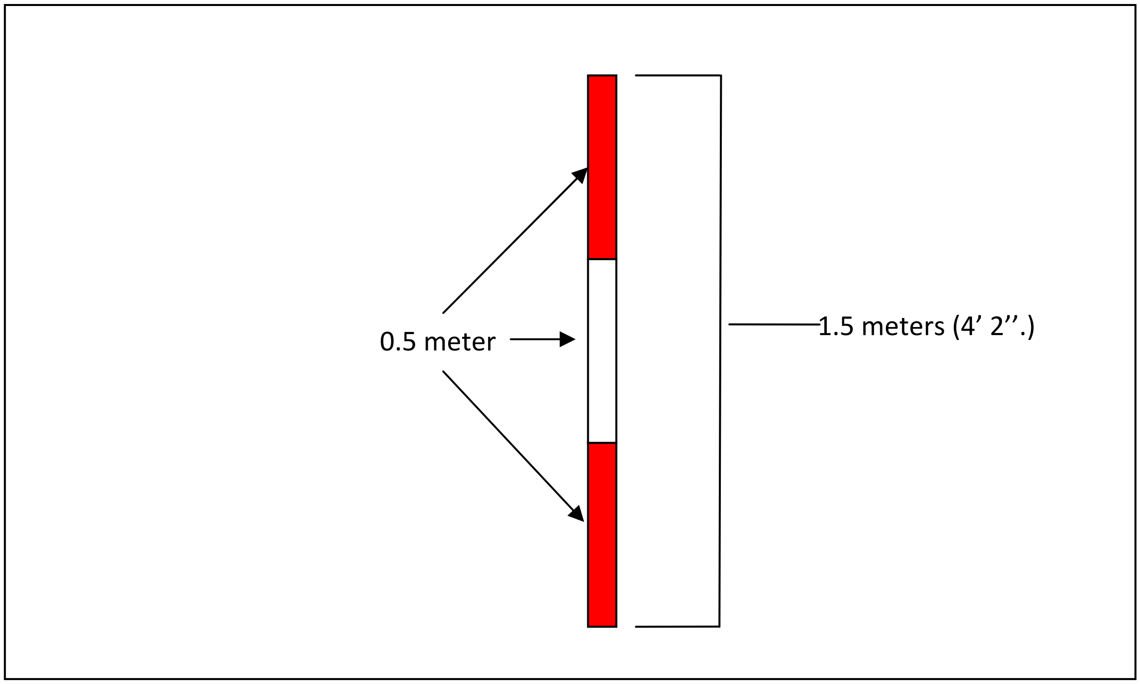

Figure 26 White-tailed deer cover pole diagram

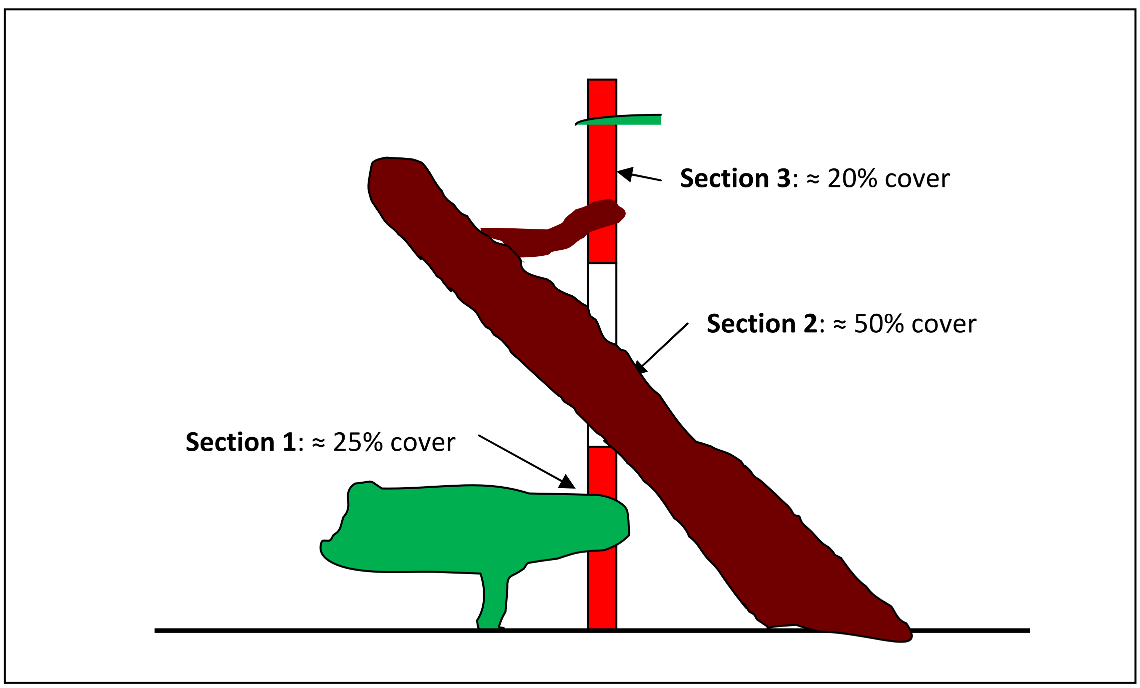

Figure 27 Percent cover example

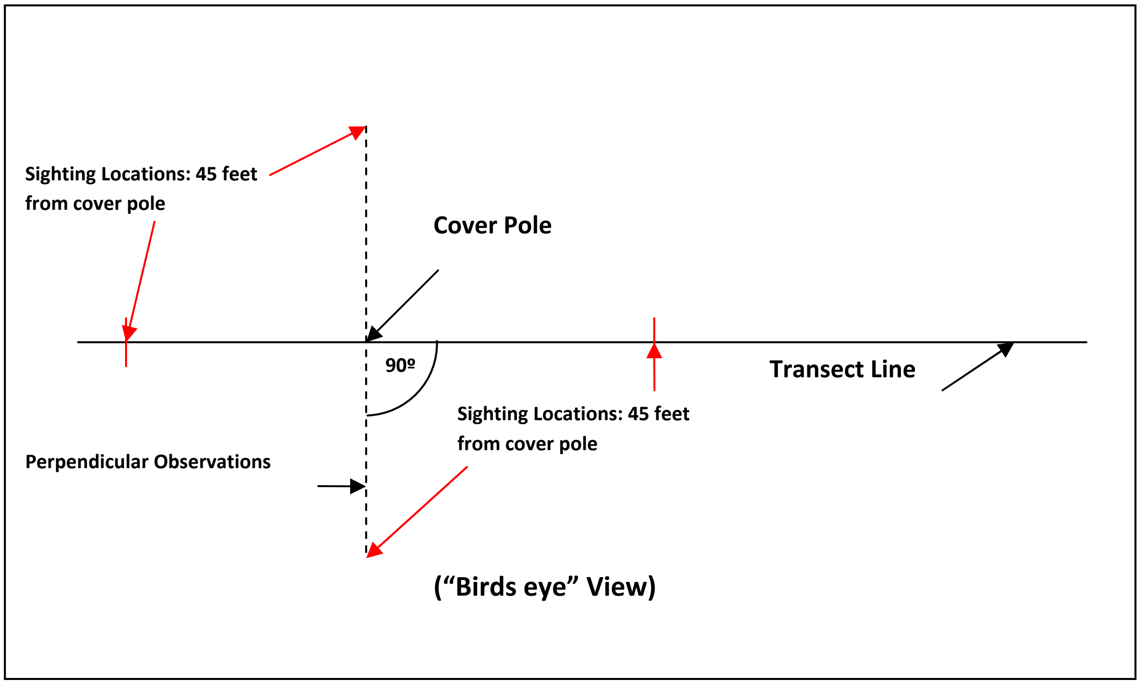

Figure 28 Cover pole measurement layout

Table 9 Data logger cover pole data spreadsheet

Sample Unit	Section	Observation Points			
		A	B	C	D
50'	Bottom				
	Mid				
	Top				
100'	Bottom				
	Mid				
	Top				

Sample Size Determination

15A. The process for determining sample size varies based on the variable measured. The RHT uses the following equation (Avery and Burkhart 1994) to determine sampling intensity for simple random samples:

$$n = \frac{t^2\ s^2}{E^2}$$

Whereas: n = number of samples

t = t value at the desired confidence interval and appropriate degrees of freedom (df)

s = standard deviation from data

E = desired level of precision or bounds

Values for “s” and “E” must be expressed in the same unit e.g., number of hits, tree height in feet, etc. The target minimum confidence level for HEP/CHAP verification transects is 80 percent (0.20) with a desired level of precision (E) of ± 20% of the mean. In contrast, the USFWS (1980) set the standard for HEP surveys at a 90 percent (0.10) confidence level with a ± 25% level of precision (E).

The following example illustrates how to determine the sample size for the shrub “hit” data listed in Table 10 using the equation described in section 15A. The number of sample units is 6 (= 600 foot transect). The transect arithmetic mean ($\bar{X}$) number of shrub “hits” is 16.16 while the standard deviation (s) is 6.11 “hits.” The “t” value at the 0.20 confidence level with 5 degrees of freedom (n – 1, or 6 – 1 = 5) is 1.476 (Appendix B).

Table 10 Sample size data set

Sample Unit	Number of Hits
1	20
2	18
3	25
4	15
5	10
6	09
$\bar{x}$	**16.16**
s	**6.11**

Substituting the transect values in the equation, we have:

$$n = \left(\frac{1.476\ x\ \ 6.11}{3.2}\right)^2$$

Solving for *n*: *n* = 7.94 or round-up to 8 sample units. To meet the desired level of precision, shrub “hit” data is needed on an additional 2 sample units for a total of 8 sample units. Stated another way, the required transect length is 800 feet. The example results indicate that we are 80% confident that the true mean ($\bar{X}$) is between 12.96 “hits” and 19.36 “hits” i.e., ± 3.2 hits from the transect mean of 16.16 “hits.”

Note: The level of precision (E) of ± 20% of the mean equates to 3.2 “hits.” This value represents 20% of the sample mean of 16.16 “hits” (0.20 x 16.16 = 3.2). The equation’s denominator is not 20%.

The equation shown in Section 15A is used with data that is not percentages. Determine sample size for percent data using the coefficient of variation (CV) equation described in Section 15B.

15B. If the allowable error is expressed as a percent of the mean and an estimate of the coefficient of variation (CV) is known, the following equation (Avery and Burkhart 1994) is used to estimate sample size:

$$n = \left[\frac{(t)^2\ (CV)^2}{A^2}\right]$$

Whereas: n = number of samples

t = t value at the desired confidence interval and appropriate degrees of freedom (df)

CV = coefficient of variation i.e., $\frac{standard\ deviation}{mean}$ x 100

A = allowable error

Substituting the same data and parameters expressed in the previous example, the equations are:

$$n = \left[\frac{(1.476)^2\ (37.81)^2}{20^2}\right]$$

$$n = \left[\frac{(2.18)\ (1429.60)}{400}\right] n = \left[\frac{(3116.53)}{400}\right]$$

n = 7.79 or round-up to 8 sample units

The difference in the estimated number of samples required as determined by the preceding two sample equations is negligible (n = 7.94 for equation 15A versus n = 7.79 for equation 15B).

15C. Other sample size equations have been used to estimate sample size. Zar (1999) suggested using the following equation to estimate an initial sample size.

$$n = \left[\frac{(\mathrm{Z}\alpha)^2\ (s)^2}{B^2}\right]$$

Whereas: n = number of samples

Z_α = the standard normal coefficient from Table 11

s= standard deviation

B = the desired precision level expressed as half of the maximum acceptable confidence interval width expressed in specific absolute value terms rather than a percentage

Table 11 Table of standard normal deviates (Z_α) for various confidence levels

Confidence Level	Alpha (α) level	Z_α
80%	0.20	1.28
90%	0.10	1.64
95%	0.05	1.96
99%	0.01	2.58

Substituting the same values used in the previous two equation examples, the estimated sample size is determined as follows:

$$n = \left[\frac{(Z\alpha)^2\ (s)^2}{B^2}\right]$$

$$n = \left[\frac{(1.28)^2\ (6.11)^2}{3.2^2}\right]$$

$$n = \left[\frac{(1.64)\ (37.33)}{10.24}\right]$$

$$n = \frac{61.22}{10.24}$$

n = 5.98 or round-up to 6 sample units

Note that the Zar (1999) equation results in fewer sample units than the previous two equations. Elzinga et. al. (2007) suggested that a sample size correction is needed because the equation under-estimates the number of sample units needed to meet the specified level of precision. Using the sample size correction table found in Appendix C, the estimated sample size is 11 sample units (6 + 5 = 11). Elzinga et. al. (2007) suggested it is easier to use the correction table than applying a more complex equation.

The Zar (1999) equation is not currently used by the RHT to estimate sample size, but has been applied by other entities. The Z_α distributions and t – distributions are nearly identical at large sample sizes; however, at small sample sizes (n < 30) the Z coefficients under-estimate the sampling units required.

15D. The "running mean" can be used to estimate sample size for most habitat variables. The RHT applies the running mean to estimate sample size for visual obstruction readings (VOR). The visual obstruction readings displayed in Table 12 are from an actual data set collected in 2009 and are used to explain how to estimate sample size based on the running mean.

Field data from each point is "averaged" when multiple observations (**A, B, C, D**) are required. The "average" value for each data point/row is displayed in the "**Mean**" column in Table 12.

The **Mean** and **Running Mean** values are the same only for sample point 1, because the data used to determine both values is identical i. e., point 1 – A, B, C, and D. The "**Mean**" and "**Running Mean**" values diverge starting with sample point 2 (Table 12).

The sample point 2 "**Mean**" is determined with just the values recorded at sample point 2 (4 values); whereas, the "**Running Mean**" value displayed for sample point 2 (1.97) is calculated from all preceding individual values i.e., values A, B, C, and D from both sample points 1 and 2 for a total of 8 values (Table 12).

Likewise, the **Running Mean** for sample point 3 (1.31) is calculated from the preceding 12 individual values (Table 12). This is repeated until the **Running Mean** "flattens out" as illustrated in Figure 29.

Table 12 Running mean calculations

Sample Point	A	B	C	D	Mean	Running Mean
1	0.25	15.00	0.50	0.00	3.94	3.94
2	0.00	0.00	0.00	0.00	0.00	1.97
3	0.00	0.00	0.00	0.00	0.00	1.31
4	0.50	0.00	0.00	0.00	0.13	1.02
5	0.25	0.00	0.00	0.50	0.19	0.85
6	0.25	0.00	0.00	0.00	0.06	0.72
7	0.00	0.00	0.00	0.00	0.00	0.62
8	0.25	0.50	0.25	0.25	0.31	0.58
9	0.50	0.00	0.75	1.00	0.56	0.58
10	0.50	0.25	0.25	0.50	0.38	0.56
11	0.50	0.00	0.25	0.50	0.31	0.53
12	0.50	0.25	0.75	1.00	0.63	0.54

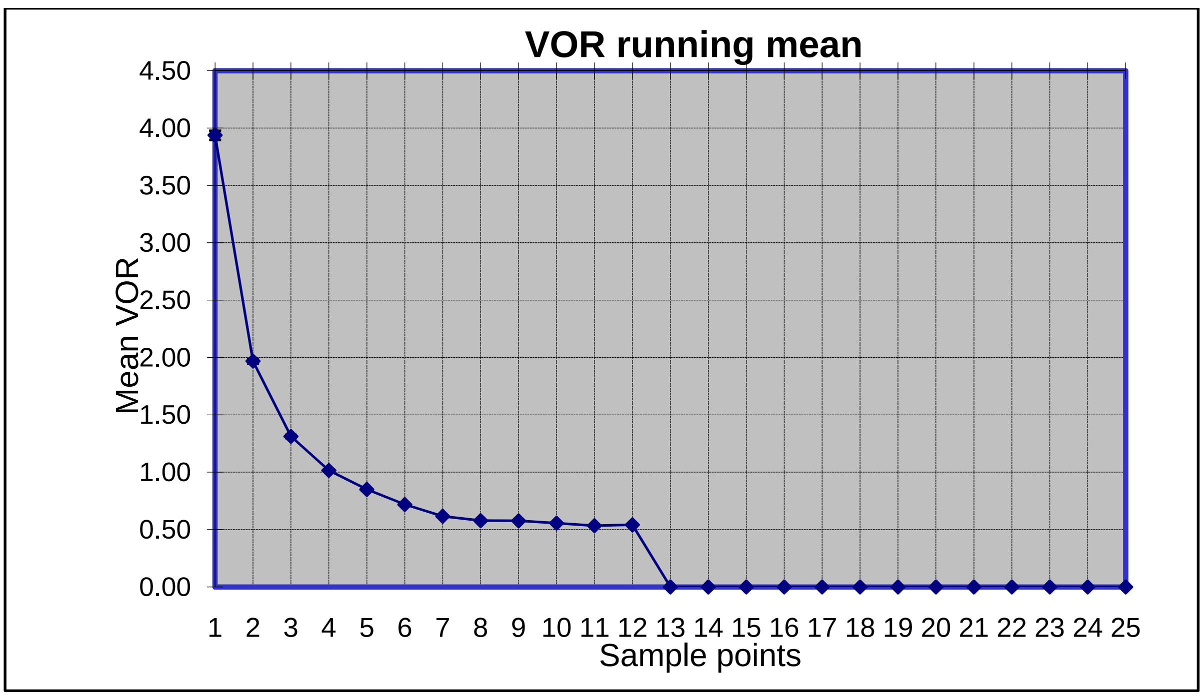

Figure 29 Running mean data display

The sample size is sufficient when the **Running Mean** varies less than ±10% for four or more consecutive sample points. In this example, the **Running Mean** did not vary more than ±10% for five sampling points as shown in Table 12 (the **Running Mean** did not exceed 0.594, which is +10%).

In addition to the running mean, the same procedure can be used to determine sample size based on the standard deviation. Elzinga et. al. (2007) suggested using both the running mean and "running standard deviation" from the same data set to determine sample size.

Acknowledgements

I want to thank the CBFWA, NPCC, and BPA staff that supported the Regional HEP Team over these many years. I also want to extend my sincere appreciation to the project managers who contributed their time and effort towards assisting the RHT and for doing all that they can to make our part of the world a better place for all wildlife species. I reserve a special thank you for Matt Berger, Sara Wagoner, Tom O'Neill, Joe DeHerrera, Peter Paquet, and Tracy Hames for their friendship, council, and personal and professional support which have made a difference in my life as a "Hepster."

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Appendix A

Transect Summary page ____ of ____

Project Area: ___________________________________ Date: ____

Cover Type: ____________________________________ Transect #: ____

Team Members:____

HEP Model(s):____ Recorder:____

	GPS #	GPS Coordinates		Mag AZ	Length
Start pt.					
Turning pt.					
Turning pt.					
Turning pt.					
End pt.					

Datum: **NAD 27** or other_______

METHODS/TECHNIQUES (check box if measurements taken, circle/fill-in methods applied)

☐ Transect Layout (Equipment): Compass GPS other:______

☐ Micro-plot: 0.1m^2 (sq.) 0.5m^2(rect.) other:________
- o Interval: 25 ft. 20 ft. 10 ft. other_______
- o Sample Unit Size: Independent 100 ft. other:______
- o Height Unit of Measure: 0.10 ft other:______

☐ Shrub: Line-intercept Point-intercept other____________
- o Interval (point-intercept): 2 ft. 5 ft 10 ft other:_____ft.
- o Sample Unit Size: 100 ft or other:______
- o Height Unit of Measure: 0.10 ft. or other:______

☐ VOR: Interval: 50ft 25ft 20ft other:______
- o Sample Unit Size: Independent or other:_____ft

☐ Tree: Interval: 10ft 5ft other:_________
- o Estimated Ht. or Measured Ht [clinometer FOR stick digital]
- o Height Unit of Measure: Feet or other:______
- o Canopy cover (equip. used) : Desitometer or other:________

☐ Snag: Height Unit of Measure: Feet or other:______

- o Belt Width: 44 ft or other:_____ Belt Length: 100 ft or other:_______
- o Circular (radius): 37 ft or other:_________

Phenologic Status of Indicator Plants:

Species:____

Status (circle one): bloom______% budding______% leaf_______% seeding_____%

Species:____

Status (circle one): bloom______% budding______% leaf_______% seeding_____%

Species:____

Status (circle one): bloom______% budding______% leaf_______% seeding_____%

Vegetation overview:

Exotic veg.____

____

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Key herbaceous/shrub/tree sp.____

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____

Weather Conditions: sunny rain snow sleet/hail overcast______% wind____mph

NOTES:

Appendix B

Table 13 Student's "t" table

df	0.5	0.4	0.3	0.2	0.1	0.05	0.02	0.01	0.001
1	1.000	1.376	1.963	3.078	6.314	12.706	31.821	63.657	636.619
2	0.816	1.061	1.386	1.886	2.920	4.303	6.965	9.925	31.599
3	0.765	0.978	1.250	1.638	2.353	3.182	4.541	5.841	12.924
4	0.741	0.941	1.190	1.533	2.132	2.776	3.747	4.604	8.610
5	0.727	0.920	1.156	1.476	2.015	2.571	3.365	4.032	6.859
6	0.718	0.906	1.134	1.440	1.943	2.447	3.143	3.707	5.959
7	0.711	0.896	1.119	1.415	1.895	2.365	2.998	3.499	5.408
8	0.706	0.889	1.108	1.397	1.860	2.306	2.896	3.355	5.041
9	0.703	0.883	1.100	1.383	1.833	2.262	2.821	3.250	4.781
10	0.700	0.879	1.093	1.372	1.812	2.228	2.764	3.169	4.587
11	0.697	0.876	1.088	1.363	1.796	2.201	2.718	3.106	4.437
12	0.695	0.873	1.083	1.356	1.782	2.179	2.681	3.055	4.318
13	0.694	0.870	1.079	1.350	1.771	2.160	2.650	3.012	4.221
14	0.692	0.868	1.076	1.345	1.761	2.145	2.624	2.977	4.140
15	0.691	0.866	1.074	1.341	1.753	2.131	2.602	2.947	4.073
16	0.690	0.865	1.071	1.337	1.746	2.120	2.583	2.921	4.015
17	0.689	0.863	1.069	1.333	1.740	2.110	2.567	2.898	3.965
18	0.688	0.862	1.067	1.330	1.734	2.101	2.552	2.878	3.922
19	0.688	0.861	1.066	1.328	1.729	2.093	2.539	2.861	3.883
20	0.687	0.860	1.064	1.325	1.725	2.086	2.528	2.845	3.850
21	0.686	0.859	1.063	1.323	1.721	2.080	2.518	2.831	3.819
22	0.686	0.858	1.061	1.321	1.717	2.074	2.508	2.819	3.792
23	0.685	0.858	1.060	1.319	1.714	2.069	2.500	2.807	3.768
24	0.685	0.857	1.059	1.318	1.711	2.064	2.492	2.797	3.745
25	0.684	0.856	1.058	1.316	1.708	2.060	2.485	2.787	3.725
26	0.684	0.856	1.058	1.315	1.706	2.056	2.479	2.779	3.707
27	0.684	0.855	1.057	1.314	1.703	2.052	2.473	2.771	3.690
28	0.683	0.855	1.056	1.313	1.701	2.048	2.467	2.763	3.674
29	0.683	0.854	1.055	1.311	1.699	2.045	2.462	2.756	3.659
30	0.683	0.854	1.055	1.310	1.697	2.042	2.457	2.750	3.646
40	0.681	0.851	1.050	1.303	1.684	2.021	2.423	2.704	3.551
60	0.679	0.848	1.045	1.296	1.671	2.000	2.390	2.660	3.460
120	0.677	0.845	1.041	1.289	1.658	1.980	2.358	2.617	3.373
∞	0.674	0.842	1.036	1.282	1.645	1.960	2.326	2.576	3.291

Appendix C

Table 14 Z_α distribution sample size correction table

80% confidence level						90% confidence level					
n	n*	n	n*	n	n*	n	n*	n	n*	n	n*
1	5	51	65	101	120	1	5	51	65	101	120
2	6	52	66	102	121	2	6	52	66	102	122
3	7	53	67	103	122	3	8	53	67	103	123
4	9	54	68	104	123	4	9	54	69	104	124
5	10	55	69	105	124	5	11	55	70	105	125
6	11	56	70	106	125	6	12	56	71	106	126
7	13	57	71	107	126	7	13	57	72	107	127
8	14	58	73	108	128	8	15	58	73	108	128
9	15	59	74	109	129	9	16	59	74	109	129
10	17	60	75	110	130	10	17	60	75	110	130
11	18	61	76	111	131	11	18	61	76	111	131
12	19	62	77	112	132	12	20	62	78	112	132
13	20	63	78	113	133	13	21	63	79	113	134
14	22	64	79	114	134	14	22	64	80	114	135
15	23	65	80	115	135	15	23	65	81	115	136
16	24	66	82	116	136	16	25	66	82	116	137
17	25	67	83	117	137	17	26	67	83	117	138
18	27	68	84	118	138	18	27	68	84	118	139
19	28	69	85	119	140	19	28	69	85	119	140
20	29	70	86	120	141	20	29	70	86	120	141
21	30	71	87	121	142	21	31	71	88	121	142
22	31	72	88	122	143	22	32	72	89	122	143
23	33	73	89	123	144	23	33	73	90	123	144
24	34	74	90	124	145	24	34	74	91	124	145
25	35	75	91	125	146	25	35	75	92	125	147
26	36	76	93	126	147	26	37	76	93	126	148
27	37	77	94	127	148	27	38	77	94	127	149
28	38	78	95	128	149	28	39	78	95	128	150
29	40	79	96	129	150	29	40	79	96	129	151
30	41	80	97	130	151	30	41	80	97	130	152
31	42	81	98	131	152	31	42	81	99	131	153
32	43	82	99	132	154	32	44	82	100	132	154
33	44	83	100	133	155	33	45	83	101	133	155
34	45	84	101	134	156	34	46	84	102	134	156
35	47	85	102	135	157	35	47	85	103	135	157
36	48	86	104	136	158	36	48	86	104	136	158
37	49	87	105	137	159	37	49	87	105	137	159
38	50	88	106	138	160	38	50	88	106	138	161
39	51	89	107	139	161	39	52	89	107	139	162
40	52	90	108	140	162	40	53	90	108	140	163
41	53	91	109	141	163	41	54	91	110	141	164
42	55	92	110	142	164	42	55	92	111	142	165
43	56	93	111	143	165	43	56	93	112	143	166
44	57	94	112	144	166	44	57	94	113	144	167
45	58	95	113	145	168	45	58	95	114	145	168
46	59	96	115	146	169	46	60	96	115	146	169
47	60	97	116	147	170	47	61	97	116	147	170
48	61	98	117	148	171	48	62	98	117	148	171
49	62	99	118	149	172	49	63	99	118	149	172
50	64	100	119	150	173	50	64	100	119	150	173

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