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FOREST HEALTH MONITORING

Vegetation Pilot Field Methods Guide

Vegetation Diversity and Structure
Down Woody Debris
Fuel Loading

May 1999

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National Forest Health Monitoring Program - Research Triangle Park, NC 27709

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Section/Title Page

1 Project Summary

1.1 Introduction

The Forest Health Monitoring Program is a national program that makes annual evaluation of the condition, changes, and trends in health of forest ecosystems in the U.S. The evaluation of health is based on the sustainable forest management criteria stated in the Santiago Agreement (Stolte, 1997). The principle ecological criteria in the agreement are productivity, diversity, vitality, conservation of soil and water, and carbon cycling. This pilot project is intended to test three vegetation indicators (understory diversity and general vegetation structure, down woody debris, and fuel loading) that will provide data to better evaluate diversity, vitality, conservation of soil, and carbon cycling. The variables collected in this field pilot will also provide information to evaluate the suitability of forest stands as habitat for wildlife.

The current FHM methods for evaluating understory plant diversity were modified for two reasons: (1) the total area sampled was too small (12m^2, twelve 1-m^2 quadrats), and (2) the single-scale approach was inadequate to evaluate plant diversity in patchy and heterogeneous habitats (i.e., most habitats on earth). Using multi-scale vegetation plots in forests and rangelands from Colorado to Minnesota, we found that ten 1-m^2 subplots captured only 40 percent to 50 percent of the plant species in a 0.1 ha area (Stohlgren et al. 1995, 1997a, 1998c). Half the exotic species in rangelands were missing with a series of 1-m^2 plots (Stohlgren et al. 1998b). The twelve 1-m^2 quadrats historically used in the FHM program probably captured even fewer native and exotic plant species in forested sites due to their patchy distributions in canopy gaps. The single-scale, 1-m^2 quadrats would gather very incomplete data on plant diversity and exotic species primarily because most plant species are locally rare (>50% of the species have <1% foliar cover) and because plants are never randomly distributed on the plot or landscape (an underlying assumption of systematic sampling) (Stohlgren et al. 1998a).

We modified the previous FHM methodology in two ways. First, qualified botanists were added to FHM field teams. Highly

qualified botanists were needed to field-identify nearly all the species at each site, including many locally rare species and invasive species from Europe, Asia, Africa, and Australia. Second, we augmented the sampling strategy of the FHM program. For a random subset of FHM plots in various forest types in different regions, an extended survey of plant diversity was conducted. In each plot we recorded cover by species in the twelve 1-m^2 quadrats and quickly surveyed the presence of all native and exotic species for each of the four subplots. This provided multi-scale data on plant diversity (i.e., quadrat, subplot, and plot-level information) that was used to evaluate species richness patterns (hot spots), areas of exotic plant invasion and spread, spatial variation on monitoring results and influences of spatial scale, and species-environment data for predictive modeling (Stohlgren et al. 1998a).

The preliminary data from Colorado show interesting and important trends. The plots were not in particularly species-rich areas, but exotic plant species have successfully invaded the most species-rich sites. This pattern has also been observed in Rocky Mountain National Park (Stohlgren et al. 199a) and in riparian zones in the Central Grasslands (Stohlgren et al. 1998b). These findings contradict generally accepted theories and small-scale experiments that suggest areas of low diversity and cover (or productivity) should be more easily invaded than species rich areas that presumably monopolize resources to inhibit invasions. Since exotic species invaded both grazed and ungrazed sites, grazing may not be a primary factor affecting exotic species richness and cover in some of these vegetation types. These results are consistent with Rocky Mountain grasslands in Montana, Wyoming, South Dakota, and Colorado (Stohlgren et al. 1999b).

Some vegetation types appear more vulnerable to invasion by exotic plants. We are particularly concerned about the high richness and cover of invasive species in aspen plots. Similar trends were reported for a few aspen stands in Rocky Mountain National Park (Stohlgren et al. 1997a). These aspen stands contain high native species richness and often have unique species assemblages of native plants, birds, and butterflies (Simonson 1998) and provide important habitat for elk, deer,

and moose. Native species may be particularly threatened in the rare and patchy habitats.

Assessing land-use practices will require additional data. Rangelands had significantly greater exotic species richness and cover than the other land-use types, but the grazing results were ambiguous without additional data on soil fertility and resource availability. Other factors such as ground disturbance by small mammals, proximity to disturbed roadsides, riparian zones and infested urban sites, etc., may be major contributors to these trends.

A greatly expanded FHM data set will document hot spots of native plant diversity and primary areas of invasion by exotic species, determine the effects of land-use practices on plant diversity, and aid in evaluating the health of the nation's forests. Such information is vital to adapting management strategies, prescribing control efforts for invasive species, and monitoring the preservation of native biodiversity. The multi-scale vegetation sampling methods are directly comparable to multi-scale vegetation sampling techniques used by the U.S. Geological Survey, National Park Service, Bureau of Land Management, Smithsonian Institution, and others. This greatly expands the potential for local, regional, and national evaluations of plant diversity. The current sampling strategy could be improved by stratified sampling in rare and important habitats (frequently missed in the FHM sampling grid), and by developing comparable data sets in non-forested areas.

1.2 Citations

Stohlgren, T. J., M. B. Falkner, and L. D. Schell. 1995. A modified-Whittaker nested vegetation sampling method. Vegetatio 117:113-121.

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Stohlgren, T.J., K.A. Bull and, Y. Otsuki. 1998b. Comparison of rangeland sampling techniques in the central grasslands. Journal of Range Management 51:164-172 March 1998.

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2 Vegetation Diversity and Structure

2.1 Introduction

The methods are designed to quantify number and abundance of forest-dependent species, quantify number of native and number of exotic species, and determine the vertical structure of the vegetation. The method tested will be based on the original vegetation method developed and tested by FHM (Cline et al., 1991), with further enhancements based on recent (last 10 years) research on methodology to quantify understory diversity (Stohlgren et al., 1997b), and changes in the vertical structure based on analysis of repeatability of multiple vertical strata sampling by Stapanian et al. (1997). We will address the diversity and vertical structure of the forested stand by sampling the following four strata in the vegetation quadrats, microplot, and subplot:

stratum 1: 0-2 ft (0-0.61 m)–number and abundance of species (vegetation quadrat and subplot)
stratum 2: 2-6 ft (0.61-1.83 m)–number and abundance of species (vegetation quadrat and subplot)
stratum 3: 6-16 ft (1.83-4.88 m) (mid-story)-- cover of tall shrubs or tree saplings
stratum 4: > 16 ft (> 4.88 m) (overstory)-- cover of trees

Diversity data:

1. Species number and abundance (based on cover) of all species on all 12 1-m^2 quadrats in four subplots, in vertical strata 1 and 2:

Vegetation Strata

Code	Definition	Stratum Height
1	Ground/ bryophyte/low-shrub, herb and grass layer	0-2 ft (0-0.61 m)
2	High shrub, herb, and grass layer, and low hanging tree branches	2-6 ft (0.61-1.83 m)

2. Species presence on all four subplots that are not found on quadrats. Cover estimates were not found to be accurate enough or repeatable.

3. Unknown plant species are assigned a standardized NRCS Plants Database code, traceable from the unknown label to the plot data sheet (Figure 1). Individual species are collected off subplot, pressed and labeled, and sent to a cooperating herbarium for identification.

4. Evaluate the degree of disturbance to the vegetation quadrat and the dominant microhabitat using the following codes:

Disturbance Codes (Trampling)

Code	Definition		Example
1	none/slight	0-10% of quadrat disturbed	Natural, pristine or undisturbed
2	moderate	>10-50% of quadrat disturbed	Some trampling, animal activity
3	heavy	>50% of quadrat disturbed	Hiking trail runs through plot, etc.

Microhabitat Variables (estimate % cover in 1% classes)

Code	Definition
1	Dead wood; log and slash (> 10cm diameter), stump
2	Dung
3	Lichen
4	Litter/Duff; accumulation of organic matter over forest mineral soil, including branches and limbs
5	Live root/bole; living roots at the base of trees or exposed at the surface of the forest floor or soil and cross-sectioned area of live tree boles at ground-line
6	Mineral soil/Sediment; physically weathered soil parent material that may or may not also be chemically and biologically altered
7	Moss
8	Road
9	Rock; a large rock or boulder or accumulations of pebbles or cobbles
10	Standing water/flooded; ponding or flowing water that is not contained within banks
11	Stream; body of flowing water contained within banks
12	Trash/junk

5. Condition class codes are recorded for each quadrat and are numbered sequentially as they are encountered.

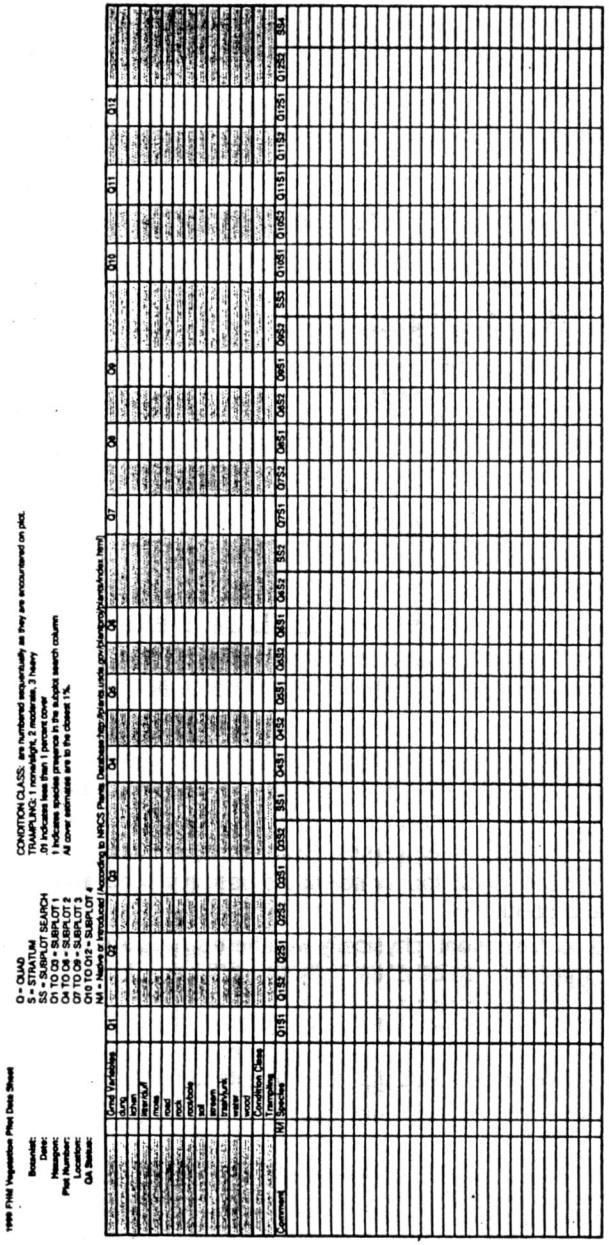


Figure 1. Vegetation Diversity Data Sheet

2.2 Training Plan

The Vegetation Indicator Pilot will continue into 1999 with 8 crews focused on ecoregion sections in the Northeast. The goal is to see how comprehensive an evaluation we can do at an ecoregion section level. Some streamlining and fine-tuning will be done to the methods this year based on last year's results. We are currently working with FHM Information Management to design and implement the data apparatus necessary for quick and efficient data crunching in 1999. Electronic data files will be sent directly from the field to the data base for rapid initial data summary and analysis. Botanists will be trained together in New Hampshire on Vegetation Indicator methods and then complete the regional trainings with their teams. Indicator Lead Kelly Rimar and Florence Peterson will train each regional botanist and trainer. Training will include: plot set-up, collecting data, collecting unknown plant samples, use of palmtops, and methodology.

1. Botanists will attend the New Hampshire vegetation indicator training. This will ensure that all botanists receive the same information. Botanists will then travel to regional trainings and join their teams. Vegetation Indicator information that involves forester team members will be included in the regional training. The goal is to promote team work.

2. Perform hot audit (quality control audit), i.e., audit botanists while they are installing first plots in order to correct any errors in performance of the method. Hot audits are typically done immediately following training to improve data collection.

3. Perform cold audit (quality assurance audit), i.e., audit vegetation pilot crew after they have installed plot (random selection). This is typically done during the field season.

2.3 Plot Establishment

1. Foresters relocate plot and center pins for subplots and microplots (Figure 2). Foresters then lay DWD (down woody debris) transect lines (T1-T3) and pin 2 corners (15 ft and 18.3 ft [4.57 m and 5.57 m]) for vegetation quadrats (Q1-Q3) on each transect as it is put in, and place flag on the edge of subplot to retain azimuth and distance measures (plot center-to-subplot edge). Foresters then move on to subplot 2, recheck center and microplot pins, and establish DWD transects and vegetation quadrats. Botanist begins vegetation diversity and fuel loading work on subplot 1 as foresters move on to subplot 2 to establish pins.

Specifically:

a. Foresters run tape at 30 degrees azimuth to edge of annular plot (59 ft [18 m]). Put 2 permanent pins in the ground along transect at 15 ft and 18.3 ft (4.57 m and 5.57 m), and 2 temporary flags to mark the corners of the 1-m^2 quadrats as indicated in Figure 2. Put temporary flags in ground along transect line at 24 ft [7.32 m] (edge of subplot) and 59 ft [18 m] (edge of annulus). Foresters repeat for T2/Q2 (150 degrees) and T3/Q3 (270 degrees).

b. Botanist uses 1-m^2 pvc quadrat to lay out the rest of vegetation quadrat Q1. Puts flags in at corners to avoid trampling. Botanist then begins to evaluate species ID and cover for all species in stratum 1 (0 - 2 ft [0-0.61 m]) and stratum 2 (2 - 6 ft [0.61-1.83 m]), and ground variables in stratum 1 as described in FHM field guide. Botanists repeats in Q2 and Q3. Remove flags of Q1-Q3 but not pins at 15 ft (4.57 m) and 18.3 ft (5.57 m).

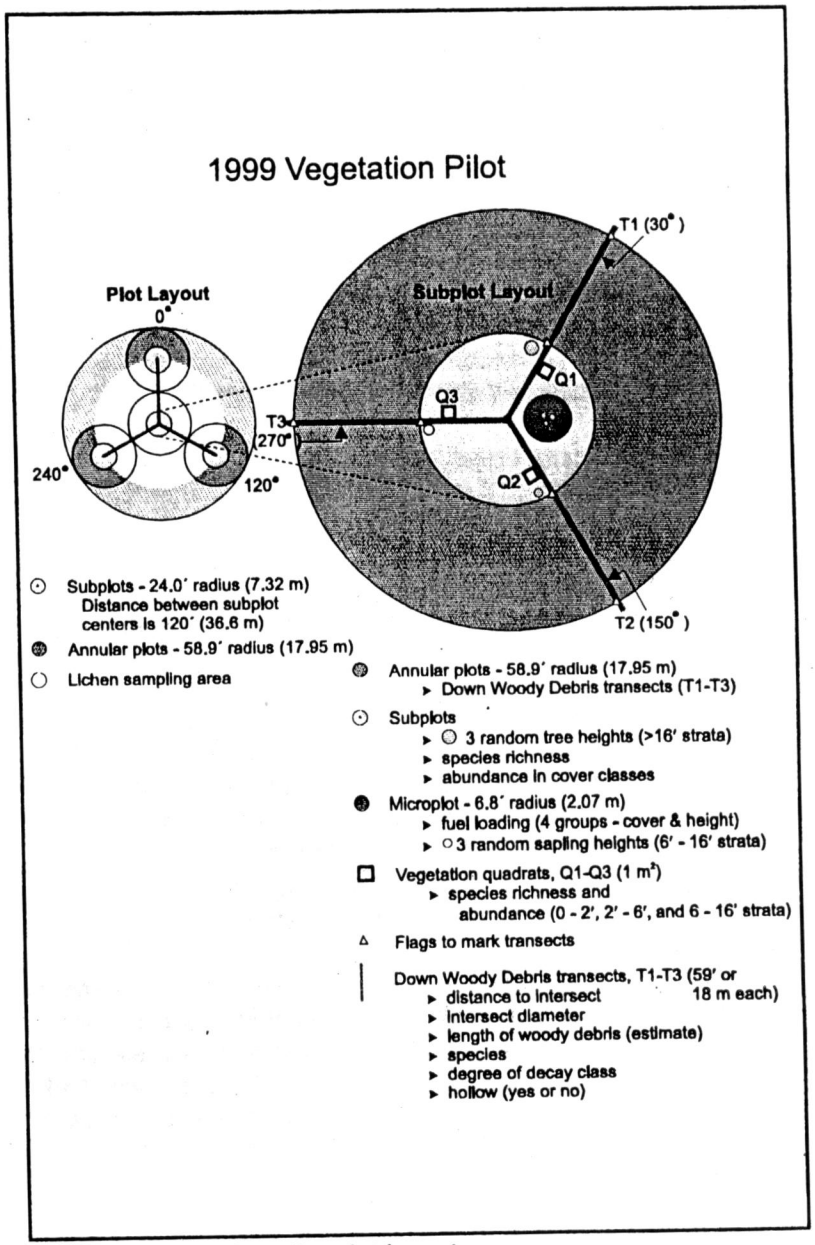


Figure 2. Vegetation pilot plot layout.

c. Botanist then surveys rest of subplot and records species ID and presence of any species not found in Q1-Q3. Botanist estimates cover and depth **by group** of grasses, shrubs, slash (wood <1 inch [2.5 cm]), litter and duff in microplot.

d. Botanist fills out vertical structure data sheet for subplot.

e. Botanist then moves to subplots 2-4 and repeats.

f. Botanist then returns to subplot 1, and with help of foresters if they are done with TALLY, runs tape along flagged transect (center point to flags at subplot and annular plot edge), and measures DWD along transects T1-T3.

2. Foresters move back to subplot 1 to begin TALLY. Botanist moves on to subplots 2, 3, and 4. In theory, botanist stays ahead of foresters' TALLY to avoid trampling of understory by foresters during TALLY.

3. After foresters have completed TALLY and botanist has completed vegetation diversity and fuel loading, foresters and botanist work together to complete DWD line transects measurements. If foresters finish before botanist finishes vegetation diversity and fuel loading, foresters help botanist. If botanist finishes vegetation diversity and fuel loading before foresters, botanist helps foresters.

4. Unknown plants that have been pressed on site are mailed to the herbarium at the University of North Carolina-Chapel Hill for species identification. At a minimum, we want to know the number of unique species at the site, even if all identifications cannot be made due to the stage of growth at time of collection (particularly for herbs and grasses).

2.4 Vegetation Data Collection and Analysis

Level 1 (1 m^2) = Twelve 1-m^2 quadrats
Level 2 (168 m^2) = Four 168-m^2 subplots
Level 3 (672 m^2) = plot
Level 4 = plot to plot comparisons

Data will be recorded using palmtop computers. Each of these computers uses Windows CE™ as its operating system. Data will be collected using the Pocket Excel™ program. This program is compatable with the Desktop version of Excel™. Blank Excel templates for entering data will be pre-loaded onto each machine and are specific to each indicator (i.e., Veg, dwd, Fine Fuels). Data files are to be saved using the seven-digit hexagon number plus *v* for vegetation, *d* for dwd, and *f* for fuels. Do not use spaces, dashes, or commas in the file name.

It is very important to include all of the plot identifying information listed at the top of the data sheets. Always record cover to the nearest one percent. To indicate less than one percent or trace, use the number 0.01. When encountering a new species in the subplot search, enter the species code in the species column and a number 1 in the subplot search column. Species code should be edited to the NRCS format before sending files. These codes will be made available in a booklet. They can also be retrieved from the NRCS Plants Database via the Internet: *http://plants.usda.gov/plantproj/plants/index.html*

Refer to the example data sheet for specifics (Figure 3). Save all files to the hard drive and a back-up copy to the flash card. At the end of each day, after any edits, download files to a laptop computer. From here make a copy on a floppy. Send disks to the Information Management team at the following address:

Brian Cordova
Harry Reid Center
UNLV
4505 S. Maryland Parkway
Las Vegas, NV 89154-4009

Files can also be sent as an attahcment on an email. Brian's email is *cordovab@nevada.edu.* If you have any questions, Brian can be reached at (702)895-4087.

2.4.1 Summary Information needed for Analysis

Level 1 (1 m^2) = Twelve 1-m^2 quadrats:
- average number of species
- cumulative number of species
- average number of native and exotic species
- cumulative number of native and exotic species
- cumulative number of unknowns
- average native and exotic cover

Level 2 (168 m^2) = Four 168-m^2 subplots
- average number of species
- cumulative number of species
- average number of natives and exotics
- cumulative number of natives and exotics
- cumulative number of unknowns
- average native and exotic cover

Level 3 (672 m^2) = Plot (four subplot totals)
- average number of species
- cumulative number of species
- cumulative number of natives and exotics
- cumulative number of unknowns
- average native and exotic cover
- 5 most dominant species in % average cover
- number of native and exotic species that make up:

  <1%
  1 - 5%
  6 - 25%
  26 - 75%
  >75%

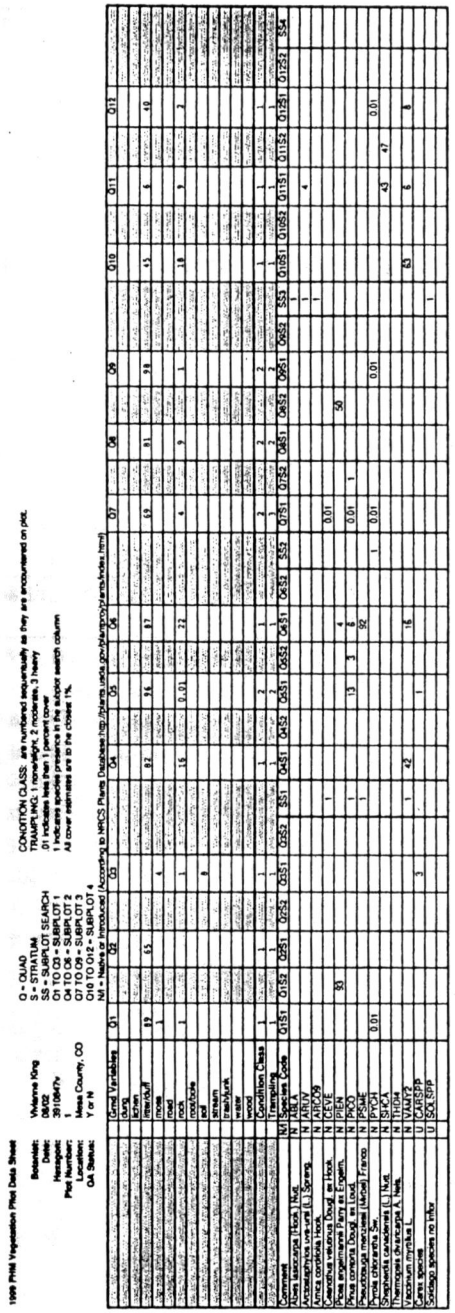


Figure 3. Example completed data sheet.

2.3.2 Analysis

Jaccard's Coefficient - J = A / (A + B + C)
- A = total in plot 1 and plot 2
- B = total in plot 1
- C = total in plot 2

Regression analysis and variance
- log area and cumulative species relationships
- variance
- means
- standard error of mean

Species area curves
Diversity indices

2.5 Equipment List (list continues on page 13)

Equipment	Personal Field Gear	Miscellaneous	In Each Vehicle
C Map	I Insect and tick repellent	I Field Guide	Tire chains
C GPS	I Bee sting antidote	I How to guide	First aid kit
I Compass	I Snake bite antidote	B Dissecting kit	Flashlight for glovebox
I Loggers tape/ refill	I Watch	B Dissecting scope	Tow strap
B Botanists need 2 tapes	I Rain gear	B Illuminator	Handiman (Hilift) Bumper jack
C Permanent quad stakes or tent stakes and quiver	I Binoculars	C Access to a laptop	Shovel
I Hammer	I Whistle	I Utility strip	Credit card for gas/service
I Flags	I Water filter	I Floppy disks	Emergency service/ towing info for vehicle
B 1 m^2 quadrat frame	I Day pack	B Palmtop manual	Accident/insurance info
B Quadrat levelers (legs)	I Lip balm	B Connectivity pack	Road maps
B Carpenters ruler	I Cooler	I Camera & film	CB radio
C Clinometer	I Sunglasses	B Binder for field Herbarium	Spare tire, jack, etc.

Equipment	Personal Field Gear	Miscellaneous	In Each Vehicle
B Calipers (DWD)	I Sunscreen	B Box for shipping unknown species	
C PDR	I Hat	I $ log & receipt envelope	
B Palmtop Computer	C 2-5 gal water/water bottles	I Extra batteries for camera and palmtop	
B Palmtop batteries	I Cruiser vest	I Extra film	
I Back-up data sheets	I Knife/leatherman		
I Field notebook	I Snake leggings		
I Pencil/sharpies	I Cold weather clothes		
I Clipboard	I Gaiters		
B Species lists	I Gloves		
B Local flora keys	I Backpack/frame pack		
B Hand lens	I Camping gear: (if needed)		
B Digger/trowel	Sleeping bag/pad		
B Labels for unknowns	Tent/grnd cloth		
B 1-gal plastic bags (ziploc type) for unknowns	Headlamp/flashlight		
	Stove/propane		
	Cookware/cutlery		
B Plant presses	Towel		
	Toilet paper		
B Newspaper/cardboard	Waterproof matches/lighter		
	sm garbage bag		
B Lrg plastic box w/lid to store plant samples	folding chair		
	folding table for keying		
B Mailing instructions for unknown species/ vouchers			
C Emergency blanket			
C First aid kit			
C Cell phone			

C = Crew
B = Botanist
I = Individual

2.6 Vegetation Structure Measurements

2.6.1 FHM Plot Layout for Vegetation Structure Measurements

Foresters relocate plot and center pins for subplots and microplots (Figure 4). Note: all distances are horizontal distance, transect line distance is corrected for slope. Subplot centers are 120 ft (36.6 m) apart. The outer subplots are located by sighting 0, 120, and 240 degree azimuths from the center pin of the center subplot and walking in each direction 120 ft (36.6 m). Foresters then locate Down Woody Debris (DWD) transect lines (T1, T2, T3) and permanently mark (using stakes) the two quadrat corners at 15 ft (4.57 m) and 18.3 ft (5.57 m) on each transect as it is put in. The DWD transects are located by sighting the 30, 150, and 270 degree azimuths and walking in each direction for 59 ft (18 m). The DWD transect line is marked with a flag at 24 ft (7.32 m) (edge of subplot) and 59 ft (18 m) (edge of annular plot). Place the quadrat frame to the right of the transect line at the marked quadrat corners and flag the four corners. This is to prevent trampling. Microplots are located 12 ft (3.7 m) at a 90 degree azimuth from the subplot center. The radius of the microplot is 6.8 ft (2.07 m) (Figure 5). Flags mark the perimeter of the circle. To make cover estimates easier, four flags are placed along the perimeter, dividing the circle visually into quarters. Use the quadrat as a reference for the smaller cover classes. A quadrat is a little greater than 7% of the microplot (7.4%)

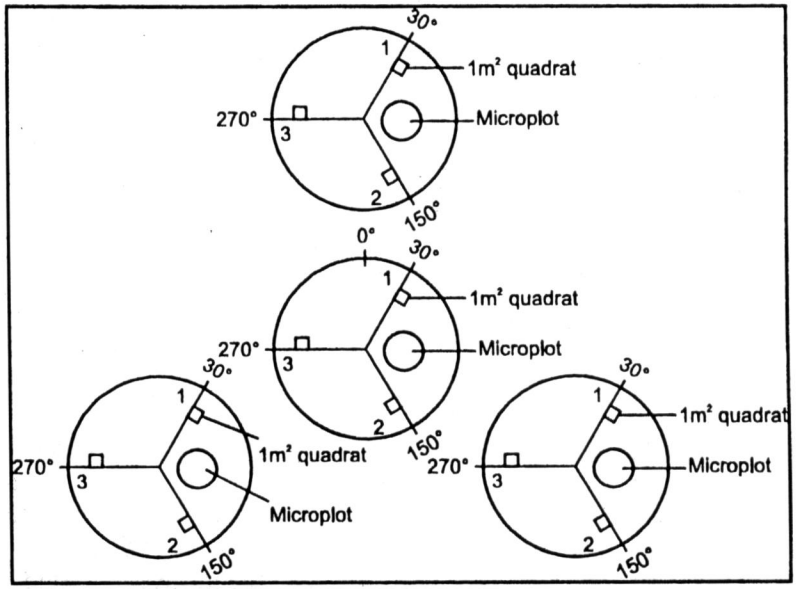


Figure 4. FHM plot layout for vegetation structure measurements (not drawn to scale).

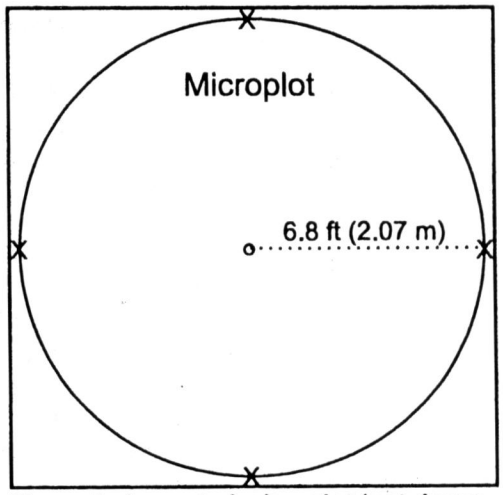


Figure 5. Layout of microplot (not drawn to scale). X = placement of temporary flags for fuel-loading cover estimates.

2.6.2 Vegetation Diversity Measurements

Vegetation measurements are taken in small 1-m^2 quadrats. On each quadrat, three basic types of data are recorded: (1) species identification, (2) strata, and (3) plant canopy cover to the nearest 1%. The botanist first identifies the plant and records a six letter code in the species column of the data sheet. These six letters stand for the first three letters of the species and genus. An example would be *Bromus inermis* or broine. In the case of two plants that have the same six letter code, add a letter to the genus. Codes must be edited to the NRCS code before sending data files.

Next, record what stratum the plant is in and estimate the cover to the nearest percent. There are two strata. Stratum 1 is from 0 to 2 ft (0 to 0.61 m) and stratum 2 is from 2 ft to 6 ft (0.61 m to 1.83 m). A height pole or plot frame legs are used to delineate the two strata. Record cover of the following ground variables: wood, water, rock, roots, duff/litter, soil, trail/road, litter, moss, dung, and other (trash, bones, etc.). Reord the condition class and trampling codes. Condition class information can be found in the *1999 Forest Health Monitoring Field Methods Guide* (p. 1-40, Section 1.6.2.3), and trampling code information is available at the top of the data sheet.

Each 1-m^2 quadrat frame is calibrated to make cover estimates easier (Figure 6). Only estimate cover on plants or portion of plant that falls inside the quadrat frame. Visually group species together into a percent cover. Fine tune that estimate by subtracting out any spaces or gaps. Familiarize yourself with what certain cover estimates (e.g., 1%, 10%, 15%, etc.) look like and use them as reference sizes. For example, if you know that 1% cover is about the same size as your fist, use your fist as a reference size. There will often be overlap of plant species. Therefore, your total cover for a plot may exceed 100%. Because plants are recorded by strata, there will be species that occur in both strata with different cover estimates. The most important thing is to be consistent. After completing the three quadrats on a subplot, the botanist does a walking search of the entire subplot and records any new species encountered (not found in quads). Enter the species code in the species column and record a 1 in the subplot search column to

indicate presence. This is a good time to make comments about the subplot as a whole.

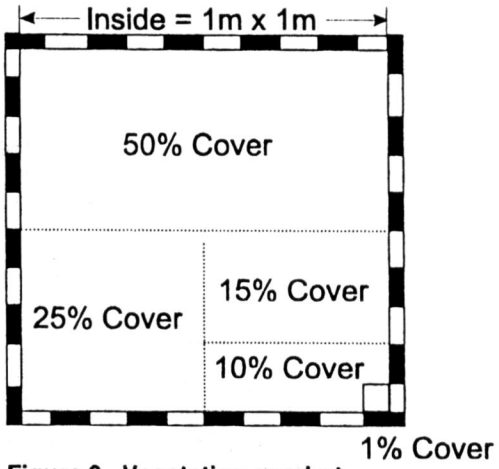


Figure 6. Vegetation quadrat.

2.6.3 Recording and Collecting Unknown Plant Species

Unknown plant specimens should be recorded using a descriptive code. Avoid using things like grass 1 and grass 2. Use something that helps to remember that plant, for example, *bgumbl* for a big umbel or *hairyst* for a hairy stem herb. You may run into that plant somewhere down the line, only this time it has a great seed head that allows you to key it to species. Make a note referring to the unknown collected earlier. Include any descriptive notes in the comments column of the data sheet. Specimens of all plants present in the quadrats that cannot be confidently identified to species should be collected off-plot, labeled, pressed, and dried for shipping and subsequent identification by the field botanist or a cooperating herbarium. Botanists are encouraged to make their own collections. When collecting a plant, use a good digging tool. Make sure to collect as much of the plant as possible, including roots, flowers, fruit, etc. Take detailed descriptive notes about each plant collected. This will help you or the follow-up botanist in their keying efforts. Each botanist will be issued preprinted labels for unknowns. Plants can be temporarily stored in plastic bags and kept cool

for later keying, but later that evening must then be pressed with identifying label and dried. Dry plants can then be boxed for shipping. Pressed specimens should be mailed weekly or after specimens from three plots have accumulated.

2.7 Literature Cited

Cline, S.P., Cassel, D.L., and Gallant, A.L. 1991. Vegetation Structure *In* Riitters, K., Papp, M., Cassell, D. and Hazard, J. (eds.), Forest Health Monitoring Plot Design and Logistics Study, EPA/600/S3-91/051. U.S. Environmental Protection Agency, Office of Research and Development, Research Triangle Park, NC. pp. 68-76.

Harmon, M.E. and Sexton, J. 1996. Guidelines for measurements of woody detritus in forest ecosystems. Publication No. 20. U.W. LTER Network Office: University of Washington, Seattle, WA, USA. 73 p.

Stapanian, M.A., Cline, S.P., and Cassell, D.L. 1997. Evaluation of a measurement method for forest vegetation in a large-scale ecological survey. Environmental Monitoring and Assessment 45:237-257.

Appendix A

Guidelines for unknown specimen collection for the 1999 US Forest Service Vegetation Pilot Project Biota of North America Program (BONAP)

Specimen collection protocol:

1. Each specimen should represent only a single species and should be placed individually inside a single sheet of newspaper that is folded in half, along with a label that includes the code that you are using to refer to the unknown, the state and county in which the specimen was collected, and the date. We request that you follow this protocol even if the specimen is a small fragment. When more than one specimen is included within a folded sheet of newspaper, at least one of the specimens tends to be placed near the edges of the newspaper, which often results in some specimens being dislodged during shipping. Larger plant specimens should be folded to fit completely inside the newspaper folder.

2. We will work with incomplete collections (i.e., those without flowers or fruits), since they may represent all of the material that is available, but an exact identification of these specimens may not be possible and cannot be expected. In many cases, however, it will be possible to identify such incomplete specimens to genus or family. For specimens that include flowers and/or fruits in addition to vegetation, the expectation for accurate identifications to the species level is realistic.

3. Specimens collected with flowers and/or fruits with labels documenting the collection details are valuable and greatly desired by numerous museums. While it requires more effort to provide detailed labels, carefully collected specimens would serve as documentation of your work and would be a valuable resource that could be deposited in a museum after the identifications are completed. We will return specimens to collectors or provide them to museums upon request.

4. Please send shipments of specimens as you collect them throughout the field season, rather than holding on to them and sending one large shipment at the end of the summer. This will enable us to complete the identifications and return them to you more efficiently.

Please include the following information with all packages of specimens:

1. Please include your name and the address to which you would like your identifications sent. Please also include your email address if you have one. We would be happy to send identifications in the text of email messages or as attachments. Please let us know if you would like any of your specimens to be returned (they will not be returned unless you request them specifically).

2. Please include a file on diskette (or as an email attachment) with the following information for each specimen, in WordPerfect 6.1, MS Word 6.0, Excel, ASCII text, or Paradox (we can also work with other formats, so please contact us if you would prefer to use a different format):

3. The Hexagon number, Subplot number, and quad number

4. The code that you are using to refer to the unknown collection in your own data (exactly as it appears in your data file.)

5. The state and county in which the collection was made.

6. Your name and the date the specimen was collected.

7. Any relevant information regarding habitat and community associations. This information often is of great help in achieving identifications.

8. Descriptive information about flower color, plant habit, whether it is an annual or perenial and any unusual or identifying characteristics useful for keying.

9. A blank line for us to type in the scientific name of the unknown.

Hexagon, Subplot, Quad Numbers:	8405521, 2, 1
Unknown Code:	Grnfuzzy
State and County:	Larimer, Colorado
Name and Date:	Kelly Rimar, 6/12/99
Habitat or Community:	Spruce-fir
Description:	Bunch grass with fuzzy ligule, missing infloresence, possibly Koeleria.
Scientific Name:	

Label and Electronic file example

Once we have identified your specimens, we will type the name of each of the specimens (to the degree possible) in your digital file, and return your file to you. We will be using the nomenclature and taxonomy of Dr. Kartesz's 1994 *A Synonymized Checklist of the Vascular Flora of the United States, Canada, and Greenland*, updated to 1999 standards.

Contact information for the Biota of North America Program:

All specimens should be sent to:

Attention: Amy Farstad/Misako Nishino
Biota of North America Program (BONAP)
CB 3280 Coker Hall Room 417A
University of North Carolina at Chapel Hill
Chapel Hill, NC 27599-3280

Office telephone: (919) 962-0578. All members of the BONAP staff can be reached at this number.

Drs. Guy Nesom and John Kartesz will identify the specimens. Any questions regarding the identifications should be addressed to them.

email: Dr. Nesom: guynesom@intrex.net
Dr. Kartesz: kartesz@email.unc.edu

Amy Farstad and Misako Nishino will be coordinating the specimen identification. Any general questions regarding whether specimens have been received, when identifications can be expected to be returned, or data format for the information requested should be addressed to them.

email: Amy Farstad: afarstad@email.unc.edu
Misako Nishino: nishino@email.unc.edu

3 Down Woody Debris and Fuel Loading

3.1 Introduction

3.1.1 Down Woody Debris

Woody debris, i.e., dead tree parts, is an important variable in forest ecosystems for wildlife habitat, fuel loading, and carbon budgets. Down woody debris is typically measured using line transects (Harmon et al.), but can be done with area plots. Transects are an efficient way of estimating the current level of down woody material. Transects are good for estimating the amount (biomass, volume, and abundance) of down wood by size. Ideally we would like to track all tally trees (as tree records) until they are completely decomposed. Currently FHM tracks the status of all trees within the subplot, including the recently deceased. This provides a good history of what happens to a tree and how long it takes the tree to decompose. It should help in model development for regional biomass estimates. In this pilot we will measure down woody debris (DWD) which can be subdivided into measurements of coarse woody debris (CWD: pieces > 3 inches [> 7.6 cm] in diameter) and fine wood debris (FWD: pieces 0 - 3 inches [0 - 7.6 cm] in diameter).

In this pilot we will measure the number and volume of all down woody debris pieces that are greater than 3 inches (7.6 cm) in diameter. To a large degree, we are following the guidelines established by USDA Forest Service Pacific Northwest Region Forest Inventory and Analysis in their 1997 field manual, with a few exceptions: our transects will be at different azimuths (30, 150, and 270 degrees) than PNW (0, 135, and 225 degrees), to accommodate the placement of our vegetation quadrats outside of the microplot, which is located off-subplot center (Figure 3). Our tally cutoff point will be 3 inches (7.6 cm) in diameter as opposed to 5 inches (12.5 cm) for PNW. In addition, we will count the number of pieces of wood that intersect our transect line that are between 0 inches (0 cm) and 3 inches (7.6 cm)in diameter, which is our definition of the fine woody debris component (FWD) of the down woody debris. However, we will not do any volume measurements, species identification, degree of decay, or point of intersection for fine pieces; we will simply make a count of the pieces.

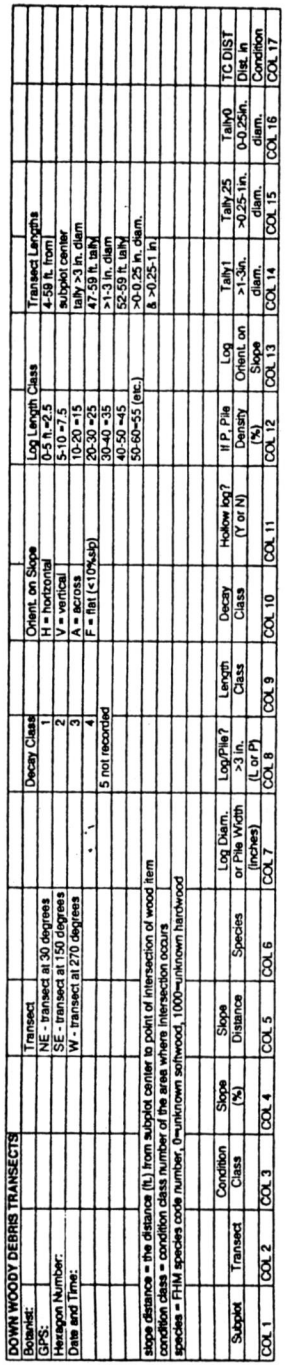
Detailed directions (modified from the PNW FIA field manual; with figures) for conducting the DWD data collection are found starting with Section 2.3 and continuing in Section3.6.4.3. The data sheet shown in Figure 1 will be used to program the palmtop computer for collection of these data, and for development of a field guide with backup data sheets on waterproof paper.

3.1.2 Fuel Loading

Fire has been a powerful, selective, regulatory mechanism in forest ecosystems for thousands of years. Fire alters ecosystems in the following ways:

- Removes overstory and understory vegetation.
- Exposes mineral soil, which provides a seedbed for regeneration but also increases the risk of erosion with resulting stream sedimentation.
- Releases nutrients and alters soil permeability.
- Triggers regeneration of serotinous seeds of some species.
- Often improves wildlife habitat.

Table 1 shows the data requirements for fuel-loading models and flammability assessments. The variables and FHM sources for the data are also shown. Figure 2 is an example of the field data sheets used by FHM crews to record fuel-loading data.



DOWN WOODY DEBRIS TRANSECTS		Transect			Decay Class		Orient. on Slope	Log Length Class		Transect Lengths				
Botanist:					1		H = horizontal	0-5 ft.=2.5		4-59 ft. from				
GPS:		NE - transect at 30 degrees												
Hexagon Number:		SE - transect at 150 degrees			2		V = vertical	5-10 =7.5		subplot center				
Date and Time:		W - transect at 270 degrees			3		A = across	10-20 =15		tally >3 in. diam				
					4		F = flat (<10%slp)	20-30 =25		47-59 ft. tally				
					5 not recorded			30-40 =35		>1-3 in. diam				
								40-50 =45		52-59 ft. tally				
		slope distance = the distance (ft.) from subplot center to point of intersection of wood item						50-60=55 (etc.)		>0-0.25 in. diam.				
		condition class = condition class number of the area where intersection occurs								& >0.25-1 in				
		species = FHM species code number, 0=unknown softwood, 1000=unknown hardwood												
			Condition	Slope		Log Diam.	Log/Pile?	Length	Decay		Hollow log?	If P_Pile	Log	Tally1	Tally.25	Tally0	TC DIST
Subplot	Transect		Class	(%)	Distance	Species	or Pile Width	>3 in.	Class	Class	(Y or N)	Density	Orient. on	>1-3in.	>0.25-1in.	0-0.25in.	Dist. in
							(inches)	(L or P)				(%)	Slope	diam.	diam.	diam.	Condition
COL 1	COL 2	COL 3	COL 4	COL 5	COL 6	COL 7	COL 8	COL 9	COL 10	COL 11		COL 12	COL 13	COL 14	COL 15	COL 16	COL 17

Figure 1. Coarse woody debris tally data sheet.

Table 1. Data requirements for fuel-loading models and flammability assessments

Data Required	Variables	FHM Data Source
Fuel Loading (Missoula fire lab index)	Grass (cover and depth)[1] Shrub (cover and depth)[1] Slash (cover and depth)[1] Litter (cover and depth)[1] Duff (cover and Depth)	Veg. Indicator Pilot " " " "
Biomass accumulation index Understory Overstory	Vegetation diversity/cover Tree basal area, crown cover	Veg. Indicator Pilot, Mensuration & Crowns
Stand age (> 40 years at risk)	Site tree and stand age	Mensuration and Veg. Indicator Pilot
Species composition	Diversity of overstory, midstory and understory microplot cover, forest type	Veg. Indicator Pilot and Mensuration
Stand structure	Tree spacing, size and height Crown class, tree history	Mensuration and Veg. Indicator Pilot
Drought potential	Palmer Drought Index	NOAA[2]
Soils (erosion and fertility)	Litter depth/cover, carbon and nitrogen pools	Soils Indicator
Habitat groups Based on temperature/ moisture regimes	Condition class, forest types Site slope and aspect	Mensuration
Intervals between fires	Tree mortality-year and cause Interim and past disturbance	Mensuration and Damage

[1]New variables to be collected by FHM in vegetation pilot in 1998 &1999
[2]National Oceanic and Atmospheric Administration

Botanist:								Microplot Cover Classes							
GPS:								0		absent					
Hexagon Number:								1		trace (<1%)					
Date and Time:								5		1- 5% cover					
								10		6-10% cover					
								15		11- 15% cover					
								20		16-20% cover					
								.							
Cover is done by group								.							
Depth is the average height in inches															
Slash is wood 1 in. or more diam.								95		91- 95% cover					
								100		96-100% cover					
	Live Grass	Grass	Dead grass	Live Forb	Forb	Dead forb	Live Shrub	Shrub	Dead shrub	Slash	Slash	Litter	Litter	Duff	Duff
Subplot#	Cover %	Depth	Cover %	Cover %	Depth	Cover %	Cover %	Depth	Cover %	Cover %	Depth	Cover %	Depth	Cover %	Depth
1															
2															
3															
4															

Figure 2. Fuel loading data sheet.

3.2 Training Plan

The Vegetation Indicator Pilot will continue into 1999 with 8 crews focused on ecoregion sections in the Northeast. The goal is to see how comprehensive an evaluation we can do at an ecoregion section level. Some streamlining and fine-tuning will be done to the methods this year based on last year's results. We are currently working with FHM Information Management to design and implement the data apparatus necessary for quick and efficient data crunching in 1999. Electronic data files will be sent directly from the field to the data base for rapid initial data summary and analysis. Botanists will be trained together on Vegetation Indicator methods and then complete the regional trainings with their teams. Indicator Leaders Kelly Rimar and Rick Busing will train the botanists. Training will include transect set-up and methodology for fuels on microplot.

1. Botanists will attend the New Hampshire vegetation indicator training. This will ensure that all botanists receive the same information. Botanists will then travel to regional trainings and join their teams. Vegetation Indicator information that involves forester team members will be included in the regional training. The goal is to promote team work.

2. Perform hot audit (quality control audit), i.e., audit botanists while they are installing first plots in order to correct any errors in performance of the method. Hot audits are typically done immediately following training to improve data collection.

3. Perform cold audit (quality assurance audit), i.e., audit vegetation pilot crew after they have installed plot (random selection). This is typically done during the field season.

3.3 Plot Establishment

Follow Procedures in Section 2.3 of this field guide.

3.4 Data Collection and Analysis Outline

Twelve transects
Four microplots

Data Variables

Plot ID
Microplot (fuel loading)
- 2.07 m (6.8 ft) radius
- Cover and depth of group (grasses, shrubs, slash, litter, duff)

Transects (woody debris):
- 3 transects per subplot or 12 per plot (59 ft each)
- Intersect length
- Length and diameter
- Species and degree of decay
- Fine debris tallies

3.5 Equipment List

See Section 2.5 in this field guide.

3.6 Procedures

3.6.1 FHM Plot Layout for Vegetation Structure Measurements

Foresters relocate plot and center pins for subplots and microplots (Figure 3). Note: all distances are horizontal distance, transect line distance is corrected for slope. Subplot centers are 120 ft (36.6 m) apart. The outer subplots are located by sighting 0, 120, and 240 degree azimuths from the center pin of the center subplot and walking in each direction 120 ft (36.6 m). Foresters then locate Down Woody Debris (DWD) transect lines (T1, T2, T3) and permanently mark (using stakes) the two quadrat corners at 15 ft (4.57 m) and 18.3 ft (5.57 m) on each transect as it is put in. The DWD transects are located by sighting the 30, 150, and 270 degree azimuths and

walking in each direction for 59 ft (18 m). The DWD transect line is marked with a flag at 24 ft (7.32 m) (edge of subplot) and 59 ft (18 m) (edge of annular plot). Place the quadrat frame to the right of the transect line at the marked quadrat corners and flag the four corners. This is to prevent trampling. Microplots are located 12 ft (3.7 m) at a 90 degree azimuth from the subplot center. The radius of the microplot is 6.8 ft (2.07 m) (Figure 4). Flags mark the perimeter of the circle. To make cover estimates easier, four flags are placed along the perimeter, dividing the circle visually into quarters. Use the quadrat as a reference for the smaller cover classes. A quadrat is a little greater than 7% of the microplot (7.4%).

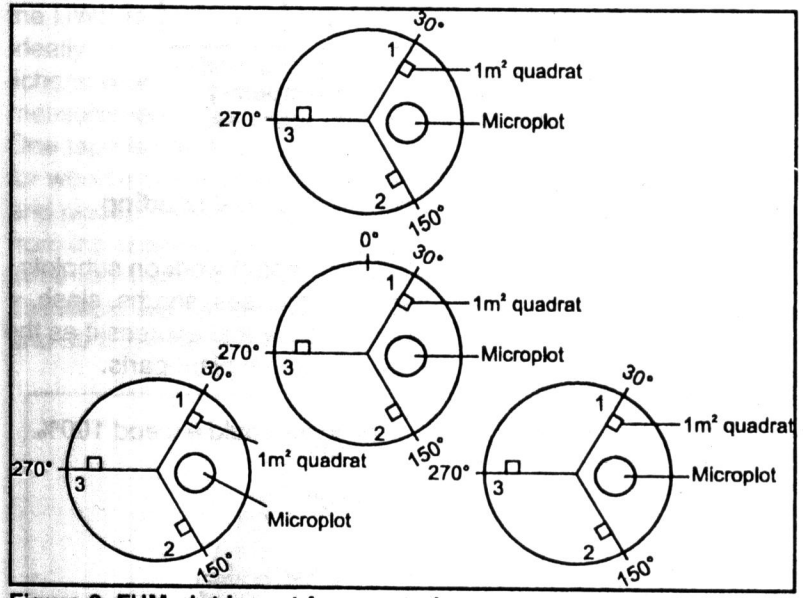


Figure 3. FHM plot layout for vegetation structure measurements (not drawn to scale).

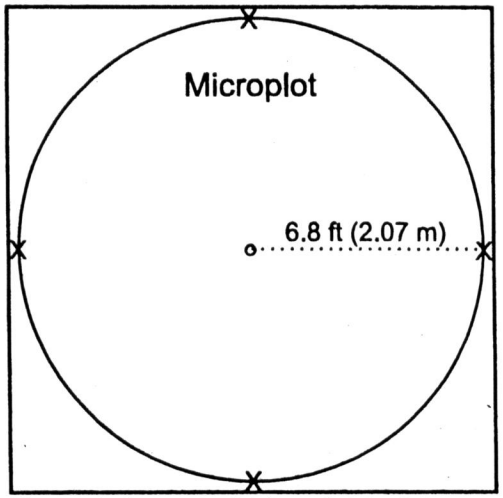


Figure 4. Layout of microplot (not drawn to scale). X = placement of temporary flags for fuel-loading cover estimates.

3.6.2 Microplot Measurements and Fuel Loading

Botanists begin fuel loading (microplot) work on subplots. Estimate the cover of each life form; grasses, shrubs, slash, duff, and litter (as groups) independently and express it as the percentage of ground surface under aerial plant parts.

Because of overlap, the total cover could exceed 100%. Cover classes are as follows:

Code	Definition
00	absent
01	trace (< 1% cover)
05	1 - 5% cover
10	6 - 10% cover
15	11 - 15% cover
20	16 - 20% cover
.	.
95	91 - 95% cover
99	96 - 100% cover

Then estimate the average depth for each of the five life forms. This is done by taking several measurements of a group using a tape and estimating the average depth. Note: slash is wood > 1 inch (2.5 cm) in diameter.

3.6.3 Down Woody Debris (Coarse and Fine)

Down Woody Debris (DWD) is simply dead tree parts or downed pieces of wood. In this pilot we will measure DWD which are subdivided into coarse woody debris (CWD: pieces > 3 inches (7.6 cm) in diameter) and fine woody debris (FWD: pieces 0-3 inches (0-7.6 cm) in diameter). Whomever finishes their other measurements first (foresters or botanist), will begin the DWD tally. This is a decision for the crew leader to make. Ideally, the foresters will do the DWD, and the botanist will do lichens when fully implemented nationally. These measurements are much simpler and faster with two people. One tape is needed for the transect line and one tape or calipers for wood measurements. Transect lines are 59 ft (18 m) long and placed on the 30, 150, and 270 degree azimuths starting from the subplot center and radiating out (Figure 5). There are three transects per subplot and a total of twelve per plot. Transects are flagged at the 24 ft (7.32 m) (subplot perimeter) and 59 ft (18 m) (annular plot perimeter). Botanist or forester

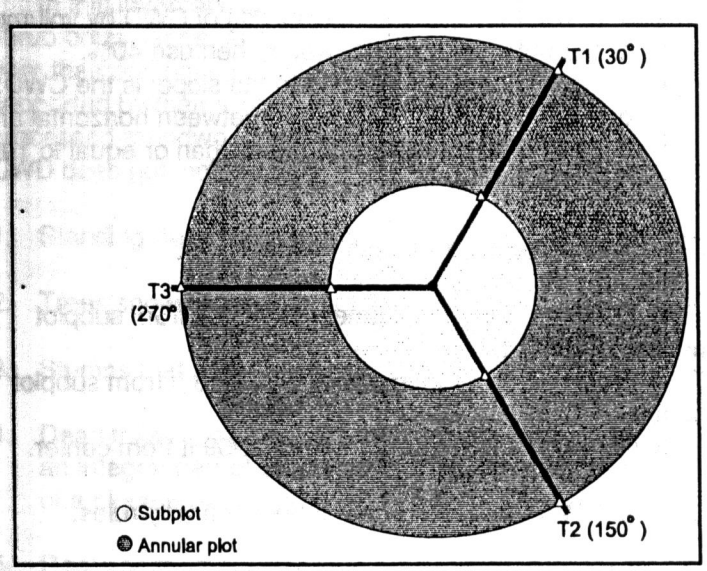


Figure 5. Down woody debris transects (not drawn to scale).

runs tape along flagged transect and begins measurements. Starting at 4 ft from the center of the subplot, the botanist walks along the transect line looking for woody debris. FWD that is between 0 inch (0 cm) and 3 inches (7.6 cm) is counted but not measured. Totals for each transect are entered on the data sheet in each of the three FWD tally columns. For each piece of CWD, greater than 3 inches (7.6 cm) at the point of intersection with the transect, the following measurements are taken:

1. Transect slope, in percent.
2. Condition Class - the condition class to which the piece is assigned.
3. Slope Distance - the distance on the tape where it intersects the wood.
4. Species - species of wood if possible (for example, FHM code number)
5. Diameter or pile width - the diameter of the CWD where it intersects the transect.
6. Log or Pile - record L for logs, P for piles of CWD > 3 inches.
7. Record the total length of the CWD using length classes.
8. Decay Class - refer to the Decay Class Table (Table 2).
9. Is the CWD hollow? The cavity must be greater than or equal to 19.6 inches (0.5 m) and the opening must be equal to or greater than a quarter of the whole diameter to qualify.
10. For piles only, estimate the density (%) of CWD by volume. If the pile is 60% air and 40% wood, then use 40%.
11. Orientation on Slope - in relation to the slope, is the CWD: H (horizontal), V (vertical), A (across - between horizontal and vertical), or F (flat on the ground (less than or equal to 10% slope)).

For FWD, use a segment of each transect:

12. Tally FWD > 1-3 inches diameter, 47-59 ft from subplot center. Enter total for transect.
13. Tally FWD > 0.25 - 1 inch diameter, 52-59 ft from subplot center.
14. Tally FWD 0-0.25 inches diameter, 52-59 ft from center.

Refer to the DWD methods for more detail on tally rules.

3.6.4 Coarse Woody Debris

3.6.4.1 Introduction

Coarse woody debris (CWD) is dead pieces of wood. CWD, like live trees, nontree vegetation and litter, is a component of vegetative structural diversity. Wildlife biologists, mycologists, ecologists, foresters and others are interested in CWD because it relates to:

- wildlife habitats
- vegetation diversity
- storage and cycling of nutrients and water
- carbon sequestration, a factor in global carbon cycles
- fire behavior

Knowledge about the nature and function of CWD is incomplete. Most studies have been conducted in mature and old-growth forests that originated naturally after fire. Little is known about the characteristics of woody debris in managed forest stands and in stands that originated after logging.

3.6.4.2 Definition of Coarse Woody Debris

In this inventory, CWD includes downed, dead tree and shrub boles, limbs, and other woody pieces that are severed from their original source of growth or uprooted (no longer self-supported by their roots). It also includes other non-machine processed roundwood such as fence posts and cabin logs. CWD does not include:

1. Standing dead trees or shrubs self-supported by their roots.
2. Trees showing any sign of life.
3. Stumps that are rooted in the ground (i.e.,not uprooted).
4. Dead foliage, bark or other non-woody pieces that are not an integral part of a bole or limb. (Bark attached to a portion of a piece is an integral part).
5. Roots or main bole below the root collar.

3.6.4.3 Sampling Methods

Transect sampling methods are used to sample CWD. Normally, line intersect sampling is used. In this method, transects are established, and downed pieces meeting specified dimensions and criteria are selected if their central axis is intersected by the transect.

CWD piles in which individual pieces are absolutely impossible to tally separately are entered as one observation. Pile width at intersection is measured. Pile length class is assigned. Pile density is estimated (what percentage is CWD?).

3.6.4.4 Locating and Establishing Line Transects

Three transects are established on a subplot and annular plot if the subplot meets **ALL** of the following criteria:

1. At least one condition class mapped on the subplot's 24 ft (7.32 m) fixed-radius plot is classified as forest land, **AND**

2. The subplot center is in inventoried area.

Each transect originates at the subplot center and extends 59 feet (18 meters) horizontal distance. The azimuths from subplot center to the end of the three transects are, respectively, 30, 150, and 270 degrees (Figure 6). It is extremely important to lay out the transect in a straight line to avoid biasing the selection of pieces and to allow the remeasuring the transect lines and tally pieces in the future for change.

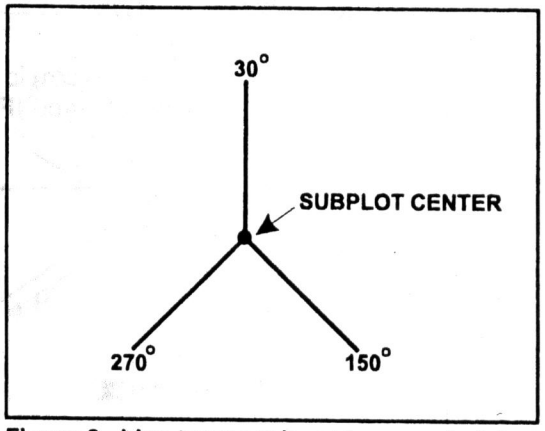


Figure 6. Line transect layout on a subplot.

On subplots where a transect intersects a boundary between condition classes, the transect continues across the boundary into the adjacent class (Figure 7). Individual pieces of CWD intersected by a transect are tallied if they meet the tally rules specified in the next two sections (Sections 3.6.4.5 and 3.6.4.6).

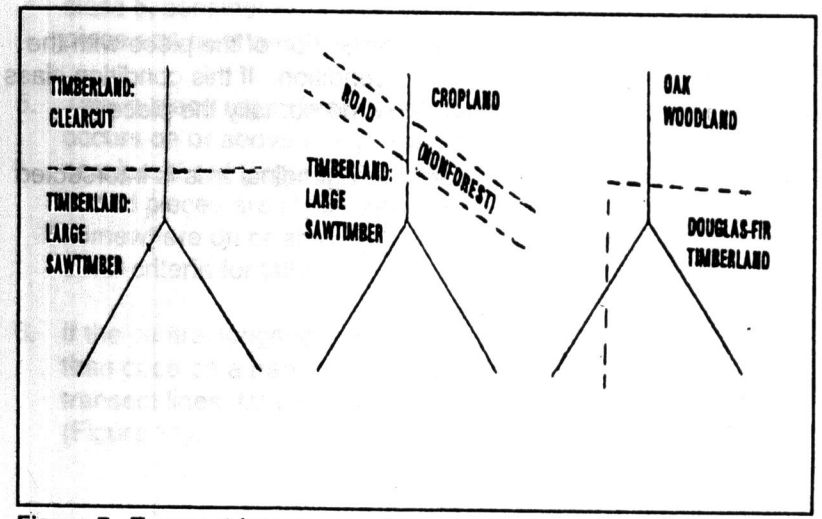


Figure 7. Transect intersects a boundary between condition classes.

3.6.4.5 Tally Rules for Coarse Woody Debris

1. Tally a piece only if it is at least 3 inches (7.6 cm) in diameter at the point of intersection with the transect plane (Figure 8).

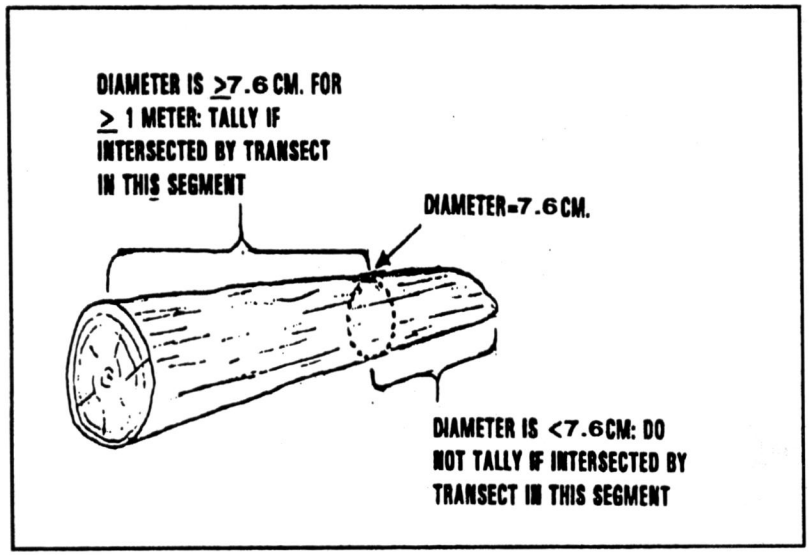


Figure 8. Tally length and width requirements .

2. Tally a piece only if (1) the intersection of the piece with the transect plane lies in a forest condition. If this condition class is nonforest or out-of-inventory, do not tally the piece.

3. Tally a piece only if its central longitudinal axis is intersected by the transect plane (Figure 9).

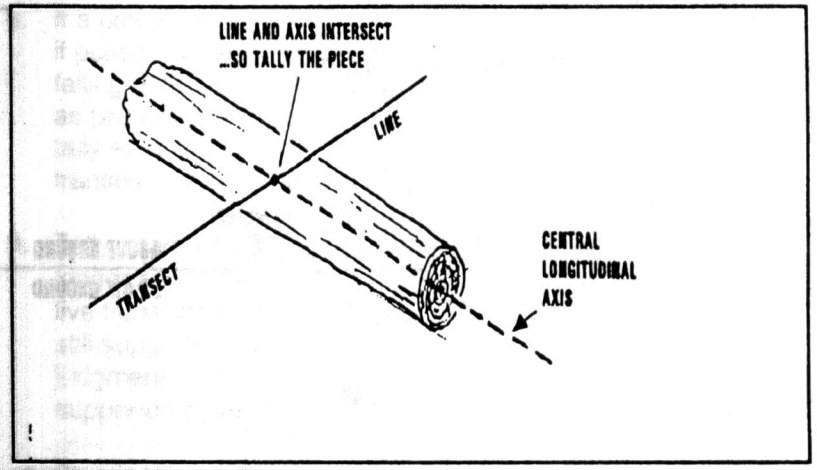


Figure 9. Additional tally requirements.

4. Tally only those portions of pieces that are decay class 1, 2, 3, or 4. Do not tally pieces or segments of pieces that are decay class 5. Pieces in decay class 5 are not tallied due to the difficulty in defining pieces in this category (the entire ground surface in some areas seems to be decay class 5 material) and the subjectivity in measuring them. If a piece has segments that are decay classes 1, 2, 3, or 4 and decay class 5, consider the decay class 5 segment a break in the piece and treat as two separate pieces.

5. Tally a piece regardless of whether the point of intersection occurs on or above the ground, or is buried in the litter, duff, or mineral soil (Figure 10). The only restriction on tallying buried pieces are (1) that the piece must be visible somewhere on or above the ground and (2) that it meets all other criteria for tally.

6. If the central longitudinal axis of a piece is intersected more than once on a transect line or if it is intersected by two transect lines, tally the piece each time it is intersected (Figure 11).

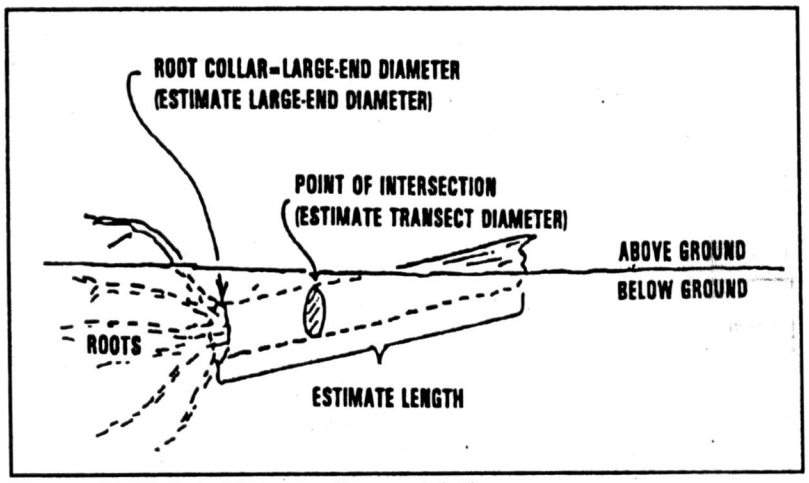


Figure 10. Point of intersection restrictions.

7. If a piece is fractured across its diameter, and would pull apart at the fracture if pulled from either end, treat it as two separate pieces. If judged that it would not pull apart, tally as one piece. Tally only the piece intersected by the transect line.

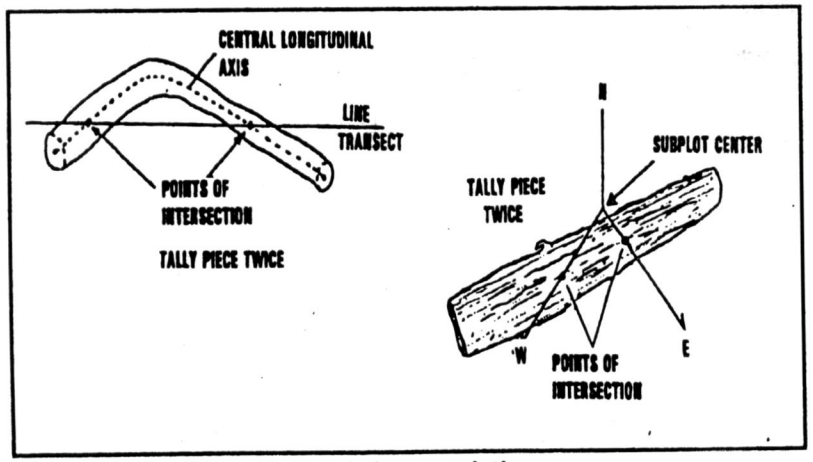


Figure 11. Additional intersection restrictions.

8. If a piece is split along its length, would pull apart at the split if pulled from either side, and the split was due to the piece falling or to the impact of another piece or object, then treat it as two separate pieces. If judged that it would not pull apart, tally as one piece. Tally only pieces intersected by the transect line.

9. Tally dead, uprooted trees, snags, and stumps that are no longer supported by their roots from falling over. Do not tally live trees, dead trees, snags or stumps that are leaning, but still supported by their roots from falling over. The crew's judgment on whether or not a tree, snag or stump is self-supported by its roots is final.

10. Do not tally a piece if the transect intersects the piece on the root side of the root collar. Do not tally roots.

11. When the transect crosses forks, branches or boles of one tree (i.e., two or more pieces that are connected), tally each qualifying piece separately. To be tallied, each individual piece must meet the minimum diameter and length requirements. In the case of forked trees, consider the "main bole" to be the piece with the largest diameter at the fork. Characteristics for this fork such as length and decay class should pertain to the entire main bole. For smaller forks, or branches connected to a main bole (even if the main bole is not a tally piece) characteristics pertain only to that portion of the piece up to the point where it attaches to the main bole (Figure 12).

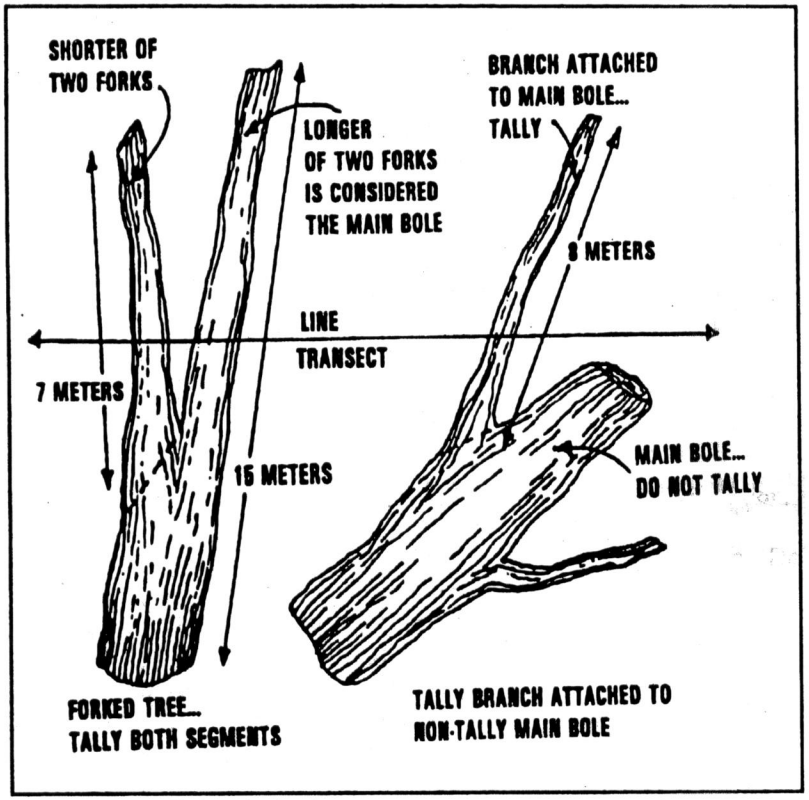


Figure 12. Tallying forked trees.

3.6.4.6 Tally Rules for Coarse Woody Debris When the Piece Lays Across Two or More Condition Classes

1. A piece is assigned to the condition class that contains the intercept point.

2. If a transect intersects a piece on a condition class boundary, the transect will be considered to intersect the piece in the condition class which contains the large end of the piece. Do not tally a piece if its intersection with the transect is in a condition class that is nonforest or out-of-inventory (Figure 13).

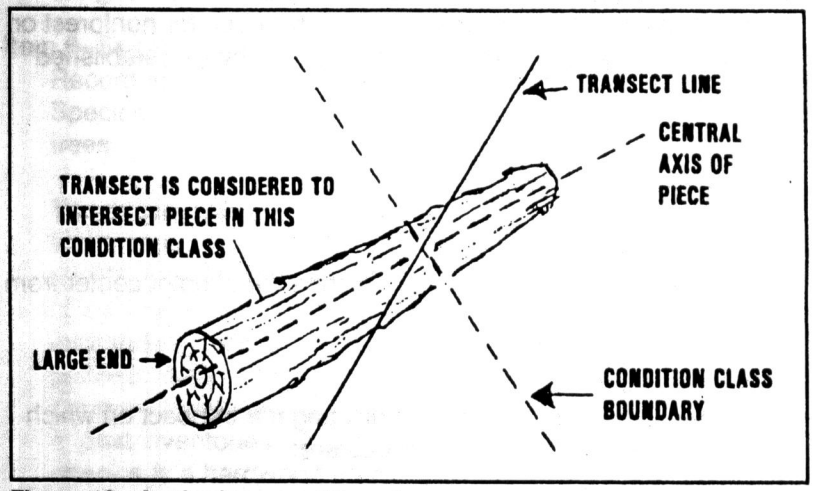


Figure 13. Assigning condition class.

3.6.4.7 Marking CWD

If, at the point of intersection, a qualifying piece is decay class 1, 2, or 3, mark the point of intersection on the piece with a nail. Position the nail on top of the piece at the point of intersection with the transect. If possible, drive the nail into the piece so that only about 1.2 inches (3 cm) of the nail is left exposed. Stop driving the nail if the next blow means breaking the piece or seriously disturbing the location of the piece.

3.6.4.8 Recording Procedures

Record each CWD piece on a transect as a single line entry, completing the items indicated with "X"s on the CWD tally guide (Figure 1). In addition, on the record of the first piece tallied in each condition class crossed by a transect, enter (1) the slope distance along the transect, and (2) the average slope percent (SLP PCT) along the transect.

If no pieces are tallied on a transect in a condition class, enter a line with the following data for the condition class: (1) subplot number (SUB PL), (2) transect (T), (3) condition class (C), (4) "-1" for species (SPC), (5) slope distance along the

transect, and (6) average slope percent (SLP PCT) along the transect within the condition class. Do this even for nonforest or out-of-inventory condition classes if crossed by an established transect.

3.6.4.9 Individual Data Items

Item 1--Subplot number (PT)

Record a 1-character code indicating the subplot center from which the transect originates.

Item 2--Transect (T)

Record a 2-character code indicating the transect on which the piece is sampled. The codes are:

Code	Definition
NE	Transect extends 30 degrees from subplot center.
SE	Transect extends 150 degrees from subplot center
W	Transect extends 270 degrees from subplot center

Item 3--Condition Class (c)

Record a 1-digit code indicating the condition class to the piece is assigned.

Item 4--Percent Slope

Record percent slope of transect.

Item 5--CWD slope distance (CWD DIST)

Record a 3-digit code indicating the slope distance from the subplot center to the point where the transect intersects the longitudinal center of the piece. Measure and record to the nearest 0.1 ft (0.1 m). CWD slope distance will be used in locating the piece for remeasurement in future inventories.

If two or more pieces have the same slope distances, record the top piece first.

Item 6--Species (SPC)

Record a numeric code indicating the species of the piece. Species codes are the same as those used for FHM tally trees.

Species identification may be uncertain for some pieces. Make an educated guess. The piece's bark (either attached or sloughed and laying beside the piece), branching pattern (if the branches are still present), or heartwood smell (particularly if cedars, Douglas-fir, or western hemlock) may provide clues. Observe the tree species currently on the site. On remeasurement plots, see what tree species were tallied in past inventories. At a minimum, record whether the species is a hardwood (deciduous) or softwood (conifer) species. An educated guess is preferable to using the unknown species code (999). Use 0 for unknown softwood; 1000 for unknown hardwood.

Item 7--Diameter at point of intersection (TRAN DIAM)

Record a 4-digit code indicating the piece's diameter at the point where the transect intersects the longitudinal center of the piece. The diameter is recorded in 0.1 inches (0.1 cm).

For pieces that are not round in cross-section because of missing chunks of wood or due to "settling" due to decay, measure the diameter if possible. If not possible, estimate the longest and shortest axis of the cross-section ("A" and "B" in Figure 14). Record the average of these two estimates as the diameter. This technique applies to transect, small-end, and large-end diameters. For CWD piles, record the width of the pile at transect interception (see Section 3.6.5).

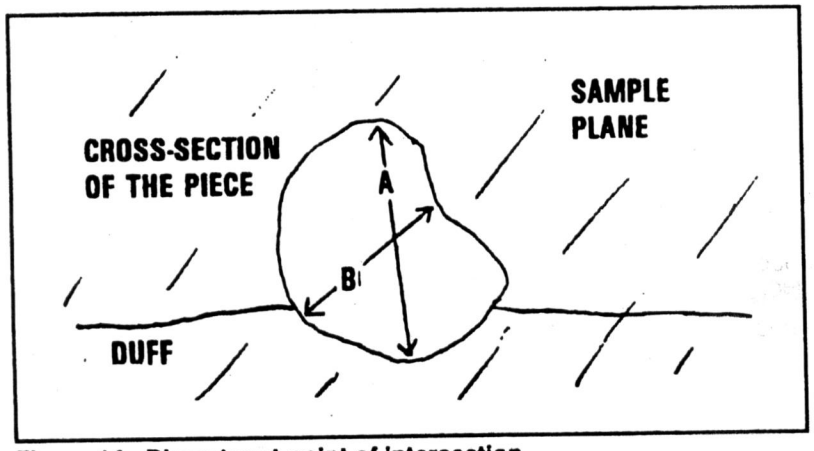


Figure 14. Diameter at point of intersection.

Item 8–Is the item a log or a pile?

Record "L" or "P".

Item 9--Total length (ESTIMATED TOTAL LENGTH)

Record a class number indicating the estimated total length of the piece. Estimate in classes and record class midpoint in feet (see data sheet).

Item 10--Decay class (DECAY CLASS)

Record a 1-digit code indicating the decay class of the piece. Code the decay class which predominates along the recorded total length (Item 9) of the piece. Do not tally decay class 5 pieces. When tallying a piece, the sampled portion ends where the decay class 5 begins. Use the following table as a guide to decay class for CWD: (Decay class descriptions for snags are not applicable for CWD). The characteristics of down logs by decay class are summarized in Table 2.

Table 2. Characteristics of down logs by decay classes

Decay Class	Structural Integrity	Texture of Rotten Portions	Color of Wood	Invading Roots	Branches and Twigs
1	Sound	Intact, no rot; conks of stem decay absent	Original color	Absent	If branches are present, fine twigs are still attached and have tight bark
2	Sound	Mostly intact; sapwood partly soft (starting to decay) but can't be pulled apart by hand	Original color	Absent	If branches are present, many fine twigs are gone and remaining fine twigs have peeling bark
3	Heartwood sound; piece supports its own weight	Hard, large pieces; sapwood can be pulled apart by hand	Reddish-brown or original color	Sapwood only	Branch stubs will not pull out
4	Heartwood rotten; piece does not support its own weight, but maintains its shape	Soft, small blocky pieces; metal pin can be pushed into heartwood	Reddish or light brown	Through-out	Branch stubs pull out
5	None, piece no longer maintains its shape, but instead spreads out on the ground	Soft; powdery when dry	Red-brown to dark brown	Through-out	Branch stubs and pitch pockets have usually rotted down

Item 11--Is the piece hollow? (HOL?)

Record a 1-letter code indicating whether the piece is hollow (Figure 15).

Code	Definition
Y	A piece is considered hollow if a cavity extends at least 19.6 inches (0.5 m) along the central longitudinal axis of the piece, and the diameter of the entrance to the cavity is at least 1/4 of the diameter of the piece where the entrance occurs. The entrance occurs at the point where the circumference of the cavity is whole -- the point where wood is present completely around the circumference of the cavity. The length of the cavity

begins at this point.

N Does not meet criteria for hollow

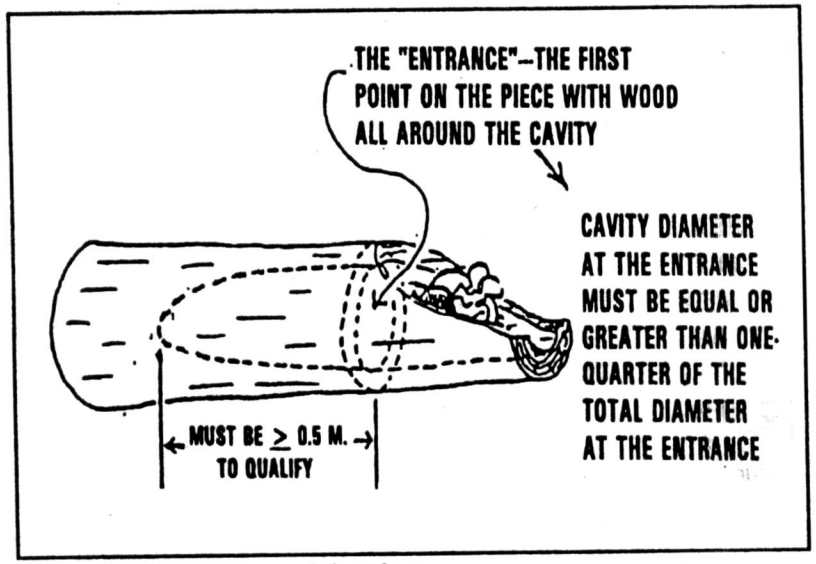


Figure 15. Hollowness of the piece.

Item 12–Density of pile in percent

Record the percentage of the total pile volume that is CWD.

Item 13–Orientation on slope (ORNT)

Record a 1-letter code indicating the orientation of the piece on the slope. If the piece is suspended above the ground, select the code which best estimates the orientation if the piece were on the ground (Figure 16).

Code	Orientation	Definition
H	Horizontal	Piece is oriented within 15 degrees of the contour.
V	Vertical	Piece is oriented within 15 degrees of perpendicular to the contour.
A	Across	Piece is oriented between vertical and horizontal.
F	Flat	Piece is on flat ground (≤10% slope).

Item 14-Fine woody debris tally (FWD Tally1)

From 47-59 ft along transect, count the number of pieces of woody debris that are 1 inch - 3 inches (2.5 cm - 7.6 cm) in diameter where the transect line crosses the piece.

Item 15–Fine woody debris tally (FWD.25)

From 52-59 ft along transect, count the number of pieces of woody debris that are 0.25-1 inch in diameter at the point of intersect.

Item 16–Fine woody debris tally (FWD0)

From 52-59 ft along transect count woody debris 0-0.25 inches in diameter.

Item 17-Transect condition class distance (TC DIST)

Record a 3-digit code indicating the measured slope distance along the transect in a condition class. When only one condition class is present on a transect, slope distance is the distance from subplot center to the end of the horizontal 59 ft (18 m) transect. When the transect crosses two or more condition classes, slope distances along the transect are measured and recorded for each condition class.

3.6.5 Sampling Residue Piles

Piles of CWD should be considered on the transects (4-59 ft from subplot center). The width of the pile where it intercepts the transect should be measured in inches. The overall maximum length of the pile should be estimated using the same length classes (feet) as for logs. The decay class that best describes the condition of the wood in the pile should be recorded. Finally, the amount of pile wood by volume (0-100 %) should be estimated and recorded, where 100% would be entirely wood, and 50% would be a pile that is half wood and half other materials including air.

3.7 Literature Cited

Cline, S.P., Cassel, D.L., and Gallant, A.L. 1991. Vegetation Structure *In* Riitters, K., Papp, M., Cassell, D. and Hazard, J. (eds.), Forest Health Monitoring Plot Design and Logistics Study, EPA/600/S3-91/051. U.S. Environmental Protection

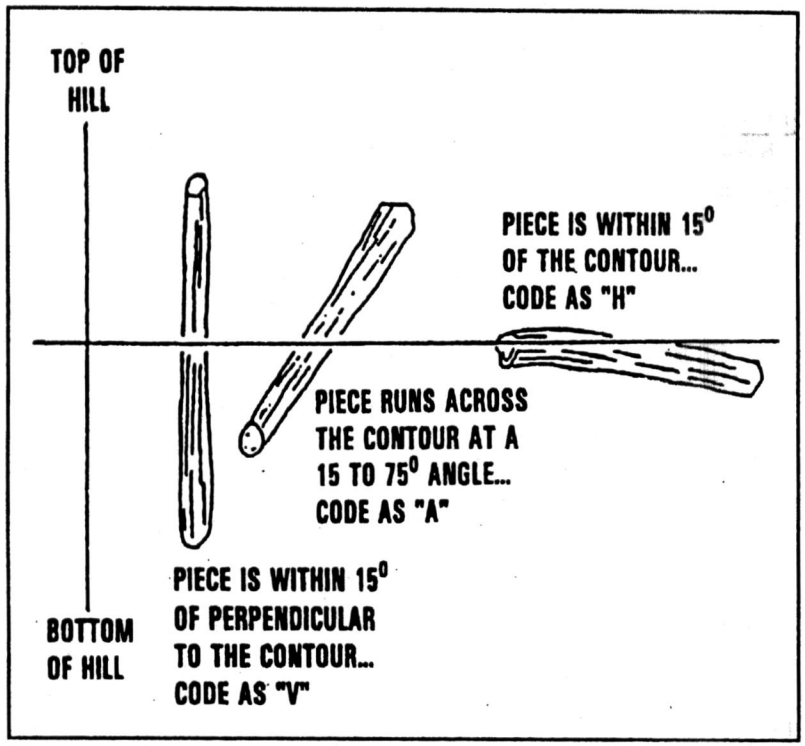


Figure 16. Orientation on slope.

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Harmon, M.E. and Sexton, J. 1996. Guidelines for measurements of woody detritus in forest ecosystems. Publication No. 20. U.W. LTER Network Office: University of Washington, Seattle, WA, USA. 73 p.

Stapanian, M.A., Cline, S.P., and Cassell, D.L. 1997. Evaluation of a measurement method for forest vegetation in a large-scale ecological survey. Environmental Monitoring and Assessment 45:237-257.