FOREST HEALTH GRANT AND PRESCRIBED FIRE PROTOCOLS FOR FIELD-BASED MONITORING MANUAL VERSION 1.0


BEFORE AND AFTER PHOTOS OF SHADED FUEL BREAK

March 14, 2023

Version V1.0

This manual provides field monitoring protocols for California Prescribed Fire Monitoring Program and outcome monitoring of completed Forest Health grants. This includes project and unit selection; data collection instructions for various project types; use of tools and technologies by field personnel; and data storage, handling and analysis procedures.

INTRODUCTION

Overview

Public Resources Code § 4137 (e) – (g) provides that CAL FIRE post on its internet website various information specific to hazardous fuel reduction and vegetation management projects funded or conducted by the department. One of the requirements involve CAL FIRE developing a standardized protocol for monitoring implementation and evaluating the positive and negative ecological and fire behavior impacts from vegetation management projects undertaken by the state. To fulfill this requirement, CAL FIRE has developed the following recommendations based on existing Departmental protocols:

A recent paper (1) suggests a framework for monitoring treatment effectiveness that involves both assessing fire hazard at the stand level and evaluating outcomes of fires at the landscape level. We suggest adopting a similar approach, where monitoring occurs across three levels to address both project and landscape level monitoring. This document provides a description of the existing Level 1 protocols being used by CAL FIRE. Level 2 and Level 3 protocols are currently under development but will be designed to complement and integrate with Level 1 protocols.

Framework for project and landscape level monitoring. Level 1 monitoring utilizes existing field-based protocol and provide rigorous project level monitoring; level 2 is a simplified field-based protocol designed to expand project level monitoring (underdevelopment; level 3 provides monitoring at the landscape level (under development).

Level 1: Field-based protocols following a statistically rigorous design (i.e. research grade)
Summary: Use existing field-based protocols to establish rigorous longer-term monitoring that evaluates prescribed fire and other fuels reduction projects. Workload is higher for this more intensive level of sampling, so it is suggested to only do this level of data collection for a subset of representative projects (e.g., 10% of projects as stipulated under California Climate Investment funding requirements).

Level 2: Simplified protocol – Field-based protocols that are implemented over broad spatial scales by CAL FIRE Units and other State agencies implementing treatments (under development)
Summary: A simplified protocol will allow CAL FIRE to expand project level monitoring while minimizing workload to CAL FIRE Units as compared to the labor-intensive Level 1 methods. This will enhance the information currently captured in CalMAPPER. Level 2 monitoring can be complementary to CNRA remote sensing programs, and feed into landscape scale evaluations (e.g. Level 3). Similar to Level 1, Level 2 involves field-based data collection of surface fuels and overstory canopy conditions but uses reduced and more rapid data collection methods. Field staff such as CAL FIRE unit Environmental Scientists could enter this data directly into CalMapper or the CNRA Treatment Tracker. This data could be used in conjunction with CNRA remote sensing data.

Level 3: Landscape level – Remote sensing, FIA plots, and landscape scale assessment (under development)
Summary: Forest ecosystems are shaped by disturbance events that operate at larger scales than individual projects. Data collected via remote sensing methods are useful at the landscape scale because complete coverage of an area can be provided, and often provide data collected consistently over the entire state (9). However, field data are still an essential companion for aiding in interpretation of remotely sensed metrics and tying them to more familiar ground-based measurements such as basal area and species composition (10). FIA plots are an important field-based data source that can be tied in as a component to remote sensing-based monitoring, as well as data collected under the Level 1 and Level 2 monitoring. At the landscape level, metrics/indicators that evaluate desired conditions or outcomes are needed to better understand the collective role of fuel reduction and related management actions to moderate fire behavior (1). The WFR Task Force has developed an initial approach for this using data sets from the Regional Resource Kits.

Level 1 Monitoring Protocols (Forest Health grant outcomes and prescribed fire)

The California Prescribed Fire Monitoring Program characterizes prescribed fire effects on fuels, floristics, forest structure, carbon storage, and resultant impacts to air quality. This work services all land ownerships in California and provides a scientific foundation to inform best practices for fire planning, benefit public messaging, and mitigate public health impacts as the State advances its goals to increase the pace and scale of prescribed fire. Where possible, summarized pre-fire data is also used during burn operations as an aid to burn bosses who wish to meet specific objectives during ignition, or mitigate negative impacts from smoke. We also select and support prescribed fire projects that offer opportunity to examine a variety of research questions pertaining to prescribed fire, including: site preparation methods, prescribed fire as a restoration tool following wildfire, and the ability of prescribed fire to control invasive species.

Long-term monitoring plots are established in advance of prescribed fire ignition, and are re-measured over time (immediately following fire, 1 year post fire, 2 years post fire, etc.) to assess prescribed fire effectiveness. Changes to surface fuels and forest structure may occur directly following fire, whereas fire effects to botany often require multiple growing seasons to be observable. It is also expected that many of these plots will be re-burned over time, allowing for further fire effects analysis.

The attached protocol is designed for prescribed fire projects in forested conditions and is paired with day of burn weather data and fire behavior observations to aid analysis. Our program is concurrently developing specific protocols to support fire assessments in grassland and shrubland systems, as well as methods specific to oak woodlands. These additional protocols will be made available in 2023.

CAL FIRE Forest Health Program funds active restoration and reforestation activities aimed at providing for more resilient and sustained forests to ensure future existence of forests in California while also mitigating climate change, protecting communities from fire risk, strengthening rural economies and improving California's water & air. The Forest Health Program addresses the risk to California's forests from extreme disturbance events including catastrophic wildfires, drought, and pest mortality. These events are the result of climate change, forest overcrowding, past land management practices, and an increasing number of people living in the wildland and urban interface. Through grants to local partners and collaboratives, CAL FIRE seeks to significantly increase fuels management, fire reintroduction, treatment of degraded areas, and conservation of forests. Forest Health grants come primarily from California Climate Investments and General Fund appropriations. Forest Health grants fund on-the-groundwork in forest fuels reduction, prescribed fire, pest management, reforestation, and biomass utilization.

California Climate Investments (CCI) funding guidelines include outcome monitoring on a subset of projects for a tracking period of up to ten years. This Forest Health Field Monitoring Protocol was drafted for this outcome monitoring of completed Forest Health Grants. Forest Health Program also actively checks on grant progress during the implementation period.

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Change Log

The change log will track changes in the draft version that is used during development of this manual and a new change log will be started with version 1 of the manual.

Table 1. Change Log for Draft Document Development

Date	Person	Section	Description
7/27/2022	T. Robards	All	Initial draft.
8/29/2022	T. Robards	All	Edits and notes after 3 weeks of field data collection.
3/14/2023	R. Bellows	All	Format and copyedits. Added info to Annual Monitoring, QAQC, and Analysis and reporting sections.

Design of monitoring program

The Forest Health Grant outcome monitoring protocol is composed of a required core module and optional modules that may be implemented when module objectives are a priority and resources allow.

The core module contains the data elements for California Climate Investments, which are specified for California Air Resources Board outcome reports for grants funded by California Climate Investments. The core module is designed to provide inferences about the grants program as a complete population. Statistically, this is a design-based approach that relies on standard survey statistics to provide estimates of contemporary field conditions including carbon stocks. A model-based approach will be used to compare the original projected outcomes to the outcomes projected from monitoring data. Baseline estimates will also be updated as part of monitoring, where appropriate and feasible.

The optional modules may be designed to answer questions about the population of projects, in which case they will have a design like the core module, or they may be designed to address questions on a subset of projects or project components. As an example, an optional module might be designed to address the question, "What is the average per acre basal area retention of shaded fuel break treatments for all completed projects?". In this case, we would be using a design-based approach to provide an inference about the entire grants program (at least the portion completed), but the data is not part of the CARB required data elements and therefore falls into an optional rather than the core module. Another optional module might be designed to answer the question, "What are the effects of completed treatments on [pests, regeneration, windfall, growth] in adjacent stands, for the Southern Sierra Nevada?". This design would move outside the population of the projects and is geographically constrained; it would likely be design based but could be model based as well.

The following table was taken from the draft AB 1492 monitoring plan (Moreno, Henly and Cafferata 2018). The table describes the types of monitoring applicable to forestry activities. An additional column was added to the table to describe where forest health monitoring is utilized.

Type of Monitoring	Definition	Forest Health Monitoring
Baseline Monitoring	Characterizes current conditions as a baseline, or a reference point to compare against future monitoring results. Baseline monitoring is often used as a first step in determining the effectiveness of project implementation.	Baseline in this context is the pre-treatment condition and subsequent forest development in the absence of treatment. We use the baseline as a comparison to treated areas. Pre-treatment field data will not be collected but paired control areas may be identified for comparison.
Implementation Monitoring	Consists of monitoring project areas or design features to ensure project elements and best management practices were implemented in accordance with the project language and all applicable permits and laws. Its purpose is to ensure that proposed work was successfully completed as designed.	In this context implementation is measured against the proposal and contract. This could include actual acres treated, planted seedling survival, residual tree damage after thinning, road plan, piles burned and unburned, etc. This is conducted by Forest Health Grant staff via progress reports and site

Type of Monitoring	Definition	Forest Health Monitoring
		visits while the grant is active and work is in progress.
Trend Monitoring	Conducted to determine the condition of physical, chemical, or biological attributes across a given area and evaluate their change over time.	This applies to the 10-year timeframe for post-treatment monitoring for data collection and to the full time used for projections of GHGs (i.e. 50/60/80 years). Fuel load recovery will be a trend analyzed during the 10-year period, for example.
Effectiveness Monitoring	An in-depth analysis focused on evaluating whether specified activities had the desired effect. Effectiveness monitoring is designed to determine if the project is effective at meeting its physical, biological, and ecological objectives.	This applies to the effectiveness for GHG projections. Post-treatment data will be used to improve projections, which will be compared to both baseline estimates and initial estimates. Outcome monitoring data may be used for effectiveness analysis.
Validation Monitoring	Assesses the soundness of assumptions, models, methods, and proposals through research.	Effectiveness monitoring may provide insight into this, causing modifications to analysis methods to improve accuracy. Research components of projects may address this. Outcome monitoring data may be used for validation of carbon quantification and forest management best practices.
Compliance Monitoring	Verifies that environmental regulations have been correctly followed.	This is not generally applicable in this context but may have occasional use with road monitoring or ad-hoc observations of potential issues when on site.

The figures below show the core and optional model process at a high level.

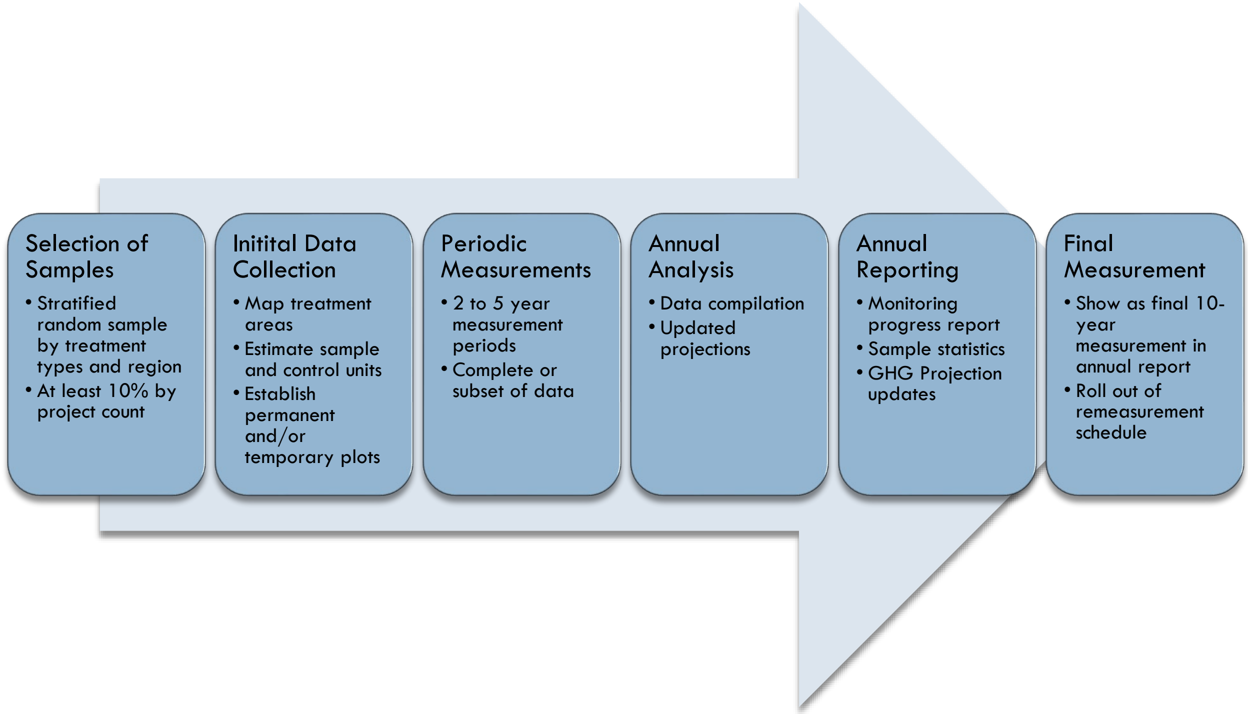


Figure 1. Core module process.

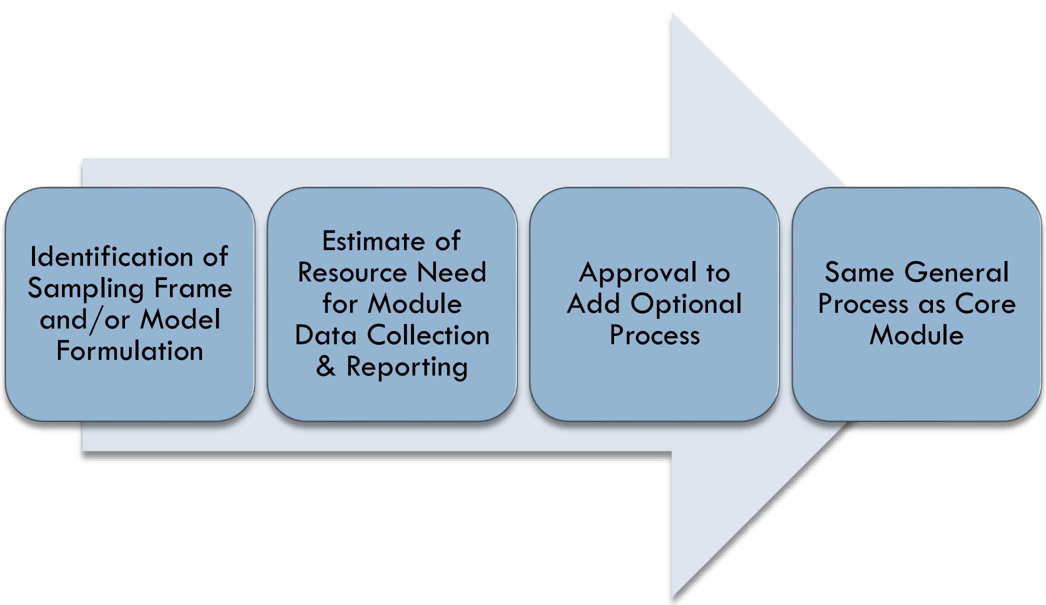


Figure 2. Optional module process.

Either temporary or permanent plots will be used, depending on the treatment type and objectives of the data analysis, as well as permission from landowner. All data will be made available to the landowner including plot data and GIS data. Permanent plot monumentation (plot center stakes, tree tags) will be removed at the last measurement if desired by the landowner. Generally, measurement frequency will be on a biannual basis. Permanent plots in mature forest may be measured every 3 to 5 years if resources are limiting and/or a subset of data may be collected on the biannual basis.

Control units will be identified to compare non-treated areas to the treated to address two questions:

1) What is the actual post-treatment condition compared to control areas?
2) How does the actual forest condition compare from the treated vs. the control areas over the 10-year monitoring period?
3) How does the projected forest condition compare from the treated vs. the control areas, over the period of interest, beyond the 10-year monitoring period? This might require data collection in the control units, which is not currently budgeted for.

Control units may be identified a priori using remote sensing (forester using aerial imagery or automated system such as use by Adam Moreno at CARB), by identification in the field, or a combination of the approaches.

Core Module Design

The projects that have reached a trigger event to begin monitoring, and the acres they cover, are the population of interest for sampling. This population grows each year as more projects start monitoring and contracts as projects reach the end of the monitoring period and are removed from sampling. Final monitoring estimates from projects past the end of the monitoring period will still be included in reporting and therefore remain part of the population for purposes of reporting. A project may consist of multiple treatment types including fuels treatments, reforestation, pest management, and prescribed fire. These treatment types are considered strata for purposes of the sampling design.

The statistical methodology utilized is three-stage list sampling with stratification. The three stages of sampling are 1) the project/strata at the first stage, 2) the treatment units or stands at the second stage, and 3) the plots at the third stage. The stratification will consist of treatment type and CAL FIRE region (north and south). The second stage is used where projects are large, and a subsample of treatment units is selected for sampling. The second stage may be ignored where all treatment units on a project are sampled.

We shall use acres as the importance measure at the first stage. We shall select from a projects/strata list with a probability proportional to size. This way, each acre in the population has an equal probability of selection. The "list" also refers to the list of treatment units at the second stage, which is a second list constructed where the second stage of sampling is implemented. These units are selected with equal probability.

Selection of projects for monitoring

Projects will be selected randomly from a list of newly eligible projects on an annual basis. Cumulative percentages by project count, treatment type, CAL FIRE Region, and acres shall be tracked. Random selections will be made from this list with probability proportional to size or acres. The treatment types that are allowed for in the design:

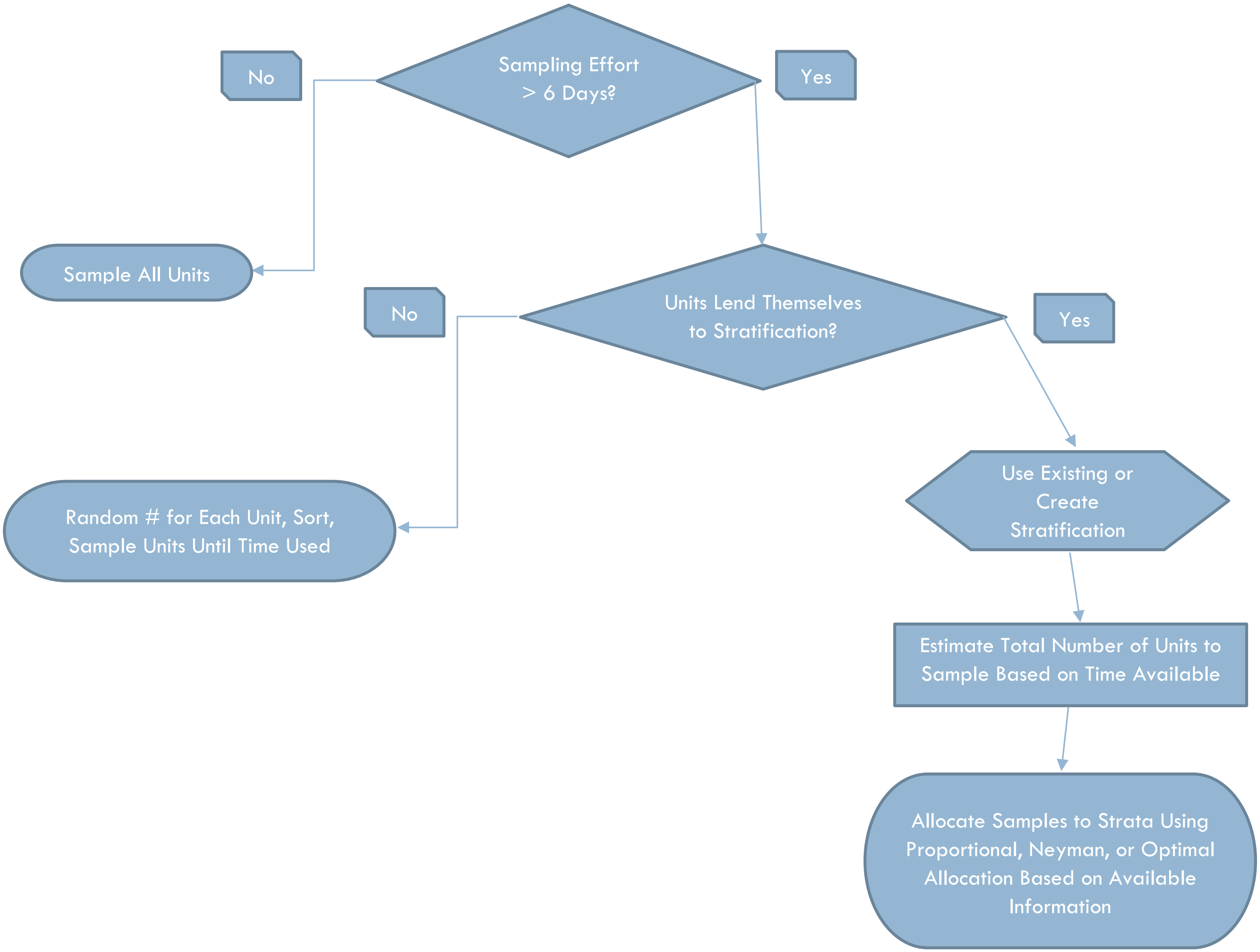
- Reforestation
- Pest management
- Fuels reduction
- Prescribed Fire
- Other, including
  - Ecological restoration
  - MSA development
  - Road improvement and/or abandonment

Samples are selected to meet a minimum 10 percent sample by project/treatment count. The percentage by acres is also provided so that an adjustment can be made if this estimate is below 10 percent. The Other category shall be considered by the listed, and other new, types as they come up in approved projects.

Selection of sampling units in a project

Selected projects, by treatment type, will be examined to determine if a subsample of units is warranted due to size and time it would take to sample. The diagram on the next page shows how to determine if we need to draw a subsample, and if so how to select the units.

A maximum effort of 6 days is allowed to sample a project/treatment type. If more than the maximum effort is required and the project cannot reasonably be stratified then select a random number between 0 and 1 for each unit, sort the units by random numbers ascending, and sample the units in order until the maximum effort is expended.


Sampling Effort
> 6 Days?
No
Yes
Sample All Units
Units Lend Themselves
to Stratification?
No
Yes
Random # for Each Unit, Sort,
Sample Units Until Time Used
Use Existing or
Create
Stratification
Estimate Total Number of Units to
Sample Based on Time Available
Allocate Samples to Strata Using
Proportional, Neyman, or Optimal
Allocation Based on Available
Information

If more than the maximum effort is required and the units can be logically stratified, then estimate the total number of units to sample using the maximum effort. Then allocate the sample to the strata based on the selected method (proportional, Neyman, or optimal).

Control units will be established for each project/treatment sampled. Control units may be identified before going to the field using remote sensing information, if possible. Otherwise, they may be identified in the field. Locate the control units as pairs to treatment units where feasible. Inquire with the landowner if treatments are planned in the potential control units during the 10-year monitoring period. It may be desirable to keep control units untreated, or if the treatment is common in the area, to have the control unit treated during the 10-year monitoring period. Emphasize to the landowner that the designation of a control area does not mean that we wish them to lock up the area from treatment for 10 years. Control unit size will ideally be similar to treatment unit sizes. Try to identify 3 control units to measure. This number may be modified based on data needs and statistical analysis used to compare treatments to controls. Follow the specific procedures in control units, which does not entail plot level data in some cases.

Sampling unit data collection

Each unit will have geographic data collected including slope, aspect and elevation. A field call of forest vegetation type, size and density will be made. A representative photo shall be taken of each sampled unit with the photo location waypoint collected along with a description of the location relative to persistent landmarks.

The sampling procedure will vary by treatment type. Each treatment type is considered below with the attributes of interest listed with their sampling methodology. Where multiple treatments have occurred, the total of all attributes shall be sampled.

Fuels Transects Module

This module is used in many of the treatment types and is in a separate section so that it may be referenced without repeating the details.

Fuels transects are divided into coarse woody debris (CWD) and fine woody debris (FWD). The definition and layout are from the FIA inventory, and all transect lengths are horizontal distance. The ends of all transects should be marked with a wire flag noting the transect type so that check cruising may evaluate transect placement and measure the same transect. CWD are 3.0 inches and larger and include downed, dead tree and shrub boles, large limbs, and other woody pieces. Two CWD transects are installed per plot at 90° angles to account for wood that may be aligned with the slope (Figure 5, Figure 6):

1) First CWD transect is from plot center due north 24.0 feet,
2) Second CWD transect is from plot center due east 24.0 feet.

The transect lengths match the radius of the standard FIA subplot.

FWD transects are on a portion of the CWD transects, from 14 feet from plot center to 6 or 10 feet depending on FWD size class (Table 3). Follow the FIA instructions for data collection found in the appendix (Table 2 and Table 4). Ignore references in the FIA manual to condition class. If transect abuts a boundary then record the short length of the transect, from plot center to boundary. For piles, add a variable indicating if pile burned or unburned.

Table 2. FIA manual sections for CWD.

FIA Section(s)	Description	Collect?	Notes
10.4.1	Procedure	Yes	Diameter measurement aids useful
10.4.2	Marking CWD	Yes	Need wax crayon
10.4.3.6	Decay class	Yes	Decay class table should be readily available
10.4.3.7	Species	Yes	
10.4.3.8.1-2	Diameters	Yes	Diam. at intersect sufficient for unbiased estimate
10.4.8.3-4	End diameters	No	
10.4.3.9	Length	Yes	To 3” minimum diameter
10.4.3.9.2-10	Total length & hollow	No	
10.4.3.11	Piece inclination	No	Assumes small bias
10.4.3.12	CWD history	Yes	Useful for categorizing source of CWD
10.4.3.13	Log charred	No	
10.4.3.14	Large end	No	
10.5	Sampling piles	Yes	Ignore 10.5.3
10.5.2	Pile transect	Yes	Replace with 1 for 360(N) and 2 for 90(E)
10.5.7	Pile decay class	Yes	Decay class table should be readily available

Table 3. Fine Woody Debris (FWD) size categories.

Category of FWD	Size Class	Diameter Range	Transect Length (horizontal distance)	Transect Location (horizontal distance)
Small	1	0 in to 0.24 in	6 feet	14 to 20 feet
Medium	2	0.25 in to 0.9 in	6 feet	14 to 20 feet
Large	3	1.0 in to 2.9 in	10 feet	14 to 24 feet

Follow the instructions in the FIA manual, found in the appendix, for FWD sampling (Table 4).

Table 4. FIA manual sections for FWD.

FIA Section(s)	Description	Collect?	Notes
10.6	Procedure	Yes	Sample alternating 0 and 90 degree transects
10.6.2	FWD transect	Yes	1=0°(N) and 2=90°(E)
10.6.3	Condition class	No	

Duff and litter depth are measured on each transect at 24-feet from plot center. Follow the directions in the FIA manual (Table 5).

Table 5. FIA manual sections for duff and litter depth.

FIA Section(s)	Description	Collect?	Notes
10.7	Procedure	Yes	Sample both transects
10.7.3	Subplot number	No	
10.7.4	Transect	Yes	1=0°(N) and 2=90°(E)

Road Monitoring Module

This module is used in many of the treatment types and is in a separate section so that it may be referenced without repeating the details.

Only monitor roads where the contract may have paid for all or part of the road work done. The road work must be specified in the contract; do not include road work incidental to the project such as brushing/mowing to open roads for access or road work used to access nearby project areas but also used on this project (but not paid for by project).

The following procedure was adapted from (CAL FIRE 2018).

1) Use the project map to identify the closest non-public road segment that includes at least one watercourse crossing. If a crossing has been pulled, this will be treated as a crossing regardless and assessed. Record the crossing type as "Other" and include comments.
    a. If all roads within the notice area are public roads, there will be no road segment assessment.
    b. If no watercourse crossings on the non-public road segment are present, a substitute road segment will be found by:
        i. Select the next nearest non-public road segment.
        ii. Continue as needed to find a road segment with at least one watercourse crossing.
2) Make note if the sampled road also serves as residential access.
3) From the intersection of the road and the most central watercourse crossing in the road segment in the project, road sampling will be conducted **660 feet in each direction** (1,320 feet or 0.25 miles total)
    a. If the road segment ends, or leaves the project area, the sampling stops at that point.
    b. At road forks and intersections, flip a coin to determine travel direction.
4) If the watercourse survey starts at a road crossing, record the **crossing type** ("Bridge", "Culvert", "Ford", "Open bottom arch", "Other"). Additionally:
    a. Record (if it can be determined) if the crossing was pre-existing, new with the project activity; if it can't be determined, record as such.
    b. Record the diameter in feet (if a culvert, open bottom arch, or other circular feature) or the width (if ford or bridge).
    c. Assess the potential for diversion from the initial watercourse crossing (as applicable)

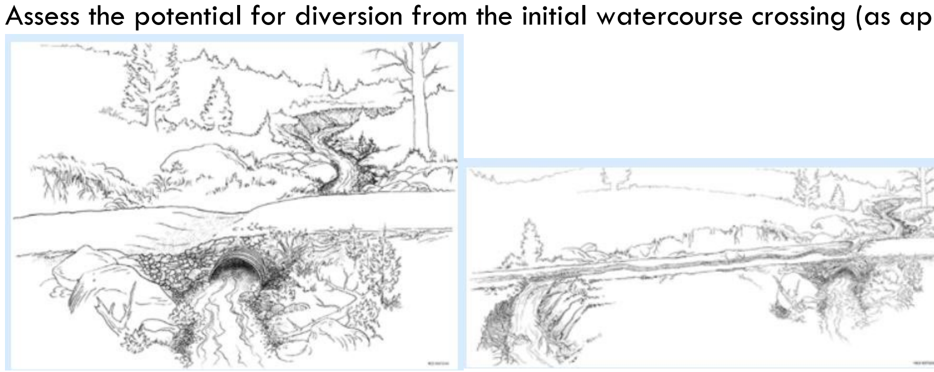


Figure 3. No potential for diversion (Left), and potential for diversion (Right) (Images from Furnis et al., 1997)

    d. Assess (using professional judgement) if the watercourse crossing is adequately sized (Yes/No, as applicable).
    e. Record the watercourse class at the crossing (Class 1, 2, 3, or 4).
5) Start the survey in one direction, walking 660 feet, noting the following (make notes only – this data will be entered in as a summary for the entire segment at the end):
    a. Rill, gully, or ponding features on the road surface ("Yes" or "No" for presence).

i. A rill is defined as incision into the surface of at least 1" (IMMP, 2007).
ii. A gully is defined as incision into the surface of 6" or more (IMMP, 2007).
iii. Ponding for this protocol is defined as standing water of at least ½" that covers 50% of the roadway or more.

Figure 4. A road surface with rills (Left) and a gully formed (Right).

b. Cut bank and fill bank failures ("Yes" or "No" for presence).
c. Rill or gully features at road drainage points ("Yes" or "No" for presence)
   i. These features do not need to connect to a watercourse. These are general observations to determine the construction and nature of runoff and drainage along the road segment.
d. Count the number of Class 1, 2 or 3 watercourse crossings encountered (including the crossing used to start the survey, as applicable).
e. Count the number of waterbars, rolling dips, lead-outs, and other **constructed** road drainage features encountered.
f. The total length surveyed out of the possible 660 feet for that portion.
g. Note points of sediment delivery to watercourses from the road segment; this data will be collected as you return to the starting location.

6) **Road sediment delivery data**
   a. Sediment delivered from the initial starting point at the crossing (as applicable) will be recorded as a sediment delivery.
   b. If sediment delivery from the road to a watercourse is not readily apparent, but possibly occurred, a field investigation should be undertaken if the watercourse is visible from the road **and** the sediment flow path terminus is not visible from the road.
   c. Determine the road sediment source, i.e., where did the sediment come from ("Crossing", "Ditch failure", "Road failure", "Rolling dip", "Surface sheetwash", "Waterbar", "Other").
   d. Collect a GPS point at the point of discharge from the road.
   e. Collect a photo of the erosional feature.
   f. Determine the "Flowpath Length" category (measured as from the point of discharge from the road to the watercourse; or at a crossing, the longest approach length).
      i. In the case of a crossing, it is the cumulative length of the approaches.
   g. Determine the "Roughness Class" along the flow path (**see Reference 2**).

Reference 2: Roughness class to assess cover on flowpaths that sediment is delivered along [adopted from Litschert and MacDonald (2009)]

Class	Description
1	Bare mineral soil, little to no surface roughness
2	Over 50% bare soil, live vegetation absent on > 50% of flowpath, some presence of litter, coarse wood, rocks, light slash cover
3	Less than 50% bare soil, live vegetation present on > 50% of flowpath, litter, duff, coarse wood, rock, light slash cover
4	Dense cover of vegetation, litter, duff, coarse wood, rock, and/or heavy slash that interrupts downslope surface runoff pathway.
5	Intentionally armored road surface

h. Estimate the volume discharged to the watercourse.
    i. "Trace" indicates sediment was delivered, but a volumetric estimate can't be readily determined.
    ii. "Significant Event" indicates the volume of sediment delivered exceeds 10 cy and is closer in magnitude to a mass movement/landslide scale.
i. Determine the classification of the receiving watercourse.
j. Determine if the sediment discharge is a chronic feature, or episodic only in nature
    i. This determination implies that a chronic feature is an ongoing issue, while an episodic discharge may only occur during heavy rain events, following heavy road traffic, rain on snow events, etc.
k. Determine the erosion feature, or what is the mechanism by which sediment was delivered downslope to the watercourse (e.g., by rill or gully).
l. Add any additional comments within the App/Data sheet that will help to clarify the sediment discharge point (i.e., "Occurred below a severely burned hillslope).

7) Repeat **step 4**, traveling in the opposite direction from the starting point for 660 feet or until the road segment ends or leaves the project area.
8) Repeat **step 5** for the second segment, while traveling back to the starting point, collecting data on any road sediment delivery.
9) At the end of the second 660-foot segment, enter in the total length sampled, number of Class 1/2/3 watercourse crossings, and the number of drainage features encountered, and the presence ("Yes"/ "No") of road surface rill/gully/ponding features, cut/fill bank failure, and road drainage rill/gully features.
10) Determine the road surface for the segment, road shape, road class, topographic position, road gradient, and hillslope gradient (using the following categories):
    a. Surface categories are "Native", "Gravel/Rocked", "Oiled/Chip Sealed", "Paved", "Other"
    b. Road class categories are "Permanent", "Seasonal", "Temporary", "Abandoned/Deactivated"
    c. Road shape categories are "Crowned", "Flat", "Insloped", "Outsloped", "Throughcut"
    d. Topographic position categories are "Ridgetop", "Mid-slope", "Valley Bottom"
    e. The road gradient class is representative of both the entire segment sampled (0-5%, 5-10%, 10-15%, >15%)
    f. The hillslope gradient class is representative of the entire road segment (0-30%, 30-50%, >50%)

Reforestation

Table 6. List of data attributes to collect for the reforestation project type.

Attribute	Categories	Variables	Description
Trees per Acre	Planted/Natural/Legacy	Species, diameter, height, crown ratio	Used to assess site occupancy and success of reforestation effort.
Shrubs*		Species, cover, height	Used to assess competing vegetation, fuels, invasive plants and biodiversity.
Forbes*		Species, cover, height	Used to assess competing vegetation, fuels, invasive plants and biodiversity.
Graminoids*		Species, cover, height	Used to assess competing vegetation, fuels, invasive plants and biodiversity.
Site Index	Regeneration/Mature	Species, diameter, breast-ht age, total height, 4-year internode length for young ponderosa pine	Used as input to growth projections. Generally, use appropriate mature trees in nearby stands to core for age and measure height to estimate site index. For young stands of ponderosa pine, use Oliver (1972).
Soil Disturbance	Ripped, masticated, broadcast burned, pile burned	Bare soil cover	Used to assess site preparation intensity.
Fuel Load	Live/Dead, Fuel model	Tons per acre of 1, 10, 100, 1000-hour dead fuels, duff, litter depth.	Make an estimate of fuel model(s) using table 2.4.8 of the FVS-FFE guide (2022) and see Scott and Burgan (2005) for photos of 40 of the fuel models. Both photo-based fuel models and fuels transects are installed in this treatment type.
Piles	Burned/Unburned	Material type, volume (cu ft)	Used to assess the amount of burned and unburned fuel in piles after treatment.

* Requires training and field guides for plant identification.

Fixed sized circular plots are used to collect data. Select one of three plot sizes, depending on the estimated average tree density for a unit. Only one plot size is to be used per unit.

Plot Name	Plot Size	Range of Estimated Trees per Acre	Plot Radius (ft)
L	0.05 (1/20-acre)	0 to 150	11.78
M	0.02 (1/50-acre)	150 to 300	7.45
S	0.01 (1/100-acre)	Over 300	5.27

Figure 5 on the next page shows the relative plot sizes.

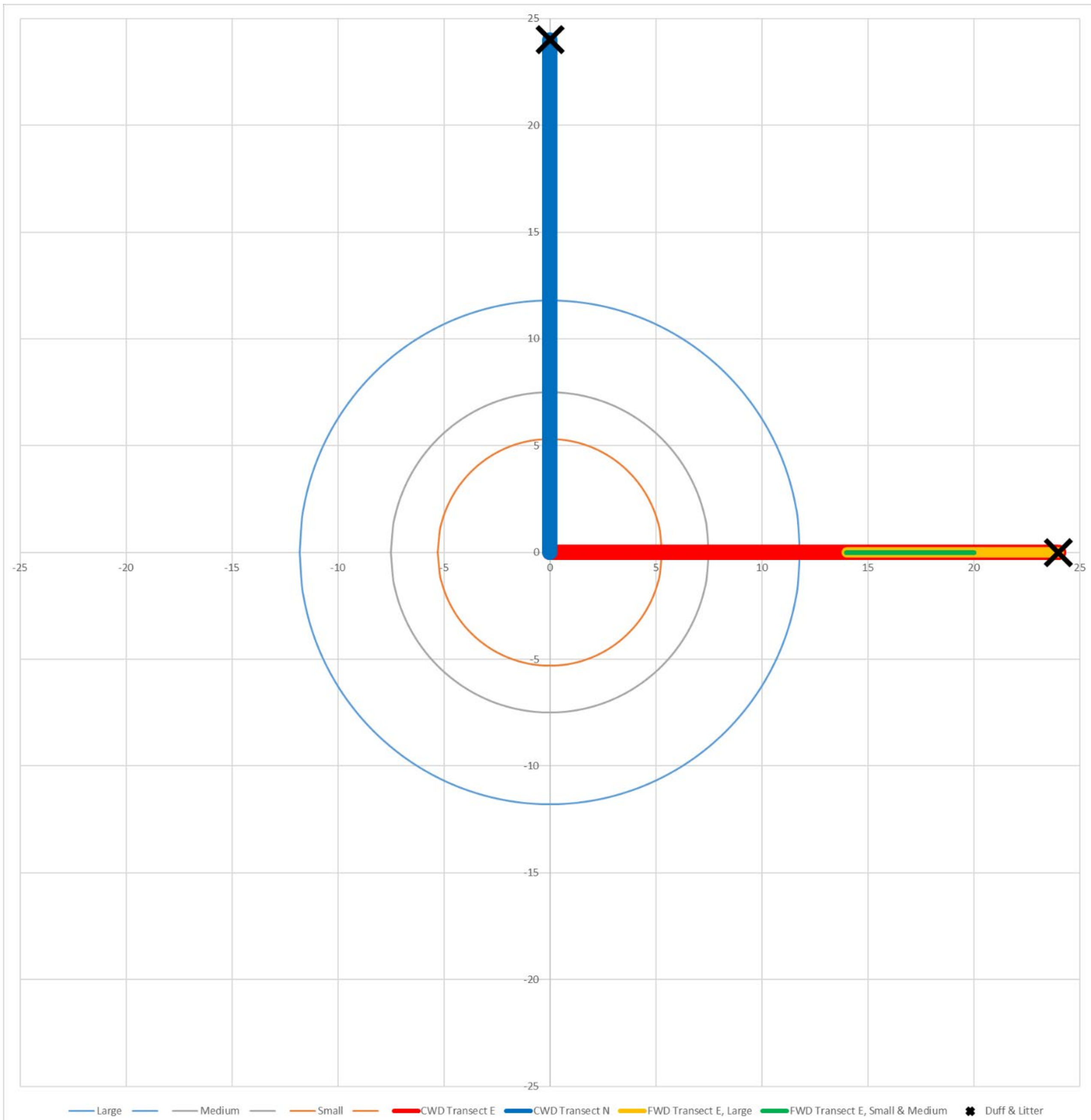


Figure 5. Reforestation plot choices shown with fuels transects. East transect shows the shorter fine woody debris (FWD) transects; the FWD transects alternate to the north and east.

Target plot intensity is one plot per two acres. A minimum of 5 plots, and a maximum of 10 plots, shall be installed in a unit for reforestation. Locate the plots on a square systematic grid using the following procedure:

1) Based on the shape and orientation of the unit decide which azimuth the plot grid shall be oriented, using N-S, E-W as the default.
2) Calculate the acres per plot based on the acres of the unit and the number of plots.

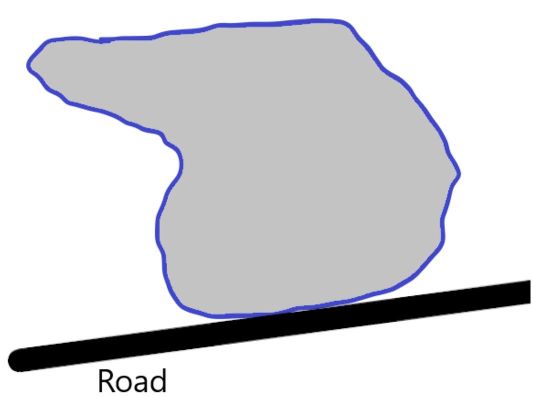
3) Calculate the square feet per plot by multiplying the acres per plot by 43,560. Take the square root of the square feet per plot.
4) Draw two random numbers between zero and the value from step #3.
5) Start from a convenient corner of the unit and pace the distance over and in (90 degrees apart) to locate the center of the first plot, which is a random start to the systematic sample.
6) Install the first plot and move along the predetermined grid to the next plot location. The distance between plots is the value calculated in step #3.

If the unit is linear in shape, such as a reforested road or fireline, then modify the above procedure to be a single line of plots with a fixed distance between the plots with a random start, and a random plot location across the narrow width of the unit.

When a plot is near the edge of the unit and part of it is outside the unit then the following procedure is to be followed. This is to ensure that the edge of units is not under-sampled by moving plots away from the edge. Measure the portion of the plot edge that intersects the plot; this will be used to calculate the area of the plot outside the unit and adjust the tree weights in the plot accordingly. If the plot is in a corner or some other non-straightforward configuration, then ocularly estimate the percentage of the plot outside the unit.

This is an example of the procedure:

1) The unit has the following shape, with a road on its southern edge. It makes sense to run the grid in a north-south orientation, which is generally the case unless there is an overriding reason to change it. For efficiency it would make sense to start with the first plot near a "corner of the unit near the road but be careful to ensure that the grid of plots is considered over the entire unit area, especially in oddly shaped portions of the area.



2) The unit is 15 acres. The plot intensity based on one plot per two acres, and rounding up to the nearest integer, is int(15/2)=8 plots. Since the minimum number of plots is 5, we will install 8 plots in the unit. These equates to 15 acres/8 plots = 1.875 acres/plot.
3) The square feet per plot is 1.875 X 43,560 = 81,675 sq ft. The square root of the sq.ft./plot is 285.79 feet.
4) Two random numbers between 0 and 285.79 are 232.9 and 69.5 feet.

5) From the starting location on the southwest edge of the unit, pace 232.9 feet to the east and 69.5 feet to the north. If the plot lands in the unit, then this is your first plot. If it lands outside the unit then pace the distance between plots to the north (or other cardinal direction to get you in the unit), 285.8 feet in this example.
6) Continue to fill out the grid of plots until all plot centers have been placed in the unit.

Mark the plot center with a wire flag. Write CCI, date, and initials on the flag with a sharpie. This is for check cruising purposes. Work from due north in a clockwise direction to facilitate check cruising.

Record the following data for the plot.

- Plot ID: Project#_TreatmentType_Plot#
- Date
- Crew
- Coordinate system (UTM)
- Gps unit
- Gps datum
- Gps coordinates
- QA status
- Water on plot
- Plot notes

1) Record the species, total height, and percent crown ratio. If a tree is 4.5 feet tall or higher then measure dbh to the nearest 0.1 inch.
2) Make ocular estimates for the entire plot on the species, percent cover of the species, average height of the species of shrubs, forbs and graminoids. Use a siting tube to help calibrate your estimates, and/or partition the plot into smaller sections to improve accuracy.
3) Make ocular estimates of the percent of bare mineral soil, dead vegetative cover and pile and broadcast burned area on the plot.
4) Estimate the percentages of up to 3 fuel models by comparing the photos and description from Scott and Burgan. Must sum to 100 percent. Install the fuels transects as described in the fuels transection module, above.
5) Find two to three site trees to core in the area of the unit. The site trees should be on similar soil type, slope and aspect. If the site estimates from two trees are similar then stop, otherwise collect a third tree. Use trees that have been relatively free to grow (dominants and co-dominants) throughout their life. If no suitable site trees are available, then note that and skip the step.
6) Locate a control unit in proximity to the unit being sampled. A control unit is one that was similar to the sampled unit before the unit was treated. Do not install plots in the control unit but make estimates as for items 2, 3, and 4 above.

Pest management (Fuels Reduction for Tree'd Areas)

Table 7. List of data attributes for the pest management treatment type.

Attribute	Categories	Variables	Description
Trees and Basal Area per Acre		Species, diameter, breast-ht age, height, crown ratio	Used to assess post treatment density and tree vigor.
Tree damage		Skin-ups to bole and roots; crown damage	Assess post-harvest residual tree damage.
Brood material		Slash quantity and treatments	Evaluate potential for pest infestation due to treatments
Site Index		Species, diameter, breast-ht age, height	Used as input to growth projections. Generally, use appropriate mature trees in stands to core for age and measure height to estimate site index.
Pest indicators	Insect, Pathogen, Plant, Animal	Tree damage from trees on plot, observations of pests within stand	Identify post treatment pests and intensity.
Fuel Load	Live/Dead, Fuel model	Tons per acre of 1, 10, 100, 1000-hour dead fuels, duff, litter depth.	Make an estimate of fuel model(s) using table 2.4.8 of the FVS-FFE guide (2022) and see Scott and Burgan (2005) for photos of 40 of the fuel models. Both photo-based fuel models and fuels transects are installed in this treatment type.
Piles	Burned/Unburned	Material type, volume (cu ft)	Used to assess the amount of burned and unburned fuel in piles after treatment.

Nested fixed sized circular plots are used to collect data. There are three nested plots as explained in the following table and figure. This is the same setup as for a plot in FIA (actually this is a subplot in the 4-subplot cluster for FIA, we are not doing clusters). For clarity, we are using the same vernacular as FIA (USDA Forest Service 2018) to describe the names of the 3 nested plots sizes.

Table 8. Pest management plot configuration.

Names (FIA)	Radius (ft)	Area (ft^2)	Area (acre)	DBH Range (in)	Location
Macroplot	58.9	10,898.8	0.250	≥ 24	Plot center
Subplot	24.0	1,809.6	0.042	≥ 5 and < 24	Plot center
Microplot	6.8	145.3	0.003	≥ 1 and < 5	Offset 12.0 ft horiz. 90°

Figure 6 shows the relative plot sizes.

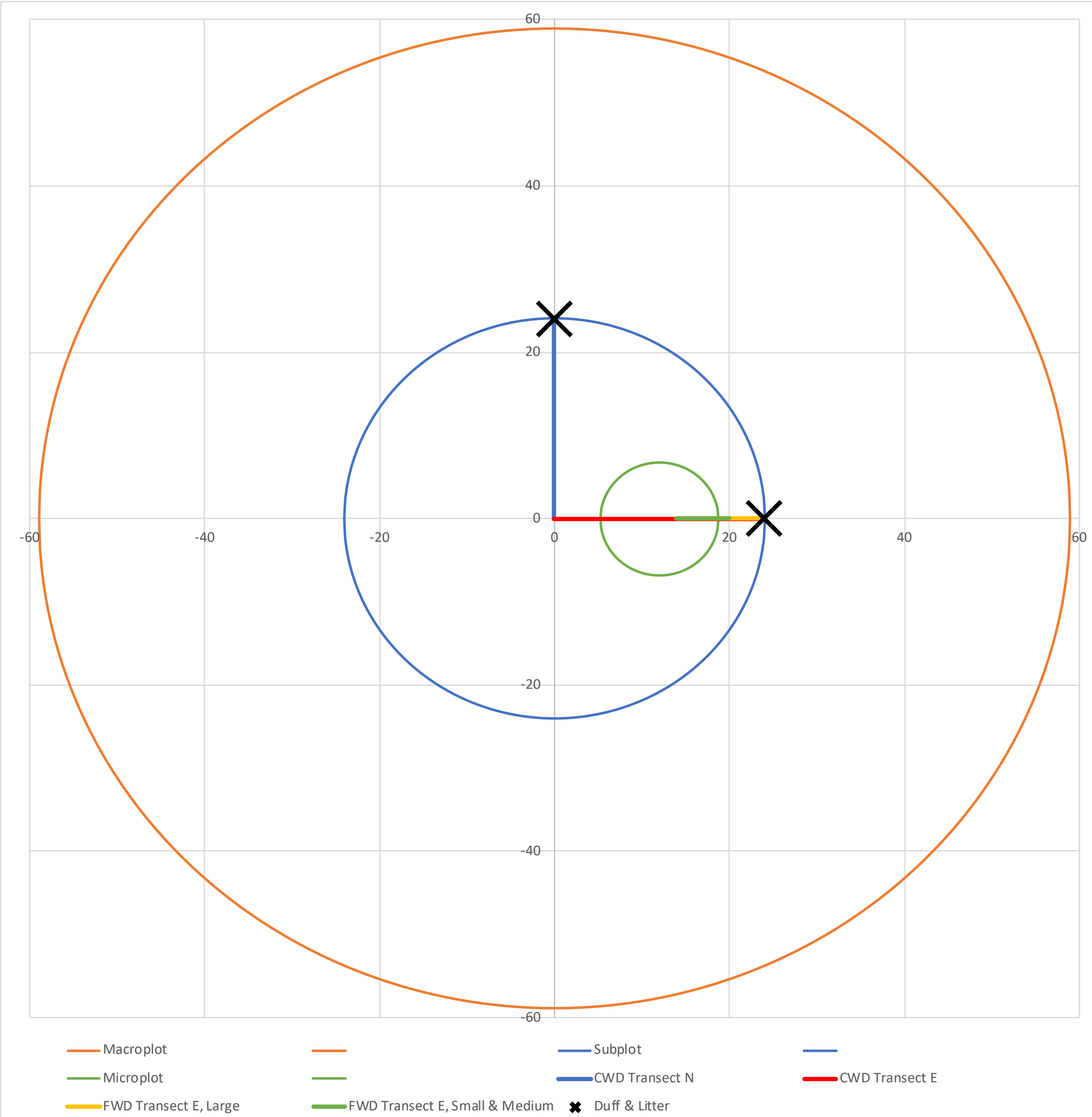


Figure 6. Pest management plot layout and fuels transects. East transect shows the shorter fine woody debris (FWD) transects; the FWD transects alternate to the north and east.

The target plot intensity is one plot per four acres, which is a percent sampled of .25-acre/4 acres = 1/16 = 6.25%. A minimum of 5 plots, and a maximum of 10 plots, shall be installed in a unit for pest management. Locate the plots on a square systematic grid using the following procedure:

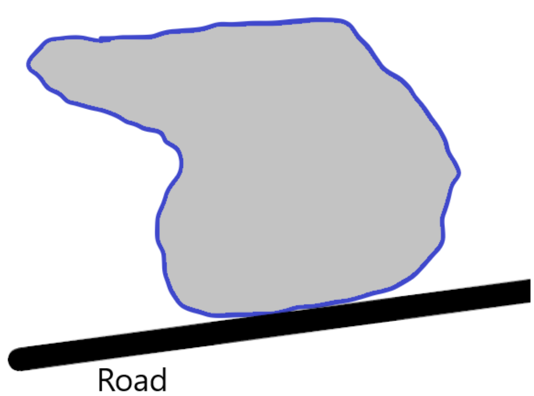
1) Based on the shape and orientation of the unit decide which azimuth the plot grid shall be oriented, but use north-south, east-west as the default.
2) Calculate the acres per plot based on the acres of the unit and the number of plots.

3) Calculate the square feet per plot by multiplying the acres per plot by 43,560. Take the square root of the square feet per plot.
4) Draw two random numbers between zero and the value from step #3.
5) Start from a convenient corner of the unit and pace the distance over and in (90 degrees apart) to locate the center of the first plot, which is a random start to the systematic sample.
6) Install the first plot and move along the predetermined grid to the next plot location. The distance between plots is the value calculated in step #3.

When a plot is near the edge of the unit and part of it is outside the unit then the following procedure is to be followed. This is to ensure that the edge of units is not under-sampled by moving plots away from the edge. Measure the portion of the plot edge that intersects the plot; this will be used to calculate the area of the plot outside the unit and adjust the tree weights in the plot accordingly. If the plot is in a corner or some other non-straightforward configuration, then measure all the edges, sketch the plot with dimensions, and calculate the portion of the plot outside the unit.

This is an example of the procedure:

1) The unit has the following shape, with a road on its southern edge. It makes sense to run the grid in a north-south orientation, which is generally the case unless there is an overriding reason to change it. For efficiency, it would make sense to start with the first plot near a "corner of the unit near the road but be careful to ensure that the grid of plots is considered over the entire unit area, especially in oddly shaped portions of the area.



2) The unit is 55 acres. The plot intensity based on one plot per four acres, and rounding up to the nearest integer, is int(55/4)=14 plots. Since the minimum number of plots is 5 and maximum is 20, we will install 14 plots in the unit. This equates to 55 acres/14 plots = 3.929 acres/plot.
3) The square feet per plot is 3.929 X 43,560 = 171,128.6 sq ft. The square root of the sq.ft./plot is 413.68 feet.
4) Two random numbers between 0 and 413.68 are 250.8 and 154.2 feet.
5) From the starting location on the southwest edge of the unit, pace 232.8 feet to the east and 154.2 feet to the north. If the plot lands in the unit, then this is your first plot. If it lands outside the unit then pace the distance between plots to the north (or other cardinal direction to get you in the unit), 413.7 feet in this example.

6) Continue to fill out the grid of plots until all plot centers have been placed in the unit.

For a temporary plot, mark the plot center with a wire flag. Write CCI, date, and initials on the flag with a sharpie. This is for check cruising purposes. Work from due north in a clockwise direction to facilitate check cruising, by plot size.

For a permanent plot, mark the plot center with a plastic stake (something flush to the ground and metal so metal detector could be used to relocate it. Place flagging on the stake and higher up on a branch near the stake. Write CCI, date, and initials on the stake and the high flag with a sharpie. This is for check cruising purposes and so plot can be relocated during re-measurement. Work from due north in a clockwise direction to facilitate check cruising, by plot size.

Identify three witness trees that can be used to triangulate the location of plot center. Paint the tree number on the stump area of the tree using a color that cannot be confused with a cut or leave mark (suggest white); or use an aluminum tag. Mark the point of breast height measurement (4.5 feet uphill side) with an aluminum nail, on every tree. Put the nail just deep enough so that it can grow out with the bark if possible.

Record the following data for the plot.

- Plot ID: Project#_TreatmentType_Plot#
- Date
- Crew
- Coordinate system (UTM)
- Gps unit
- Gps datum
- Gps coordinates
- QA status
- Water on plot
- Plot notes
- Direction and distance from each witness tree to plot center

Record the species, total height, and percent crown ratio. If a tree is 4.5 feet tall or higher then measure dbh to the nearest 0.1 inch.

Make ocular estimates for the entire plot on the species, percent cover of the species, average height of the species of both shrubs, forbs and graminoids. Use a siting tube to help calibrate your estimates, and/or partition the plot into smaller sections to improve accuracy.

Make ocular estimates of the percent of bare mineral soil, dead vegetative cover and pile and broadcast burned area on the plot.

Estimate the percentages of up to 3 fuel models by comparing the photos and description from Scott and Burgan. Must sum to 100 percent. Install the fuels transects as described in the fuels transection module, above.

Find two to three site trees to core in the area of the unit. The site trees should be on similar soil type, slope and aspect. If the site estimates from two trees are similar then stop, otherwise collect a third tree. Use trees that have been relatively free to grow (dominants and co-dominants) throughout their life.

Fuels reduction and Prescribed Fire

Fuels reduction, including prescribed fire, projects may be in any vegetation type and might include removal of all flammable vegetation or forested shaded fuel breaks.

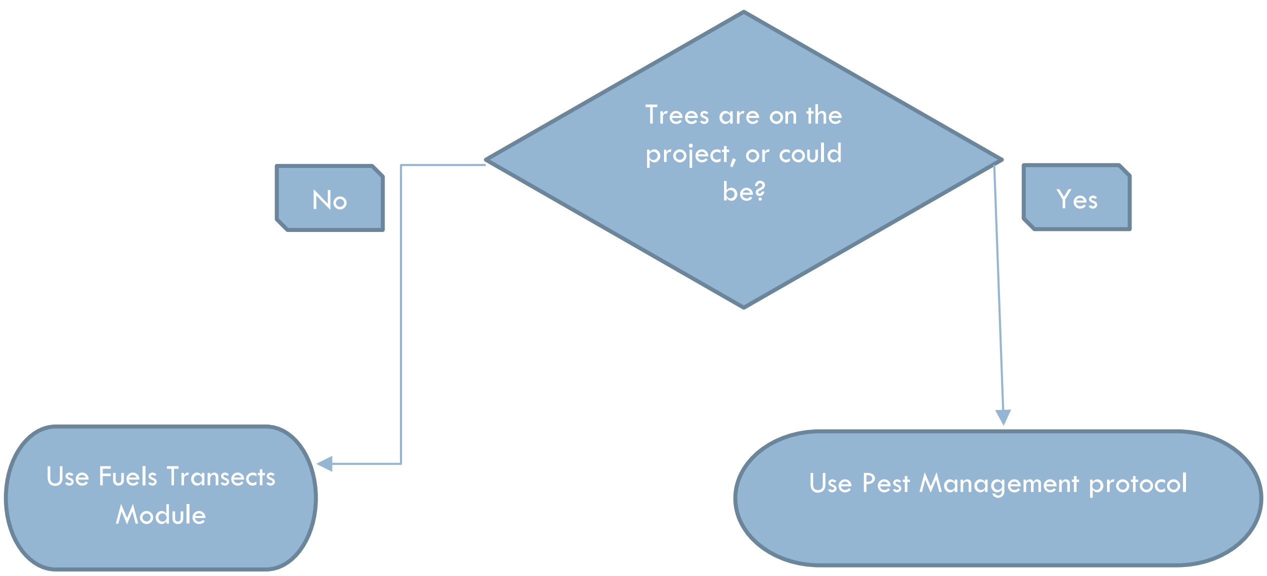


Figure 7. Decision tree for fuels reduction treatments.

As shown in Figure 5, if there are no trees in the project area now and none are anticipated to seed in or be planted then use the fuels transects to measure fuel load. Install the fuels transects using plot centers installed like with the pest management protocol. Also, collect fuel type estimates. If trees are involved, then use the pest management methodology as given in that section.

Data management

Data will be managed in a database, which will be housed in a shared location.

A database administrator (DBA) shall be assigned. The DBA will be responsible for:

- maintaining and updating the DB, including QAQC
- backing up the DB on a regular schedule.

Manual data collection forms are available from an excel workbook. These are used for testing the monitoring procedures initially and as a back-up in case the tablet application fails. Generally, a tablet application will be used to collect data. This tablet will upload data to the data.

Annual monitoring

CCI outcome reporting specifies collecting data to track project outcomes for 120 months. A monitoring schedule will be developed to collect data annually from monitoring sites statewide. Generally, sites will be measured every 2 to 5 years over during the outcome tracking period.

Analysis and reporting

CAL FIRE will analyze data and reporting for CCI's Forest Health outcome reporting template. Data will be used to characterize the outcome of grant-funded projects on fuel loads and forest carbon. CAL FIRE may use the monitoring program to understand the ecological and fire behavior impacts of vegetation management projects. CAL FIRE may also use monitoring data to improve grant processes, assess fuel loads, forest treatment effectiveness, forest treatment costs, carbon quantification methodology, conduct and publish research, or other objectives.

Quality assurance

A quality assurance system will be developed and updated for field measurements and data quality. Field measurement quality measurements may include check plots or paired sequential sampling to re-measure plots and confirm accurate results and measurements are recorded. The Database Administrator will be responsible for database QAQC, such as identifying nonsensical values or unexpected changes in data.

References

Moreno, Loretta, Russ Henly, and Pete Cafferata. 2018. *Monitoring and Assessment of California's Timberland Ecosystems Under Assembly Bill 1492 and the Timber Regulation and Forest Restoration Program*. Draft, Sacramento: California Natural Resources Agency.

USDA Forest Service. 2018. "Forest inventory and analysis national core field guide, volume I: field data collection proceedures for phase 2 plots." October.

Checklists

This section contains prompts for checklists which serve as convenient reminders for a variety of tasks.

Field Equipment Checklist

First-Year Monitoring Checklist

Annual Monitoring Checklist

Analysis and Reporting Checklist

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Appendices

Appendix I: Excerpts from FIA Field Guide Version 8.0.

This appendix contains excerpts from the field guide. The section title is provided above each section for ease of reference back to the original document.

0.2 PLOT INTEGRITY

The following practices are specifically prohibited:

- Boring and scribing some specific tree species that are known to be negatively affected (e.g., the initiation of infection or callusing).
- Chopping vines from tally trees. When possible, vines should be pried off trunks to enable accurate measurement. If this is not possible, alternative tools (calipers, biltmore sticks) should be used.

Note: Avoid becoming part of the problem! There is a risk that field crews walking into plot locations could pick up seeds along roadsides or other patches of invasive plants and spread them through the forest and on to the plot. Be aware of the vegetation you are traveling through and consider stopping and removing seeds from boots and clothing before entering uninvaded lands, particularly remote areas that are rarely visited.

1.19.6 GPS DATUM

Record the acronym indicating the map datum that the GPS coordinates are collected in (i.e., the map datum selected on the GPS unit to display the coordinates).

Values: NAD83	North American Datum of 1983

1.19.10 UTM ZONE

Record a 2-digit and 1 character field UTM ZONE as determined by GPS.
Values: Number varies from 2 in Alaska to 19 on the East Coast. The letter varies from Q in Hawaii to W in Alaska.

1.19.11 EASTING (X) UTM

Record the Easting coordinate of the plot center as determined by GPS.
Values: 0000000 – 9999999

1.19.12 NORTHING (Y) UTM

Record the Northing coordinate of the plot center as determined by GPS.
Values: 0000000 - 9999999

1.19.13 CORRECTION FOR "OFFSET" LOCATION

As described in Section 1.19.2, coordinates may be collected at a location other than the plot center (an "offset" location). If the GPS unit is capable of calculating plot center coordinates, then AZIMUTH TO PLOT CENTER and DISTANCE TO PLOT CENTER both equal 000.

1.19.14 AZIMUTH TO PLOT CENTER

Record the azimuth from the location where coordinates were collected to actual plot center. If coordinates are collected at plot center or are corrected in the field to plot center, record 000.
Values: 000 when coordinates **are** collected at plot center
001 to 360 when coordinates **are not** collected at plot center

1.19.15 DISTANCE TO PLOT CENTER

Record the horizontal distance in feet from the location where coordinates were collected to the actual plot center. If coordinates are collected at plot center or are corrected in the field to plot center, record 000. As described in Section 1.19.2, if a laser range finder is used to determine DISTANCE TO PLOT CENTER, offset locations may be up to 999 feet from the plot center. If a range finder is not used, the offset location must be within 200 feet.
Values: 000 when coordinates **are** collected at plot center
001 to 200 when a Laser range finder **is not** used to determine distance
001 to 999 when a Laser range finder **is** used to determine distance

1.19.16 GPS ELEVATION

Record the elevation above mean sea level of the plot center, in feet, as determined by GPS.
Values: -00100 to +20000

1.19.17 GPS ERROR

Record the error as shown on the GPS unit to the nearest foot up to 999 feet.
Values: 000 - 999

1.19.19 GPS FILENAME (CORE OPTIONAL)

Record the filename containing the GPS positions collected on the plot.
Values: English words, phrases and numbers

1.21 PLOT NOTES

Use these fields to record notes pertaining to the entire plot. If the notes apply only to a specific subplot or other specific aspect of the plot, then make that clear in the notes.
Values: English language words, phrases and numbers

2.5.3 FOREST TYPE

Record the code corresponding to the FOREST TYPE (from Appendix 2) that best describes the species with the plurality of stocking for all live trees in the condition class that are not overtopped. Note: Canopy cover is used to determine whether an area is forest or nonforest.

2.5.4 STAND SIZE CLASS

Record the code that best describes the predominant size class of all live trees, seedlings and saplings in the condition class. Note: Canopy cover is used to determine whether an area is forest or nonforest. Stocking is used with other variables such as this one.

Values: **Value**	**Description**
0	Nonstocked Meeting the definition of accessible forest land, and one of the following applies: (a) less than 10 percent stocked by trees, seedlings, and saplings, and not classified as cover trees, or (b) for several woodland species where stocking standards are not available, less than 10 percent **canopy cover** of trees, seedlings, and saplings.
1	< 4.9 inches (seedlings / saplings) At least 10 percent stocking (or 10 percent canopy cover if stocking standards are not available) in trees, seedlings, and saplings; and at least 2/3 of the canopy cover is in trees less than 5.0 inches DBH/DRC.
2	5.0 – 8.9 inches (softwoods) / 5.0 – 10.9 inches (hardwoods) At least 10 percent stocking (or 10 percent canopy cover if stocking standards are not available) in trees, seedlings, and saplings; and at least 1/3 of the canopy cover is in trees greater than 5.0 inches DBH/DRC **and** the plurality of the canopy cover is in softwoods between 5.0 – 8.9 inches diameter and/or hardwoods between 5.0 – 10.9 inches DBH, and/or woodland trees 5.0 – 8.9 inches DRC.
3	9.0 – 19.9 inches (softwoods) / 11.0 – 19.9 inches (hardwoods) At least 10 percent stocking (or 10 percent canopy cover if stocking standards are not available) in trees, seedlings, and saplings; and at least 1/3 of the canopy cover is in trees greater than 5.0 inches DBH/DRC **and** the plurality of the canopy cover is in softwoods between 9.0 – 19.9 inches diameter and/or hardwoods between 11.0 – 19.9 inches DBH, and/or woodland trees 9.0 – 19.9 inches DRC.
4	20.0 – 39.9 inches At least 10 percent stocking (or 10 percent canopy cover if stocking standards are not available) in trees, seedlings, and saplings; and at least 1/3 of the canopy cover is in trees greater than 5.0 inches DBH/DRC

	and the plurality of the canopy cover is in trees between 20.0 – 39.9 inches DBH.
5	40.0 + inches At least 10 percent stocking (or 10 percent canopy cover if stocking standards are not available) in trees, seedlings, and saplings; and at least 1/3 of the canopy cover is in trees greater than 5.0 inches DBH/DRC **and** the plurality of the canopy cover is in trees >40.0 inches DBH.

2.5.14 STAND AGE

Record the average total age, to the nearest year, of the trees (plurality of all live trees, seedlings, and saplings not overtopped) in the predominant STAND SIZE CLASS of the condition, determined using local procedures. Record 000 for nonstocked stands. Note: Canopy cover is used to determine whether an area is forest or nonforest. Stocking is used with other variables such as this one.

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

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

$(34 \times 0.25) + (62 \times 0.60) + (59 \times 0.15) = 55$ years.

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

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

If all of the trees in a condition class are of a species which, by regional standards, cannot be bored for age (e.g., mountain mahogany, tupelo) record 998. This code should be used in these cases only.

If tree cores are not counted in the field but are collected and sent to the office for the counting of rings, record 999. Note on the core the percent of stand that type of core represents so that STAND AGE can be calculated later.

Values: 000 to 997, 998, 999

2.5.15 DISTURBANCE 1

Record the code corresponding to the presence of the following disturbances. Disturbance can connote positive or negative effects. The area affected by any natural or human-caused disturbance must be at least 1.0 acre in size. Record up to three different disturbances per condition class from most important to least important. This attribute is ancillary; that is, contrasting conditions are never delineated based on variation in this attribute.

For initial plot establishment (SAMPLE KIND =1 or 3), the disturbance must be within the last 5 years. For remeasured plots recognize only those disturbances that have occurred since the previous inventory.

Disturbance codes require "significant threshold" damage, which implies mortality and/or damage to 25 percent of all trees in a stand or 50 percent of an individual species' count. Additionally, some disturbances affect land and/or vegetation, but initially may not affect vegetation growth or health (e.g., grazing, browsing, flooding, etc.). In these cases, a disturbance should be coded when at least 25 percent of the soil surface or understory vegetation has been affected.

Values: **Value**	**Description**
00	None - no observable disturbance
10	Insect damage
11	Insect damage to understory vegetation
12	Insect damage to trees, including seedlings and saplings
20	Disease damage
21	Disease damage to understory vegetation
22	Disease damage to trees, including seedlings and saplings
30	Fire (from crown and ground fire, either prescribed or natural)
31	Ground fire
32	Crown fire
40	Animal damage
41	Beaver (includes flooding caused by beaver)
42	Porcupine
43	Deer/ungulate
44	Bear (CORE OPTIONAL)
45	Rabbit (CORE OPTIONAL)
46	Domestic animal/livestock (includes grazing)
50	Weather damage
51	Ice

52	Wind (includes hurricane, tornado)
53	Flooding (weather induced)
54	Drought
60	Vegetation (suppression, competition, vines)
70	Unknown/not sure/other (include in NOTES)
80	Human-caused damage – any significant threshold of human-caused damage not described in the DISTURBANCE codes listed or in the TREATMENT codes listed. Must include a condition-level note to describe further.
90	Geologic disturbances
91	Landslide
92	Avalanche track
93	Volcanic blast zone
94	Other geologic event
95	Earth movement/avalanches

2.5.16 DISTURBANCE YEAR 1

Record the year in which DISTURBANCE 1 occurred. If the disturbance occurs continuously over a period of time, record 9999.
Values: Since the previous plot visit, or the past 5 years for plots visited for the first time; 9999

2.5.21 TREATMENT 1

Forestry treatments are a form of disturbance. These human disturbances are recorded separately here for ease of coding and analysis. The term treatment further implies that a silvicultural application has been prescribed. This does not include occasional stumps of unknown origin or sparse removals for firewood, Christmas trees, or other miscellaneous purposes. The area affected by any treatment must be at least 1.0 acre in size. Record up to three different treatments per condition class from most important to least important as best as can be determined. This attribute is ancillary; that is, contrasting conditions are never delineated based on variation in this attribute.

For initial plot establishment (SAMPLE KIND = 1 or 3), the treatment must be within the last 5 years. For remeasured plots recognize only those treatments that have occurred since the previous inventory.

Values: **Value**	**Description**
00	None - No observable treatment.
10	Cutting - The removal of one or more trees from a stand.
20	Site preparation - Clearing, slash burning, chopping, disking, bedding, or other practices clearly intended to prepare a site for either natural or artificial regeneration.
30	Artificial regeneration - Following a disturbance or treatment (usually cutting), a new stand where at least 50% of the

	live trees present resulted from planting or direct seeding.
40	Natural regeneration - Following a disturbance or treatment (usually cutting), a new stand where at least 50% of the live trees present (of any size) were established through the growth of existing trees and/or natural seeding or sprouting.
50	Other silvicultural treatment - The use of fertilizers, herbicides, girdling, pruning, or other activities (not covered by codes 10-40) designed to improve the commercial value of the residual stand, or chaining, which is a practice used on woodlands to encourage wildlife forage.

2.5.22 TREATMENT YEAR 1

Record the year in which TREATMENT 1 occurred.
Values: Since the previous plot visit, or the past 5 years for plots visited for the first time

2.6.1 CONDITION FUELBED TYPE (OPTIONAL)

Record the fuelbed code from the Scott and Burgan (2005; RMRS-GTR-153) fuel model guide that best corresponds with the combined fire behavior characteristics of live and dead materials on and near the ground surface. The visual appearance of the condition on the plot is not as important as the amount and packing density of live and dead fuels of different sizes. Refer to fuelbed descriptions, keys, and photos in Scott and Burgan (2005) to select the fuel model which best matches conditions on the condition class. This is a CORE-OPTIONAL field.

Values: **Value**	**Description**
GR1	Short, Sparse Dry Climate Grass
GR2	Low Load, Dry Climate Grass
GR3	Low Load, Very Coarse, Humid Climate Grass
GR4	Moderate Load, Dry Climate Grass
GR5	Low Load, Humid Climate Grass
GR6	Moderate Load, Humid Climate Grass
GR7	High Load, Dry Climate Grass
GR8	High Load, Very Coarse, Humid Climate Grass
GR9	Very High Load, Humid Climate Grass
GS1	Low Load, Dry Climate Grass-Shrub
GS2	Moderate Load, Dry Climate Grass-Shrub
GS3	Moderate Load, Humid Climate Grass-Shrub
GS4	High Load, Humid Climate Grass-Shrub
SB1	Slash-Blowdown: Low Load Activity Fuel
SB2	Moderate Load Activity Fuel or Low Load Blowdown
SB3	High Load Activity Fuel or Moderate Load Blowdown
SB4	High Load Blowdown
SH1	Low Load Dry Climate Shrub
SH2	Moderate Load Dry Climate Shrub
SH3	Moderate Load, Humid Climate Shrub
SH4	Low Load, Humid Climate Timber-Shrub
SH5	High Load, Dry Climate Shrub
SH6	Low Load, Humid Climate Shrub
SH7	Very High Load, Dry Climate Shrub
SH8	High Load, Humid Climate Shrub

SH9	Very High Load, Humid Climate Shrub
TL1	Low Load Compact Conifer Litter
TL2	Low Load Broadleaf Litter
TL3	Moderate Load Conifer Litter
TL4	Small, downed logs
TL5	High Load Conifer Litter
TL6	Moderate Load Broadleaf Litter
TL7	Large Downed Logs
TL8	Long-Needle Litter
TL9	Very High Load Broadleaf Litter
TU1	Low Load Dry Climate Timber-Grass-Shrub
TU2	Moderate Load, Humid Climate Timber-Shrub
TU3	Moderate Load, Humid Climate Timber-Grass-Shrub
TU4	Dwarf Conifer with Understory
TU5	Very High Load, Dry Climate Timber-Shrub
NB1	Nonburnable Urban/developed
NB2	Nonburnable Snow/ice
NB3	Nonburnable Agricultural
NB8	Nonburnable Open water
NB9	Nonburnable Bare ground

3.8 SUBPLOT SLOPE

Record the angle of slope across the subplot to the nearest 1 percent. SUBPLOT SLOPE is determined by sighting the clinometer along a line parallel to the average incline (or decline) of each subplot. This angle is measured along the shortest pathway down slope before the drainage direction changes. To measure SUBPLOT SLOPE, Observer 1 should stand at the uphill edge of the subplot and sight Observer 2, who stands at the downhill edge of the subplot. Sight Observer 2 at the same height as the eye-level of Observer 1. Read the slope directly from the percent scale of the clinometer:

- If slope changes gradually across the subplot, record an average slope.
- If slope changes across the subplot but the slope is predominantly of one direction, code the predominant slope percentage rather than the average.
- If the subplot falls directly on or straddles a canyon bottom or narrow ridge top, code the average slope of the side hill(s).
- If the subplot falls on a canyon bottom or on a narrow ridge top, but most of the area lies on one side hill, code the slope of the side hill where most of the area lies.

Values: 000 to 155

3.9 SUBPLOT ASPECT

Record the aspect across the subplot, to the nearest 1 degree. SUBPLOT ASPECT is determined along the direction of slope for land surfaces with at least 5 percent slope in a generally uniform direction. SUBPLOT ASPECT is measured with a hand compass along the same direction used to determine slope.

- If aspect changes gradually across the subplot, record an average aspect.
- If aspect changes across the subplot but the aspect is predominately of one direction, code the predominate direction rather than the average.
- If the subplot falls on or straddles a canyon bottom or narrow ridge top, code the aspect of the ridge line or canyon bottom.
- If the subplot falls on a canyon bottom or on a narrow ridge top, but most of the area lies on one side hill, code the aspect of the side hill.

Values:

Value	**Description**
000	No aspect, slope < 5 percent
001	1 degree
002	2 degrees
.	.
.	.
360	360 degrees, due north

5.0 TREE AND SAPLING DATA

Trees at least 5.0 inches in diameter are sampled within the subplot. 'Tally trees' are defined as all live and standing dead trees in accessible forest land condition classes encountered on the subplot the first time a subplot is established, and all trees that grow into a subplot thereafter. These data yield information on tree volume, growth, mortality, and removals; wildlife habitats; forest structure and composition; biomass; and carbon sequestration.

Trees with a diameter at least 1.0 inch but less than 5.0 inches, termed saplings, are sampled within the microplot. 'Tally saplings' are defined as all live and standing dead saplings in accessible forest land condition classes encountered the first time a microplot is established, and all saplings that grow into each microplot thereafter are included until they grow to 5.0 inches or larger, at which time they are tallied on the subplot and referenced (new AZIMUTH and HORIZONTAL DISTANCE taken) to the subplot center.

For multi-stemmed woodland species, a cumulative DRC is used to compute diameter as described in Sections 5.9 and 5.9.4.

Trees are alive if they have any living parts (leaves, buds, cambium) at or above the point of diameter measurement, either diameter at breast height (DBH) or diameter at root collar (DRC). Trees that have been temporarily defoliated are still alive.

Once tallied, dead trees 1.0 inch and greater in diameter are tracked until they no longer qualify as standing dead. **Working around dead trees is a safety hazard - crews should exercise extreme caution! Trees that are deemed unsafe to measure should be estimated.**

To qualify as a standing dead tally tree, dead trees must be at least 1.0 inch in diameter, have a bole which has an unbroken ACTUAL LENGTH of at least 4.5 feet, and lean less than 45 degrees from vertical as measured from the base of the tree to 4.5 feet.

The portion of a bole on dead trees that are separated greater than 50 percent (either above or below 4.5 feet), are considered severed and may qualify as Down Woody Material (DWM). See DWM procedures for tally criteria.

For woodland species (Appendix 3) with multiple stems, a tree is considered down if more than 2/3 of the volume is no longer attached or upright; do not consider cut and removed volume. For woodland species with single stems to qualify as a standing dead tally tree, dead trees must be at least 1.0 inch in diameter, be at least 1.0 foot in unbroken ACTUAL LENGTH, and lean less than 45 degrees from vertical.

Live and dead standing tally trees, and partially separated boles of dead tally trees, do not have to be self-supported. They may be supported by other trees, branches, or their crown.
Trees that have been cut above DBH qualify as tally trees, provided they meet the size requirement.

5.4 AZIMUTH

Record the AZIMUTH from the subplot center (for trees greater than or equal to 5.0 inches DBH/DRC) or the microplot center (for trees greater than or equal to 1.0 inch and less than 5.0 inches DBH/DRC), sight the center of the base of each tree with a compass. Sight to the geographic center for multi-stemmed woodland species (Appendix 3). The geographic center is a point of equal distance between all tallied stems for a given woodland tree. Record AZIMUTH to the nearest degree. Use 360 for north.

Values: 001 to 360

5.5 HORIZONTAL DISTANCE

Record the measured HORIZONTAL DISTANCE, to the nearest 0.1 foot, from the subplot center (for trees greater than or equal to 5.0 inches DBH/DRC) or microplot center (for trees greater than or equal to 1.0 inch and less than 5.0 inches DBH/DRC) to the pith of the tree at the base. For all multi-stemmed woodland trees (woodland species indicated in Appendix 3), the HORIZONTAL DISTANCE is measured from subplot or microplot center to the "geographic center" of the tree. The geographic center is a point of equal distance between all tallied stems for a given woodland tree.

5.7 PRESENT TREE STATUS

Record a current PRESENT TREE STATUS for each tallied tree; this code is used to track the status of sample trees over time: as they first appear, as ingrowth, as they survive, and when they die or are removed. This information is needed to correctly assign the tree’s volume to the proper component of volume change.

Values: **Value**	**Description**
0	No status – tree is not presently in the sample (remeasurement plots only). Tree was incorrectly tallied at the previous inventory, currently is not tallied due to

	definition or procedural change or is not tallied due to natural causes. Requires RECONCILE code = 5-9.
1	Live tree – any live tree (new, remeasured or ingrowth)
2	Dead tree – any dead tree (new, remeasured, or ingrowth), regardless of cause of death. Includes all previously standing dead trees that no longer qualify as standing dead, trees killed by silvicultural or land clearing activity and assumed not to have been utilized, as well as dead trees that may have been present at the time of plot establishment but only tallied now due to procedural change.
3	Removed – a tree that has been cut and removed by direct human activity related to harvesting, silviculture or land clearing (remeasurement plots only). The tree is assumed to have been utilized.

5.7.2 STANDING DEAD

Record the code that describes whether or not a tree qualifies as standing dead. To qualify as a standing dead tally tree, dead trees must be at least 1.0 inch in diameter, have a bole that has an unbroken ACTUAL LENGTH of at least 4.5 feet, and lean less than 45 degrees from vertical as measured from the base of the tree to 4.5 feet. See figures 20-22 for examples.

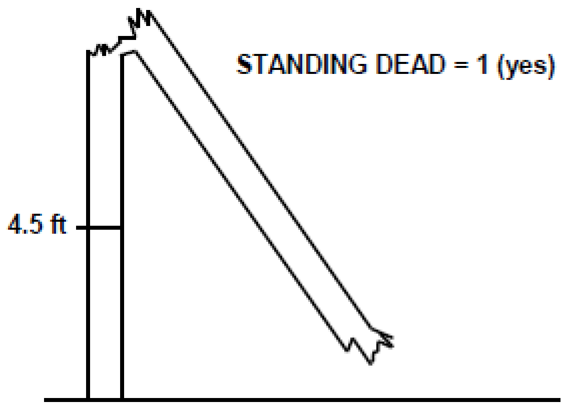
"Unbroken" is defined as at least 50 percent attached to the original source of growth.
Portions of boles on dead trees that are separated greater than 50 percent (either above or below 4.5 feet), are considered severed and are included in Down Woody Material (DWM) if they otherwise meet DWM tally criteria.

For woodland species (Appendix 3) with multiple stems, a tree is considered down if more than 2/3 of the volume is no longer attached or upright; do not consider cut and removed volume. For woodland species with single stems to qualify as a standing dead tally tree, dead trees must be at least 1.0 inch in diameter, be at least 1.0 foot in unbroken ACTUAL LENGTH, and lean less than 45 degrees from vertical.

Live and dead standing tally trees, and partially separated boles of dead tally trees, do not have to be self-supported. They may be supported by other trees, branches, or their crown.

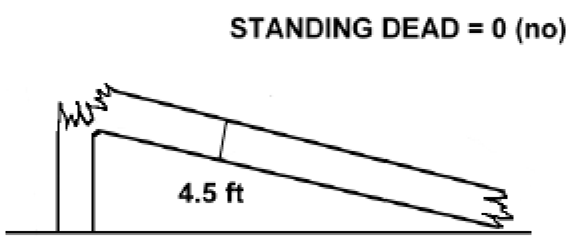
Values:

Value	Description
0	No – tree does not qualify as standing dead.
1	Yes – tree does qualify as standing dead.



(Tree is at least 1.0 inch at 4.5 feet and is at least 4.5 feet in unbroken ACTUAL LENGTH)

Figure 20. Example of an unbroken bole to 4.5 feet.



(Tree is at least 1.0 inch at 4.5 feet, but does not have 4.5 feet in unbroken ACTUAL LENGTH)

Figure 21. Example of an unbroken length of < 4.5 feet.

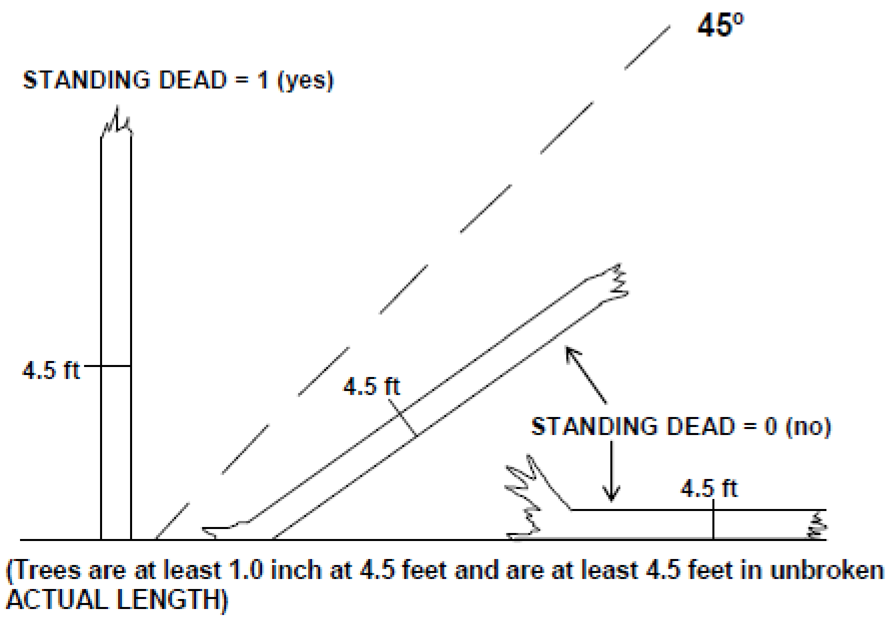


Figure 22. Other examples of dead trees

5.8 SPECIES

Record the appropriate SPECIES code from the list in Appendix 3. If the species cannot be determined in the field, tally the tree, but bring branch samples, foliage, cones, flowers, bark, etc. to the supervisor for identification. If possible, collect samples outside the subplots from similar specimens and make a note to correct the SPECIES code later. Use code 0299 for unknown dead conifer, 0998 for unknown dead hardwood when the genus or species codes cannot be used, and 0999 for other or unknown live tree. The generic code should only be used when you are sure the species is on the species list, but you cannot differentiate among acceptable species. This is often the case withstanding dead trees on newly established plots. In this case use the sample collections procedures described earlier in this paragraph. The species code list in Appendix 3 includes all tree species tallied in the Continental U.S., Alaska, and the Caribbean. Species designated East/West are commonly found in those regions, although species designated for one region may occasionally be found in another. Species marked as Woodland designate species where DRC is measured instead of DBH. Species that have an "X" in the Core column are tallied in all regions. All other species on the list are "core optional."

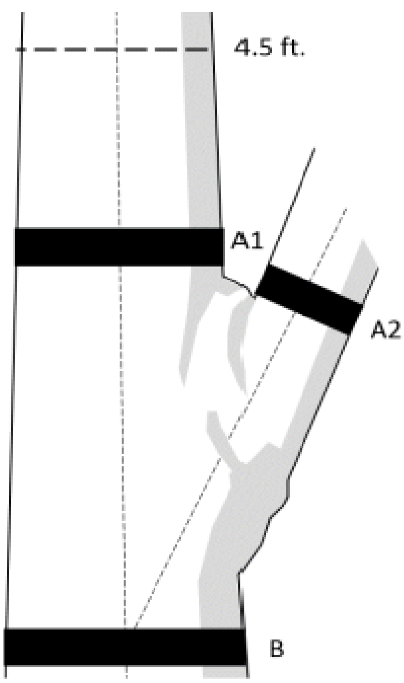
Values: See Appendix 3

5.9.2 DIAMETER AT BREAST HEIGHT (DBH)

Unless one of the following special situations is encountered, measure DBH at 4.5 feet above the ground line on the uphill side of the tree. Round each measurement down to the last 0.1 inch. For example, a reading of 3.68 inches is recorded as 3.6 inches.

Special DBH situations:

1. Forked tree: In order to qualify as a fork, the stem in question must be at least 1/3 the diameter of the main stem and must branch out from the main stem at an angle of 45 degrees or less (figs. 23-26), AND must be judged to have, or have the potential to assume an obvious "tree like" form and function as opposed to an obvious "branch like" form and function. If there is any doubt as to the form and function of a potential fork, call it a fork instead of a branch. Figure 27 provides examples where the form and function are considerations. Forks originate at the point on the bole where the piths intersect. Forked trees are handled differently depending on whether the fork originates below 1.0 foot, between 1.0 and 4.5 feet, or above 4.5 feet.

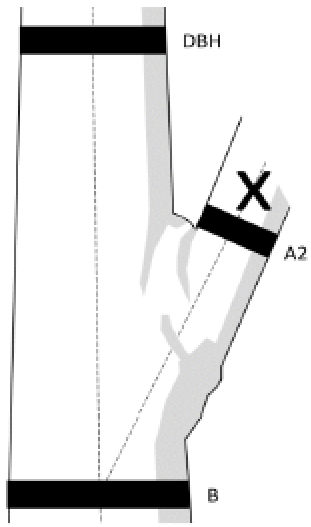


A1, A2 and B represent diameter locations for determining if minimum diameter ratios are met. Diameter ratios are met if:

$$\frac{A1}{B} \geq \frac{1}{3}$$

$$\frac{A2}{B} \geq \frac{1}{3}$$

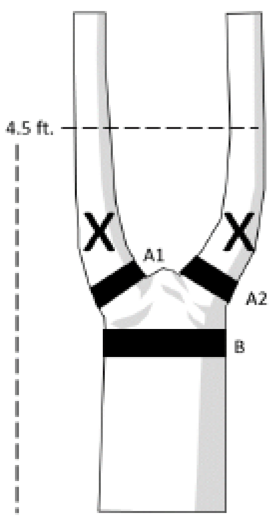
Figure 23. Determining diameter ratio of forks. When determining if a fork meets the 1/3 diameter requirement for qualifying as a fork, the diameter of the potential fork taken at locations A1 and A2 must be 1/3 of the diameter at location B.



If one of the potential forks is less than 1/3 the diameter at B, then no fork exists and the diameter would be placed at 4.5 feet from the ground on the qualifying stem.

$$\frac{A2}{B} < \frac{1}{3}$$

Figure 24. A single non-qualifying fork. If one of the forks does not meet the minimum ratio, then no fork exists and the diameter is placed at the normal location on the dominant stem.



If neither stem above a fork meets the minimum 1/3 diameter requirement, neither stem is tallied.

$$\frac{A1}{B} < \frac{1}{3}$$

$$\frac{A2}{B} < \frac{1}{3}$$

Figure 25. Two non-qualifying stems. If neither stem meets the 1/3 diameter requirement, neither is tallied. This is often associated with broken tops and is consistent with the point at which a stem is considered recovered from a break.

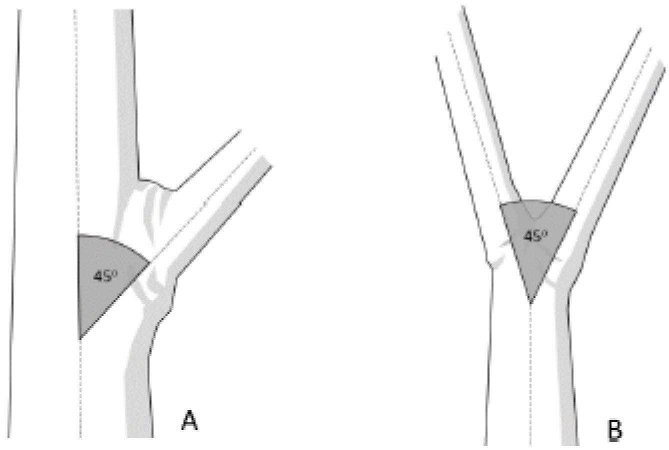


Figure 26. Forking angle. In order to qualify as a fork, the piths must diverge at an angle not exceeding 45 degrees from the main stem (A). In cases where there is no obvious main stem (B), consider the angle of pith separation between the two stems.

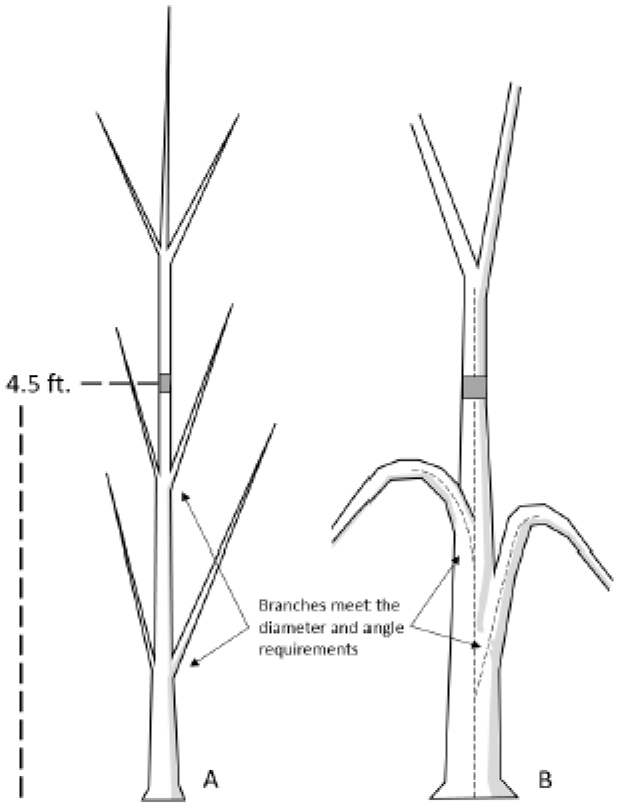


Figure 27. Forks that have branch-like form and function, leading to the tally of a single tree instead of multiple trees. In example A, although the potential fork is currently 1/3 the diameter of the main bole and is within 45 degrees of the main bole at the point of attachment, it appears to be serving as a branch as opposed to an additional independent tree. In addition, as the main bole continues to grow, the "branch" may reach the point where it is no longer 1/3 the main bole, dropping out of the inventory based on definition. Such potential forks would be ignored and the main bole would be tallied as a single tree with diameter measured at 4.5 feet. The tree is evaluated at each future visit and tallied following standard remeasurement procedures. In example B, although the potential fork is 1/3 the diameter of the main bole and is within 45 degrees of the main bole at point of attachment, it deviates drastically beyond 45 degrees about 1 inch from the main bole, taking on the form and function of a branch. This should be tallied as a single tree with diameter measured at 4.5 feet.

- <u>Trees forked below 1.0 foot.</u> Trees forked below 1.0 foot are treated as distinctly separate trees (fig. 28). Distances and azimuths are measured individually to the center of each stem where it splits from the stump (fig. 34 A-C). DBH is measured for each stem at 4.5 feet above the ground. When stems originate from pith intersections below 1 foot, it is possible for some stems to be within the limiting distance of the microplot or subplot, and others to be beyond the limiting distance. If stems originating from forks that occur below 1.0 foot fork

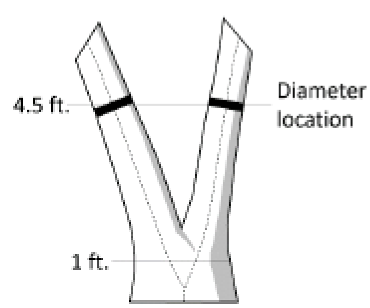


Figure 28. Forked below 1.0 foot.

again between 1.0 and 4.5 feet (fig. 34-E), the rules in the next paragraph apply.

- Trees forked between 1.0 foot and 4.5 feet. Trees forked between 1.0 foot and 4.5 feet are also counted as separate trees (fig. 29), but only one distance and azimuth (to the central stump) is recorded for each stem (fig. 34 D-F). Although a single azimuth and distance applies to all, multiple stems should be recorded as they occur in clockwise order (from front to back when one stem is directly in front of another). The DBH of each fork is measured at a point 3.5 feet above the pith intersection. When forks originate from pith intersections between 1.0 and 4.5 feet, the limiting distance is the same for all forks--they are either all on, or all off the plot.

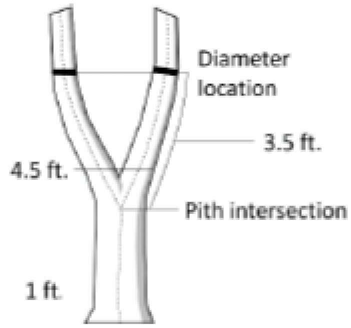


Figure 29. Forked between 1.0 foot and 4.5 feet.

Measure Low Approach

Crews may encounter trees of any species displaying growth forms with multiple forks that make applying traditional forking rules very difficult. In some instances these growth forms are species specific and in others they are the result of either the immediate growing conditions or the fact that the trees have been bred, pruned, or managed in a way that promotes multiple stems resulting in a specific crown shape.

In cases where such multiple forks all originate from approximately the same point on the main stem, follow the **Measure Low Approach**, where the diameter is taken at the highest, most repeatable location between the 1-foot stump and initial pith separation. This approach is applicable in instances where any of the following are present between the 1-foot stump and DBH (4.5 feet):

(1) Multiple forks (fig. 30).

(2) Prolific branching originating from approximately the same location that prevents accurate and repeatable diameter (fig. 31). This is a rare situation that should not be confused with normal branching patterns that allow for accurate diameter placement.

(3) Any combination of multiple forks and prolific branching originating at approximately the same location.

(4) The stems of a forked tree are grown together in such a fashion that an accurate DBH cannot be measured or estimated due to deformation resulting from the presence of the above mentioned criteria (fig. 32).

Figures 30, 31, and 32 illustrate a combination of forks and or branches all originating at the approximate same location will trigger a measure low approach.

Figure 30. Multiple forks originating from the same area. In cases such as this the diameter is taken low and all stems are treated as one tree.

Figure 31. Multiple forks and branches originating from the same area. Similar to having multiple forks, when there are multiple forks and branches, the diameter is taken low and all stems are treated as one tree.

A tree can only fork once. Following are specific procedures to secondary forking:

Once a stem is tallied as a fork that originated from a pith intersection between 1.0 and 4.5 feet, do not recognize any additional forks (or potential forks) that may occur on that stem. When such secondary forks are encountered, measure/estimate the diameter of such stems at the most repeatable location below stem separation but above the first pith separation (fig. 34 F-I) while attempting to avoid measuring double piths (fig. 40) where possible (i.e., do not move the point of diameter the entire 3.5 feet above the first fork).

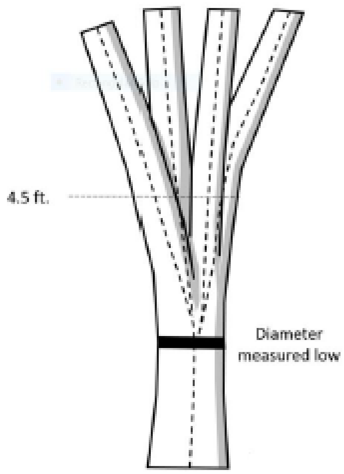


Figure 32. Using pith separation to determine diameter locations. In this example it is clear that all piths appear to separate from approximately the same location; this triggers the **"Measure Low Approach".** In cases where the piths do NOT originate within approximately the same location, normal forking rules are applied as demonstrated in figures 34 A-D and F-I.

- Trees forked at or above 4.5 feet. Trees forked at or above 4.5 feet count as one single tree (fig. 33). If a fork occurs at or immediately above 4.5 feet, measure diameter below the fork just beneath any swelling that would inflate DBH.

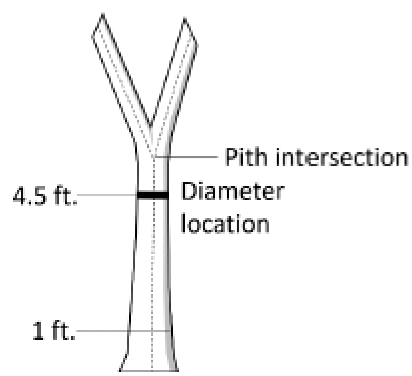


Figure 33. One Tree.

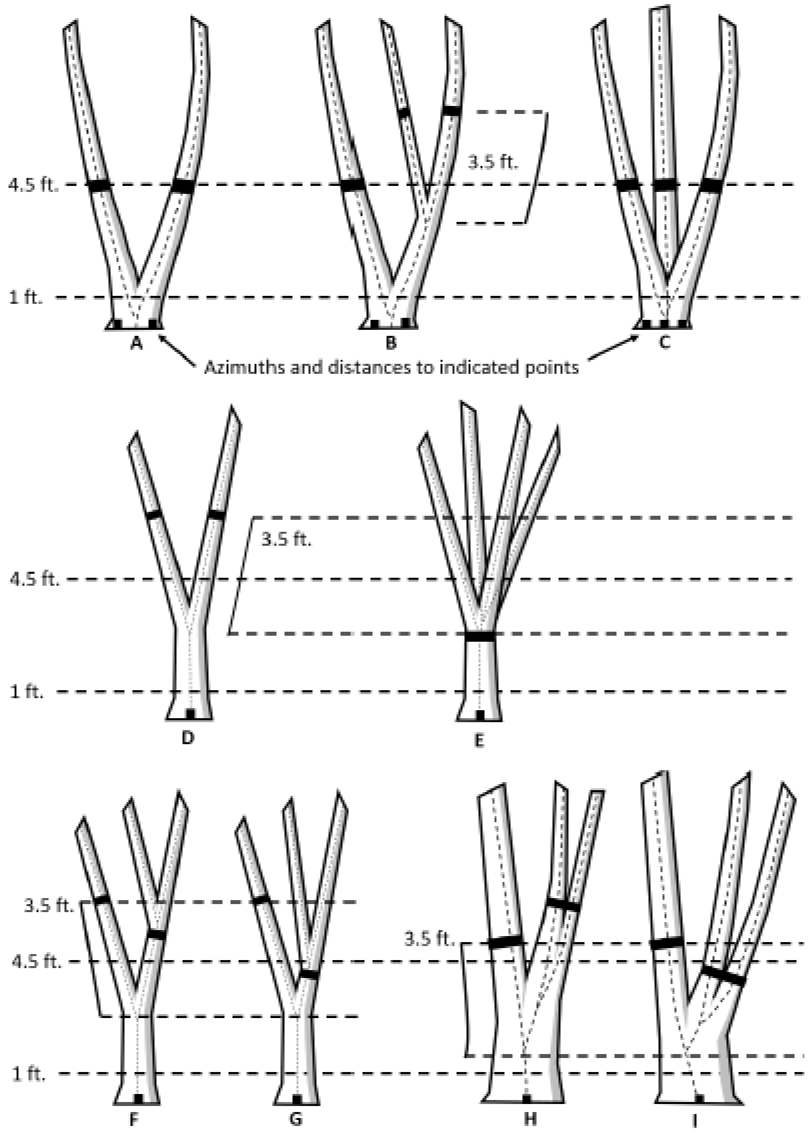


Figure 34 Summary of where to measure diameter, distance and azimuth on trees that fork below 1.0 foot (A, B, C) and trees that fork above 1.0 foot (D, E, F, G, H, I). Figure E represents the **"Measure Low Approach".** Figures F and G represent secondary forks with abnormal diameters at stem separation. Figures H and I represent secondary forks with normal diameters at stem separation.

2. Stump sprouts: Stump sprouts originate between ground level and 4.5 feet on the boles of trees that have died or been cut. Stump sprouts are handled the same as forked trees, with the exception that stump sprouts are not required to be 1/3 the diameter of the dead bole. Stump sprouts originating below 1.0 foot are measured at 4.5 feet from ground line. Stump sprouts originating between 1.0 foot and 4.5 feet are measured at 3.5 feet above their point of occurrence. As with forks, rules for measuring distance and azimuth depend on whether the sprouts originate above or below 1.0 foot. For multi-stemmed woodland species, treat all new sprouts as part of the same new tree.

3. Tree with butt-swell or bottleneck: Measure these trees 1.5 feet above the end of the swell or bottleneck if the swell or bottleneck extends 3.0 feet or more above the ground (fig. 35).

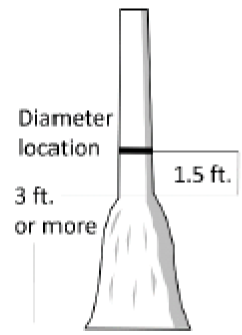


Figure 35. Bottleneck tree.

4. Tree with irregularities at DBH: On trees with swellings (fig. 36), bumps, depressions, and branches (fig. 37) at DBH, diameter will be measured immediately above the irregularity at the place it ceases to affect normal stem form.

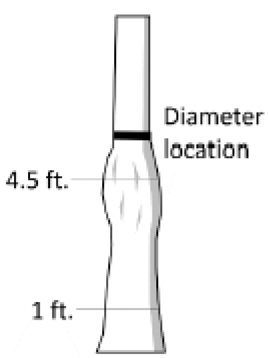


Figure 36. Tree with swelling.

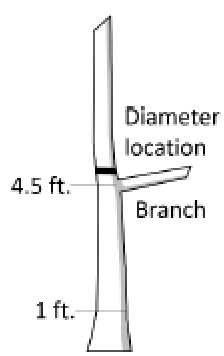


Figure 37. Tree with branch.

5. Tree on slope: Measure diameter at 4.5 feet from the ground along the bole on the uphill side of the tree (fig. 38).

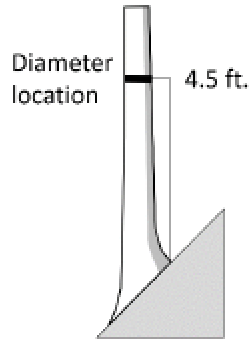


Figure 38. Tree on a slope.

6. Leaning tree: Measure diameter at 4.5 feet from the ground along the bole. The 4.5-foot distance is measured along the underside face of the bole (fig. 39).

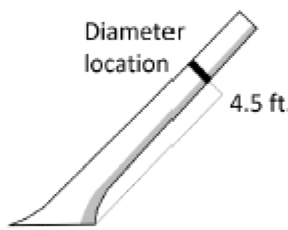


Figure 39. Leaning tree.

7. Turpentine tree: On trees with turpentine face extending above 4.5 feet, estimate the diameter at 10.0 feet above the ground and multiply by 1.1 to estimate DBH outside bark.

8. Independent trees that grow together: If two or more independent stems have grown together at or above the point of DBH, continue to treat them as separate trees. Estimate the diameter of each, set the "DIAMETER CHECK" code to 1, and explain the situation in the notes (fig. 40).

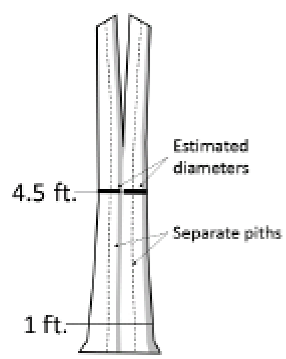


Figure 40. Independent trees grown together.

9. Missing wood or bark: Do not reconstruct the DBH of a tree that is missing wood or bark at the point of measurement. Record the diameter, to the nearest 0.1 inch, of the wood and bark that is still attached to the tree (fig. 41). If a tree has a localized abnormality (gouge, depression, etc.) at the point of DBH, apply the procedure described for trees with irregularities at DBH (fig.36).

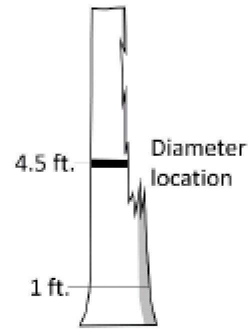


Figure 41. Tree with part of stem missing.

10. Live windthrown tree: Measure from the top of the root collar along the length to 4.5 feet (fig. 42).

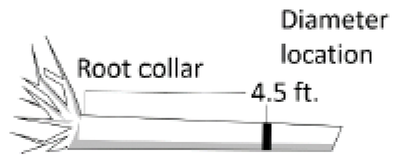


Figure 42. Tree on the ground.

11. Down live tree with tree-form branches growing vertical from main bole: When a down live tree, touching the ground, has vertical (less than 45 degrees from vertical) tree-like branches coming off the main bole, first determine whether or not the pith of the main bole (averaged along the first log of the tree) is above or below the duff layer.

- If the pith of the main bole is above the duff layer, use the same forking rules specified for a forked tree, and take all measurements accordingly (fig. 43).

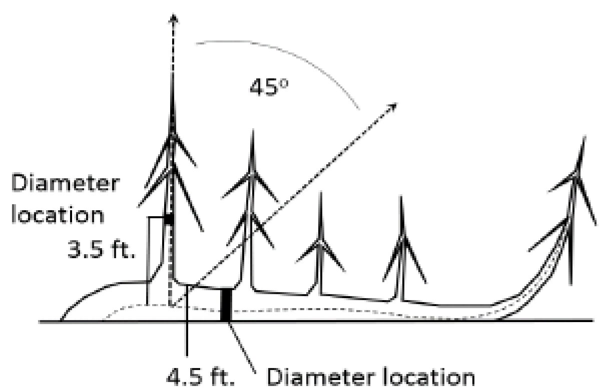


Figure 43. Down tree with pith above the duff.

- If the pith intersection of the main down bole and vertical tree-like branch occurs below 4.5 feet from the stump along the main bole, treat that branch as a separate tree, and measure DBH 3.5 feet above the pith intersection for both the main bole and the tree-like branch.

- If the intersection between the main down bole and the tree-like branch occurs beyond the 4.5 feet point from the stump along the main bole, treat that branch as part of the main down bole.

- If the pith of main tree bole is below the duff layer, ignore the main bole, and treat each tree-like branch as a separate tree; take DBH and length measurements from the ground, not necessarily from the top of the down bole (fig. 44). However, if the top of the main tree bole curves out of the ground towards a vertical angle, treat that portion of that top as an individual tree originating where the pith leaves the duff layer.

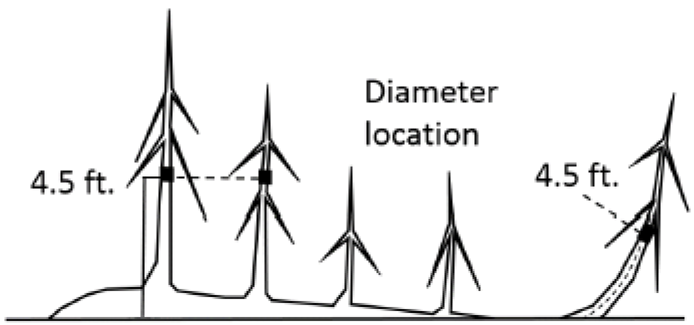


Figure 44. Down tree with pith below the duff.

12. Tree with curved bole (pistol butt tree): Measure along the bole on the uphill side (upper surface) of the tree (fig. 45).

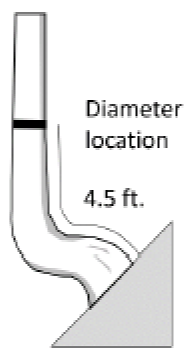


Figure 45. Tree with curved bole (pistol butt tree).

5.9.4 DIAMETER AT ROOT COLLAR (DRC)

For species requiring diameter at the root collar (refer to Appendix 3), measure the diameter at the ground line or at the stem root collar, whichever is higher. For these trees, treat clumps of stems having a unified crown and common root stock as a single tree; examples include mesquite, juniper, and mountain mahogany. Treat stems of woodland species such as Gambel oak and bigtooth maple as individual trees if they originate below the ground. For woodland trees, record DRC STEM DIAMETER and DRC STEM STATUS (described below). Then compute and record the DRC value from the individual stem diameter information.

Measuring woodland stem diameters: Before measuring DRC, remove the loose material on the ground (e.g., litter) but not mineral soil. Measure just above any swells present, and in a location so that the diameter measurements are a good representation of the volume in the stems (especially when trees are extremely deformed at the base). Stems must be at least 1 foot in length and at least 1.0 inch in diameter 1 foot up from the stem diameter measurement point to qualify for measurement. Whenever DRC is impossible or extremely difficult to measure with a diameter tape (e.g., due to thorns, extreme number of limbs), stems may be estimated and recorded to the nearest 1.0-inch class. Additional instructions for DRC measurements are illustrated in figure 46. For each qualifying stem of the woodland tree, measure and record DRC STEM DIAMETER (5.9.4.1) and indicate the DRC STEM STATUS (5.9.4.2).

Computing and Recording DRC: For all tally trees requiring DRC, with at least one stem 1 foot in length and at least 1.0 inch in diameter 1 foot up from the stem diameter measurement point, DRC is computed as the square root of the sum of the squared stem diameters. For a single-stemmed DRC tree, the computed DRC is equal to the single diameter measured.

Use the following formula to compute DRC:

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

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

$$\begin{aligned} DRC &= SQRT\ (12.2^2 + 13.2^2 + 3.8^2 + 22.1^2) \\ &= SQRT\ (825.93) \\ &= 28.74 \\ &= 28.7 \end{aligned}$$

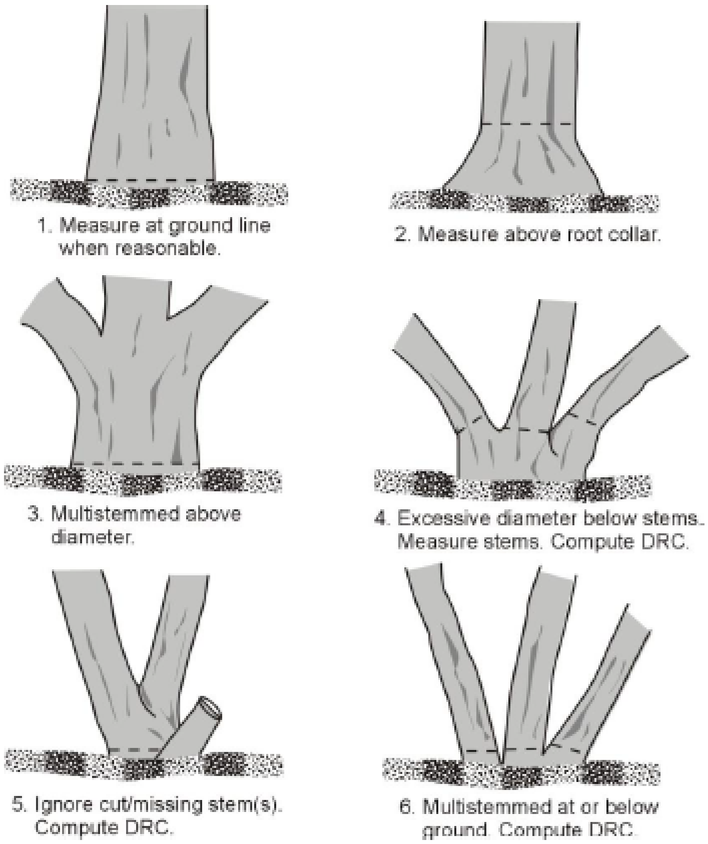


Figure 46. How to measure DRC in a variety of situations.

5.9.4.1 DRC STEM DIAMETER

Record the diameter of each individual qualifying stem on the woodland tree.

Values: 001.0 to 999.9

5.9.4.2 DRC STEM STATUS

Record the status of each individual stem on the woodland tally tree.

Values:

Value	Description
1	Live stem
2	Dead stem

5.11 CURRENT NUMBER OF STEMS

Record the total number of stems that were measured for DRC (e.g., record 1 stem as 01; record 12 stems as 12). Count only the number of qualifying stems used to calculate DRC. Qualifying stems are those that are at least 1.0 foot in length and at least 1.0 inch in diameter, 1 foot up from the measurement point.

Values: 1 to 99

5.13 ROTTEN/MISSING CULL

Record the percent rotten or missing cubic-foot cull for all live tally trees greater than or equal to 5.0 inches DBH/DRC (CORE) and all standing dead tally trees greater than or equal to 5.0 inches DBH/DRC (CORE OPTIONAL).

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

Rotten and missing volume loss is often difficult to estimate. Refer to supplemental disease and insect pests field guides and local defect guidelines as an aid in identifying damaging agents and their impact on volume loss. Use your best judgment and be alert to such defect indicators as the following:

- Cankers or fruiting bodies.
- Swollen or punky knots.
- Dull, hollow sound of bole (use regional standards).
- Large dead limbs, especially those with frayed ends.
- Sawdust around the base of the tree.
- Metal imbedded in the wood.

Values: 00 to 99

5.14 TOTAL LENGTH

Record the TOTAL LENGTH of the tree, to the nearest 1.0 foot from ground level to the top of the tree. For trees growing on a slope, measure on the uphill side of the tree. If the tree has a missing top (top is broken and completely detached from the tree), estimate what the total length would be if there were no missing top. Forked trees should be treated the same as unforked trees.

Values: 001 to 400

5.15 ACTUAL LENGTH

Record for trees with missing tops (top on live trees is completely detached; top on dead trees is greater than 50 percent detached from the tree). If the top is intact, this item may be omitted. Record the ACTUAL LENGTH of the tree to the nearest 1.0 foot from ground level to the break. Use the length to the break for ACTUAL LENGTH until a new leader qualifies as the new top for TOTAL LENGTH; until that occurs, continue to record ACTUAL LENGTH to the break. Trees with previously broken tops are considered recovered (i.e., ACTUAL LENGTH = TOTAL LENGTH) when a new leader (dead or alive) is 1/3 the diameter of the broken top at the point where the top was broken (not where the new leader originates from the trunk). Forked trees should be treated the same as unforked trees.

Note: Some regions will measure ACTUAL LENGTH differently due to growth form. Some examples are swamp tupelo, cypress, and trees growing off of old high stumps with stilted roots in the West. Check regional field guides for regional guidance.

Values: 001 to 400

5.16 LENGTH METHOD

Record the code that indicates the method used to determine tree lengths.

Values: **Value**	**Description**
1	Total and actual lengths are field measured with a measurement instrument (e.g., clinometer, relascope, tape).
2	Total length is visually estimated, actual length is measured with an instrument.
3	Total and actual lengths are visually estimated.

5.17 CROWN CLASS

Rate tree crowns in relation to the sunlight received and proximity to neighboring trees (fig. 47). Base the assessment on the position of the crown at the time of observation. Example: a formerly overtopped tree that is now dominant due to tree removal is classified as dominant.

Values:

Value	Description
1	Open Grown – trees with crowns that received full light from above and from all sides throughout most of its life, particularly during its early developmental period.
2	Dominant – trees with crown extending above the general level of the crown canopy and receiving full light from above and partly from the sides. These trees are taller than the average trees in the stand and their crowns are well developed, but they could be somewhat crowded on the sides. Also, trees whose crowns have received full light from above and from all sides during early development and most of their life. Their crown form or shape appears to be free of influence from neighboring trees.
3	Co-dominant – trees with crowns at the general level of the crown canopy. Crowns receive full light from above but little direct sunlight penetrates their sides. Usually they have medium-sized crowns and are somewhat crowded from the sides. In stagnated stands, co-dominant trees have small-sized crowns and are crowded on the sides.
4	Intermediate – trees that are shorter than dominants and co-dominant, but their crowns extend into the canopy of co-dominant and dominant trees. They receive little direct light from above and none from the sides. As a result, intermediate trees usually have small crowns and are very crowded from the sides.
5	Overtopped – trees with crowns entirely below the general level of the crown canopy that receive no direct sunlight either from above or the sides.

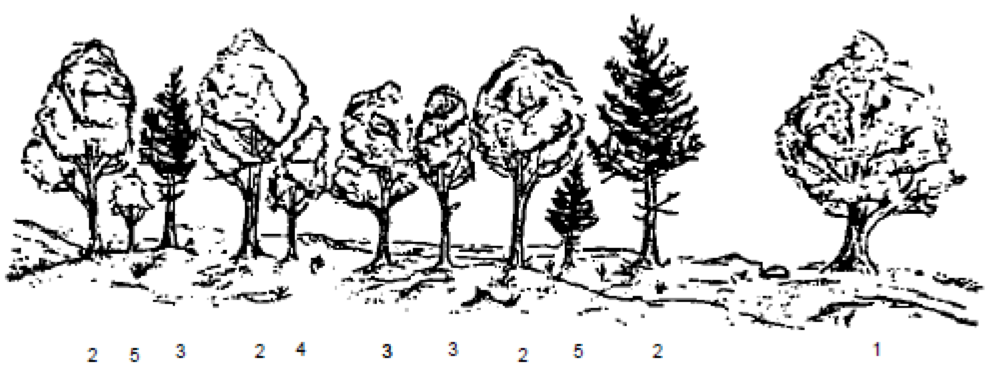


Figure 47. Examples of CROWN CLASS code definitions (numbers are the CROWN CLASS codes).

5.19 COMPACTED CROWN RATIO

Record the COMPACTED CROWN RATIO for each live tally tree, 1.0 inch and larger, to the nearest one percent. COMPACTED CROWN RATIO is that portion of the tree supporting live foliage (or in the case of extreme defoliation should be supporting live foliage) and is expressed as a percentage of the actual tree length. To determine COMPACTED CROWN RATIO, ocularly transfer lower live branches to fill in large holes in the upper portion of the tree until a full, even crown is visualized.

Do not over-compact trees beyond their typical full crown situation. For example, if tree branches tend to average 2 feet between whorls, do not compact crowns any tighter than the 2-foot spacing (fig. 50). Figure 51 shows an example of COMPACTED CROWN RATIO on a leaning tree.

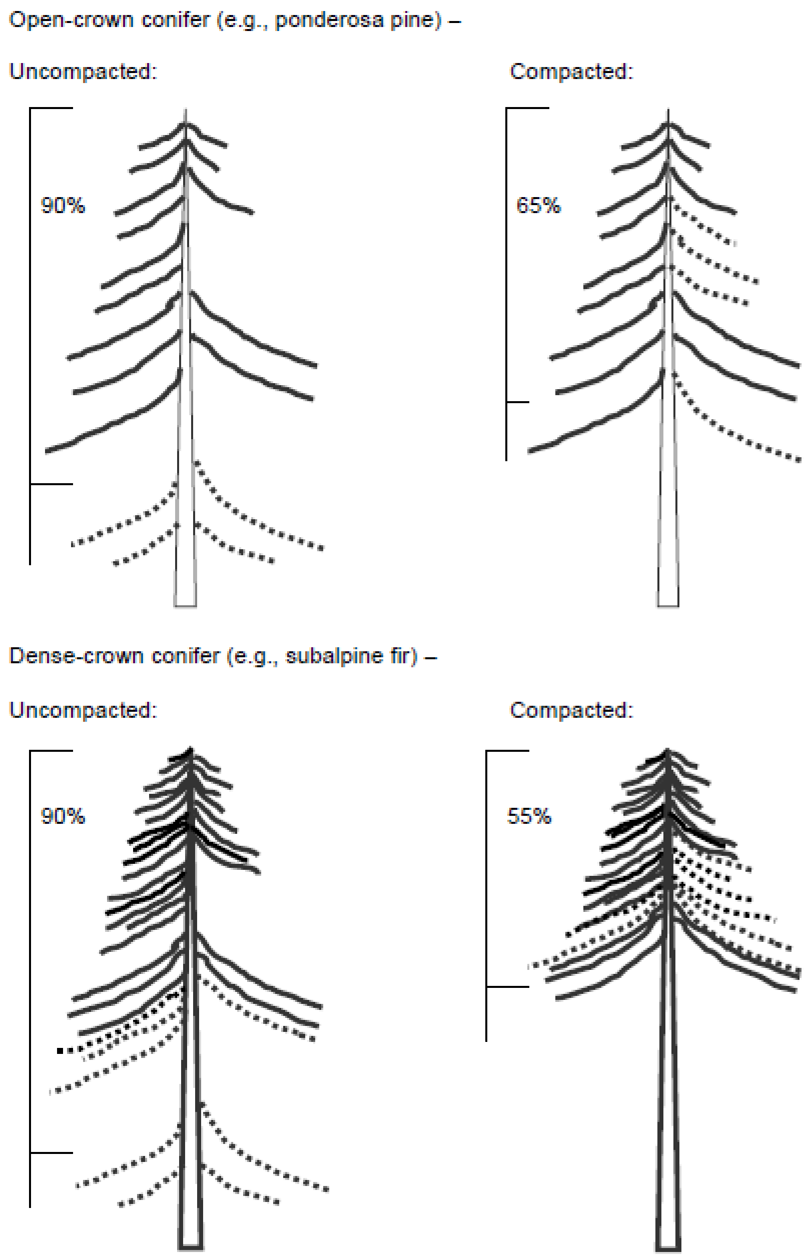


Figure 50. Examples of and comparison between COMPACTED CROWN RATIO and UNCOMPACTED LIVE CROWN RATIO of conifers.

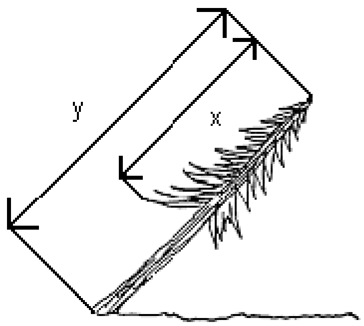


Figure 51. COMPACTED CROWN RATIO on a leaning tree. CROWN RATIO = (x/y)100.

For multi-stemmed woodland species, ocularly transfer lower live foliage to fill large holes on all stems and form an even crown across the tree (fig. 52).

Values: 00 to 99

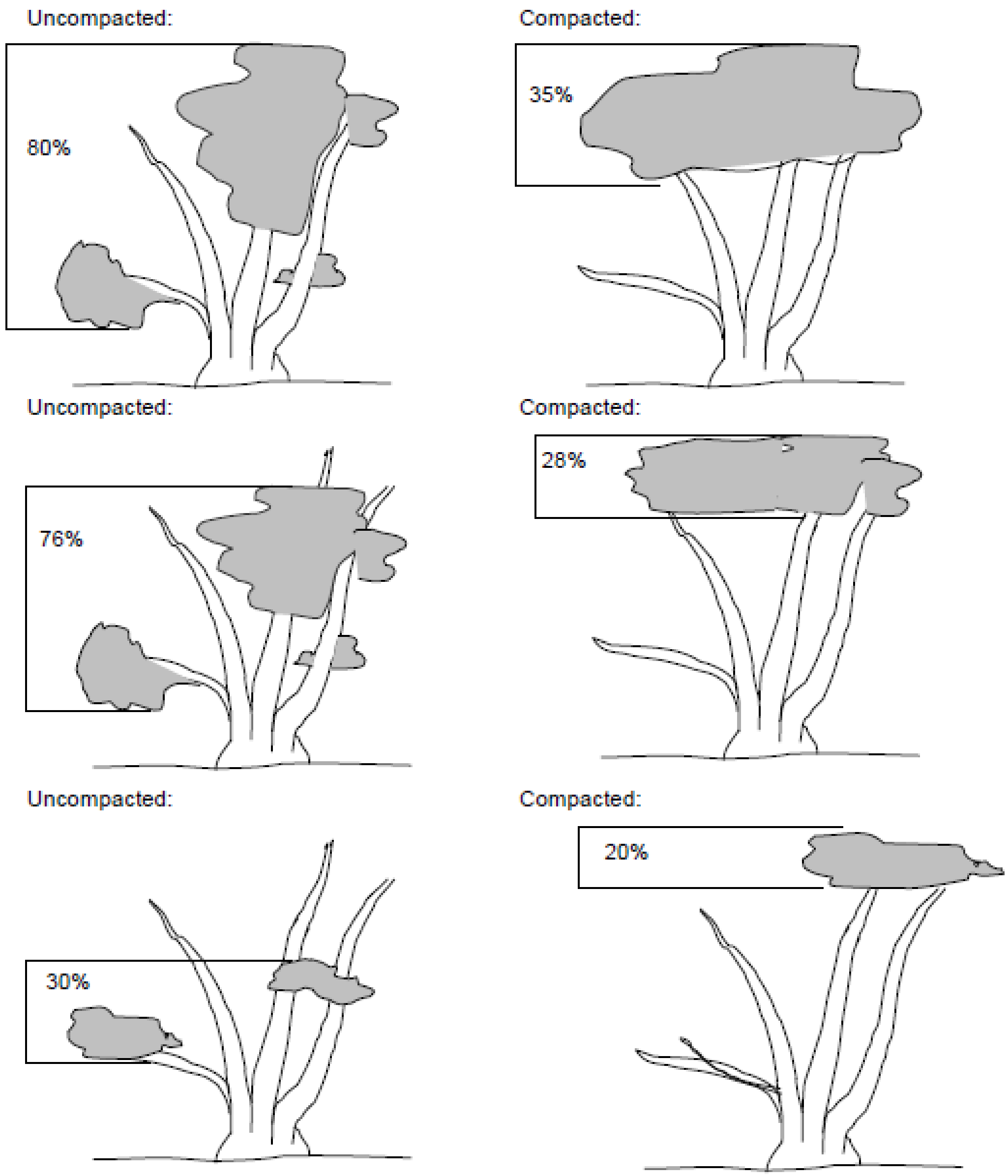


Figure 52. Examples of and comparison between COMPACTED CROWN RATIO and UNCOMPACTED LIVE CROWN RATIO of woodland species.

5.20 TREE DAMAGE (CORE)

Damage is a composite variable. Up to three damaging agents may be recorded per tree. Many damaging agents are host specific and their potential for damage could vary by region. In general, a recorded damage is likely to:

1. Prevent the tree from surviving more than 1-2 years
2. Reduce the growth of the tree in the near term
3. Negatively affect a tree's marketable products (cubic, BF, or other)

It is not necessary to record damage agents in order of their severity unless there are more than three agents. If there are more than three agents, record only the most important ones using the list of impacts above as a guide (i.e., agents threatening survival are more important than agents that reduce wood quality). In general, agents that affect the roots or bole tend to be most threatening, because they have the capacity to affect the entire tree; damage to peripheral parts of the tree may be temporary because leaves, shoots, and reproductive structures may be replaced.

Codes used for this variable come from a January 2012 Pest Trend Impact Plot System, (PTIPS) list from the Forest Health Technology Enterprise Team (FHTET) that has been modified to meet FIA needs. This list is made up of General Agents and then further subdivided into specific agents. Not every General Agent PTIPS code will be available for use for this variable; some do not cause tree damage as defined above while others are better recorded in a different General Agent. Not every specific agent PTIPS code will be available for use for this variable. Regions will decide which specific agents they will identify in their areas.

Record the general agent unless the Region opts to collect specific agents. Specific agents can later be collapsed into the general agent categories for cross-region comparisons. In the unusual instance when more than one specific agent in the same general category occurs on the same tree, record them both. If a specific agent is identified on that plot but that agent is not on the regionally recognized list of codes for damage agents, use its General Agent code. Appendix 11 contains the regionally recognized list of codes for damage agent based on the modified PTIPS list from FHTET. Only the specific agent codes from appendix 11 may be used instead of the general codes listed under DAMAGE AGENT 1. Any damage code in appendix 11 may be used for DAMAGE AGENT 1, DAMAGE AGENT 2, or DAMAGE AGENT 3

5.20.1 DAMAGE AGENT 1

Inspect the tree from bottom to top – roots, bole, branches, foliage (including buds and shoots), Record the first damage agent observed from the list of agents (unless you observe more than 3 damages). If there are more than three agents, record only the most important ones using the list of impacts listed in section 5.20 as a guide (i.e., agents threatening survival are more important than agents that reduce wood quality). The general agent codes, damage thresholds, and general agent descriptions are listed here. Specific agents within the general categories, if required by your Region, are listed in appendix 11, along with their associated thresholds. These codes can be collapsed into the national core general codes. Note: in some cases, thresholds for specific agents may be different from the threshold for the corresponding general agent. If a region is collecting a specific insect agent and no one is collecting the general agent, then the specific insect agent is collapsed into the general insect category 10000.

Values:

General Agent Damage Codes, Damage Thresholds, and Descriptions. Specific agent codes are in appendix 11.

Code	General Agent	Damage Threshold*	Descriptions
0		No damage	

Code	General Agent	Damage Threshold*	Descriptions
10000	General insects	Any damage to the terminal leader; damage >20% of the roots or boles with >20% of the circumference affected; damage >20% of the multiple-stems (on multi-stemmed woodland species) with >20% of the circumference affected; >20% of the branches affected; damage ≥20% of the foliage with ≥50% of the leaf/needle affected.	Insect damage that cannot be placed in any of the following insect categories.
11000	Bark beetles	Any evidence of a successful attack (successful attacks generally exhibit boring dust, many pitch tubes and/or fading crowns).	Bark beetles (*Dendroctonus*, *Ips*, and other genera) are phloem-feeding insects that bore through the bark and create extensive galleries between the bark and the wood. Symptoms of beetle damage include fading or discolored tree crown (yellow or red), pitch tubes or pitch streaks on the bark, extensive egg galleries in the phloem, boring dust in the bark crevices or at the base of the tree. Bark chipping by woodpeckers may be conspicuous. They inflict damage or destroy all parts of trees at all stages of growth by boring in the bark, inner bark, and phloem. Visible signs of attack include pitch tubes or large pitch masses on the tree, dust and frass on the bark and ground, and resin streaming. Internal tunneling has various patterns. Most have tunnels of uniform width with smaller galleries of variable width radiating from them. Galleries may or may not be packed with fine boring dust.
12000	Defoliators	Any damage to the terminal leader; damage ≥20% of the foliage with ≥50% of the leaf/needle affected.	These are foliage-feeding insects that may reduce growth and weaken the tree causing it to be more susceptible to other damaging agents. General symptoms of defoliation damage include large amounts of missing foliage, browning foliage, extensive branch mortality, or dead tree tops.
13000	Chewing insects Note: this is only collected by IW and SRS	Any damage to the terminal leader; damage ≥20% of the foliage with ≥50% of the leaf/needle affected	Insects, like grasshoppers and cicadas that chew on trees (those insects not covered by defoliators in code 12000).
14000	Sucking insects	Any damage to the terminal leader; damage ≥20% of the foliage with ≥50% of the leaf/needle affected	Adelgids, scales and aphids feed on all parts of the tree. Often they cause galling on branches and trunks. Some appear benign but enable fungi to invade where they otherwise could not (e.g., beech bark disease). The most important ones become conspicuous because of the mass of white, cottony wax that conceals eggs and young nymphs.

Code	General Agent	Damage Threshold*	Descriptions
15000	Boring insects	Any damage to the terminal leader; damage ≥20% of the roots, stems, or branches.	Most wood boring insects attack only severely declining and dead trees. Certain wood boring insects cause significant damage to trees, especially the exotic Asian longhorn beetle, emerald ash borer, and Sirex wood wasp. Bark beetles have both larval and adult galleries in the phloem and adjacent surface of the wood. Wood borers have galleries caused only by larval feeding. Some, such as the genus *Agrilus* (including the emerald ash borer) have galleries only in the phloem and surface of the wood. Other wood borers, such as Asian longhorn beetle bore directly into the phloem and wood. Sirex adults oviposit their eggs through the bark, and developing larvae bore directly into the wood of pines.
19000	General diseases	Any damage to the terminal leader; damage ≥20% of the roots or boles with >20% of the circumference affected; damage >20% of the multiple-stems (on multi-stemmed woodland species) with >20% of the circumference affected; >20% of the branches affected; damage ≥20% of the foliage with ≥50% of the leaf/needle affected.	Diseases that cannot be placed in any of the following disease categories.
21000	Root/butt diseases	Any occurrence.	Root disease kills all or a portion of a tree's roots. Quite often, the pathogenic fungus girdles the tree at the root collar. Tree damage includes mortality (often occurring in groups or "centers"), reduced tree growth, and increased susceptibility to other agents (especially bark beetles). General symptoms include resin at the root collar, thin, chlorotic (faded) foliage, and decay of roots. A rot is a wood decay caused by fungi. Rots are characterized by a progression of symptoms in the affected wood. First, the wood stains and discolors, then it begins to lose its structural strength, and finally the wood starts to break down, forming cavities in the stem. Even early stages of wood decay can cause cull due to losses in wood strength and staining of the wood. Rot can lead to mortality, cull, an increased susceptibility to other agents (such as insects), wind throw, and stem breakage.

Code	General Agent	Damage Threshold*	Descriptions
22000	Cankers (non-rust)	Any occurrence.	A canker -- a sunken lesion on the stem caused by the death of cambium -- may cause tree breakage or kill the portion of the tree above the canker. Cankers may be caused by various agents but are most often caused by fungi. A necrotic lesion begins in the bark of branches, trunk or roots, and progresses inward killing the cambium and underlying cells. The causal agent may or may not penetrate the wood. This results in areas of dead tissue that become deeper and wider. There are two types of cankers, annual and perennial. Annual cankers enlarge only once and do so within an interval briefer than the growth cycle of the tree, usually less than one year. Little or no callus is associated with annual cankers, and they may be difficult to distinguish from mechanical injuries. Perennial cankers are usually the more serious of the two, and grow from year to year with callus forming each year on the canker margin, often resulting in a target shape. The most serious non-rust cankers occur on hardwoods, although branch mortality often occurs on conifers.
22500	Stem decays	Any visual evidence (conks; fruiting bodies; rotten wood)	Rot occurring in the bole/stems of trees above the roots and stump.
23000	Parasitic / Epiphytic plants	Dwarf mistletoes with Hawksworth rating of ≥3; true mistletoes and vines covering ≥ 50% of crown.	Parasitic and epiphytic plants can cause damage to trees in a variety of ways. The most serious ones are dwarf mistletoes, which reduce growth and can cause severe deformities. Vines may damage trees by strangulation, shading, or physical damage. Benign epiphytes, such as lichens or mosses, are not considered damaging agents.
24000	Decline Complexes/ Dieback/Wilts	Damage ≥ 20% dieback of crown area.	Tree disease which results not from a single causal agent but from an interacting set of factors. Terms that denote the symptom syndrome, such as dieback and wilt, are commonly used to identify these diseases.
25000	Foliage diseases	Damage ≥20% of the foliage with ≥50% of the leaf/needle affected.	Foliage diseases are caused by fungi and result in needle shed, growth loss, and, potentially, tree mortality. This category includes needle casts, blights, and needle rusts.

Code	General Agent	Damage Threshold*	Descriptions
26000	Stem rusts	Any occurrence on the bole or stems (on multi-stemmed woodland species), or on branches ≤1 foot from boles or stems; damage to ≥20% of branches	A stem rust is a disease caused by fungi that kill or deform all or a portion of the stem or branches of a tree. Stem rusts are obligate parasites and host specialization is very common. They infect and develop on fast-growing tissues and cause accelerated growth of infected tissues resulting in galls or cankers. Heavy resinosis is usually associated with infections. Sometimes yellow or reddish-orange spores are present giving a "rusty" appearance. Damage occurs when the disease attacks the cambium of the host, girdling and eventually killing the stem above the attack. Symptoms of rusts include galls (an abnormal and pronounced swelling or deformation of plant tissue that forms on branches or stems) and cankers (a sunken lesion on the stem caused by death of the cambium which often results in the death of tree tops and branches).
27000	Broom rusts	≥50% of crown area affected.	Broom rust is a disease caused by fungi that kill or deform all or a portion of the branches of a tree. Broom rusts are obligate parasites and host specialization is very common. They infect and develop on fast-growing tissues and cause accelerated growth of infected tissues resulting in galls. Symptoms of rusts include galls, an abnormal and pronounced swelling or deformation of plant tissue that forms on branches or stems.
30000	Fire	Damage ≥ 20% of bole circumference; >20% of stems on multi-stemmed woodland species affected; ≥20% of crown affected.	Fire damage may be temporary, such as scorched foliage, or may be permanent, such as in cases where cambium is killed around some portion of the bole. The location and amount of fire damage will determine how the damage may affect the growth and survival of the tree. Fire often causes physiological stress, which may predispose the tree to attack by insects of other damaging agents.
41000	Wild animals	Any damage to the terminal leader; damage ≥20% of the roots or boles with> 20% of the circumference affected; damage >20% of the multiple-stems (on multi-stemmed woodland species) with >20% of the circumference affected; >20% of the branches affected; damage ≥20% of the foliage with ≥50% of the leaf/needle affected.	Wild animals from birds to large mammals cause open wounds. Some common types of damage include: sapsucker bird peck, deer rub, bear clawing, porcupine feeding, and beaver gnawing.

Code	General Agent	Damage Threshold*	Descriptions
42000	Domestic animals	Any damage to the terminal leader; damage ≥20% of the roots or boles with> 20% of the circumference affected; damage >20% of the multiple-stems (on multi-stemmed woodland species) with >20% of the circumference affected; >20% of the branches affected; damage ≥20% of the foliage with ≥50% of the leaf/needle affected.	Open wounds caused by cattle and horses occur on the roots and lower trunk. Soil compaction from the long term presence of these animals in a woodlot can also cause indirect damage.
50000	Abiotic	Any damage to the terminal leader; damage ≥20% of the roots or boles with> 20% of the circumference affected; damage >20% of the multiple-stems (on multi-stemmed woodland species) with >20% of the circumference affected; >20% of the branches affected; damage ≥20% of the foliage with ≥50% of the leaf/needle affected.	Abiotic damages are those that are not caused by other organisms. In some cases, the type and severity of damage may be similar for different types of agents (e.g., broken branches from wind, snow, or ice).
60000	Competition	Overtopped shade intolerant trees that are not expected to survive for 5 years or saplings not expected to reach tree size (5.0 inches DBH/DRC).	Suppression of overtopped shade intolerant species. Trees that are not expected to survive for 5 years or saplings not expected to reach tree size (5.0 inches DBH/DRC).
70000	Human activities	Any damage to the terminal leader, damage ≥20% of the roots or boles with> 20% of the circumference affected; damage >20% of the multiple-stems (on multi-stemmed woodland species) with >20% of the circumference affected; >20% of the branches affected; damage ≥20% of the foliage with ≥50% of the leaf/needle affected.	People can injure trees in a variety of ways, from poor pruning, to vandalism, to logging injury. Signs include open wounds or foreign embedded objects.
71000	Harvest	Removal of ≥10% of cubic volume	Only recorded for woodland species trees that have partial cutting
90000	Other damage	Any damage to the terminal leader; damage ≥20% of the roots or boles with> 20% of the circumference affected; damage >20% of the multiple-stems (on multi-stemmed woodland species) with >20% of the circumference affected; >20% of the branches affected; damage ≥20% of the foliage with ≥50% of the leaf/needle affected.	

Code	General Agent	Damage Threshold*	Descriptions
99000	Unknown damage	Any damage to the terminal leader; damage ≥20% of the roots or boles with> 20% of the circumference affected; damage >20% of the multiple-stems (on multi-stemmed woodland species) with >20% of the circumference affected; >20% of the branches affected; damage ≥20% of the foliage with ≥50% of the leaf/needle affected.	Use this code only when observed damage cannot be attributed to a general or specific agent.

* Some Regional specific damage agents within a category may have differing damage thresholds.

5.21 CAUSE OF DEATH

Record a cause of death for all trees that have died or been cut since the previous survey. If cause of death cannot be reliably estimated, record unknown/not sure/other.

Values:

Value	Description
10	Insect
20	Disease
30	Fire
40	Animal
50	Weather
60	Vegetation (suppression, competition, vines/kudzu)
70	Unknown/not sure/other - includes death from human activity not related to silvicultural or landclearing activity (accidental, random, etc.). TREE NOTES required.
80	Silvicultural or landclearing activity (death caused by harvesting or other silvicultural activity, including girdling, chaining, etc., or to landclearing activity)

5.23 DECAY CLASS 6.0 SEEDLING DATA

Record for each standing dead tally tree, 1.0 inch in diameter and larger, the code indicating the tree's stage of decay.

Values: Use the following table for guidelines:

Decay class stage (code)	Limbs and branches	Top	% Bark Remaining	Sapwood presence and condition*	Heartwood condition*
1	All present	Pointed	100	Intact; sound, incipient decay, hard, original color	Sound, hard, original color
2	Few limbs, no fine branches	May be broken	Variable	Sloughing; advanced decay, fibrous, firm to soft, light brown	Sound at base, incipient decay in outer edge of upper bole, hard, light to reddish brown
3	Limb stubs only	Broken	Variable	Sloughing; fibrous, soft, light to reddish brown	Incipient decay at base, advanced decay throughout upper bole, fibrous, hard to firm, reddish brown
4	Few or no stubs	Broken	Variable	Sloughing; cubical, soft, reddish to dark brown	Advanced decay at base, sloughing from upper bole, fibrous to cubical, soft, dark reddish brown
5	None	Broken	Less than 20	Gone	Sloughing, cubical, soft, dark brown, OR fibrous, very soft, dark reddish brown, encased in hardened shell

*Characteristics are for Douglas-fir. Dead trees of other species may vary somewhat. Use this only as a guide.

Regeneration information is obtained by counting live seedlings within the 6.8-foot radius microplot located 90 degrees and 12.0 feet from each subplot center within each of the four subplots. Conifer seedlings must be at least 6.0 inches in length and less than 1.0 inch at DBH/DRC in order to qualify for tallying. Hardwood seedlings must be at least 12.0 inches in length and less than 1.0 inch at DBH/DRC in order to qualify for tallying. For woodland species, each stem on a single tree must be less than 1.0 inch in DRC. Seedlings are counted in groups by species and condition class, up to five individuals per species. Counts beyond five estimated.

7.2.2 [SITE TREE] SPECIES

Ideally, site trees in the western U.S. should be between 35-80 years old. If preferred trees cannot be found in this age range, expand the age range to 15-250 years. Reject trees outside the 15-250 year age range, trees that exhibit signs of damage, trees with ring patterns that show signs of suppression, trees less than 5.0 inches DBH, trees with abnormalities at DBH, trees with rotten cores, and woodland species. A list of preferred site-tree species is provided. Site trees should be selected in the following order of preference:

- 1st Choice: representative of the stand, on the list for your region.

- 2nd Choice: representative of the stand, on the list for an adjoining western region.
- 3rd Choice: not representative of the stand, on the list for your region.
- 4th Choice: not representative of the stand, on the list for an adjoining western region.

Values:

Western U.S. Site-Tree Species: PNW = Pacific Northwest FIA, RMRS = Rocky Mountain FIA

Code	Common Name	Region
	-------------------- **Softwood Species** --------------------	
0011	Pacific silver fir	PNW
0015	white fir	RMRS, PNW
0017	grand fir	RMRS, PNW
0018	corkbark fir	RMRS
0019	subalpine fir	RMRS, PNW
0020	California red fir	RMRS, PNW
0021	shasta red fir	PNW
0022	noble fir	PNW
0042	Alaska yellow-cedar	PNW
0068	eastern red cedar	RMRS
0073	western larch	RMRS, PNW
0081	incense-cedar	RMRS, PNW
0093	Engelmann spruce	RMRS, PNW
0094	white spruce	RMRS, PNW
0095	black spruce	PNW
0096	blue spruce	RMRS
0098	sitka spruce	PNW
0101	whitebark pine	RMRS, PNW
0104	foxtail pine	RMRS
0108	lodgepole pine	RMRS, PNW
0109	Coulter pine	PNW
0112	Apache pine	RMRS

Western U.S. Site-Tree Species: PNW = Pacific Northwest FIA, RMRS = Rocky Mountain FIA

Code	Common Name	Region
0116	Jeffrey pine	RMRS, PNW
0117	sugar pine	RMRS, PNW
0119	western white pine	RMRS, PNW
0120	bishop pine	PNW
0122	ponderosa pine	RMRS, PNW
0135	Arizona pine	RMRS
0201	bigcone Douglas-fir	PNW
0202	Douglas-fir	RMRS, PNW
0211	redwood	PNW
0231	Pacific yew	RMRS, PNW
0242	western redcedar	RMRS, PNW
0263	western hemlock	RMRS, PNW
0264	mountain hemlock	RMRS, PNW
	-------------------- **Hardwood Species** --------------------	
0312	bigleaf maple	PNW
0351	red alder	RMRS, PNW
0375	paper birch	RMRS, PNW
0462	hackberry	RMRS
0544	green ash	RMRS
0741	balsam poplar	RMRS, PNW
0742	eastern cottonwood	RMRS
0745	plains cottonwood	RMRS
0746	quaking aspen	RMRS, PNW
0747	black cottonwood	RMRS, PNW
0748	Fremont poplar/cottonwood	RMRS
0749	narrowleaf cottonwood	RMRS
0972	American elm	RMRS

8.2 GENERAL DEFINITIONS

Canopy Cover – Canopy cover is defined as the area of ground surface covered by a vertical projection of the canopy of a vascular plant. The canopy is described by a polygon surrounding the outer edges of the foliage (fig. 54), without subtracting any normal spaces occurring between the leaves of plants (Daubenmire 1959[1]). Overlapping crowns are not double-counted (visualize the canopy cover collapsed into a 2-dimensional space); the maximum possible canopy cover is the percentage of the subplot area within the accessible condition.

All canopy cover estimates are focused on foliage within the sampled accessible condition class(es) within the subplot perimeter (24.0-foot radius, horizontal distance). Canopy cover is estimated for each sampled accessible condition of the subplot. If multiple sampled accessible conditions occur on a subplot, treat the condition boundary as a vertical wall on the plot: **plant foliage is included in the condition it is hanging over**, even if the plant is rooted in a different condition. However, the canopy **cover value is always estimated as a percentage of an entire subplot**. That is, if the canopy cover within the accessible condition is about equal to a circle with a radius of 5.3 feet, the canopy cover estimate will always be 5 percent, even if only 30 percent of the subplot is in the accessible condition on which the canopy cover is being measured.

Canopy cover is collected by height layer and as a total (aerial view) across all layers for each growth habit in *Vegetation Structure* (8.4). For each layer, examine the canopy cover of each Structure Growth Habit as if the other growth habits and other layers do not exist. If a Structure Growth Habit does not have foliage in a layer, enter 0 (do not count tree boles as cover). For total aerial canopy cover by Structure Growth Habit, examine each growth habit individually as if the other growth habits do not exist. Total aerial canopy cover is collected for each most abundant species in *Species Composition* (8.5); examine each species individually, as if the other species do not exist.

Canopy cover is estimated to the nearest 1 percent. For *Vegetation Structure* assessments, canopy cover >0 and ≤1 percent is coded as 1 percent (i.e., trace amounts are coded as 1%). For *Species Composition* assessments, a species must have at least 3 percent total aerial canopy cover (i.e., do not round total aerial canopy cover <3% up to 3%).

Canopy cover is vertically projected from the outline of the foliage **at the time of plot visit.** All foliage that is or was alive during the current growing season is included in the cover estimates. Canopy cover from broken tops and stems is included, unless completely detached. Do not ocularly upright leaning trees.

See tabulation below for canopy cover to area relationships for a 1/24 acre subplot and figure 54 for additional visual calibrations.

Cover	Area (ft^2)	Square length on side (ft)	Circle radius (ft)
1%	18	4.3	2.4
3%	54	7.4	4.2
5%	90	9.5	5.4
10%	181	13.4	7.6
15%	271	16.5	9.3
20%	362	19.0	10.7
25%	452	21.3	12.0
50%	905	30.1	17.0

[1] Daubenmire. R. 1959. A canopy-coverage method of vegetational analysis. Northwest Science 33(1): 43-64.

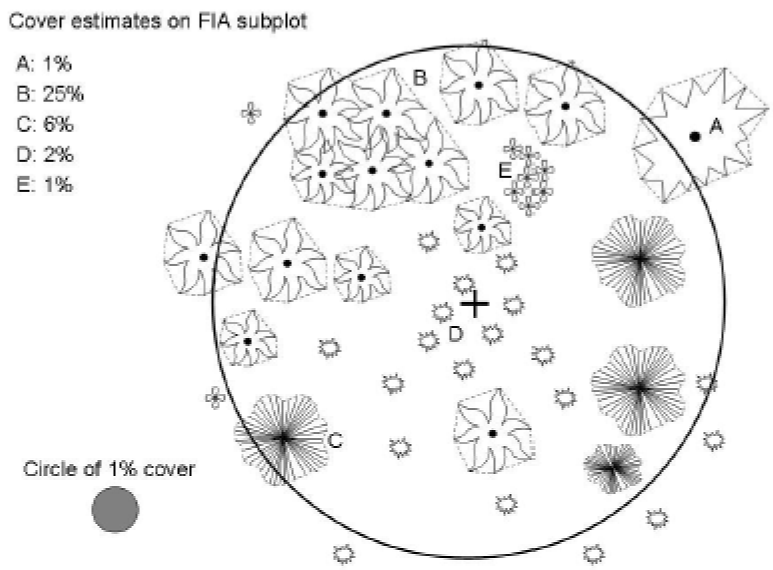


Figure 54. Assessing canopy cover.

Growth Habits – P2 Vegetation data are collected by growth habits at each LEVEL OF DETAIL. In general, growth habits for vascular plants include trees, shrubs/subshrubs/woody vines, forbs, and graminoids.

However, depending on the LEVEL OF DETAIL, trees are grouped in different ways. *Vegetation Structure* (8.4) tree Structure Growth Habits are determined by regional core/core-optional tree species lists; *Species Composition* (8.6) tree SPECIES GROWTH HABITs are determined by DBH/DRC. See sections 8.4 and 8.5 for more detail.

Layer Codes – Structure Growth Habits are assessed by layers in *Vegetation Structure* (8.4), and one of the following layer codes will be assigned to individual plant species' SPECIES GROWTH HABITs in *Species Composition* (8.5). Measure the layer height from ground level; see figure 55 for examples of measuring layer heights on sloping and uneven ground.

Layer 1	0 to 2.0 feet
Layer 2	2.1 to 6.0 feet
Layer 3	6.1 to 16.0 feet
Layer 4	Greater than 16 feet

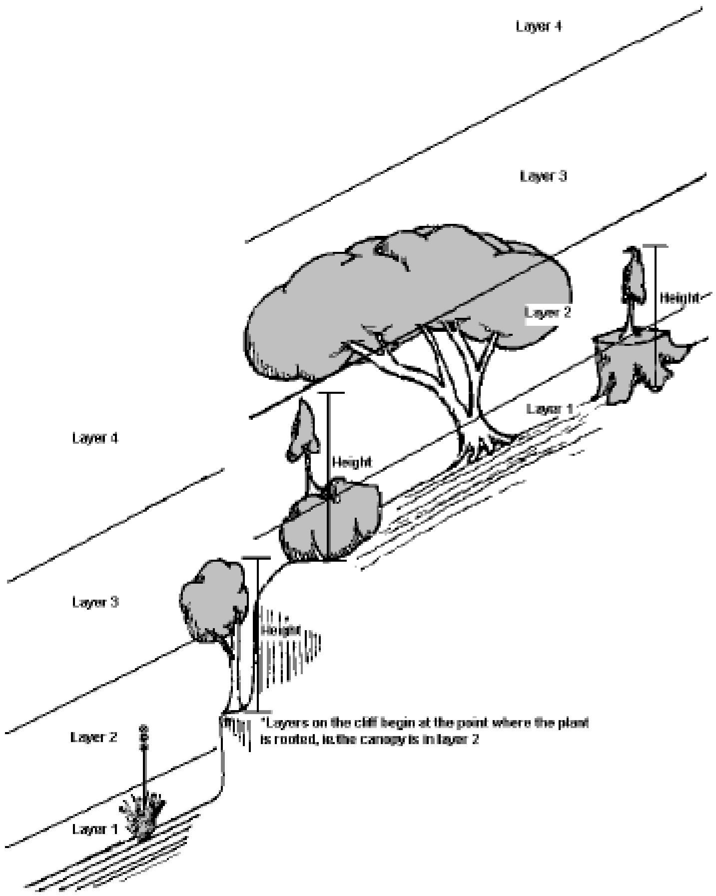


Figure 55. To determine the layer of a plant, measure the height of the layer from the ground.

NRCS PLANTS database – The Natural Resource Conservation Service (NRCS) PLANTS Database provides standardized information about the vascular plants, mosses, liverworts, hornworts, and lichens of the U.S. and its territories. It includes names, plant symbols, checklists, distributional data, species abstracts, characteristics (including growth habits), images, crop information, automated tools, onward Web links, and references:

USDA, NRCS. 2017. The PLANTS Database (http://plants.usda.gov, September 15, 2017). National Plant Data Center, Baton Rouge, LA 70874-4490 USA.

FIA currently uses a stable code set downloaded September 15, 2017.

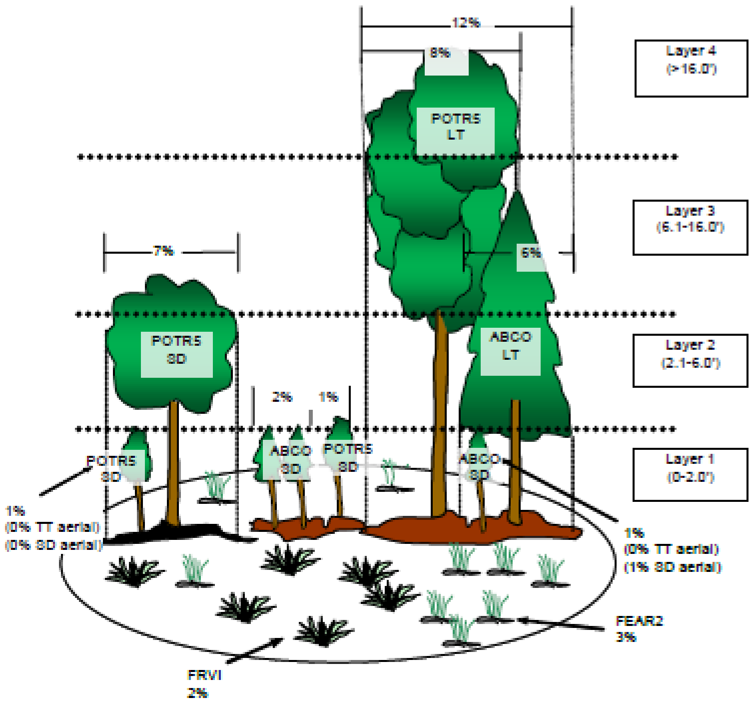


Figure 56. Example of growth habit by layer and species composition.

Table 1-Estimation of canopy cover by layer and aerial view of each Structure Growth Habit in figure 56

Vegetation Structure Growth Habit	**Layer 1 (0-2.0 ft)**	**Layer 2 (2.1-6.0 ft)**	**Layer 3 (6.1-16.0 ft)**	**Layer 4 (>16.0 ft)**	**Aerial**
			Percent canopy cover		
Tally tree sp (TT)	005	013	019	008	022
Non-tally tree sp (NT)	000	000	000	000	000
Shrub/Subshrub/Woody Vine (SH)	000	000	000	000	000
Forb (FB)	002	000	000	000	002
Graminoid (GR)	003	000	000	000	003

Table 2-Estimation of total aerial canopy cover by species in figure 56

Level of Detail	**Species Growth Habit**	**Species Code**	**Cover**	**Layer**
2	GR	FEAR2	003	1
2	SD	ABCO	003	1
2	SD	POTR5	008	3
3	LT	POTR5	008	4
3	LT	ABCO	006	2

Note: FRVI, estimated at 2%, was not recorded, and ABCO and POTR5 are present as two different SPECIES GROWTH HABITs (seedling/sapling and large tree) with at least 3% total aerial canopy cover within the SPECIES GROWTH HABIT on the subplot.

10. DOWN WOODY MATERIALS (PHASE 2 – CORE OPTIONAL)

10.0 Introduction

Down woody materials (DWM) are important components of forest ecosystems across the country. DWM is dead material on the ground in various stages of decay. Wildlife biologists, ecologists, mycologists, foresters, and fuels specialists are some of the people interested in DWM because it helps describe the:

- Quality and status of wildlife habitats.
- Structural diversity within a forest.
- Fuel loading and fire behavior.
- Carbon sequestration – the amount of carbon tied up in dead wood.
- Storage and cycling of nutrients and water – important for site productivity.

Down wood components and fuels estimated by the FIA program are coarse wood, slash, fine wood, and litter and duff depth. The DWM protocol includes the following three suites of measurement options:

<u>OPTION I. BASE:</u>

The BASE option provides a minimum set of variables necessary to produce estimates for volume, biomass, carbon, and fuel load per acre on a broad scale. Base variables are required any time DWM is measured and are labeled "BASE" in this chapter. Measurements include:

<u>OPTION I: BASE Variables</u>

BASE Layout: DWM SAMPLING STATUS, DWM NUMBER OF SUBPLOTS, DWM NUMBER OF TRANSECTS ON SUBPLOT, DWM TRANSECT LENGTH, DWM NOTES

BASE Transect Line Segmenting: SUBPLOT NUMBER, TRANSECT, SEGMENT CONDITION CLASS NUMBER, SEGMENT BEGINNING DISTANCE (HD), SEGMENT ENDING DISTANCE (HD), DWM TRANSECT SEGMENT SAMPLE STATUS, DWM TRANSECT NONSAMPLED REASON

BASE CWD: SUBPLOT NUMBER, TRANSECT, CWD CONDITION CLASS, PIECE ON SUBPLOT OR ANNULAR PLOT, CWD DECAY CLASS, SPECIES, DIAMETER AT POINT OF INTERSECTION, DIAMETER OF HOLLOW AT POINT OF INTERSECTION, CWD LENGTH >=3 FEET

BASE Pile: PILE SUBPLOT NUMBER, PILE TRANSECT, PILE CONDITION CLASS NUMBER, PILE BEGINNING DISTANCE, PILE ENDING DISTANCE, COMPACTED HEIGHT OF CWD IN PILE, PILE DECAY CLASS, PILE SPECIES

BASE FWD: FWD SUBPLOT NUMBER, FWD TRANSECT, FWD CONDITION CLASS NUMBER, FWD TRANSECT SEGMENT SAMPLE STATUS, FWD TRANSECT NONSAMPLED REASON, SMALL FWD COUNT, MEDIUM FWD COUNT, LARGE FWD COUNT, HIGH COUNT REASON

BASE Duff/Litter Depth: DUFF/LITTER SUBPLOT NUMBER, DUFF/LITTER TRANSECT, DUFF/LITTER CONDITION CLASS NUMBER, DUFF/LITTER SAMPLE STATUS, DUFF/LITTER NONSAMPLED REASON, DUFF DEPTH, LITTER DEPTH, DUFF AND LITTER METHOD

<u>OPTION II. WILDLIFE/ECOLOGICAL</u>

This option includes all the BASE Option variables plus additional CWD structural variables. These additional measurements allow users to quantify wildlife habitat. This option is required when measuring P3 DWM.

<u>OPTION II: WILDLIFE / ECOLOGICAL</u>

BASE Layout Variables

BASE Transect Line Segmenting Variables

BASE CWD Variables plus the following variables required for P3 DWM: CWD HORIZONTAL DISTANCE, DIAMETER AT SMALL END, DIAMETER AT LARGE END, CWD TOAL LENGTH
BASE Pile Variables
BASE FWD Variables
BASE Duff/Litter Depth Variables

OPTION III. RAPID ASSESSMENT (CUSTOMIZED PROTOCOL):

Rapid assessments may be desired to quantify down wood abundance in specific instances (for example, following a hurricane or volcanic eruption). Because information needs and funds will vary depending on the situation, a rapid assessment option is available where the transect configuration (number of transects and subplots and transect length) can be defined by the FIA unit. However, the base variables needed to estimate biomass are still required for rapid assessments.

Additional variables found to be useful by FIA units in the past are also defined in this protocol to ensure consistency if additional information is desired by different FIA units. FIA units may also choose to classify the fuelbed conditions that determine fire behavior on each condition class using standardized national fuel models. These variables are labeled "OPTIONAL" in this chapter.

ADDITIONAL OPTIONAL VARIABLES

Optional CWD Variables (for all OPTIONs): IS THE PIECE HOLLOW?, PIECE INCLINATION, CWD HISTORY, PERCENT OF LOG CHARRED BY FIRE, LARGE END DIAMETER CLASS

Optional Fuels Variable: CONDITION FUELBED TYPE (Scott and Burgan 2005; RMRS-GTR-153)

DWM is sampled on accessible forest conditions intersected by a transect, and on accessible nonforest conditions if they are being measured on the plot (NONFOREST CONDITION CLASS STATUS = 2). If a transect crosses a condition boundary, the boundary locations on the transect are recorded. All DWM in the inventory is sampled using the line intersect sampling method (also called planar intercept method). In this method, transects are established, and individual pieces of Coarse Woody Debris (CWD, ≥3 inches diameter and ≥0.5 foot long) or Fine Woody Debris (FWD, <3 inches diameter) are tallied if the central axis of the piece is intersected by the plane of the transect.

Note: DWM is a CORE OPTIONAL indicator on all Phase 2 plots. When measured on Phase 2 plots, all the BASE data items must be measured and other data items can be added as desired (designated as P2 OPTIONAL on data items.) However, DWM is a CORE indicator on all Phase 3 plots, and both BASE and WILDLIFE/ECOLOGICAL data items must be measured (see table 3).

Table 3. DWM Protocol Options Variables

OPTION I: BASE	OPTION II: WILDLIFE / ECOLOGICAL	ADDITIONAL OPTIONAL VARIABLES
REQUIRED: BASE Layout Variables	**REQUIRED:** BASE Layout Variables	
REQUIRED: BASE Transect Line Segmenting Variables	**REQUIRED:** BASE Transect Line Segmenting Variables	
REQUIRED: BASE CWD Variables **P2 OPTIONAL:** CWD HORIZONTAL DISTANCE, DIAMETER AT SMALL END, DIAMETER AT LARGE END, CWD TOTAL LENGTH	**REQUIRED:** BASE CWD Variables, CWD HORIZONTAL DISTANCE, DIAMETER AT SMALL END, DIAMETER AT LARGE END, CWD TOTAL LENGTH, IS THE PIECE HOLLOW?	**OPTIONAL CWD Variables (for all OPTIONs):** IS THE PIECE HOLLOW?, PIECE INCLINATION, CWD HISTORY, PERCENT OF LOG CHARRED BY FIRE, LARGE END DIAMETER CLASS
REQUIRED: BASE Pile Variables	**REQUIRED:** BASE Pile Variables	
REQUIRED: BASE FWD Variables	**REQUIRED:** BASE FWD Variables	
REQUIRED: BASE Duff/Litter Depth Variables	**REQUIRED:** BASE Duff/Litter Depth Variables	

OPTION I: BASE	OPTION II: WILDLIFE / ECOLOGICAL	ADDITIONAL OPTIONAL VARIABLES
		Optional Fuels Variable: Photo-series (Scott & Burgan 2005 RMRS-GTR-153)

10.1 Definition of Down Woody Materials

Coarse Woody Debris – In this inventory, CWD includes downed, dead tree and shrub boles, large limbs, and other woody pieces that are ≥3 inches in diameter and severed from their original source of growth. CWD also includes dead tally species trees or single-stemmed woodland species trees (either self-supported by roots, severed from roots, or uprooted and supported by other objects) that are leaning >45 degrees from vertical and not considered part of the standing tree inventory. Portions of dead trees that are separated greater than 50 percent (either above or below 4.5 feet), are considered severed and are included in the CWD inventory (see discussion and diagrams in section 5.7.2 - Standing Dead). For multi-stemmed woodland species (Appendix 3) such as juniper, only tally stems that are dead and detached. Include as CWD all dead multi-stemmed woodland tree stems that do not qualify as standing dead if they meet the size requirements for CWD pieces. Also included are non-machine processed round wood such as fence posts and cabin logs.

CWD is measured primarily using intersect diameter. In rare instances when pieces are in a pile and it is impossible to estimate the size of individual pieces, use the pile protocol.

CWD does not include:

1. Woody pieces <3.0 inches in diameter at the point of intersection with the transect.
2. Dead trees leaning 0 to 45 degrees from vertical (see discussion and diagrams in section 5.7.2 - Standing Dead).
3. Dead shrubs, self-supported by their roots.
4. Trees showing any sign of life.
5. Stumps that are rooted in the ground (i.e., not uprooted).
6. 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).
7. Roots or main bole below the root collar.

Fine Woody Debris – In this inventory, FWD includes downed, dead branches, twigs, and small tree or shrub boles <3 inches in diameter that are not attached to a living or standing dead source. FWD can be connected to a larger branch, as long as this branch is on the ground and not connected to a standing dead or live tree. Only the woody branches, twigs, and fragments that intersect the transect are counted. FWD can be connected to a down, dead tree bole or down, dead shrub. FWD can be twigs from shrubs and vines. FWD must be no higher than 6 feet above the ground to be counted.

FWD does not include:

1) Woody pieces ≥3.0 inches in diameter at the point of intersection with the transect.
2) Dead branches connected to a live tree or shrub; or to a standing dead tree or dead shrub.
3) Dead foliage (i.e., pine or fir needles, or leaf petioles).
4) Bark fragments or other non-woody pieces that are not an integral part of a branch, twig, or small bole.
5) Small pieces of decomposed wood (i.e., chunks of cubical rot)

10.2 LOCATING AND ESTABLISHING LINE TRANSECTS

Transects are established on each subplot if the subplot center is accessible (i.e., not census water, access denied, or hazardous), and there is at least one forest or measured nonforest land condition class mapped within the 24.0-foot radius subplot (CONDITION CLASS STATUS = 1 or (NONFOREST CONDITION CLASS STATUS = 2)). Transects begin at the subplot center and extend 24.0 feet to the edge of the subplot. The location of condition class boundaries are recorded along the transect, starting at the subplot center and working towards the fixed radius plot boundary. It is extremely important to lay out the transect in a straight line to avoid biasing the selection of pieces and to allow the remeasurement of transect lines and tally pieces for QA purposes.

Transect lines should be marked with a pin or small piece of flagging at the end of the line (24.0 feet, horizontal distance) to help the QA staff identify the path of the transect during the check-plot procedure. Because the tolerance for the transect azimuth is +/- 2 degrees, the line might have been laid down in a slightly different direction from the check-plot crew. This could affect the location of diameter measurements for CWD pieces as well as identifying whether a CWD piece is a valid tally piece. It is also helpful to mark the point where the FWD transect begins (14 feet, horizontal distance).

10.2.1 CWD TRANSECTS

Two transects are established that originate at the subplot center and extend out 24.0 feet horizontal distance (the radius of the subplot) (fig. 59). This transect configuration was chosen to avoid sampling bias on sloped land, where it is possible that CWD may be oriented in one direction. This configuration of transects should pick up CWD logs that are lying parallel to the slope, perpendicular to the slope, and across slope. On plots where the macroplot is measured and mapped for condition classes, FIA units have the option of extending transects up to 58.9 feet from subplot center. In addition, an optional third transect on each subplot provides the ability to add or retain transect length on P3 plots.

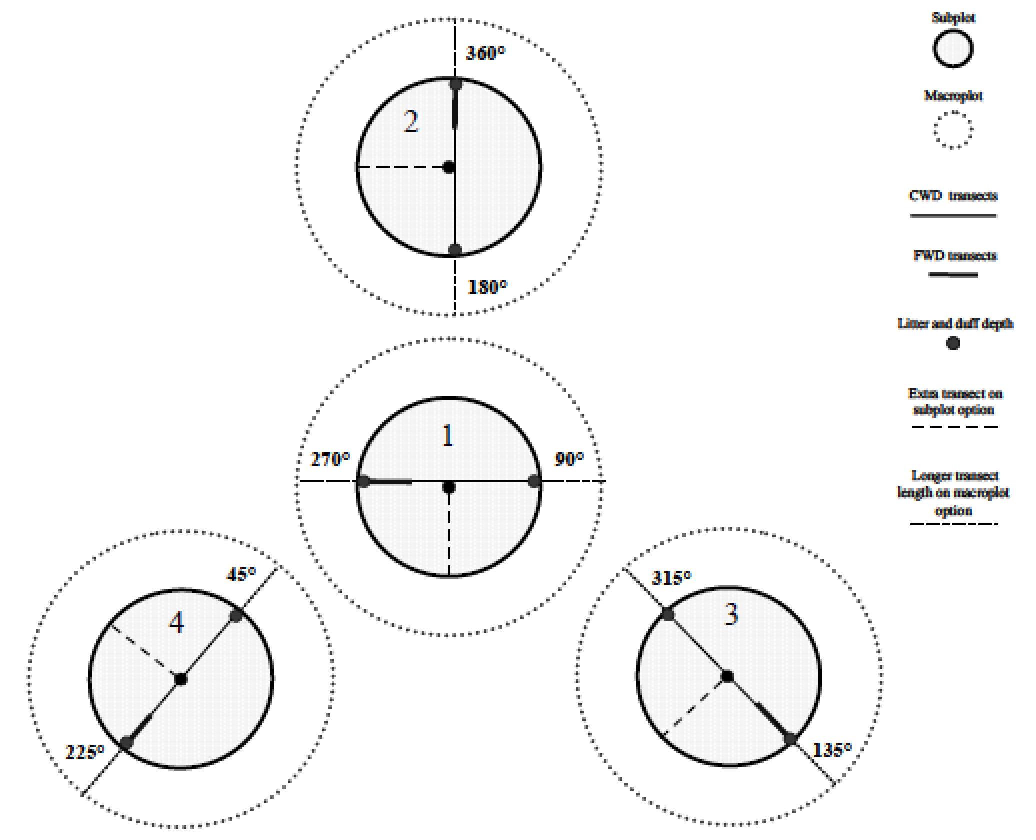


Figure 59. Plot layout for sampling CWD, FWD, and litter and duff depth. CWD transects include two 24-foot transects per subplot (starting at subplot center designated by its azimuth as labeled), optional extension onto condition mapped macroplots, and optional third transect for CWD.

10.2.2 FWD TRANSECTS

On a portion of one CWD transect on each subplot, FWD is tallied within 3 size classes. Because FWD is generally present in high densities, a shorter transect will pick up an acceptable amount of tally. The transect begins at 14 feet (horizontal distance) from the subplot center and extends out either 6 or 10 feet (horizontal distance) depending on the FWD size class, as follows:

Category of FWD	Size Class	Diameter range	Transect length (horizontal distance)	Transect location (horizontal distance)
Small FWD	1	0 in to 0.24 in	6 feet	14 to 20 feet
Medium FWD	2	0.25 in to 0.9 in	6 feet	14 to 20 feet
Large FWD	3	1.0 in to 2.9 in	10 feet	14 to 24 feet

It is helpful to have a size gauge available until your eye is 'trained' to recognize the 3 FWD size classes. Examples include a plastic or cardboard card with 3 notches cut for each size class, or a set of 3 dowels representing each size class.

10.3 TRANSECT LINE SEGMENTING

Transect lines are segmented to determine the length of transect that occurs within each mapped condition class intersecting the line. These lengths determine the expansion factors for the measured DWM. It is important that any changes or corrections to condition identity, location and size mapped on the subplot/macroplot spatially match the segmentation done on the transects. A segment is a length of transect that is in one condition. Segments are identified by recording the BEGINNING DISTANCE and ENDING DISTANCE from subplot center towards the end of the transect.

If any part of the transect segment is in a measured condition but the CWD is not measurable (e.g., snow or water), do not measure any DWM (CWD, FWD, or duff/litter depth) on that transect segment and set DWM TRANSECT SEGMENT SAMPLE STATUS = 0.

Starting at the subplot center and working towards the fixed radius plot boundary, each segment of transect line in a different condition class is delineated and recorded as a separate record. The horizontal BEGINNING DISTANCE and ENDING DISTANCE are recorded for each condition class encountered (fig. 60). The first record for each transect will have a BEGINNING DISTANCE of 0 feet. If only one condition class occurs on the transect line, only one segment is recorded. The last segment on all transects must have an ENDING DISTANCE of 24.0 feet horizontal distance if sampling the subplot, or up to DWM TRANSECT LENGTH if sampling on the macroplot. All condition segments on the transect must be defined and all transect length recorded and accounted for, either by condition, or by DWM TRANSECT SEGMENT SAMPLE STATUS.

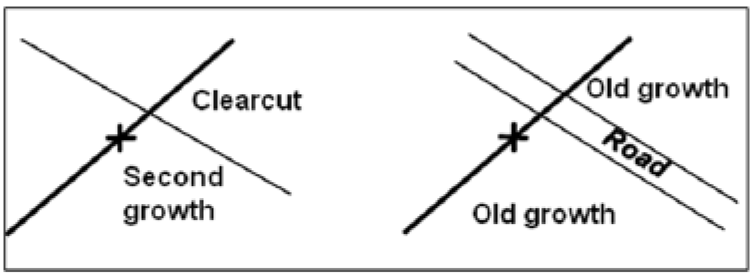


Figure 60. Transects are installed across condition class boundaries.

10.3.2 TRANSECT (BASE)

Record the transect azimuth (degrees) on which a condition class is being delineated. These transects, when being installed, have a tolerance of +/- 2 degrees.

Values:

Subplot	Transect direction (degrees) from center of subplot
1	090
1	270
1	180 (Extra optional transect)
2	360
2	180
2	270 (Extra optional transect)
3	135
3	315
3	225 (Extra optional transect)
4	045
4	225
4	315 (Extra optional transect)

10.3.3 SEGMENT CONDITION CLASS NUMBER (BASE)

Record the code indicating the number of the condition class for the transect segment. Use the same code assigned to the condition class on the subplot or elsewhere on the plot. The first segment recorded for each transect will have the same CONDITION CLASS NUMBER as assigned to the subplot center.

Values: 1 to 9

10.3.4 SEGMENT BEGINNING DISTANCE (BASE)

Record the location (using horizontal distance to nearest 0.1 foot) on the transect line where the transect intersects the boundary with the adjacent condition class nearer to the subplot center. The first record for each transect will have a BEGINNING DISTANCE of 0 ft. Each subsequent record will have a BEGINNING DISTANCE equal to the ENDING DISTANCE of the previous record.

Values: 00.0 to 58.9 horizontal feet

10.3.5 SEGMENT ENDING DISTANCE (BASE)

Record the location (using horizontal distance to nearest 0.1 foot) on the transect line where the transect exits the condition class being delineated and intersects the boundary with a different condition class further away from the subplot center. If no other condition classes are encountered, record the location (using horizontal distance) of the end of the transect line.

Values: 00.1 to 58.9 horizontal feet

10.3.6 DWM TRANSECT SEGMENT SAMPLE STATUS (BASE)

Record the sample status for the transect segment. If any part of the segment is in an accessible condition that would be measured (CONDITION CLASS STATUS = 1 or NONFOREST CONDITION CLASS STATUS = 2), but the CWD is not measurable due to an obstruction such as snow or water, do not measure DWM on any part of the transect segment, and set code to 0 for that segment. In all other situations, set the code to 1. For conditions on which DWM would not be measured regardless (CONDITION CLASS STATUS = 3 or NONFOREST CONDITION CLASS STATUS = 2), will automatically be coded 1; those conditions should be identified in the transect segmenting.

Values:

Value	Description
0	Transect segment not sampled
1	Transect segment sampled

10.3.7 DWM TRANSECT SEGMENT NONSAMPLED REASON (BASE)

Record the reason that DWM cannot be measured on the transect.

Values:

Value	Description
04	Time Limitation
05	Lost data (office use only)
10	Other (for example, snow or water covering CWD that is supposed to be sampled). "Note required" when using this code.

10.4 Sampling Methods for COARSE WOODY DEBRIS (CWD)

10.4.1 Tally Rules for Coarse Woody Debris (CWD)

1. Coarse woody debris (CWD) is sampled on accessible forest conditions, and on accessible nonforest conditions if they are being measured on the plot (i.e., NONFOREST CONDITION CLASS STATUS = 2). Tally CWD by starting at the subplot center and working towards the fixed radius plot boundary. Measurements should not be taken along transects moving inward toward subplot center. Tally a piece if its central longitudinal axis intersects the transect, and the condition class is measured at the point of intersection (fig. 61). The entire piece is assigned to this condition.

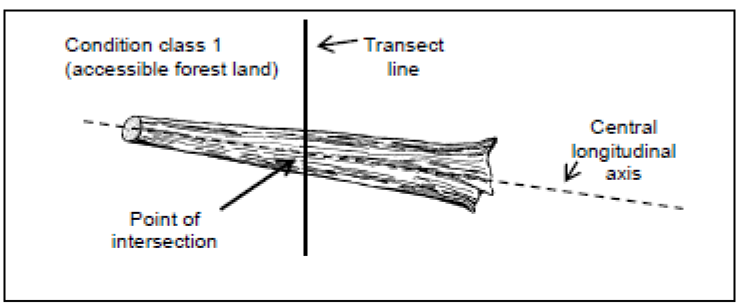


Figure 61. Tally rules for CWD.

2. Tally dead trees and tall stumps that are leaning > 45 degrees from vertical. Do not tally live trees or standing dead trees and tall stumps that are still upright and leaning < 45 degrees from vertical. Follow the same rules for down trees as outlined in section 5.0 'Tree and Sapling Data' for

determining what qualifies as standing and down dead trees and portions/tops of trees. Most CWD will be laying on the ground.

Note: In order to avoid double counting or totally missing trees or portions in either protocol, once a decision is made on whether a tree or portion/top of a tree is considered standing or down it is important to include it in either one or the other protocol (standing tree or CWD), but not both. See additional diagrams in section 5.7.2 – Standing Dead.

3. The minimum length for any tally piece is 0.5 feet and it needs to meet the minimum transect diameter guidelines.

4. Decay class of the piece determines whether or not the piece is tallied (see section 10.4.3.6).

   <u>For decay classes 1 to 4</u>: tally a piece if it is ≥3.0 inches in diameter at the point of intersection with the transect (fig. 62).

   <u>For decay class 5</u>: tally a piece if it is ≥5.0 inches in diameter at the point of intersection and ≥5.0 inches high from the uphill side of the ground. The reason for treating decay class 5 pieces differently is because they are difficult to identify, especially when heavily decomposed. Only pieces that still have some shape and log form are tallied—humps of decomposed wood that are becoming part of the duff layer are not tallied.

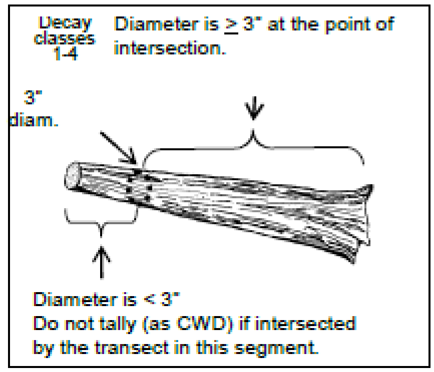


Figure 62. Tally rules for CWD decay classes 1-4.

5. Tally pieces created by natural causes (examples: natural breakage or uprooting) or by human activities such as cutting. In some cases it may be impossible to measure or estimate individual pieces—for example when CWD pieces are in machine-piled slash piles or windrows, or are part of jumble from flooding, landslide or avalanche. In these situations, piles are described using the instructions in section 10.6 'Sampling Residue Piles'. Because biomass estimates from piles have great uncertainty associated with them, pieces should be measured individually if at all possible.

6. Tally a piece only if the point of intersection occurs above the ground. If one end of a piece is buried in the litter, duff, or mineral soil, the piece ends at the point where it is no longer visible. Measure the diameter and length at this point.

7. 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 (uncommon situation, see fig. 63).

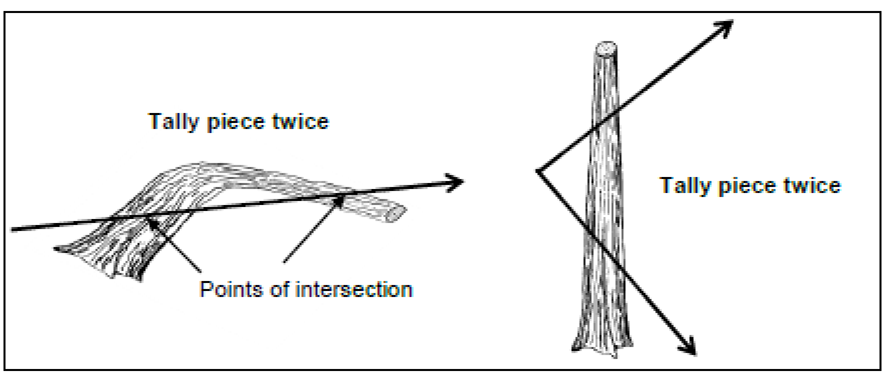


Figure 63. CWD tally rules: intersections.

8. Tally a piece only once if the subplot center falls directly on the central longitudinal axis of the piece. Tally the piece on the smallest azimuth degree transect.

9. If a piece is fractured across its diameter or length, and would pull apart at the fracture if pulled from either end or sides, 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.

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

11. When the transect crosses a forked down tree bole or large branch connected to a down tree, tally each qualifying piece separately. To be tallied, each individual piece must meet the minimum diameter requirements.

12. In the case of forked trees, consider the "main bole" to be the piece with the largest diameter at the fork. Variables for this fork such as TOTAL 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), variables pertain only to that portion of the piece up to the point where it attaches to the main bole (see figure 64).

13. If a transect intersects a non-measured condition (e.g., a road when NONFOREST CONDITION CLASS STATUS = 5, or an inaccessible condition class, or a non-sampled code for CWD), CWD is not tallied.

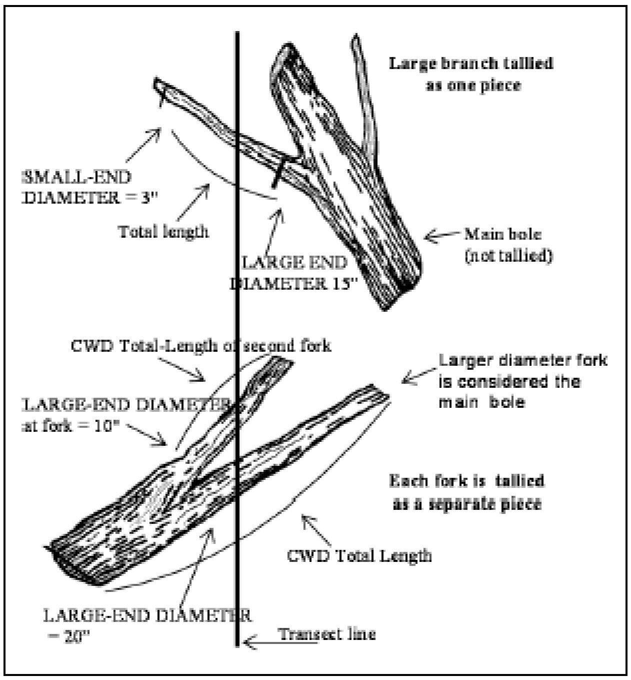


Figure 64. CWD tally rules for forked trees.

10.4.2 Marking CWD (OPTIONAL)

Marking CWD is highly recommended if allowed by the land owner—wax crayon is a good option or nails can be used as well. Marked CWD is an aid to future crews returning to the plot for a QA check.

10.4.3.6 CWD DECAY CLASS (BASE)

Record a 1-digit code indicating the decay class of the piece. Code the decay class that predominates along the observed length of the piece. Use the guide below to determine CWD DECAY CLASS.

Values:

Decay Class	Structural Integrity	Texture of Rotten Portions	Color of Wood	Invading Roots	Branches and Twigs
1	Sound, freshly fallen, intact logs	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 or sapwood absent	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; a 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, it spreads out on ground	Soft; powdery when dry	Red-brown to dark brown	Through-out	Branch stubs and pitch pockets have usually rotted down

CWD DECAY CLASS: The chart above was developed primarily for Douglas-fir in the Pacific Northwest. At the present time, there are no other charts available to use to describe decay classes for other species or locations. Concentrate on the structural integrity and texture when estimating a decay class for CWD logs.

If a log is case hardened (hard, intact outer sapwood shell) but the heartwood is rotten, code this log as a CWD DECAY CLASS 2. CWD DECAY CLASS 1 should be reserved for 'freshly fallen' logs that are completely intact (i.e., recent windfalls, or harvest).

10.4.3.7 SPECIES (BASE)

Record the code indicating the species of the piece. Since CWD pieces are not necessarily always tally species, record the most detailed available species code (see appendix 3). Some species codes are only genus specific (e.g., Prunus), or hardwood-softwood specific. Search for the species code that has the most detail for the identified piece. For shrubs or vines enter unknown softwood (0299) or hardwood (0998).

Species identification may be uncertain for some pieces. 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. On remeasurement plots, see what tree species were tallied in past inventories. One way to distinguish hardwoods from softwoods is by the type of decay present. Hardwoods usually have a white or grayish stringy rot, while softwoods usually have a reddish-brown blocky rot. If it is not possible to identify the species, attempt to estimate if it is softwood or hardwood. Enter code 0299 for unknown dead conifer or 0998 for unknown dead hardwood. If all else fails, enter the unknown SPECIES code (0999).

Values: See species codes in appendix 3

10.4.3.8 Diameters

If possible, the best way to measure diameter is to wrap the tape perpendicular to the longitudinal axis at the point of transect intersection (fig. 65). If that is not possible it is useful to carry a steel carpenters retracting tape to measure diameters. Other methods include wrapping a tape around the bole if possible, holding a straight-edge ruler above the piece, or using calipers.

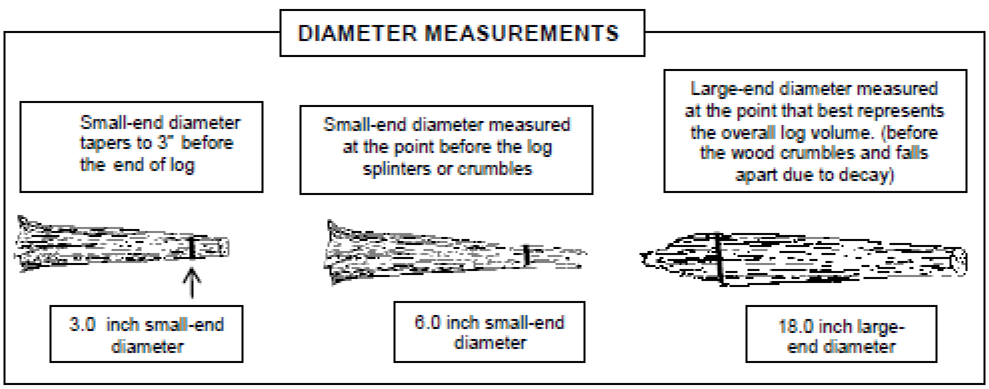


Figure 65. Diameter measurements

For pieces that cannot be taped and are not round in cross-section because of missing chunks of wood or "settling" due to decay, measure the diameter in two directions and take an average. Estimate the longest and shortest axis of the cross-section ("A" and "B" in figure 66), and enter the average in the diameter field. This technique applies to intersect, small-end, and large-end diameters.

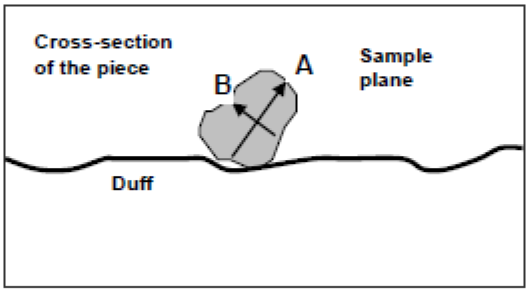


Figure 66. Estimating the diameter of pieces that are not round in cross-section.

If the transect intersects the log at the decayed or splintered end (fig. 67), record the diameter at this location as the intersect diameter. Record the large end and small end diameters on the same side of the transect diameter as illustrated. Record the small end diameter as 3 inches if it tapers below 3 inches. If the splintered end appears to be two separate pieces (i.e., a major split located just at the end) – in this situation treat it as one log and take a diameter around the end (take two measurements if it is odd shaped.

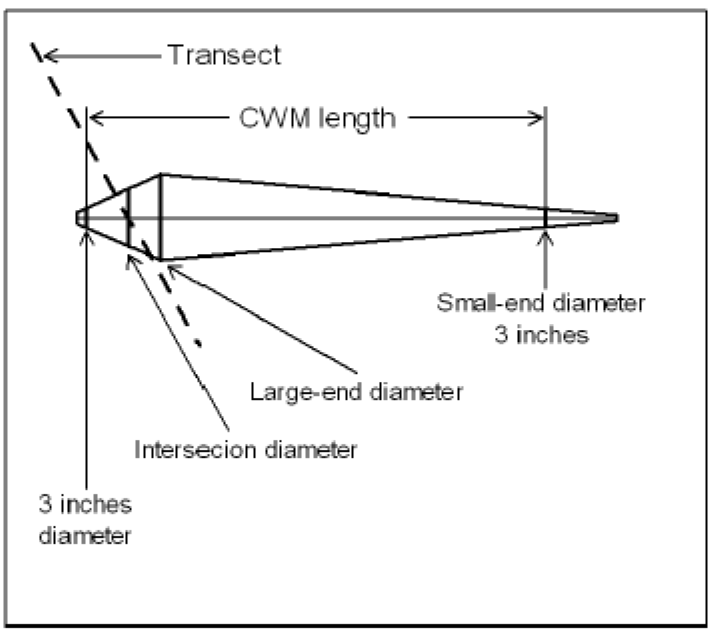


Figure 67. Example of decayed end intersecting the transect

10.4.3.8.1 DIAMETER AT POINT OF INTERSECTION (BASE)

Record the piece's diameter at the point where the transect intersects the longitudinal center of the piece. Record the diameter to the nearest inch. If the diameter is close to 3 inches, measure the diameter to the nearest 0.1 inch to determine if the piece is actually ≥3.0 inches and a valid tally piece.

Values: 003 to 200 inches

10.4.3.8.2 DIAMETER OF HOLLOW AT POINT OF INTERSECTION (BASE)

Record the diameter of hollow at the point of intersection. This variable contributes to reducing bias in biomass estimate and only applies to the point of intersection. If it can be ascertained that the piece is hollow at the transect diameter location, measure or estimate the diameter of hollow to the nearest inch, otherwise record as 0. Diameter of hollow must be less than the transect diameter. Note: Record a hollow diameter only when it is obvious that a piece is hollow at the point of intersection (a hole or crack in the piece, evidence of hollow as observed from the end, etc.). Unlike 10.4.3.10, there is no hollow size requirement for this variable.

Values: 000, 001 to 200 inches

10.4.3.8.3 DIAMETER AT THE SMALL END (WILDLIFE OPTION)

Record the diameter at the piece's small end. The diameter is recorded to the nearest inch. The DIAMETER AT THE SMALL END occurs either at (1) the actual end of the piece, if the end has a diameter ≥3.0 inches, or (2) at the point where the piece tapers down to 3.0 inches in diameter. If the end is splintered or decomposing (sloughing off), measure the diameter at the point where it best represents the overall log volume. Use the same measuring procedures described in 10.4.3.8 (see figure 65).

Values: 003 to 200 inches

10.4.3.8.4 DIAMETER AT THE LARGE END (WILDLIFE OPTION)

Record the diameter at the piece's large end. The diameter is recorded to the nearest inch. The large end will occur either at a broken or sawn end, at a fracture, or at the root collar. If the end is splintered or decomposing (sloughing off), measure the diameter at the point where it best represents the overall log volume. Use the same measuring procedures used for 10.4.3.8.

Values: 003 to 250 inches

10.4.3.9 Length Measurements

Measure the length of the piece (to the nearest foot) along its centerline, either to the end of the piece or to the point where the diameter reaches 3 inches. If the piece tapers at both sides, due to decay or breakage, the length is measured for the 3-inch diameter cutoff at both ends, regardless of where the large end-diameter may be (see fig. 67). No length is recorded for pieces <3 feet long.

10.4.3.9.1 CWD LENGTH >= 3 FEET (BASE)

Record the code that indicates whether the CWD TOTAL LENGTH is less than 3 feet long (and at least 0.5 foot long). Distinguished length orientation by direction of the pith. Note: the diameter of a small piece may be larger than its length. Total length of the log is measured between the physical ends of the log.

Values:

Value	Description
1	CWD TOTAL LENGTH ≥3 feet
2	CWD TOTAL LENGTH ≥0.5 foot and < 3 feet

10.4.3.9.2 CWD TOTAL LENGTH (WILDLIFE OPTION)

Record the total length of the piece to the nearest foot. For DECAY CLASS = 5, DIAMETER AT THE SMALL END and DIAMETER AT THE LARGE END are not recorded for a log, therefore the length is measured between the two physical ends of the log. For curved logs, measure along the curve. CWD TOTAL LENGTH is recorded to the nearest foot.

Values: 003 to 250 feet

10.4.3.10 IS THE PIECE HOLLOW? (OPTIONAL)

Record the code indicating whether or not the piece is hollow (see figure 68). This definition of hollow is different from the definition used in 10.6.3.8.2 DIAMETER OF HOLLOW AT POINT OF INTERSECTION. This variable provides information for wildlife assessment.

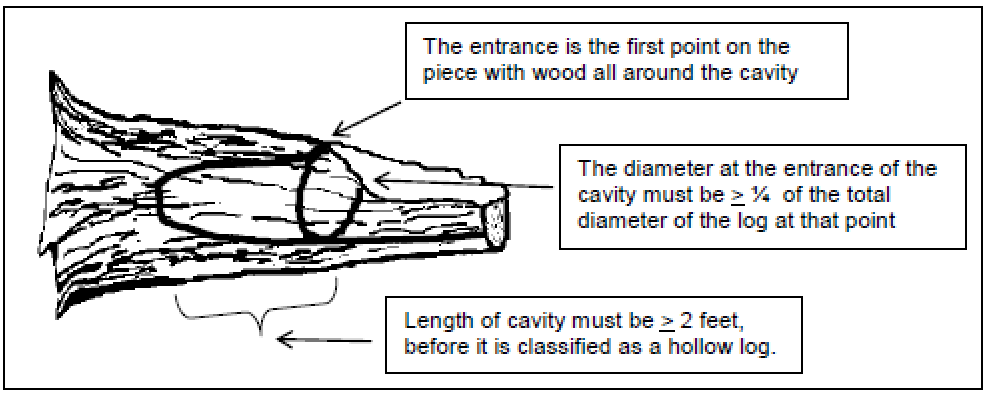


Figure 68. Determining if the piece is hollow.

Values:

Value	Description
0	Does not meet criteria for being a hollow log
1	A piece is considered hollow if a cavity extends at least 2 feet 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. This definition of hollow is different from the definition used in 10.4.3.8.2 DIAMETER OF HOLLOW AT POINT OF INTERSECTION.

10.4.3.11 PIECE INCLINATION (OPTIONAL)

Record the inclination from horizontal of the piece in degrees. Measure the inclination with a clinometer. Inclination from horizontal should be estimated rapidly by setting a clinometer along the top of the log, adjusting if necessary to match the angle between the location of the large end diameter and the location of the small end diameter, and reading the inclination from the face of the clinometer in degrees.

Values: 00 to 90 degrees

10.4.3.12 CWD HISTORY (OPTIONAL)

Record the code that indicates whether or not the piece of CWD is on the ground as a result of harvesting operations or as a result of natural circumstances. One objective of this item is to identify those pieces that are considered logging residue. If the piece appears to have fallen to the ground as a result of natural causes such as decomposition or windfall, enter a code of 1. This category would include blown out tops, snapped off boles, wind-fallen trees on clearcut edges, and trees that basically collapsed and fell over due to decomposition.

If the piece is on the ground as a result of recent (since last annual remeasurement; if the plot is new, the time between the panel remeasurements) harvesting activity, either because the tree was cut down with a chainsaw (or other device) or pushed over by harvesting equipment (bulldozer), enter a code of 2. A code of 2 would be considered logging residue (usually you are in the middle of a recent clearcut).

If the piece is on the ground as a result of older (more than 15 years) harvesting activity, enter a code of 3. This would be a situation where you tally an old decomposing log that has a sawn end – if it appears that the log was cut and left on site, then enter a code of "3".

If a piece is on the ground as a result of incidental harvest (such as a standing tree was cut for firewood or small clearing), enter a code of "4". Incidental harvest involves a few trees and is not a part of a major organized harvesting operation.

If the crew cannot decide the history of the CWD log, classify it as "unknown", and give it a code of "5".

Values:

Value	Description
1	CWD piece is on the ground as a result of natural causes
2	CWD piece is on the ground as a result of major recent harvest activity (<= 15 yrs old)
3	CWD piece is on the ground as a result of older harvest activity (> 15 yrs old)
4	CWD piece is on the ground as a result of an incidental harvest (such as firewood cutting)
5	Exact Reason Unknown

10.4.3.13 PERCENT OF LOG CHARRED BY FIRE (OPTIONAL)

Record a code that represents the percentage of the log's surface area that has been charred by fire. Only examine the visible surface of the log. These data will be used by wildlife biologists to determine the impact fire has had on wildlife habitat. Wildlife tend to avoid charred logs because fire seals the wood making it slow to rot and hard to excavate.

Values:

Value	Description
0	None of the log is charred by fire
1	Up to 1/3 of the log is charred by fire
2	1/3 to 2/3 of the log is charred by fire
3	2/3 or more of the log is charred by fire

10.4.3.14 LARGE END DIAMETER CLASS (OPTIONAL)

Estimate the appropriate class code for the large end diameter for each CWD piece. If the large end diameter is close to a class breaking point it may be necessary to directly measure the diameter. Use the same established rules for determining the large end diameter point (see figure 67).

Values:

Value	Description
1	3.0 to 4.9 inches
2	5.0 to 8.9 inches
3	9.0 to 14.9 inches
4	15.0 to 20.9 inches
5	21.0 to 39.9 inches
6	40.0+ inches

10.5 SAMPLING RESIDUE PILES

A pile is an accumulation of large woody material in which individual pieces are impossible to tally separately. Piles may be created by human activity or natural causes. However, loose piles created by windthrow, landslides, fires or other natural causes, or by thinning or logging operations, should be tallied using the regular CWD protocols unless it is physically impossible to separate individual pieces. The pile protocol should only be used as a last resort, when the regular CWD protocols cannot be used.

Piles are tallied only if intersected by a transect and located in an accessible forest condition class (CONDITION CLASS STATUS = 1) or a measurable nonforest condition (NONFOREST CONDITION CLASS STATUS = 2). An estimate of the length and depth of the pile, species composition and decay class are recorded:

1. Tally individual pieces along the transect until it is not possible to measure them separately and record the horizontal transect distance to this point. Then, record the horizontal transect distance to the point where individual pieces can again be tallied separately (see figure 69).

2. If the pile straddles two condition classes, assign it to the condition class that is closest to subplot center along the transect.

3. Estimate the average height of the pile along the transect. Visually compact the pile to estimate the height of wood, excluding air, rocks, debris and pieces of wood less than 3 inches in diameter at the plane of intersection with the transect. There is a tendency to overestimate the proportion of the cross-section of the pile made of wood. Note that when packing perfect circles of equal diameter, the maximum attainable packing ratio is less than 90% (see figure 70).

4. Record the predominant species in the pile. If it is not possible to identify the species, or if there is an even mixture of several species, record the genus, or hardwood / softwood code.

10.5 SAMPLING RESIDUE PILES

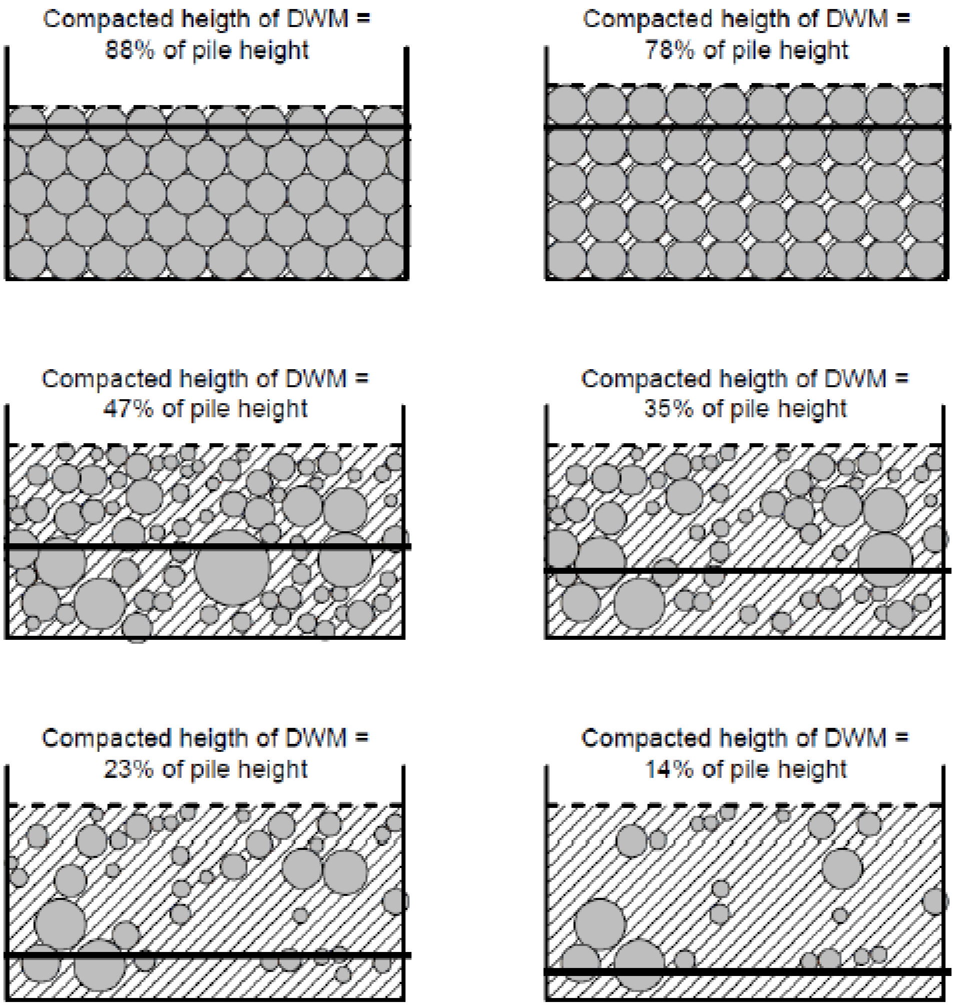


Figure 70. Calculating compacted height of CWD. The dashed line represents the height of the pile, the solid, thick line the compacted height of wood. Grey circles are cross sections of woody pieces greater than 3 inches of diameter and the fill represents debris, air and smaller pieces of wood.

5. Record the predominant decay class of the pieces in the pile.

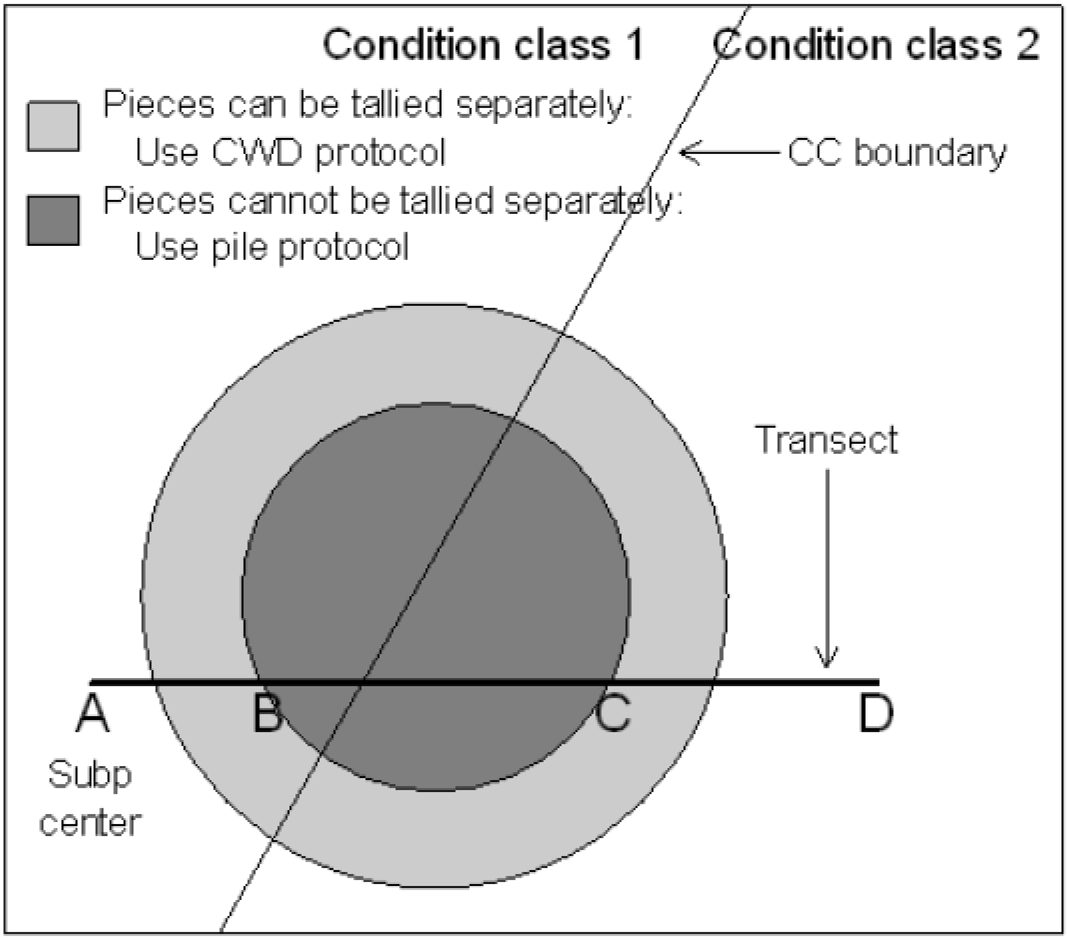


Figure 69. Example for measuring a pile. Pieces can be identified and tallied separately between points A-B and C-D, so the CWD protocols are used, even though part of the transect may be within the pile. Between points B and C, pieces cannot be tallied separately and the pile protocol is used. Enter the horizontal distance at B as the pile beginning distance, the horizontal distance at C as the pile ending distance, and estimate the compacted height of wood, predominant species, and predominant decay class between B and C. Assign the entire pile to condition class 1.

10.5.2 PILE TRANSECT (BASE)
Record the azimuth of the transect on which the pile is sampled.

Values:

Subplot	Transect direction (degrees) from center of subplot
1	090
1	270
1	180 (Extra optional transect)
2	360
2	180
2	270 (Extra optional transect)
3	135
3	315
3	225 (Extra optional transect)
4	045
4	225
4	315 (Extra optional transect)

10.5.3 PILE CONDITION CLASS NUMBER (BASE)
Record the code indicating the number of the condition class. If the pile straddles two condition classes, assign it to the one closest to subplot center along the transect.

Values: 1 to 9

10.5.4 PILE BEGINNING DISTANCE (BASE)
Record the horizontal length of the transect to the beginning of the pile (to the nearest 0.1 foot), defined as the point when pieces cannot be tallied individually. If the pile occupies subplot center, record 00.0 for the beginning distance.

Values: 00.0 to 58.8 feet

10.5.5 PILE ENDING DISTANCE (BASE)
Record the horizontal length of the transect to the end of the pile, defined as the point when pieces can be tallied individually again. If the transect ends within the pile, record DWM TRANSECT LENGTH.

Values: 00.1 to 58.9 feet

10.5.6 COMPACTED HEIGHT OF CWD IN PILE (BASE)
Record average height of wood pieces greater than 3 inches in diameter at the intersection of the transect with the pile. Record value to the nearest foot. Visually compact the pile to estimate the height of wood, excluding air, debris and pieces of wood less than 3 inches in diameter at the point of intersection with the transect. If the transect starts or ends within a pile, only consider the portion of cross-section of the pile above the measured transect.

Values: 1 to 99 feet

10.5.7 PILE DECAY CLASS (BASE)

Record a 1-digit code indicating the predominant decay class in the pile. Use the guide below to determine CWD DECAY CLASS.

Values:

Decay Class	Structural Integrity	Texture of Rotten Portions	Color of Wood	Invading Roots	Branches and Twigs
1	Sound, freshly fallen, intact logs	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 or sapwood absent	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; a 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, it spreads out on ground	Soft; powdery when dry	Red-brown to dark brown	Through-out	Branch stubs and pitch pockets have usually rotted down

10.5.8 PILE SPECIES (BASE)

Record the code indicating the predominant species / species group in the pile. If it is not possible to identify the species, or if there is an even mixture of several species, record the genus, or hardwood / softwood code.

Values: See species codes in appendix 3

10.6 Sampling Methods for Fine Woody Debris (FWD)

1. Fine Woody Debris (FWD) is only sampled on accessible forest land conditions (CONDITION CLASS STATUS = 1) and measurable nonforest conditions (NONFOEST CONDITION CLASS STATUS = 2) intersected by the transect. FWD is tallied on the outer portion of the following transects: 270°on subplot 1, 360°on subplot 2, 135°on subplot 3, and 225°on subplot 4. The length of FWD transects is measured in horizontal distance, starting at 14.0 feet and extending for 6.0 or 10.0 feet depending on FWD size class.
2. If the start of the FWD transect segment is in a measured condition (see item 1 above) but a portion of the transect segment is not visible due to the presence of snow or standing water, consider the entire transect segment not measurable. In this situation, do not sample anything on

the transect segment--set FWD TRANSECT SEGMENTSAMPLE STATUS code = 0 and record the reason in FWD TRANSECT SEGMENT NONSAMPLED REASON.

3. Only sample FWD that intersects the transect in a plane from the ground to a height of 6 feet.

4. FWD is sampled in three size classes, along transect azimuths described in item 1 above (see section 10.2 for details on transects). Pieces in two FWD size classes (0.01 to 0.24 inches and 0.25 to 0.9 inches) are counted on a 6-foot transect, from 14 to 20 feet horizontal distance. Pieces in the largest size class (1.0 to 2.9 inches) are counted on a 10-foot transect, from 14 to 24 feet. These transects overlap. Note: individual diameters are not recorded for FWD.

5. Count a piece of FWD if it intersects the transect. Be sure to count only woody material such as a twig, branch, wood fragment, or small shrub or tree bole Do not count material that is actually litter, such as pine or fir needles, non-woody parts (e.g., petiole and rachis) of a shrub or tree, etc.

6. Accumulate the number of pieces counted within each size class and enter the total count on one record for the subplot. If there is no tally on a transect, enter zeros for the count. If the transect is not measured (FWD TRANSECT SAMPLE STATUS = 0) the count is null.

7. Accurate counts of FWD can be conducted efficiently up to about 50 pieces for small and medium size classes, and up to 20 pieces for the large size class. After that, crews can begin estimating counts in a systematic fashion. Transects that fall on very dense FWD where counting is nearly impossible, can be sub-sampled and calculated. For example, an accurate count can be conducted on a 2.0-foot section of the transect and then multiplied by 3 to provide an estimate for the 6 foot transect, as long as the crew feels that the remaining transect has a similar density of FWD pieces.

8. If a transect intersects a large pile of material such as a wood rat's nest, recently fallen tree (with many attached fine branches), or a residue pile, crews should estimate a count based on # 7 above, but also enter a code indicating that this is an unusual situation (see section 10.3.7). In the case of a residue pile on the transect, estimate a count by looking at the transect just before and after the pile along with assessing what's inside the pile, and enter a count for the whole transect.

9. If rocks or logs are present along the transect (14- to 24-foot section) include any FWD that is present on top of these things in the respective FWD counts. If the obstructions are so large (huge boulder) that the top surface cannot be seen, assume the count is zero in this area, and continue counting if there is transect line beyond the boulder.

10. If a transect crosses a condition class boundary, record the condition class number and enter a count for each condition on separate records. Transect lengths within each condition class will be obtained from the transect segmenting data entered for the plot.

10.6.2 FWD TRANSECT (BASE)
Record the azimuth (degrees) of the transect on which FWD is sampled.

Values: degrees

Subplot	Transect direction (degrees) from center of subplot
1	270
2	360
3	135
4	225

10.6.3 FWD CONDITION CLASS NUMBER (BASE)
Record the code indicating the number of the condition class at the start of the transect (14.0 feet horizontal distance from subplot center).

Values: 1 to 9

10.6.4 FWD TRANSECT SEGMENT SAMPLE STATUS (BASE)
Record the sample status for FWD on the transect. There may be situations where the CWD is measurable, but the FWD is hidden from view by snow or water and not measurable. If any part of the FWD transect segment is on a measured condition but the FWD is not measurable, do not count any FWD and set the STATUS code to 0 and the FWD TRANSECT NONSAMPLED REASON code to 10.

In all other situations, set the code to 1. Conditions on which FWD would not be measured regardless (CONDITION CLASS STATUS = 3 or CONDITION CLASS STATUS = 2 AND NONFOREST CONDITION CLASS STATUS = 5) should always be coded 1.

Values:

Value	Description
0	FWD transect segment not sampled
1	FWD transect segment sampled

10.6.5 FWD TRANSECT SEGMENT NONSAMPLED REASON (BASE)
Record the reason that FWD cannot be measured on the transect.

Values:

Value	Description
04	Time Limitation
05	Lost data (office use only)
10	Other (for example, snow or water covering CWD that is supposed to be sampled). "Note required" when using this code.

10.6.6 SMALL FWD COUNT (BASE)
Record the number of pieces counted in this size class (0.01 to 0.24-inch diameter) along the transect segment. An accurate count should be conducted up to 50 pieces. If the count exceeds 50, the transect can be sub-sampled to estimate a total count for the transect length (see 10.6, #8).

Values: 000 to 999 pieces

10.6.7 MEDIUM FWD COUNT (BASE)

Record the number of pieces counted in this size class (0.25 to 0.99-inch diameter) along the transect segment. An accurate count should be conducted up to 50 pieces. If the count exceeds 50, the transect can be sub-sampled to estimate a total count for the transect segment (see 10.6, # 8).

Values: 000 to 999 pieces

10.6.8 LARGE FWD COUNT (BASE)

Record the number of pieces counted in this size class (1.0 to 2.9 inch diameter) along the transect segment. An accurate count should be conducted up to 20 pieces. If the count exceeds 20, the transect can be sub-sampled to estimate a total count for the transect segment (see 10.6, # 8).

Values: 000 to 500 pieces

10.6.9 HIGH COUNT REASON (BASE)

Enter a code that applies to the situation encountered on the transect. Enter a code if any of the counts on the transect are greater than 100 pieces.

Values:

Value	Description
1	High count is due to an overall high density of FWD across the transect
2	Wood Rat's nest located on transect
3	Tree or shrub laying across transect
4	Other reason
5	Residue pile

10.7 DUFF AND LITTER DEPTH MEASUREMENTS

Depth measurements are sampled in accessible forest land conditions (and accessible nonforest conditions, where nonforest conditions are measured). The depth of the duff layer and litter layer are important components of carbon tracking and fire models that estimate fire behavior, fire spread, fire effects, and smoke production. These measurements are taken at the 24-foot location on each transect. If an object such as a rock, log, or residue pile is present at the sample point, depths will be estimated by examining the surface of the object or the area surrounding the object. In the office, an average depth will be calculated and stored with other information about the condition class on the plot.

10.7.1 Definitions

1. Litter is the layer of freshly fallen leaves, needles, twigs (<0.25 inch in diameter), cones, detached bark chunks, dead moss, dead lichens, detached small chunks of rotted wood, dead herbaceous stems, and flower parts (detached and not upright). Litter is the loose plant material found on the top surface of the forest floor which is undecomposed or only partially decomposed organic material. The components of the litter layer can still be readily identified (e.g., plant leaves, twigs, and peat, etc.).

Litter is flash fuel – so think about it as the loose material that is exposed to the air, capable of igniting quickly and carrying a fire across the surface of the forest floor.

Litter does not include bark that is still attached to a down log, or rotten chunks of wood that are still inside a decaying log or log end (i.e., if a decayed log end has a lot of rotten cubes or pieces laying on a log surface and exposed to air, they are considered part of the log and not litter – fire would burn differently if it hit a pile of rotten punky wood chips cradled by the unrotted sapwood shell). If these rotten chunks have spilled out to the ground and are actually on the ground surface, then they would be included in the litter layer.

Litter does not include animal manure.

2. Duff is the layer just below litter located just above the A-horizon (or uppermost soil mineral horizon). Duff is a dark soil layer dominated by organic material derived from the decomposition of plant and animal litter (pine straw, leaves, twigs, etc.) and deposited on top of an organic or mineral surface. This layer is distinguished from the litter layer in that the original organic material has undergone sufficient decomposition that the source of this material (e.g., individual plant parts) can no longer be identified. You should see no recognizable plant parts. When moss is present, the top of the duff layer is just below the green portion of the moss.

   If peat is present in your part of the country, record it with the duff layer. Peat is an accumulation of partially decayed vegetation matter that forms under conditions of poor drainage such as those found in wetlands or bogs. A layer of peat develops when dead plant material is inhibited from decaying fully because of acidic or anaerobic conditions. In some areas of the U.S. the depth of this layer can be extensive.

10.7.2 Overview of Measurements

Depth measurements will be taken at the 24-foot (horizontal distance) location on each transect. If a log, rock, or residue pile occurs at the sample location, record the depth of the litter on top and below these objects and estimate the duff depth as close to the object as possible. Examine the area around the object to develop an average depth for these layers.

DUFF/LITTER SAMPLE STATUS identifies whether or not the duff and litter depth could be measured or reasonably estimated. Examples of situations where measurement is not possible include the presence of snow or standing water at the sample location. In this case, the STATUS code is set to 0 with the DUFF/LITTER NONSAMPLED REASON code set to 10.

The DUFF AND LITTER METHOD variable has three options for indicating if duff and litter were measured or estimated at each sample location. The default value for this variable is 1, indicating that both depths were measured and recorded. A code of 2 means that litter depth was measured, but duff depth was estimated and a code of 3 indicates that both duff and litter depths were estimated.

Carefully expose a shallow profile of the forest floor by digging out an area at the sample point using a knife, hatchet, or other tool. Estimate the depth of each layer with a ruler to the nearest 0.1 inch. As you dig the hole for this measurement, if you encounter a subsurface rock, root, or buried log – stop the depth measurement at this point. If there is a log, rock, or residue pile on the surface at the sample point, and there appears to be duff and litter under it (or litter on top of it), record a reasonable estimate for each depth. Most likely, the area immediately adjacent to the obstruction will have to be examined to determine an average depth. Depths of zero are perfectly valid: for example if the point falls on bedrock or on top of a log that it resting on mineral soil.

As a general rule, duff depth should rarely exceed a few inches (except when a peat layer is present). Crews should be absolutely sure they are measuring deep duff depths, instead of mineral soil layers or parts of the litter layer. Duff can easily weigh more than 6 times that of litter. If unsure of the bottom of the duff layer, crews should feel the texture of the suspect material in their hand. Rub the soil between your fingers. Does it crumble (duff) or feel more like modeling clay (mineral). If the layer includes a substantial amount of peat, stop the measurement at 2 feet.

The height of the litter should be measured at the top of the loose material located at the sample point on the transect (or nearby if an obstruction exists). Try to preserve the conditions of this location by walking around this point, so the QA staff will measure the same height as the original crew.

10.7.3 DUFF/LITTER SUBPLOT NUMBER (BASE)

Record the code indicating the number of the subplot center from which the transect originates.

Values:

Value	Description
1	Center subplot
2	North subplot
3	Southeast subplot
4	Southwest subplot

10.7.4 DUFF/LITTER TRANSECT (BASE)

Record the azimuth (degrees) of the transect on which duff/litter is sampled.

Values:

Subplot	Transect direction (degrees) from center of subplot
1	090
1	270
2	360
2	180
3	135
3	315
4	045
4	225

10.7.7 DUFF/LITTER NONSAMPLED REASON (BASE)

Record the reason that duff/litter cannot be measured on the transect.

Values:

Value	Description
04	Time Limitation
05	Lost data (office use only)
10	Other (for example, snow or water covering measurement point that is supposed to be sampled). "Note required" when using this code

10.7.8 DUFF DEPTH (BASE)

Record the code indicating the depth of the duff layer to the nearest 0.1 inch. Record 24.0 inches when DUFF DEPTH is >24.0 inches and enter Code #4 (Litter depth was measured, duff (peat) depth exceeds 24.0 inches) for 10.9.8 DUFF AND LITTER METHOD.

Values: 00.0 to 24.0 inches

10.7.9 LITTER DEPTH (BASE)

Record the code indicating the depth of the litter layer to the nearest 0.1 inch.

Values: 00.0 to 99.9 inches

10.7.10 DUFF AND LITTER METHOD (BASE)

Record the code indicating whether duff and litter depths were measured or estimated.

Values:

Value	Description
1	Both duff and litter depth were measured
2	Litter depth was measured, duff depth (≤ 24.0 inches) was estimated
3	Both duff and litter depth were estimated
4	Litter depth was measured, duff (peat) depth exceeds 24.0 inches (note required)

10.8 References

Scott, J.E.; Burgan, R.H. 2005. Standard Fire Behavior Fuel Models: A Comprehensive Set for Use with Rothermel's Surface Fire Spread Model. General Technical Report RMRS-GTR-153. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 72 p.

10.9 Contact Information

Contact information for the National Advisor for this indicator is: Chris Woodall, USDA Forest Service, Northern Research Station, 1992 Folwell Ave, St. Paul, MN 55108, cwoodall@fs.fed.us,

Appendix 2. FIA Forest Type Codes

East	West	Code	Species Type
			White / Red / Jack Pine Group
E		101	Jack pine
E		102	Red pine
E		103	Eastern white pine
E		104	Eastern white pine / eastern hemlock
E		105	Eastern hemlock
			Spruce / Fir Group
E		121	Balsam fir
E		122	White spruce
E		123	Red spruce
E		124	Red spruce / balsam fir
E	W	125	Black spruce
E		126	Tamarack
E		127	Northern white-cedar
E		128	Fraser fir
E		129	Red spruce / Fraser fir
			Longleaf / Slash Pine Group
E		141	Longleaf pine
E		142	Slash pine
			Tropical Softwoods Group
E		151	Tropical pines
			Loblolly / Shortleaf Pine Group
E		161	Loblolly pine
E		162	Shortleaf pine
E		163	Virginia pine
E		164	Sand pine
E		165	Table-mountain pine
E		166	Pond pine
E		167	Pitch pine
E		168	Spruce pine
			Other Eastern Softwoods Group
E		171	Eastern redcedar
E		172	Florida softwoods
			Pinyon / Juniper Group
E	W	182	Rocky Mountain juniper
E	W	184	Juniper woodland
E	W	185	Pinyon-juniper woodland
			Douglas-fir Group
E	W	201	Douglas-fir
	W	202	Port-Orford-cedar

East	West	Code	Species Type
	W	203	Bigcone Douglas-fir
			Ponderosa Pine Group
E	W	221	Ponderosa pine
	W	222	Incense-cedar
	W	224	Sugar pine
	W	225	Jeffrey pine
	W	226	Coulter pine
			Western White Pine Group
	W	241	Western white pine
			Fir / Spruce / Mountain Hemlock Group
	W	261	White fir
	W	262	Red fir
	W	263	Noble fir
	W	264	Pacific silver fir
	W	265	Engelmann spruce
	W	266	Engelmann spruce / subalpine fir
	W	267	Grand fir
	W	268	Subalpine fir
	W	269	Blue spruce
	W	270	Mountain hemlock
	W	271	Alaska-yellow-cedar
			Lodgepole Pine Group
	W	281	Lodgepole pine
			Hemlock / Sitka Spruce Group
	W	301	Western hemlock
	W	304	Western redcedar
	W	305	Sitka spruce
			Western Larch Group
	W	321	Western larch
			Redwood Group
	W	341	Redwood
	W	342	Giant sequoia
			Other Western Softwoods Group
	W	361	Knobcone pine
	W	362	Southwestern white pine
	W	363	Bishop pine
	W	364	Monterey pine
	W	365	Foxtail pine / bristlecone pine
	W	366	Limber pine
	W	367	Whitebark pine
	W	368	Misc. western softwoods
	W	369	Western juniper
			California Mixed Conifer Group
	W	371	California mixed conifer

East	West	Code	Species Type
			Exotic Softwoods Group
E		381	Scotch pine
E	W	383	Other exotic softwoods
E		384	Norway spruce
E		385	Introduced larch
			Other Softwoods Group
		391	Other softwoods
			Oak / Pine Group
E		401	Eastern white pine / N. red oak / white ash
E		402	Eastern redcedar / hardwood
E		403	Longleaf pine / oak
E		404	Shortleaf pine / oak
E		405	Virginia pine / southern red oak
E		406	Loblolly pine / hardwood
E		407	Slash pine / hardwood
E		409	Other pine / hardwood
			Oak / Hickory Group
E		501	Post oak / blackjack oak
E		502	Chestnut oak
E		503	White oak / red oak / hickory
E		504	White oak
E		505	Northern red oak
E		506	Yellow-poplar / white oak / N. red oak
E		507	Sassafras / persimmon
E		508	Sweetgum / yellow-poplar
E		509	Bur oak
E		510	Scarlet oak
E		511	Yellow-poplar
E		512	Black walnut
E		513	Black locust
E		514	Southern scrub oak
E		515	Chestnut oak / black oak / scarlet oak
E		516	Cherry / white ash / yellow-poplar
E		517	Elm / ash / black locust
E		519	Red maple / oak
E		520	Mixed upland hardwoods
			Oak / Gum / Cypress Group
E		601	Swamp chestnut oak / cherrybark oak
E		602	Sweetgum / Nuttall oak / willow oak
E		605	Overcup oak / water hickory
E		606	Atlantic white-cedar
E		607	Baldcypress / water tupelo
E		608	Sweetbay / swamp tupelo / red maple
E		609	Baldcypress / pondcypress
			Elm / Ash / Cottonwood Group
E		701	Black ash / American elm / red maple
E		702	River birch / sycamore
E	W	703	Cottonwood

East	West	Code	Species Type
E	W	704	Willow
E		705	Sycamore / pecan / American elm
E		706	Sugarberry / hackberry / elm / green ash
E		707	Silver maple / American elm
E		708	Red maple / lowland
E	W	709	Cottonwood / willow
	W	722	Oregon ash
			Maple / Beech / Birch Group
E		801	Sugar maple / beech / yellow birch
E		802	Black cherry
E		805	Hard maple / basswood
E		809	Red maple / upland
			Aspen / Birch Group
E	W	901	Aspen
E	W	902	Paper birch
E		903	Gray birch
E	W	904	Balsam poplar
E	W	905	Pin cherry
			Alder / Maple Group
	W	911	Red alder
	W	912	Bigleaf maple
			Western Oak Group
	W	921	Gray pine
	W	922	California black oak
	W	923	Oregon white oak
	W	924	Blue oak
	W	931	Coast live oak
	W	933	Canyon live oak
	W	934	Interior live oak
	W	935	California white oak (valley oak)
			Tanoak / Laurel Group
	W	941	Tanoak
	W	942	California laurel
	W	943	Giant chinkapin
			Other Hardwoods Group
	W	961	Pacific madrone
	W	962	Other hardwoods
			Woodland Hardwoods Group
	W	971	Deciduous oak woodland
	W	972	Evergreen oak woodland
	W	973	Mesquite woodland
	W	974	Cercocarpus (Mountain brush) woodland
	W	975	Intermountain maple woodland
	W	976	Misc. woodland hardwoods
			Tropical Hardwoods Group
E		982	Mangrove

East	West	Code	Species Type
E	W	983	Palms
		984	Dry forest
		985	Moist forest
		986	Wet and rain forest
		987	Lower montane wet and rain forest
		988	Cloud forest
E		989	Other tropical hardwoods
			Exotic Hardwoods Group
E		991	Paulownia
E		992	Melaleuca
E	W	993	Eucalyptus
E	W	995	Other exotic hardwoods

For nonstocked stands, see section 2.5.3 for procedures to determine FOREST TYPE.

Unless otherwise stated, forest types are named for the predominant species (or group of species) on the condition. In order to determine if the type should be classified as softwood versus hardwood, first estimate the stocking (site occupancy) of trees in each of these two categories. If softwoods predominate (50% or more), then the forest type will be one of the softwood types (codes 101 through 391) and vice versa for hardwoods (codes 401 through 995).

Appendix 3. FIA Tree Species Codes

This list includes all tree species tallied in the Continental U.S., Alaska, and the Caribbean. Species designated East/West/Caribbean are commonly found in those regions, although species designated for one region may occasionally be found in another. Woodland species designate species where DRC is measured instead of DBH. Species that have an “X” in the *Core* column are tallied in all regions. All other species on the list are “core optional”.

Core	East	West	Carib bean	Wood land	FIA Code	PLANTS Code	Common Name	Common name SRS	Common name RMRS	Common name PNWRS	Common name Caribbean	Genus	Species
	E	W			0010	ABIES	Fir spp.					Abies	spp.
X		W			0011	ABAM	Pacific silver fir					Abies	amabilis
X	E	W			0012	ABBA	balsam fir					Abies	balsamea
X		W			0014	ABBR	Santa Lucia fir, bristlecone fir			Santa Lucia fir		Abies	bracteata
X		W			0015	ABCO	white fir					Abies	concolor
X	E				0016	ABFR	Fraser fir					Abies	fraseri
X		W			0017	ABGR	grand fir					Abies	grandis
X		W			0018	ABLAA	corkbark fir					Abies	lasiocarpa var. arizonica
X		W			0019	ABLA	subalpine fir					Abies	lasiocarpa
X		W			0020	ABMA	California red fir					Abies	magnifica
X		W			0021	ABSH	Shasta red fir					Abies	shastensis
X		W			0022	ABPR	noble fir					Abies	procera
	E	W			0040	CHAMA4	cedar spp.					Chamaecyparis	spp.
X		W			0041	CHLA	Port-Orford-cedar					Chamaecyparis	lawsoniana
X		W			0042	CHNO	Alaska yellow-cedar					Chamaecyparis	nootkatensis
X	E				0043	CHTH2	Atlantic white-cedar					Chamaecyparis	thyoides
		W	C		0050	CUPRE	cypress					Cupressus	spp.
X		W			0051	CUAR	Arizona cypress					Cupressus	arizonica
X		W			0052	CUBA	Baker cypress, Modoc cypress			Baker cypress		Cupressus	bakeri
X		W			0053	CUFO2	tecate cypress					Cupressus	forbesii
X		W			0054	CUMA2	Monterey cypress					Cupressus	macrocarpa

Core	East	West	Carib bean	Wood land	FIA Code	PLANTS Code	Common Name	Common name SRS	Common name RMRS	Common name PNWRS	Common name Caribbean	Genus	Species
		W			0055	CUSA3	Sargent's cypress					Cupressus	sargentii
X		W			0056	CUMA	MacNab's cypress					Cupressus	macnabiana
	E	W			0057	JUNIP	redcedar, juniper spp.					Juniperus	spp.
X		W		w	0058	JUPI	Pinchot juniper					Juniperus	pinchotii
X		W		w	0059	JUCO11	redberry juniper					Juniperus	coahuilensis
	E			w	0060	JUFL	drooping juniper					Juniperus	flaccida
X	E			w	0061	JUAS	Ashe juniper					Juniperus	ashei
X		W		w	0062	JUCA7	California juniper					Juniperus	californica
X		W		w	0063	JUDE2	alligator juniper					Juniperus	deppeana
X		W			0064	JUOC	western juniper					Juniperus	occidentalis
X		W		w	0065	JUOS	Utah juniper					Juniperus	osteosperma
X	E	W		w	0066	JUSC2	Rocky Mountain juniper					Juniperus	scopulorum
	E				0067	JUVIS	southern redcedar					Juniperus	virginiana var. silicicola
X	E				0068	JUVI	eastern redcedar					Juniperus	virginiana
X		W		w	0069	JUMO	oneseed juniper					Juniperus	monosperma
	E	W			0070	LARIX	larch spp.					Larix	spp.
X	E	W			0071	LALA	tamarack (native)					Larix	laricina
X		W			0072	LALY	subalpine larch					Larix	lyallii
X		W			0073	LAOC	western larch					Larix	occidentalis
X		W			0081	CADE27	incense-cedar					Calocedrus	decurrens
	E	W			0090	PICEA	spruce spp.					Picea	spp.
X	E				0091	PIAB	Norway spruce					Picea	abies
X		W			0092	PIBR	Brewer spruce					Picea	breweriana
X		W			0093	PIEN	Engelmann spruce					Picea	engelmannii
X	E	W			0094	PIGL	white spruce					Picea	glauca

Core	East	West	Carib bean	Wood land	FIA Code	PLANTS Code	Common Name	Common name SRS	Common name RMRS	Common name PNWRS	Common name Caribbean	Genus	Species
X	E	W			0095	PIMA	black spruce					Picea	mariana
X	E	W			0096	PIPU	blue spruce					Picea	pungens
X	E				0097	PIRU	red spruce					Picea	rubens
X		W			0098	PISI	Sitka spruce					Picea	sitchensis
	E	W	C		0100	PINUS	pine spp.					Pinus	spp.
X		W			0101	PIAL	whitebark pine					Pinus	albicaulis
X		W			0102	PIAR	Rocky Mountain bristlecone pine					Pinus	aristata
X		W			0103	PIAT	knobcone pine					Pinus	attenuata
X		W			0104	PIBA	foxtail pine					Pinus	balfouriana
X	E				0105	PIBA2	jack pine					Pinus	banksiana
X		W		w	0106	PIED	Common pinyon, two-needle pinyon			common pinyon		Pinus	edulis
X	E				0107	PICL	sand pine					Pinus	clausa
X		W			0108	PICO	lodgepole pine					Pinus	contorta
X		W			0109	PICO3	Coulter pine					Pinus	coulteri
X	E				0110	PIEC2	shortleaf pine					Pinus	echinata
X	E				0111	PIEL	slash pine					Pinus	elliottii
X		W			0112	PIEN2	Apache pine					Pinus	engelmannii
X		W			0113	PIFL2	limber pine					Pinus	flexilis
X		W			0114	PIST3	southwestern white pine					Pinus	strobiformis
X	E				0115	PIGL2	spruce pine					Pinus	glabra
X		W			0116	PIJE	Jeffrey pine					Pinus	jeffreyi
X		W			0117	PILA	sugar pine					Pinus	lambertiana
X		W			0118	PILE	Chihuahuan pine					Pinus	leiophylla
X		W			0119	PIMO3	western white pine					Pinus	monticola

Core	East	West	Carib bean	Wood land	FIA Code	PLANTS Code	Common Name	Common name SRS	Common name RMRS	Common name PNWRS	Common name Caribbean	Genus	Species
X		W			0120	PIMU	bishop pine					Pinus	muricata
X	E				0121	PIPA2	longleaf pine					Pinus	palustris
X	E	W			0122	PIPO	ponderosa pine					Pinus	ponderosa
X	E				0123	PIPU5	Table Mountain pine					Pinus	pungens
X		W			0124	PIRA2	Monterey pine					Pinus	radiata
X	E				0125	PIRE	red pine					Pinus	resinosa
X	E				0126	PIRI	pitch pine					Pinus	rigida
X		W			0127	PISA2	gray pine, California foothill pine			gray pine		Pinus	sabiniana
X	E				0128	PISE	pond pine					Pinus	serotina
X	E				0129	PIST	eastern white pine					Pinus	strobus
X	E	W			0130	PISY	Scotch pine					Pinus	sylvestris
X	E				0131	PITA	loblolly pine					Pinus	taeda
X	E				0132	PIVI2	Virginia pine					Pinus	virginiana
X		W		w	0133	PIMO	singleleaf pinyon					Pinus	monophylla
X		W		w	0134	PIDI3	border pinyon					Pinus	discolor
X		W			0135	PIAR5	Arizona pine					Pinus	arizonica
X	E				0136	PINI	Austrian pine					Pinus	nigra
X		W			0137	PIWA	Washoe pine					Pinus	washoensis
X		W		w	0138	PIQU	four-leaf pine, Parry pinyon pine			four-leaf pine		Pinus	quadrifolia
X		W			0139	PITO	Torrey pine			torreya pine		Pinus	torreyana
X		W		w	0140	PICE	Mexican pinyon pine					Pinus	cembroides
	E			w	0141	PIRE5	papershell pinyon pine					Pinus	remota
X		W			0142	PILO	Great Basin bristlecone pine					Pinus	longaeva

Core	East	West	Caribbean	Woodland	FIA Code	PLANTS Code	Common Name	Common name SRS	Common name RMRS	Common name PNWRS	Common name Caribbean	Genus	Species
X		W		w	0143	PIMOF	Arizona pinyon pine					Pinus	monophylla var. fallax
X	E				0144	PIELE2	Caribbean pine					Pinus	elliottii var. elliottii
		W			0200	PSEUD7	Douglas-fir spp.					Pseudotsuga	spp.
X		W			0201	PSMA	bigcone Douglas-fir					Pseudotsuga	macrocarpa
X		W			0202	PSME	Douglas-fir					Pseudotsuga	menziesii
X		W			0211	SESE3	redwood					Sequoia	sempervirens
X		W			0212	SEGI2	giant sequoia					Sequoiadendron	giganteum
	E				0220	TAXOD	cypress spp.					Taxodium	spp.
X	E				0221	TADI2	baldcypress					Taxodium	distichum
X	E				0222	TAAS	pondcypress					Taxodium	ascendens
	E				0223	TAMU	Montezuma baldcypress					Taxodium	mucronatum
	E	W			0230	TAXUS	yew spp.					Taxus	spp.
		W			0231	TABR2	Pacific yew					Taxus	brevifolia
X	E				0232	TAFL	Florida yew					Taxus	floridana
	E	W	C		0240	THUJA	Thuja spp.					Thuja	spp.
X	E				0241	THOC2	northern white-cedar					Thuja	occidentalis
X		W			0242	THPL	western redcedar					Thuja	plicata
	E	W			0250	TORRE	torreya (nutmeg) spp.					Torreya	spp.
X		W			0251	TOCA	California torreya (nutmeg)					Torreya	californica
X	E				0252	TOTA	Florida torreya (nutmeg)					Torreya	taxifolia
	E	W			0260	TSUGA	hemlock spp.					Tsuga	spp.
X	E				0261	TSCA	eastern hemlock					Tsuga	canadensis
X	E				0262	TSCA2	Carolina hemlock					Tsuga	caroliniana
X		W			0263	TSHE	western hemlock					Tsuga	heterophylla

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X		W			0264	TSME	mountain hemlock					Tsuga	mertensiana
X	E	W	C		0299	2TE	unknown dead conifer					Tree	evergreen
	E	W	C	w	0300	ACACI	acacia spp.					Acacia	spp.
	E	W	C	w	0303	ACFA	sweet acacia					Acacia	farnesiana
	E	W		w	0304	ACGR	catclaw acacia					Acacia	greggii
	E	W			0310	ACER	maple spp.					Acer	spp.
X	E				0311	ACBA3	Florida maple					Acer	barbatum
X		W			0312	ACMA3	bigleaf maple					Acer	macrophyllum
X	E	W			0313	ACNE2	boxelder					Acer	negundo
X	E				0314	ACNI5	black maple					Acer	nigrum
X	E				0315	ACPE	striped maple					Acer	pensylvanicum
X	E				0316	ACRU	red maple					Acer	rubrum
X	E				0317	ACSA2	silver maple					Acer	saccharinum
X	E				0318	ACSA3	sugar maple					Acer	saccharum
	E				0319	ACSP2	mountain maple					Acer	spicatum
	E				0320	ACPL	Norway maple					Acer	platanoides
		W		w	0321	ACGL	Rocky Mountain maple					Acer	glabrum
		W		w	0322	ACGR3	bigtooth maple					Acer	grandidentatum
X	E				0323	ACLE	chalk maple					Acer	leucoderme
	E	W			0330	AESCU	buckeye, horsechestnut spp.					Aesculus	spp.
X	E				0331	AEGL	Ohio buckeye					Aesculus	glabra
X	E				0332	AEFL	yellow buckeye					Aesculus	flava
		W			0333	AECA	California buckeye					Aesculus	californica
	E				0334	AEGLA	Texas buckeye					Aesculus	glabra var. arguta

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	E				0336	AEPA	red buckeye					Aesculus	pavia
X	E				0337	AESY	painted buckeye					Aesculus	sylvatica
X	E	W			0341	AIAL	ailanthus					Ailanthus	altissima
X	E	W			0345	ALJU	mimosa/silktree					Albizia	julibrissin
		W			0350	ALNUS	alder spp.					Alnus	spp.
X		W			0351	ALRU2	red alder					Alnus	rubra
X		W			0352	ALRH2	white alder					Alnus	rhombifolia
X		W			0353	ALOB2	Arizona alder					Alnus	oblongifolia
X	E				0355	ALGL2	European alder					Alnus	glutinosa
	E	W			0356	AMELA	serviceberry spp.					Amelanchier	spp.
	E	W			0357	AMAR3	common serviceberry					Amelanchier	arborea
	E	W			0358	AMSA	roundleaf serviceberry					Amelanchier	sanguinea
		W			0360	ARBUT	Madrone spp.					Arbutus	spp.
X		W			0361	ARME	Pacific madrone					Arbutus	menziesii
X		W			0362	ARAR2	Arizona madrone					Arbutus	arizonica
	E	W		w	0363	ARXA80	Texas madrone					Arbutus	xalapensis
X	E				0367	ASTR	Pawpaw					Asimina	triloba
	E	W			0370	BETUL	birch spp.					Betula	spp.
X	E				0371	BEAL2	yellow birch					Betula	alleghaniensis
X	E				0372	BELE	sweet birch					Betula	lenta
X	E				0373	BENI	river birch					Betula	nigra
X	E	W			0374	BEOC2	water birch					Betula	occidentalis
X	E	W			0375	BEPA	paper birch					Betula	papyrifera
X		W			0376	BENE4	paper birch			Alaska paper birch		Betula	neoalaskana
X	E				0377	BEUB	Virginia roundleaf birch					Betula	uber

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X		W			0378	BEUT	northwestern paper birch					Betula	X utahensis
X	E				0379	BEPO	gray birch					Betula	populifolia
	E				0381	SILAL3	Chittamwood, gum bumelia					Sideroxylon	lanuginosum ssp. lanuginosum
X	E				0391	CACA18	American hornbeam, musclewood					Carpinus	caroliniana
	E				0400	CARYA	hickory spp.					Carya	spp.
X	E				0401	CAAQ2	water hickory					Carya	aquatica
X	E				0402	CACO15	bitternut hickory					Carya	cordiformis
X	E				0403	CAGL8	pignut hickory					Carya	glabra
X	E				0404	CAIL2	pecan					Carya	illinoinensis
X	E				0405	CALA21	shellbark hickory					Carya	laciniosa
X	E				0406	CAMY	nutmeg hickory					Carya	myristiciformis
X	E				0407	CAOV2	shagbark hickory					Carya	ovata
X	E				0408	CATE9	black hickory					Carya	texana
X	E				0409	CAAL27	mockernut hickory					Carya	alba
X	E				0410	CAPA24	sand hickory					Carya	pallida
X	E				0411	CAFL6	scrub hickory					Carya	floridana
X	E				0412	CAOV3	red hickory					Carya	ovalis
X	E				0413	CACA38	southern shagbark hickory					Carya	carolinae-septentrionalis
	E	W			0420	CASTA	chestnut spp.					Castanea	spp.
	E				0421	CADE12	American chestnut					Castanea	dentata
X	E				0422	CAPU9	Allegheny chinkapin					Castanea	pumila
	E				0423	CAPUO	Ozark chinkapin					Castanea	pumila var. ozarkensis
X	E	W			0424	CAMO83	Chinese chestnut					Castanea	mollissima

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		W			0431	CHCHC4	giant chinkapin, golden chinkapin					Chrysolepis	chrysophylla var. chrysophylla
	E		C		0450	CATAL	catalpa spp.					Catalpa	spp.
X	E				0451	CABI8	southern catalpa					Catalpa	bignonioides
X	E				0452	CASP8	northern catalpa					Catalpa	speciosa
	E	W	C		0460	CELTI	hackberry spp.					Celtis	spp.
X	E	W			0461	CELA	sugarberry					Celtis	laevigata
X	E	W			0462	CEOC	hackberry					Celtis	occidentalis
	E	W			0463	CELAR	netleaf hackberry					Celtis	laevigata var. reticulata
X	E				0471	CECA4	eastern redbud					Cercis	canadensis
		W		w	0475	CELE3	curlleaf mountain-mahogany					Cercocarpus	ledifolius
X	E				0481	CLKE	yellowwood					Cladrastis	kentukea
	E	W			0490	CORNU	dogwood spp.					Cornus	spp.
X	E				0491	COFL2	flowering dogwood					Cornus	florida
X		W			0492	CONU4	Pacific dogwood					Cornus	nuttallii
	E				0500	CRATA	hawthorn spp.					Crataegus	spp.
	E				0501	CRCR2	cockspur hawthorn					Crataegus	crus-galli
	E				0502	CRMO2	downy hawthorn					Crataegus	mollis
	E				0503	CRBR3	Brainerd hawthorn					Crataegus	brainerdii
	E				0504	CRCA	pear hawthorn					Crataegus	calpodendron
	E				0505	CRCH	fireberry hawthorn					Crataegus	chrysocarpa
	E				0506	CRDI	broadleaf hawthorn					Crataegus	dilatata
	E				0507	CRFL	fanleaf hawthorn					Crataegus	flabellata
	E				0508	CRMO3	oneseed hawthorn					Crataegus	monogyna
	E				0509	CRPE	scarlet hawthorn					Crataegus	pedicellata

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	E				5091	CRPH	Washington hawthorn					Crataegus	phaenopyrum
	E				5092	CRSU5	fleshy hawthorn					Crataegus	succulenta
	E				5093	CRUN	dwarf hawthorn					Crataegus	uniflora
	E	W	C		0510	EUCAL	eucalyptus spp.					Eucalyptus	spp.
X		W			0511	EUGL	Tasmanian bluegum			Tasmanian bluegum, eucalyptus		Eucalyptus	globulus
X	E				0512	EUCA2	river redgum					Eucalyptus	camaldulensis
X	E		C		0513	EUGR12	grand eucalyptus					Eucalyptus	grandis
X	E		C		0514	EURO2	swamp mahogany					Eucalyptus	robusta
	E		C		0520	DIOSP	persimmon spp.					Diospyros	spp.
X	E				0521	DIVI5	common persimmon					Diospyros	virginiana
X	E				0522	DITE3	Texas persimmon					Diospyros	texana
	E			w	0523	EHAN	Anacua	knockaway				Ehretia	anacua
X	E				0531	FAGR	American beech					Fagus	grandifolia
	E	W	C		0540	FRAXI	ash spp.					Fraxinus	spp.
X	E				0541	FRAM2	white ash					Fraxinus	americana
X		W			0542	FRLA	Oregon ash					Fraxinus	latifolia
X	E				0543	FRNI	black ash					Fraxinus	nigra
X	E				0544	FRPE	green ash					Fraxinus	pennsylvanica
X	E				0545	FRPR	pumpkin ash					Fraxinus	profunda
X	E				0546	FRQU	blue ash					Fraxinus	quadrangulata
X		W			0547	FRVE2	velvet ash					Fraxinus	velutina
X	E				0548	FRCA3	Carolina ash					Fraxinus	caroliniana
X	E				0549	FRTE	Texas ash					Fraxinus	texensis
	E				5491	FRBE	Berlandier ash	Mexican ash				Fraxinus	berlandieriana
	E				0550	GLEDI	locust spp.					Gleditsia	spp.

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X	E				0551	GLAQ	waterlocust					Gleditsia	aquatica
X	E				0552	GLTR	honeylocust					Gleditsia	triacanthos
X	E				0555	GOLA	loblolly bay					Gordonia	lasianthus
X	E	W			0561	GIBI2	Ginkgo, maidenhair tree					Ginkgo	biloba
X	E				0571	GYDI	Kentucky coffeetree					Gymnocladus	dioicus
	E				0580	HALES	silverbell spp.					Halesia	spp.
X	E				0581	HACA3	Carolina silverbell					Halesia	carolina
X	E				0582	HADI3	two-wing silverbell					Halesia	diptera
X	E				0583	HAPA2	little silverbell					Halesia	parviflora
X	E				0591	ILOP	American holly					Ilex	opaca
	E	W	C		0600	JUGLA	walnut spp.					Juglans	spp.
X	E				0601	JUCI	butternut					Juglans	cinerea
X	E	W			0602	JUNI	black walnut					Juglans	nigra
		W			0603	JUHI	Northern California black walnut			California black walnut		Juglans	hindsii
X		W			0604	JUCA	Southern California black walnut					Juglans	californica
	E	W			0605	JUMI	Texas walnut					Juglans	microcarpa
X		W			0606	JUMA	Arizona walnut					Juglans	major
X	E				0611	LIST2	sweetgum					Liquidambar	styraciflua
X	E				0621	LITU	yellow-poplar					Liriodendron	tulipifera
X		W			0631	LIDE3	tanoak					Lithocarpus	densiflorus
X	E				0641	MAPO	Osage-orange					Maclura	pomifera
	E		C		0650	MAGNO	magnolia spp.					Magnolia	spp.
X	E				0651	MAAC	cucumbertree					Magnolia	acuminata
X	E				0652	MAGR4	southern magnolia					Magnolia	grandiflora
X	E				0653	MAVI2	sweetbay					Magnolia	virginiana
X	E				0654	MAMA2	bigleaf magnolia					Magnolia	macrophylla

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X	E				0655	MAFR	mountain magnolia, Fraser magnolia			mountain magnolia		Magnolia	fraseri
X	E				0657	MAPY	pyramid magnolia					Magnolia	pyramidata
X	E				0658	MATR	umbrella magnolia					Magnolia	tripetala
	E	W			0660	MALUS	apple spp.					Malus	spp.
X		W			0661	MAFU	Oregon crabapple			Oregon crab apple		Malus	fusca
X	E				0662	MAAN3	southern crabapple					Malus	angustifolia
X	E				0663	MACO5	sweet crabapple					Malus	coronaria
X	E				0664	MAIO	prairie crabapple					Malus	ioensis
	E		C		0680	MORUS	mulberry spp.					Morus	spp.
X	E		C		0681	MOAL	white mulberry					Morus	alba
X	E				0682	MORU2	red mulberry					Morus	rubra
	E	W			0683	MOMI	Texas mulberry					Morus	microphylla
X	E		C		0684	MONI	black mulberry					Morus	nigra
	E				0690	NYSSA	tupelo spp.					Nyssa	spp.
X	E				0691	NYAQ2	water tupelo					Nyssa	aquatica
X	E				0692	NYOG	Ogeechee tupelo					Nyssa	ogeche
X	E				0693	NYSY	blackgum					Nyssa	sylvatica
X	E				0694	NYBI	swamp tupelo					Nyssa	biflora
X	E				0701	OSVI	eastern hophornbeam					Ostrya	virginiana
X	E				0711	OXAR	sourwood					Oxydendrum	arboreum
X	E				0712	PATO2	paulownia, empress-tree					Paulownia	tomentosa
	E	W	C		0720	PERSE	bay spp.					Persea	spp.
X	E				0721	PEBO	redbay					Persea	borbonia
X		W	C		7211	PEAM3	avocado					Persea	americana

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X	E				0722	PLAQ	water-elm, planertree					Planera	aquatica
	E	W			0729	PLATA	sycamore spp.					Platanus	spp.
X		W			0730	PLRA	California sycamore					Platanus	racemosa
X	E				0731	PLOC	American sycamore					Platanus	occidentalis
X		W			0732	PLWR2	Arizona sycamore					Platanus	wrightii
	E	W			0740	POPUL	cottonwood and poplar spp.					Populus	spp.
X	E	W			0741	POBA2	balsam poplar					Populus	balsamifera
X	E				0742	PODE3	eastern cottonwood					Populus	deltoides
X	E				0743	POGR4	bigtooth aspen					Populus	grandidentata
X	E				0744	POHE4	swamp cottonwood					Populus	heterophylla
X	E	W			0745	PODEM	plains cottonwood					Populus	deltoides ssp. monilifera
X	E	W			0746	POTR5	quaking aspen					Populus	tremuloides
X		W			0747	POBAT	black cottonwood					Populus	balsamifera ssp. trichocarpa
X		W			0748	POFR2	Fremont cottonwood		Rio Grande cottonwood, Fremont's poplar			Populus	fremontii
X		W			0749	POAN3	narrowleaf cottonwood					Populus	angustifolia
X	E				0752	POAL7	silver poplar					Populus	alba
X	E				0753	PONI	Lombardy poplar					Populus	nigra
	E	W	C	w	0755	PROSO	mesquite spp.					Prosopis	spp.
X	E	W		w	0756	PRGL2	honey mesquite		western honey mesquite	western honey mesquite		Prosopis	glandulosa
X	E	W		w	0757	PRVE	velvet mesquite					Prosopis	velutina
X	E	W		w	0758	PRPU	screwbean mesquite					Prosopis	pubescens
	E	W	C		0760	PRUNU	cherry and plum spp.					Prunus	spp.

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	E	W			0761	PRPE2	pin cherry					Prunus	pensylvanica
X	E				0762	PRSE2	black cherry					Prunus	serotina
	E	W			0763	PRVI	common chokecherry			chokecherry		Prunus	virginiana
	E				0764	PRPE3	peach					Prunus	persica
X	E				0765	PRNI	Canada plum					Prunus	nigra
X	E				0766	PRAM	American plum			wild plum		Prunus	americana
		W			0768	PREM	bitter cherry					Prunus	emarginata
	E				0769	PRAL5	Allegheny plum					Prunus	alleghaniensis
	E	W			0770	PRAN3	Chickasaw plum					Prunus	angustifolia
X	E				0771	PRAV	sweet cherry (domesticated)					Prunus	avium
	E				0772	PRCE	sour cherry (domesticated)					Prunus	cerasus
	E				0773	PRDO	European plum (domesticated)					Prunus	domestica
	E				0774	PRMA	Mahaleb plum (domesticated)					Prunus	mahaleb
	E	W			0800	QUERC	oak spp.					Quercus	spp.
X		W			0801	QUAG	California live oak			coast live oak		Quercus	agrifolia
X	E				0802	QUAL	white oak					Quercus	alba
X		W		w	0803	QUAR	Arizona white oak			Arizona white and gray oak		Quercus	arizonica
X	E				0804	QUBI	swamp white oak					Quercus	bicolor
		W			0805	QUCH2	canyon live oak					Quercus	chrysolepis
X	E				0806	QUCO2	scarlet oak					Quercus	coccinea
X		W			0807	QUDO	blue oak					Quercus	douglasii
X	E				0808	QUSIS	Durand oak					Quercus	sinuata var. sinuata
X	E				0809	QUEL	northern pin oak					Quercus	ellipsoidalis

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X		W		w	0810	QUEM	Emory oak					Quercus	emoryi
X		W			0811	QUEN	Engelmann oak					Quercus	engelmannii
X	E				0812	QUFA	southern red oak					Quercus	falcata
X	E				0813	QUPA5	cherrybark oak					Quercus	pagoda
X		W		w	0814	QUGA	Gambel oak					Quercus	gambelii
X		W			0815	QUGA4	Oregon white oak					Quercus	garryana
X	E				0816	QUIL	scrub oak					Quercus	ilicifolia
X	E				0817	QUIM	shingle oak					Quercus	imbricaria
X		W			0818	QUKE	California black oak					Quercus	kelloggii
X	E				0819	QULA2	turkey oak					Quercus	laevis
X	E				0820	QULA3	laurel oak					Quercus	laurifolia
X		W			0821	QULO	California white oak					Quercus	lobata
X	E				0822	QULY	overcup oak					Quercus	lyrata
X	E				0823	QUMA2	bur oak					Quercus	macrocarpa
X	E				0824	QUMA3	blackjack oak					Quercus	marilandica
X	E				0825	QUMI	swamp chestnut oak					Quercus	michauxii
X	E				0826	QUMU	chinkapin oak					Quercus	muehlenbergii
X	E				0827	QUNI	water oak					Quercus	nigra
X	E				0828	QUTE	Nuttall oak, Texas red oak					Quercus	texana
X		W		w	0829	QUOB	Mexican blue oak					Quercus	oblongifolia
X	E				0830	QUPA2	pin oak					Quercus	palustris
X	E				0831	QUPH	willow oak					Quercus	phellos
X	E				0832	QUPR2	chestnut oak					Quercus	prinus
X	E				0833	QURU	northern red oak					Quercus	rubra
X	E				0834	QUSH	Shumard's oak			Shumard oak		Quercus	shumardii
X	E				0835	QUST	post oak					Quercus	stellata

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	E				0836	QUSI2	Delta post oak					Quercus	similis
X	E				0837	QUVE	black oak					Quercus	velutina
X	E				0838	QUVI	live oak					Quercus	virginiana
X		W			0839	QUWI2	interior live oak					Quercus	wislizeni
X	E				0840	QUMA6	dwarf post oak					Quercus	margarettae
X	E				0841	QUMI2	dwarf live oak					Quercus	minima
X	E				0842	QUIN	bluejack oak					Quercus	incana
X		W		w	0843	QUHY	silverleaf oak					Quercus	hypoleucoides
X	E				0844	QUOG	Oglethorpe oak					Quercus	oglethorpensis
	E				0845	QUPR	dwarf chinkapin oak					Quercus	prinoides
X		W		w	0846	QUGR3	gray oak					Quercus	grisea
X		W		w	0847	QURU4	netleaf oak					Quercus	rugosa
	E				0851	QUGR	Chisos oak					Quercus	graciliformis
	E				8511	QUGR2	Graves oak	Chisos red oak				Quercus	gravesii
	E				8512	QUPO2	Mexican white oak	netleaf white oak				Quercus	polymorpha
	E				8513	QUBU2	Spanish oak	Buckley oak, Texas red				Quercus	buckleyi
	E				8514	QULA	lacey oak					Quercus	laceyi
	E		C		0852	AMEL	torchwood				sea torch-wood	Amyris	elemifera
	E		C		0853	ANGL4	pond apple					Annona	glabra
	E		C		0854	BUSI	gumbo limbo					Bursera	simaruba
	E		C		0855	CASUA	sheoak spp.					Casuarina	spp.
X	E		C		0856	CAGL11	gray sheoak					Casuarina	glauca
X	E		C		0857	CALE28	Australian pine				Casuarina lepidophloia	Casuarina	lepidophloia
	E		C		0858	CICA	camphor tree					Cinnamomum	camphora

Core	East	West	Caribbean	Woodland	FIA Code	PLANTS Code	Common Name	Common name SRS	Common name RMRS	Common name PNWRS	Common name Caribbean	Genus	Species
	E		C		0890	SIFO	false mastic					Sideroxylon	foetidissimum
	E		C		0891	SISA6	white bully, willow bustic					Sideroxylon	salicifolium
	E				0895	SIGL3	paradise tree					Simarouba	glauca
	E				0896	SYCU	Java plum					Syzygium	cumini
	E		C		0897	TAIN2	tamarind					Tamarindus	indica
X	E	W			0901	ROPS	black locust					Robinia	pseudoacacia
		W		w	0902	RONE	New Mexico locust					Robinia	neomexicana
	E				0906	ACWR4	paurotis palm					Acoelorraphe	wrightii
	E				0907	COAR	silver palm					Coccothrinax	argentata
	E		C		0908	CONU	coconut palm					Cocos	nucifera
	E		C		0909	ROYST	royal palm spp.					Roystonea	spp.
	E				0911	SAME8	Mexican palmetto	Rio Grande palmetto				Sabal	mexicana
X	E				0912	SAPA	cabbage palmetto					Sabal	palmetto
	E		C		0913	THMO4	key thatch palm					Thrinax	morrisii
	E				0914	THRA2	Florida thatch palm					Thrinax	radiata
	E				0915	ARECA	other palms					Family Arecaceae	not listed above
	E	W			0919	SASAD	western soapberry					Sapindus	saponaria var. drummondii
	E	W	C		0920	SALIX	willow spp.					Salix	spp.
	E	W			0921	SAAM2	peachleaf willow					Salix	amygdaloides
	E	W			0922	SANI	black willow					Salix	nigra
	E	W			0923	SABE2	Bebb willow					Salix	bebbiana
		W			0924	SABO	red willow					Salix	bonplandiana
X	E				0925	SACA5	coastal plain willow					Salix	caroliniana
X	E				0926	SAPY	balsam willow					Salix	pyrifolia

Core	East	West	Carib bean	Wood land	FIA Code	PLANTS Code	Common Name	Common name SRS	Common name RMRS	Common name PNWRS	Common name Caribbean	Genus	Species
	E	W			0927	SAAL2	white willow					Salix	alba
		W			0928	SASC	Scouler's willow					Salix	scouleriana
X	E				0929	SASE10	weeping willow					Salix	sepulcralis
X	E				0931	SAAL5	sassafras					Sassafras	albidum
	E				0934	SORBU	mountain ash spp.					Sorbus	spp.
	E				0935	SOAM3	American mountain ash					Sorbus	americana
X	E				0936	SOAU	European mountain ash					Sorbus	aucuparia
X	E				0937	SODE3	northern mountain ash					Sorbus	decora
	E		C		0940	SWMA2	mahogany					Swietenia	mahagoni
	E				0950	TILIA	basswood spp.					Tilia	spp.
X	E				0951	TIAM	American basswood					Tilia	americana
	E				0952	TIAMH	white basswood					Tilia	americana var. heterophylla
	E				0953	TIAMC	Carolina basswood					Tilia	americana var. caroliniana
	E				0970	ULMUS	elm spp.					Ulmus	spp.
X	E				0971	ULAL	winged elm					Ulmus	alata
X	E				0972	ULAM	American elm					Ulmus	americana
X	E				0973	ULCR	cedar elm					Ulmus	crassifolia
X	E				0974	ULPU	Siberian elm					Ulmus	pumila
X	E				0975	ULRU	slippery elm					Ulmus	rubra
X	E				0976	ULSE	September elm					Ulmus	serotina
X	E				0977	ULTH	rock elm					Ulmus	thomasii
X		W			0981	UMCA	California laurel					Umbellularia	californica
		W			0982	YUBR	Joshua tree					Yucca	brevifolia

Core	East	West	Caribbean	Woodland	FIA Code	PLANTS Code	Common Name	Common name SRS	Common name RMRS	Common name PNWRS	Common name Caribbean	Genus	Species
	E		C		0986	AVGE	black mangrove					Avicennia	germinans
	E		C		0987	COER2	buttonwood mangrove				button mangrove	Conocarpus	erectus
	E		C		0988	LARA2	white mangrove					Laguncularia	racemosa
X	E		C		0989	RHMA2	American mangrove				red mangrove	Rhizophora	mangle
		W		w	0990	OLTE	desert ironwood			tesota, Arizona-ironwood		Olneya	tesota
	E	W	C		0991	TAMAR2	saltcedar					Tamarix	spp.
X	E		C		0992	MEQU	melaleuca				punktree	Melaleuca	quinquenervia
X	E		C		0993	MEAZ	chinaberry				Chinaberry-tree	Melia	azedarach
X	E				0994	TRSE6	Chinese tallowtree					Triadica	sebifera
X	E				0995	VEFO	tungoil tree					Vernicia	fordii
X	E				0996	COOB2	smoketree					Cotinus	obovatus
	E	W			0997	ELAN	Russian-olive					Elaeagnus	angustifolia
X	E	W	C		0998	2TB	unknown dead hardwood					Tree	broadleaf
X	E	W	C		0999	2TREE	other, or unknown live tree					Tree	unknown
			C		6001	ACAN4	blackbrush wattle					Acacia	anegadensis
			C		6008	ACMA	porknut					Acacia	macracantha
			C		6009	ACMA12	Acacia mangium					Acacia	mangium
			C		6012	ACMU	spineless wattle					Acacia	muricata
			C		6013	ACNI2	gum arabic tree					Acacia	nilotica
			C		6015	ACPO3	Acacia polyacantha					Acacia	polyacantha
			C		6018	ACTO	poponax					Acacia	tortuosa
			C		6021	ACAR	hollowheart					Acnistus	arborescens
			C		6023	ACME2	grugru palm					Acrocomia	media
			C		6025	ADDI3	baobab					Adansonia	digitata

APPENDIX 4. CALIFORNIA PRESCRIBED FIRE MONITORING PROGRAM: PRE- AND POST-FIRE SAMPLING PROTOCOL

Updated 9/20/22

Overview

Plot shape: Circular

Plot size: Default for forested vegetation: 405 sq m (11.3 m radius) = 1/10 acre. Tree regeneration protocol will be conducted in smaller 60 sq m (4.37 m radius) = 1/70 acre.

Plot location: Center the plots on the vertices of a grid that has been stratified by vegetation type and previous treatment (when applicable). These areas have been predetermined in GIS (see maps for project area per site).

Permanently mark the plot locations with a 2-foot piece of ½" rebar and topped with a rubber/plastic orange rebar cap. Leave only 3-5" above ground. Flag the rebar and a few trees near the center of the plot. Use a permanent marker (Sharpie) to label cap with plot ID and UC Davis.

All data recording will be completed in datasheets designed for tablets.

Plot Description - Form I (1/10 acre plot)

1. Enter the plot #, date, and all observers' initials.
2. Enter the burn unit ID.
3. Identify witness tree - this is the first tree tagged, clockwise from 0 degrees (true north). Where permitted, mark witness tree with pink or other highly visible flagging at approx. eye-level. Record the distance and azimuth on the tree datasheet. Distance should be to the nearest 0.1m from plot center to the base of the tree. Azimuth should be to plot center. Note tag number.
4. Photos
    a. Take a photo of the labeled rebar cap, make sure the tag number is visible or use a white board with the plot number.
    b. Take one photo of each cardinal direction moving clockwise, from the end of the opposite transect (N, E, S, W)
        i. For example, you should be standing at the S transect end to take a photo of the N transect end.
        ii. Take the picture in a horizontal direction with the horizon located at the middle of the picture.
5. Enter the UTM zone and easting and northing measurements (GPS). Does not need to be collected on already established plots.

   a. Enter compass declination used for the project location.
6. Slope, in percent: using a clinometer, measure the slope to the nearest 1% from point center in the two directions of the aspect axis to the plot edge and average these two numbers. Slope does not need to be collected on already established plots.
7. Aspect, in degrees: using a hand-held compass, measure and record the predominant aspect across the entire plot to the nearest 1 degree. Aspect is measured in the same direction as the slope. Aspect does not need to be collected on already established plots.
8. Ground cover, percent. Using the categories of bare soil, litter, rock (non-combustible), and basal vegetation, estimate percent ground surface cover to the nearest 5%. Values must sum to 100%.
   a. For basal vegetation, think about what the plot would look like if you cut everything off right at ground level, capturing just the emerging stems/trunks of plants.

Plot Description - Form II (Vegetation Cover) (1/10-acre plot)

Estimate % cover (to nearest 1%) of total plot and modal height (to the nearest 0.1m) for the classes listed under "vegetation cover". For the 1/10-acre plots, about 4 m sq is equal to 1% cover.

1. "**Total vegetation (TOT VEG)**" is the cover of living vegetation as a % of the plot when viewed from an airplane/satellite.
2. "**Total tree (Total)**", "tree ≥1.4m (TOV)," and "tree <1.4m (TSA/TSE)" refer only to live trees. Adding TOV, TSA, and TSE together will probably give a value higher than TOT, due to crown overlap
   a. **Total Overstory Trees (TOV)** = trees >1.4m tall and DBH ≥ 7.62 cm
   b. **Total Saplings (TSA)** = trees >1.4m tall and DBH < 7.62 cm
   c. **Total Seedlings** (**TSE**) = trees <1.4m tall
3. **Dead tree (DT)** = cover of dead trees as a % of the plot when viewed from above (e.g., from a plane or satellite)
4. **Resprouting Vegetation (TRE)** is the cover of live vegetation resprouting from dead vegetation. This does NOT include plants that might have the potential to resprout, but that do not currently have live resprouts.
5. "**Total live shrub cover (TOS)**" refers only to live shrub cover.
6. Record percent cover for **forbs (TOF)** and **graminoids (TOG)** in plot. Record modal height (meters) for each category

Note: If any of the above-ground cover types are present in the plot but make up ***less than 1%***, record the percent cover as "**tr**" - this represents trace cover.

Trees (1/10-acre plot, 11.3m radius)

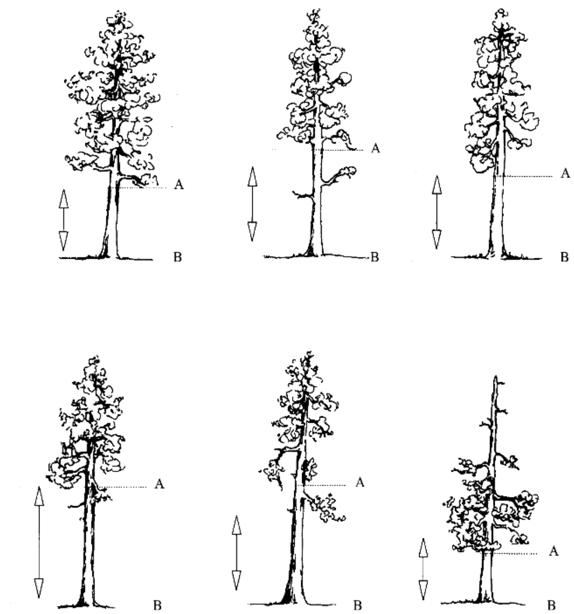
Tree data: Use a DBH cutoff of 7.6 cm and a height cutoff of 1.37 m. This means that within the plot, all live and dead trees at or greater than 7.6cm DBH and 1.37 m tall will be *individually* measured. Should a qualified hardwood species be numerous within the plot, those individuals may be assessed together as group (i.e., modal height, diameter). All live trees will be tagged in clockwise order from plot center beginning at the North transect (0 degrees). If a live tree is not tagged, add a new tag and note the tag number in the datasheet in notes.

1. Enter the tag #; live or dead status (L or D); and species code. Dead trees do not get tagged. Live trees that have died since they were previously tagged should retain their tags.
2. Enter DBH (d-tape) for live and dead trees (this should always be taken at DBH and not at the nail)
3. Height to live crown base (HTLCB) to the nearest 0.1 m (only live trees)
    a. This is defined as the height to the lowest live, vertically continuous crown (see picture below)
    b. Measure HTLCB from the point where the lowest live branch intersects with the bole of the tree, not the tip of the branch.
4. Enter decay class (1-5), see table (snag decay class)
5. If you are in a recently burned area and fire severity metrics will be taken (bole char height, crown scorch %, crown torch %, etc.).
6. Enter remarks, if necessary.

Table 13.5. Snag decay class codes and descriptions.

Code	Limbs and branches	Top	Percentage of bark remaining	Sapwood presence	Sapwood condition	Heartwood condition
1	All present	Pointed	100	Intact	Sound, incipient decay, hard, original color	Sound, hard, original color
2	Few limbs, no fine branches	Broken	Variable	Sloughing	Advanced decay, fibrous, firm to soft, light brown	Sound at base, incipient decay in outer edge of upper bole, hard, light to red brown
3	Limb stubs	Broken	Variable	Sloughing	Fibrous, soft, light to reddish brown	Incipient decay at base, advanced decay throughout upper bole, fibrous, hard to firm, reddish brown
4	Few or no stubs	Broken	Variable	Sloughing	Cubical, soft, reddish to dark brown	Advanced decay at base, sloughing from upper bole, fibrous to cubical, soft, dark reddish brown
5	None	Broken	< 20%	Gone	Gone	Sloughing, cubical, soft, dark brown, OR fibrous, very soft, dark reddish brown, encased in hardened shell

Height to Crown (branches in two quadrants)



Basal Area (BA)

Use a hand-held basal area gauge to conduct plotless estimate of stand basal area. We will use a basal area factor (BAF) of 20 in most cases, but user can choose a different BAF if fewer than 6 trees (use smaller BAF) or more than 9 trees (use larger BAF) enter. Hardwood stands often require a BAF of 10. Make sure to record the BAF used.

1. Carry out a plotless estimate of stand basal area. Enter the number of live and dead trees counted with the basal area gauge ("Cruzall") or prism, by species, using the BAF factor entered above. In each blank cell, write the tree name above the line (if unknown, write "UNK"), and the number of live or dead hits. Live and dead counts of the same species will be recorded on two different lines.

Regeneration (1/70-acre plot, 4.37m radius)

1. Establish a plot with a radius of 4.37 m, area = 60 sq m. Use pin flags to mark four places around the perimeter for reference (usually along transect tapes).
2. Tally number of tree ***seedlings*** (< 1.37 m in height) of each species (conifer and hardwood) for age classes 0 (first year) and 1+ (older than one year) seedlings (see figures below).
   a. Record height for the tallest individual seedling in each species

3. Enter data for each individual tree ***sapling*** (>1.4 m tall but <7.6 cm dbh) of each species (conifer and hardwood). Use a separate row for each individual entry. Measure and enter DBH and height.
    a. If groups of saplings (>5) are an obvious cohort, find modal DBH and height, but enter each individual from the cohort by row and use the modal measurements for each line per individual.
4. Enter data for each individual resprout of tree species (hardwood/broadleaved species). Hardwood clusters/resprouts may be counted as a group unless clumps are >1 meter apart, in which case they should be considered as separate resprouts.
    a. Record dbh if >1.4 m tall, the number of sprouts originating from each resprout clump, and the height of the tallest sprout.

- Cotyledons needle-like, isosceles triangle, glaucus above (except PICA)
    - Glaucus above
        - 3-4 (~7) cotyledons, 16-30 mm..........PICO
        - 6-10 (usu 7-8) cotyledons, 16-30 mm..........PIMO
        - 7-13 cotyledons, 40-80 mm, ±serrulate near base..........PIJE
    - Not glaucus above
- Cotyledons linear, obtuse triangle
        - >10 mm long cotyledons <--> <10 mm, 3-4 cotyledons, glaucus above.......TSME
        - Outer bud scales elongate and free, not resinous, light red-brown, 6-13 cotyledons, 30-45 mm..........ABMA
        - Outer bud scales not elongated or free, resinous, dark brown, 5-8 cotyledons, 20-30 mm..........ABCO
        - Young needles with acute end, tiny bristle, not glaucus, reddish scales, 5-8 (~10) cotyledons, 12-25 mm..........PSMA

Species Cover (1/10-acre plot)

1. Enter the species lifeform (shrub, forb, graminoid, fern, etc.) and live/dead status.
2. Enter the layer code of the plants you are measuring (see the Cheat sheet: TOV = overstory tree; TSA = saplings; TSE = seedlings)
    a. For each tree and shrub species, there may be multiple layer classes
    b. For example, most tree species will be in the TOV layer as well as the TSA/TSE layer
3. Enter the species code and record percent cover to nearest 1%.
    a. If the phenology is not well-aligned with the sampling episode, then species ID for the forb and graminoids may not be possible.
4. Enter modal height of each **shrub** species to the nearest 0.1m. If any cover types are present in plot but make up less than 1%, record the percent cover as "**tr**" - this represents trace cover.

Woody Fuels

1. Fuels data will be collected from four Brown's transects (Brown 1974). The transects are laid out at the cardinal directions that coincide with plot axes, stretching from the plot center to 37'

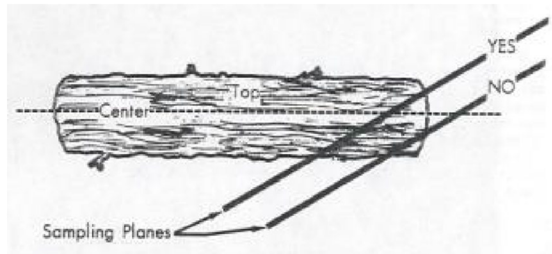
(11.3 m). The ends of the transects are the starting points, i.e., they are read starting from the edge of the plot, heading toward the middle.

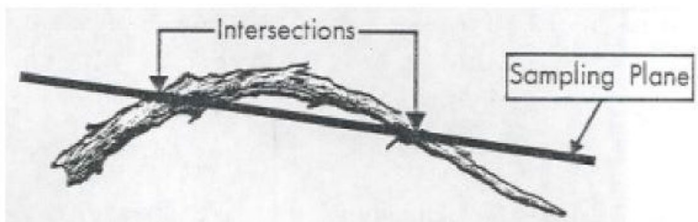
2. Enter the azimuth of the transect. Since they will be in the cardinal directions, it is OK to write, N, S, E, or W for the four different transects, rather than putting the azimuth in degrees, but if you have to diverge from the cardinal directions, then write in the azimuth in degrees. There will be four transects with the same plot number. Record transect slope if ≥20 percent.
3. Use a go/no go gauge to record the following:
   a. The number of **1-hr fuels** (<0.64 cm) that intersect the transect between the *last* ***2 meters*** of the transect line (11.3 m - 9.3 m).
   b. The number of **10-hr fuels** (0.64-2.54 cm) that intersect the transect between the *last* ***2 meters*** of the transect line (11.3 m - 9.3 m).
   c. The number of **100-hr fuels** (2.54-7.62 cm) that intersect the transect between the *last* ***4 meters*** of the transect line (11.3 m - 7.3 m)
4. **Litter & duff** fuel depth: Measure litter and duff at transect starting point (outside edge of plot) and again at the 4 m mark.
   a. Litter is undecomposed or only partially decomposed organic material that can be readily identified (e.g., plant leaves, needles, twigs, etc.).
   b. Duff is between the litter and mineral soil, and includes decomposing organic material, decomposed to the point that there are no clearly identifiable whole organic materials like pine needles, leaves, twigs, etc., although larger decomposing tree branches etc. can sometimes be found in duff.
5. Measure **fuelbed depth** at **0 m** (transect starting point) and again at **4 m** in from edge of plot. Fuelbed depth is the height between the bottom of the litter layer (top of duff) to the highest dead fuel not attached to a rooted plant (branch or needle or stick, etc.).
6. Collect information on every piece of **coarse woody debris (CWD)** that intersects the transects and meets the minimum criteria:
   a. Central longitudinal axis of the CWD intersects the transect.
   b. The diameter at the point of intersection is ≥3" (7.6 cm)
   c. Species code of CWD particle (if possible). If unknown, use UNKN as species code.
   d. Location of the CWD piece on the transect (distance from plot center).
   e. Enter the decay class (see cheat sheet)

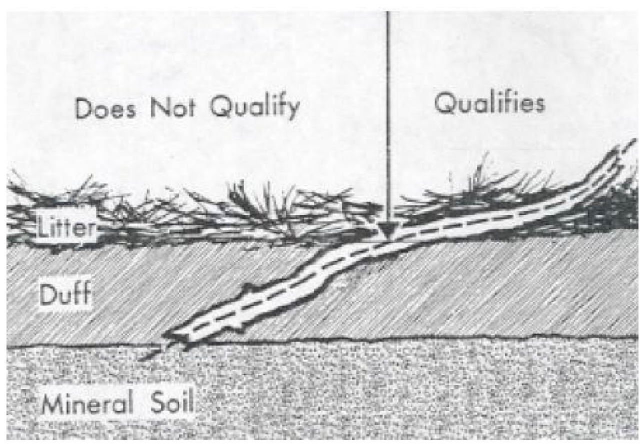
Notes:

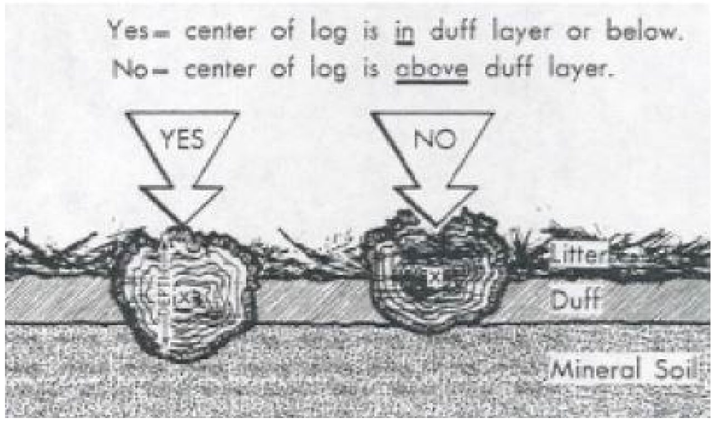
- To qualify as fuels, particles must be severed from the original source of growth.
- Be sure not to count dead shrub limbs that are attached to a standing shrub, whether the standing shrub is dead or alive. You may need attempt to move fuels to see if they are free from their source of growth.
- Do not count needles, grass, bark, or cones.
- If a branch or log intersects the transect at its end, the central axis must intersect the transect for the piece to be tallied (Fig. 3)
- Count both intersections for a curved piece (Fig. 4)
- Regardless of size, pieces are only tallied when their intersection with the transect lies above the litter and duff layers (Fig. 5)
- Do not count stumps that are still rooted in the ground.

Woody Fuel Cheat Sheet


YES
NO
Top
Center
Sampling Planes

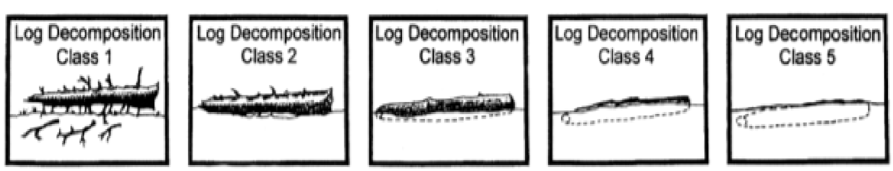

Intersections
Sampling Plane


Does Not Qualify
Qualifies
Litter
Duff
Mineral Soil



Log Decay Class

Code	Bark	Twigs	Texture	Shape	Wood Color	Portion of log on ground
1	Intact	Present	Intact	Round	Original	None, elevated on supporting points
2	Intact	Absent	Intact to soft	Round	Original	Parts touch, still elevated, sagging slightly
3	Trace	Absent	Hard large pieces	Round	Original to faded	Bole on ground
4	Absent	Absent	Soft blocky pieces	Round to oval	Light brown to faded brown	Partially below ground
5	Absent	Absent	Soft, powdery	Oval	Faded light yellow or gray	Mostly below ground



Plot Checklist

1. Review the final plot checklist to make sure everything has been accomplished before moving on.

Post-fire sampling

1. Check the status of the rebar cap and replace/re-write plot ID on cap, if necessary.
2. Plot Description
   a. Enter the plot #, date and observers initials.
   b. Enter the burn unit ID or burn date.
   c. Photos
      i. Take a photo of the labeled rebar cap, make sure the tag number is visible or use a wipe board with the plot number.
      ii. Take one photo of each cardinal direction moving clockwise, from the end of the opposite transect (N, E, S, W)
      iii. For example, you should be standing at the S transect end to take a photo of the N transect end.
   d. Measure ground cover (%) in the 11.3 m circular plot. Include the following: ash substrate and blackened litter/vegetation
   e. Estimate the % cover of bare soil (to nearest 5%) in the 11.3 m circular plot.

3. Assess overall Fire Severity Class of plot, based on the following table:

Fire Severity Class	Description
0	Unburned
1	Light patchy burn pattern, very little overstory mortality, groups of surviving shrubs/saplings
2	Lightly burned, isolated overstory mortality, most shrubs/saplings dead
3	Moderately burned, mixed overstory mortality, understory mostly burned to ground
4	High severity, significant proportion (75-100%) of overstory killed, dead needles remaining on trees 1 year later
5	High severity burn, total/near total mortality of overstory, most needles consumed in fire

4. Estimate the **percent scorch** (volume affected by fire) for each lifeform (shrubs, graminoids, forbs).
5. Trees
   a. Assess the status (L/D) of each tree previously measured in the plot.
   b. If a tree was damaged or broken during the fire, re-measure the height (m), height to live crown (m) and height to crown (m).
   c. Enter decay class (1-5), see table (dead trees)
   d. Assess crown **scorch** and **torch** for each tree previously measured in the plot.
      i. Measure **average scorch height** (m) and torch height (m) for each tree.
      ii. Estimate **% scorch** and **% torch** for each tree.
      iii. Measure the **average bole char** height (m) for each tree. This is an average of the high and low sides (if difference exists).
6. Re-measure entire Woody Fuel protocol (see above).

7. For sampling episodes at, or beyond, one-year post-fire (i.e., not immediate post-fire):
    a. Re-measure entire Regeneration protocol (see above).
    b. Re-measure entire Vegetation Cover protocol (see above).
    c. Re-measure entire Species Cover protocol (see above).
    d. Re-measure entire Basal Area protocol (see above).
8. For sampling episodes at, or beyond, two years post-fire:
    a. Re-measure entire Trees protocol (see above).

Reference Cited:

Brown, JK. 1974. Handbook for inventorying downed woody material. USDA Forest Service Intermountain Research Station General Technical Report INT-16.

Citation:

CAL FIRE. 2023. Forest Health Grant and Prescribed Fire Protocols for Field-Based Monitoring Manual (V0.3). ***Insert final web location here***

Acknowledgements:

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