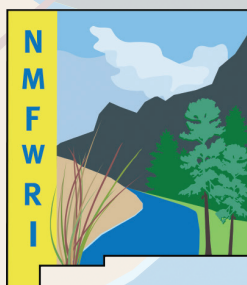


Guidelines and Protocols for Monitoring Upland Forests **Field Manual**



New Mexico
Forest and Watershed
Restoration Institute

New Mexico Highlands University

Guidelines and Protocols for Monitoring Upland Forests Field Manual

First Edition, 2024

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Dedication

To all who strive for adaptive management.

Feedback

Speaking of adaptive management – do you have feedback on this manual? Please share it! Contact us through nmfwri.org or call 505-426-2080.

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INTRODUCTION

1.0 Welcome to NMFWRI: About Us

The New Mexico Forest and Watershed Restoration Institute (NMFWRI) is a Research and Public Service Program (RPSP) based at Highlands University (HU) in Las Vegas, NM. NMFWRI staff with expertise in geospatial information systems, ecological monitoring, outreach, education, and collaboration work alongside partnering organizations around New Mexico to build capacity and develop projects that lead to healthier ecosystems and communities.

NMFWRI Institutional Alliances and Partnerships

NMFWRI is one of three Southwest Ecological Restoration Institutes (SWERI), which also include the Ecological Restoration Institute (ERI) at Northern Arizona University (NAU) and the Colorado Forest Restoration Institute (CFRI) at Colorado State University (CSU). Congress created the SWERI with the Southwest Forest Health and Wildfire Prevention Act of 2004 (SWERI Act) to promote the use of adaptive ecosystem management to reduce the risk of catastrophic wildfire and restore the health of fire-adapted ecosystems in the Interior West.

NMFWRI also participates in the Forest Restoration Triangle (FORT), along with the Department of Forestry at HU and the John T. Harrington Forestry Research Center, operated by New Mexico State University (NMSU) and located in Mora, NM. The three FORT entities share a common board that meets biannually to coordinate and review the activities of the three institutional partners.

SWERIs collaborate with a diverse set of partners and affected entities to build capacity in forest restoration, and the institutes support cooperative efforts such as shared stewardship. The partners that the SWERIs collaborate with, and the affected entities that the SWERIs serve, include land managers and regulators, such as federal, state, local and tribal agencies; interested or affected stakeholders; concerned citizens; organizations representing natural resource users; traditional groups including land grants and acequias; state and local representatives; and political subdivisions of states, such as soil and water conservation districts. SWERI administrators and staff respond to the current needs of partners and affected entities while also anticipating and preparing for future challenges.

NMFWRI Statutory Purposes and Duties

NMFWRI began operations in 2005. The SWERI Act defines the purposes and duties of the SWERIs and creates a framework for the three institutes to align their operations, cooperate with federal agencies, collaborate with partners, and serve affected entities.

The general purposes and conditions of the SWERIs listed in the SWERI Act are:

1. Promote the use of adaptive ecosystem management.
2. Reduce the risk of wildfires.

1.0 Welcome to NMFWRI: About Us

3. Restore the health of forest and woodland ecosystems in the interior West.
4. Promote the use of collaborative processes.
5. Prepare an Annual Work Plan that ensures the proposed work of the Institute serves the informational needs of affected entities.

The duties of the SWERIs as defined in the SWERI Act are:

1. develop, conduct research on, transfer, promote, and monitor restoration-based hazardous fuel reduction treatments to reduce the risk of severe wildfires and improve the health of dry forest and woodland ecosystems in the interior West;
2. synthesize and adapt scientific findings from conventional research to implement restoration-based hazardous fuel reduction treatments on a landscape scale using an adaptive ecosystem management framework;
3. translate for and transfer to affected entities any scientific and interdisciplinary knowledge about restoration-based hazardous fuel reduction treatments;
4. assist affected entities with the design of adaptive management approaches (including monitoring) for the implementation of restoration-based hazardous fuel reduction treatments; and
5. provide peer-reviewed annual reports.

NMFWRI Mission Statement: The New Mexico Forest and Watershed Restoration Institute works to reduce catastrophic wildfires and restore resilient, fire- and climate-adapted ecosystems. We collaborate with partners and engage communities to bridge scientific and local knowledge and build capacity in landscape-scale adaptive management.

NMFWRI Vision Statement: The New Mexico Forest and Watershed Restoration Institute envisions a fire- and climate-adapted New Mexico that prioritizes cross-boundary collaboration for healthier human and ecological communities, sustainable economies, and social justice.

As of 2024, staff are organized into three programmatic areas: Administration, Coordination & Organizational Development (Education & Outreach; Public Information); Technical and Applied Science Programs (Geospatial Information Systems, Ecological Monitoring); and Civic and Community Action Programs (Collaboration, Conservation Science Center).

NMFWRI Ecological Monitoring Program: Ecological monitoring data provides the scientific basis for restoration treatments and is critical for adaptive management. NMFWRI's Monitoring Program maintains a professionally managed field crew to collect data on short- and long-term ecosystem response to restoration treatments and other disturbances. The field crew also provides hands-on internship opportunities for students and recent graduates to help build New Mexico's forestry workforce. Staff collect data on partner needs and opportunities related to monitoring and adaptive management and respond to those needs through

initiatives and projects such as: creating a statewide monitoring data repository and suite of analytical tools, building a network of groups participating in ecological monitoring, and building statewide capacity for ecological monitoring and restoration work through monitoring protocol trainings and technical support.

Our goal is to become a long-term, capacity-building force within the restoration economy with a focus on assisting our partners in overcoming obstacles currently limiting use of the adaptive management model.

In 2024, projects of the Ecological Monitoring Program include:

- Monitor forested and riparian ecosystems throughout New Mexico. Provide quality, hands-on internship opportunities for college students and recent graduates in natural resource management to help build New Mexico's forestry workforce.
- Develop a database of partners working in ecological monitoring statewide; survey needs across partner organizations and develop strategies to meet those needs.
- Establish NMFWRI as a repository for ecological monitoring data collected across the state, building from our own dataset. Develop data pipelines with partners and suites of analytical tools suited to their needs.
- Conduct database analysis to investigate project-, program-, and landscape-level trends in forest and watershed health and the impacts of restoration efforts. We are uniquely situated to do this because of our own long-term monitoring datasets as well as our network of partners.
- Provide on-demand technical assistance and training in restoration and monitoring methods, protocols, and analysis to build capacity among partners and communities.
- Support the development of professional monitoring and restoration capacity across the state by expanding access to formal training (in-house or contracted) and developing accessible training materials (manuals, videos, brochures) on monitoring and restoration methods. We envision a network of professionally trained crews available to contract with agencies.
- Regularly report on and share our findings with partners and the public; set up a library of equipment, technical literature, and herbarium specimens and develop a system for providing managed access to local students and professionals.

INTRODUCTION

1.1 Why We Monitor

Ecological Monitoring efforts have been a vital part of NMFWRI since the Institute's beginning. NMFWRI has hired foresters and forestry students to collect ecological monitoring data on forest restoration treatments since 2007, which established a state-wide network of long-term monitoring sites. Ecological monitoring data provides the scientific basis for restoration treatments, such as thinning and prescribed burns, and is critical for adaptive management. Professionally collected and analyzed monitoring data can help answer questions about what works and what doesn't when forests are managed for a specific outcome such as reducing wildfire risks or increasing wildlife habitat.

More about adaptive management

Adaptive management means learning from experience. Less simply, it is a structured decision-making process that, when implemented by resource managers, should result in more informed management decisions and ecological responses that more closely match the desired and predicted outcomes. The process is defined variously in literature, but it is commonly visualized as an iterative feedback loop.

In theory, resource management should improve as more and more information (experience) becomes available. However, the Department of Interior's Adaptive Management Technical Guide (Williams & Brown, 2012) acknowledges that although adaptive management is frequently referenced by managers and management plans, it is in fact "infrequently implemented" (p. 1). Instead, processes such as trial-and-error are more common. It is this gap in ecological data that NMFWRI's long-term monitoring seeks to fill, with the recommendation that future re-evaluations should be standard practice as more data becomes available. A goal of the United States Forest Service (USFS) is to develop feedback loops using monitoring data (USDA Forest Service, 2009, p. 28). This monitoring data can provide a basis for adaptive management in both monitoring design and project implementation and follow-through for future restoration projects, including more information on the interval needed for project maintenance and/or re-entry. For instance, preliminary field crew observations of the Collaborative Forest Restoration Program (CFRP) suggest that some projects are "escaping" (i.e. returning to pre-treatment conditions in some metrics) around the 10-year mark, which a program-wide analysis also suggests may be occurring in dry mixed-conifer projects. Management implications might be that forests need to be retreated more frequently.

More about what we do

NMFWRI has conducted a variety of different ecological monitoring programs under different protocols including: wildlife monitoring, such as pellet counts, bird/butterfly surveys, etc.; rangeland monitoring, including line-point intercept transect monitoring; riparian monitoring, including plot-based protocols and New Mexico Rapid Assessment Method (NMRAM) monitoring; and upland forest monitoring, which the rest of this manual will focus on.

Riparian monitoring with GRGWA

NMFWRI has coordinated with the Greater Rio Grande Watershed Alliance (GRGWA) to conduct pre- and post-treatment monitoring on primarily riparian projects since 2011. The Greater Rio Grande Watershed Alliance is a collection of soil and water conservation districts, Pueblos, agencies, and other stakeholders in the watershed for the Middle Rio Grande working on landscape-scale watershed restoration, with a focus on non-native phreatophyte removal from the bosque. They use a variety of techniques including extraction, mastication, aerial, basal, foliar, and cut-stump herbicide applications, and planting grass, trees, and shrubs. They follow community, statewide, and national management and conservation plans and monitor the effectiveness of their restoration efforts.

The riparian field season typically runs from August through leaf-off in November. Re-measurements occur within a 2-week window of the original measurement date. NMFWRI has conducted pre- and post-treatment project monitoring and completed reports for each project monitored (<https://nmfwri.org/projects/forest-monitoring/greater-rio-grande-watershed-alliance/>). Our website hosts an extensive collection of reports and repeat photographs, a riparian monitoring guide (https://nmfwri.org/wp-content/uploads/2020/07/Riparian_forest_monitoring_guidelines-1.pdf), as well as a GRGWA Projects online map (<https://www.arcgis.com/apps/webappviewer/index.html?id=9aae429929c145418a4d5bf9296f65d1&extent=-12013351.3984%2C4110609.7455%2C-11735426.3635%2C4381808.3219%2C102100>).

The rest of this manual will focus on monitoring methods and protocols used primarily in upland forests. However, many of the techniques outlined in this manual (related to use of tools, etc.) are applicable within the riparian protocol referenced above.

Upland monitoring & CFRP

NMFWRI has partnered with USFS and other agencies to monitor more than 2,350 plots in the Collaborative Forest Restoration Program (CFRP) and other restoration projects across the state since 2007. One of our longest-running upland monitoring projects includes the remeasurement of selected CFRP projects at 5-year intervals.

The CFRP was initiated in 2001. Through this New Mexico-specific program, the USFS provided cost-share grants to many small-scale collaborative forest restoration projects carried out on federal, tribal, state, county, or municipal forest lands. Each year, a Technical Advisory Panel met and selected projects to fund from applications submitted by partnerships representing a variety of interests. Grants were for up to \$360,000 with a 20% partner match, and projects lasted 3 to 4 years. Projects could cover pre-treatment planning and carrying out analyses required by the National Environmental Policy Act (NEPA), implementing the actual on-the-ground treatments, and purchasing equipment to assist in carrying out treatments and processing timber removed from treatment sites.

The Community Forest Restoration Act (Title VI, Public Law 106-393), which established CFRP, called for monitoring of “the short- and long-term ecological effects of the restoration treatments” for at least 15 years. In 2008, 20 CFRP projects were identified for long-term monitoring (criteria available here: https://nmfwri.org/wp-content/uploads/2020/07/wp5_-draft_2-1.pdf). NMFWRI has been responsible for long-term vegetation monitoring of selected CFRP projects at 5, 10, and 15-years post-treatment since that time.

1.1 Why We Monitor

Our involvement with CFRP has been supported with federal funds, typically through our congressional appropriations, and at times with additional support from USFS supplemental funding.

In 2021, we completed an analysis of the ecological impacts of the CFRP Program from 2003–2020. This report is available on our website (https://nfmwri.org/wp-content/uploads/2022/02/CFRP_Sustainability-2021_report_final_draft_9_17_21.pdf). Our website hosts a regularly updated collection of individual project reports (<https://nfmwri.org/restoration-information/cfrp/cfrp-long-term-monitoring/>) as well as an online map (<https://www.arcgis.com/apps/webappviewer/index.html?id=1ff53fe01cbd43d9a24657225a24386c&extent=-12406484.6521%2C3666886.861%2C-10850838.2524%2C4481399.8344%2C102100>). All data collected on public lands are available upon request.

Post-wildfire

Having a network of long-term monitoring sites across the state allows opportunities to conduct monitoring on the impacts of not only restoration treatments but also disturbances, such as wildfire impacts. Post-wildfire monitoring provides unique opportunities to build on our existing knowledge about fuel treatments, prioritization, spatial fire planning, and strategies for recovery in a post-fire world. Making the most of the opportunities offered by post-disturbance monitoring allows us to contribute to the landscape-level and statewide understanding of the effectiveness of this type of restoration work in the face of wildfire impacts and learn more about long-term treatment effectiveness and treatment longevity. Generally, this data collection needs to happen immediately post-fire to best capture fire effects – rather than mitigation impacts, monsoon impacts, or some other effect – and the impacts of missing this opportunity are permanent and irreversible.

INTRODUCTION

1.2 Best Practices for Ecological Monitoring

What follows is a brief overview of the monitoring process. We have included suggestions of things to think about based on our lessons learned in doing this work. We recognize that this list is likely insufficient to support you in designing a monitoring effort from scratch. Fortunately, there are several excellent, detailed guides available for free that exist specifically to help you design a monitoring plan that meets your needs. We have links to a few of our favorites at the end of this section.

Determine project goals

- Determine project goals and interests.
- What are your scientific question(s) of interest?

Determine what indicators to monitor

- What indicators will give you information to evaluate each goal? Examples of indicators may include basal area, seedling density, or surface fuel loads.

Select appropriate data collection procedures

- What methods are needed for the indicators selected?
- What analyses of these results will you use? (use sound statistical principles)

Establish spacing and number of measurements throughout the project (scale)

- Consider the scale at which you are monitoring; project vs landscape, etc. Operate at an appropriate scale. For instance, if your monitoring is intended to quantify landscape-level trends then your sampling design should include randomly selected sites from across the landscape of interest.
- Spacing and density of measurements may be determined by the indicator and analysis method for statistical validity.
- Consider the benefits of randomization and stratification by vegetation communities or treatment units.
- Consider how to minimize impacts of limited access to sites on final sample size.

Determine when and how often to take measurements

- Be aware of the impact of season and sensitivity of your indicator.
- Gather baseline data before the project begins.
- Repeat the same measurements after the project is completed.
- Repeat the same measurements at regular intervals after project completion (5, 10, 15 years).

1.2 Best Practices for Ecological Monitoring

- Repeat the same measurements post-disturbance (e.g. wildfire).
- If appropriate, stratify your sample area into treatment units or distinct vegetation communities and sample randomly within stratified units. This will reduce unexplained noise in later statistical analysis and facilitate understanding the effects of treatments.
- Have your measurement locations permanently monumented whenever possible.

Establish who will take measurements

- Consistency is key; try to keep the same person or team involved throughout a project.
- Ensure your team has had rigorous training and has access to training materials in the field.
- Have a clear Quality Control (QC) process to identify and address concerns with the data.

Establish when and how to analyze data

- Understand how to analyze your data and when it is useful to do so.
- Consider different analysis options; for instance, when might you want to utilize photo comparisons vs statistics to best communicate a change?
- Use software or coefficient sets appropriate to the project area (for instance, make sure the formulas used in summary calculations include constants developed for the habitat or region in which you are working).
- Seek assistance if needed in interpreting results.
- Preliminary and historic data are useful in identifying trends or immediate treatment impacts; long-term data may highlight other trends or provide information on treatment longevity/need for maintenance.

Establish where and how to store data

- Determine which data points are required for the monitoring methods used by your project, as well as what additional information you will want to collect and document.
- Make sure all relevant information is documented (monitoring methods used, treatment information, etc.) and make it as easy as possible for anyone else to pick up where you've left off.
- Reduce risk of loss through proper data management – work with a data manager to outline a management plan and organizational system for your project.
- Determine how to keep your data safe, available, and understandable to others.
- Consider uses and limitations of paper data versus electronically collected data. For example, using paper datasheets may be faster in the field, but requires additional labor to enter the data later. Using electronic data collection allows for opportunities to build in QC checks to catch potential entry errors, but is more time- and equipment-intensive.

- Ensure multiple copies of data are stored (e.g. scan your paper datasheets, make backups of electronically collected data, etc.).
- Establish a data-sharing protocol with partners.

Encourage adaptive management

- Monitoring results are useful ONLY when they are analyzed, interpreted, and shared with managers to provide lessons learned and inform future design making.
- Identify target audience(s) and make efforts to share data, reports, and implications with them.

A Sampling of Resources for Monitoring Design

General Design

General Sampling Design Support: <https://www.epa.gov/sites/default/files/2015-10/documents/chap2.pdf>

Forests

USFS Common Stand Exam: <https://www.fs.usda.gov/nrm/fsveg/index.shtml>

USFS R3 Multiparty Monitoring: https://www.fs.usda.gov/detail/r3/workingtogether/grants/?cid=fsbdev3_022173

CFRP Ecological Monitoring Handbook: https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5345347.pdf

Ecological Goals and Indicators: https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fsbdev3_020912.pdf

Monitoring Tools and Methods: https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fsbdev3_021209.pdf

NPS Fire Monitoring Handbook: <https://www.nps.gov/orgs/1965/upload/fire-effects-monitoring-handbook.pdf>

Photoload Sampling Technique: https://www.fs.usda.gov/rm/pubs/rmrs_gtr190.pdf

CFRI Monitoring Protocols: https://cfri.colostate.edu/publication/?_sf_s=protocol

Riparian

NMED SWQB NMRAM: <https://www.env.nm.gov/surface-water-quality/wetlands-rapid-assessment-methods/>

NMFWRI Riparian:

https://nmfwri.org/wp-content/uploads/2022/02/Riparian_forest_monitoring_guidelines-1.pdf

https://nmfwri.org/wp-content/uploads/2020/07/Riparian_Monitoring_Field_Handbook2_14sm-1.pdf

1.2 Best Practices for Ecological Monitoring

Range/ Grassland, Shrubland, Savanna

Monitoring Manual for Grassland, Shrubland,
and Savanna Ecosystems: <https://archive.jornada.nmsu.edu/monit-assess/manuals/monitoring>

Design for Range: <https://www.landscapetoolbox.org/monitoring-design/>

WELCOME TO MONITORING

2.0 Summary of Plot Protocols

In use in current form since 2016

Note: These protocols are based on the standard procedures of the USFS's Common Stand Exam, DOI's FEAT/FIREMON Integrated, and recommendations for standards made by Derr et al. (2008) for Long-Term Monitoring of New Mexico's Collaborative Forest Restoration Program.

The USFS's Common Stand Exam chapters found here: <https://www.fs.usda.gov/nrm/fsveg/index.shtml>

DOI's FEAT/FIREMON Integrated information and user guide found here: <https://www.frames.gov/ffi/home>

Crews, Navigation, & Plot Setup

Plots are most efficiently accomplished with a 3-person crew (*See Supplement A*) but can also be taken with 2 people. More detailed plots, presented here as options, are most efficient with a 4- to 5-person crew. All crews need basic knowledge of monitoring methods and rationale, equipment, plant species, and common tree pests and diseases.

Plots are established using a random point location with project-specific boundaries (e.g., stand boundaries, treatment areas, vegetation types, etc.). For instance, for some upland projects, the following distribution rationale is used based on stand boundaries (more detailed rationale is available upon request):

For Stands 1-50 acres, 1 plot per 10 acres (standard)

For Stands 51+ acres:

51-70 ac – 5 plots

71-90 ac – 6 plots

91-110 ac – 7 plots

111-200 ac – 8-9 plots

201-400 ac – 10 plots

In our office, maps and plot locations are generated with ArcGIS utilities and are loaded onto a high-precision GPS unit (such as a Trimble GeoXT or Juniper Systems Geode GNSS Receiver with tablet) as well as smaller handheld GPS units (such as Garmin GPSMAP units). Unit maps, driving maps, and driving directions are created and sent with the field crew. Once in the project area, navigation to a plot is typically accomplished through paper maps and the handheld units. Paper maps can be easily marked with markers to indicate sequence of plot collection, dates, and teams at work; this information can be stored with the datasheets and may help answer questions that arise later (*See more in Ch. 5*). We use the handheld units because they are user-friendly and can run on AA batteries, which are easily replaced in the field. We use the high-precision unit to more accurately determine plot location and to collect updated plot location coordinates (*See more in Ch. 12*). Plots must be moved one chain (66 ft) at a random azimuth from their original,

intended location if they are within 75 ft of a road. Make sure to document if a plot was moved for future monitoring instances.

A marker – we typically use a 1 ft piece of ½ inch rebar with a plastic mushroom cap – is installed at plot center. Where plots are being re-visited, a good metal detector may be of use to locate the center stake. Copies of the previous plot photos can also be useful. Plots are set up using 8-9 pin flags in addition to the center stake (Figure 1 - pg 19). Preferred colors include blue or orange. Crew members walk cardinal azimuths (N, E, S, W) from plot center and place pin flags at 11.78 ft (11' 9") and 37.24 ft (37' 3") to give visual aids for the two plots (1/10th ac and 1/100th ac) whose purposes are described below.

Photographs, Witness Trees, & Other Plot data

Seven photo points are taken per plot. If more than one Brown's transect is collected, additional photographs are taken in the same format. Typically, a white board with marker is used to tag each photo. The first photo taken at each plot is of the white board on the ground at plot center (PC). This ensures the data technicians are able to read the plot name and number and correctly identify the photos that follow. It is helpful if the camera used can record GPS coordinates.

Additional photos include:

- “C,” (center) taken from 75 ft along the North azimuth looking at a crew member holding the white board at plot center.
- Brown's transect photo, “BR_degrees” taken from the 75 ft mark of each fuels azimuth looking towards a crew member holding the white board at plot center.



A “center” photo shows a crew member at plot center. *Photo by NMFRI Field Crew*



Plot photo showing flagged witness. Photo by NMFRI Field Crew

- “N,” “E,” “S,” and “W” photos taken from plot center facing a crew member holding the white board at 37.24 ft at each of the four cardinal azimuth flags. Additional photographs may be taken, but we recommend these be taken after the mandatory seven plot photos, and noted on the data sheets, so that there is no confusion for the data technicians.

The photo order must be recorded on the data sheets, for example, PC, C, N, BR75, E, S W. If photos are being re-taken from a previous year, it is critical to bring along copies of the previous photographs to be sure the frames and landmarks match up. In addition to recording the order of the photo points, record the camera number/model and photo numbers to aid in photo labeling, for example, CAMER001, PC (100-0434), C (100-0435), N (100-0436), etc. (*See more on photos in Ch.16*).

A witness tree or trees (typically not more than two) should be near plot center to assist with finding plot center and ideally should be expected to survive any future thinning, fire, or other disturbance. For example, mature yellow-bark pines near plot center are easy to find and not likely to be thinned. Any healthy tree will work. Don't use saplings. The selected tree(s) could be tagged with metal identifiers at the base or flagged twice around DBH. This tree must be noted as a “witness” in the overstory data table (“tree page”) and described on the Plot Description datasheet in the appropriate section. Important characteristics to record include: azimuth from PC, distance from PC, species, status, height, DBH, color of flagging used, and any other notes (e.g. unusual crown shape). The position of the witness relative to the inner and outer circles should also be

indicated with an “x” if recorded on a witness tree diagram. If the witness tree died in-between monitoring instances, record it as dead. If there are other trees on the plot that are still alive, assign one of them to be the new witness. If all trees are dead, no witness will be established or re-established. Record all observations and changes (*See more on witness trees in Ch. 19.13*).

Photo order, hill slope (i.e. wherever slope is steepest), dominant aspect (by circling N/E/S/W and/or writing in the degrees), coordinates and units, elevation and units, date, and time begun are recorded for each plot. Comment fields are available on all datasheets and it is critical that all observations, including dominant species, invasive species, land use impacts, fire history, challenges in taking plot, etc. are documented here. No plot can be so unremarkable as to have a totally blank comments box (*See more in Ch. 15*).

Overstory

All trees and snags are measured within the 1/10th acre (37.24 ft radius), circular, fixed-area sample plot (*See more in Ch. 19*). We typically define a tree as ≥ 4.5 ft in height and ≥ 1.0 in DBH or DRC (wherever its diameter is taken according to protocols), although other cutoffs may be used depending on objectives. Species, condition, DBH or DRC, number of stems, total height, live crown base height, char and scorch height (if any), and other damages (mistletoe, forking, etc. if any) are recorded for each tree located within the plot. Most trees are measured at DBH apart from those multi-stem species with more than two stems at DBH (i.e. *Quercus spp.*, *Juniperus spp.*) (*See Ch. 19.3*). In instances where DBH needs to be taken at a height other than 4.5 ft (i.e. if a large burl was located directly at 4.5 ft), measure above the deformity and indicate the height where the diameter was measured in the comments. Be aware that other trees/large shrubs with multiple stems, such as mountain mahogany or chokecherry, cannot be processed if they are measured at DRC since their conversion formulas are unavailable. Depending upon the project, other information may be collected including snag decay class, crown ratio, and crown class (Blank datasheets with these additional details are available from NMFWR I upon request). Trees are recorded starting from the north azimuth line and moving clockwise, like spokes of a wheel from plot center. Depending upon management objectives and density, it may be helpful to draw a stem map indicating the location of all trees (identified by their number) relative to the cardinal azimuths and the two circles of the plot (i.e. similar to the witness tree diagram) or install metal tree tags (*See Ch. 19.2*). In dense stands, we find it helpful to flag the first tree measured to keep the crew oriented. If appropriate, this first tree may also serve as the witness tree. Do not forget to flag and record your witness tree and remember that you flag the witness tree with two strips of flagging whereas you might flag the first tree with just one.

Tree regeneration is measured on the nested 1/100th acre circular plot (11.78 ft radius). Species, condition, and height class (>0-0.5 ft; >0.5-1.5 ft; >1.5-2.5 ft; >2.5-3.5 ft; >3.5-4.5 ft) are recorded for each seedling or sprout. (Saplings ≥ 4.5 ft but under the DBH/DRC cutoff for trees (typically <1.0 in but at other times <5.0 in) are also recorded in this way (*See Fig. 2 - pg. 20*). Shrubs are measured on the same nested subplot and species, condition, and height/diameter class are recorded for each stem just as with tree species; we typically record cacti in this category as well due to their woody structure. The definition of a “shrub” may vary depending upon management objectives but typically means any woody species which is not a tree. Examples include rose, chokecherry, mountain mahogany, holly, etc. Note that other cutoffs may be used for height and diameter classes depending upon objectives (*See more in Ch. 3, 9, 10, and 18*).

Trees and shrubs are typically recorded using their USDA PLANTS code, which is commonly a four-letter code defined by the first two letters of the genus and first two letters of the species name (e.g. PIPO, ABCO, PIFL, PIED, JUDE, JUSC2, QUGA, etc.). Note that upon entry into a database, it is common for these codes to be followed by various numbers to differentiate between other species whose names would create the same code. It is critical to verify the exact match of the symbol to the species you intend to enter into the database. These symbols can be found on the USDA PLANTS website, <https://plants.usda.gov/> (See a *Species Code Cheatsheet* in Ch. 6).

Canopy cover (density) is an average of four measurements taken with a spherical densiometer. These four measurements are taken facing out at the four small-plot pin flags along the perimeter of the nested subplot. In this way, each reading is spaced 90 degrees apart. Typically, instructions for use of a densiometer can be found on the underside of the lid. More thorough instructions are provided by Forestry Suppliers (https://www.forestry-suppliers.com/Documents/4283_msds.pdf) For more on using a densiometer, See Ch. 17.

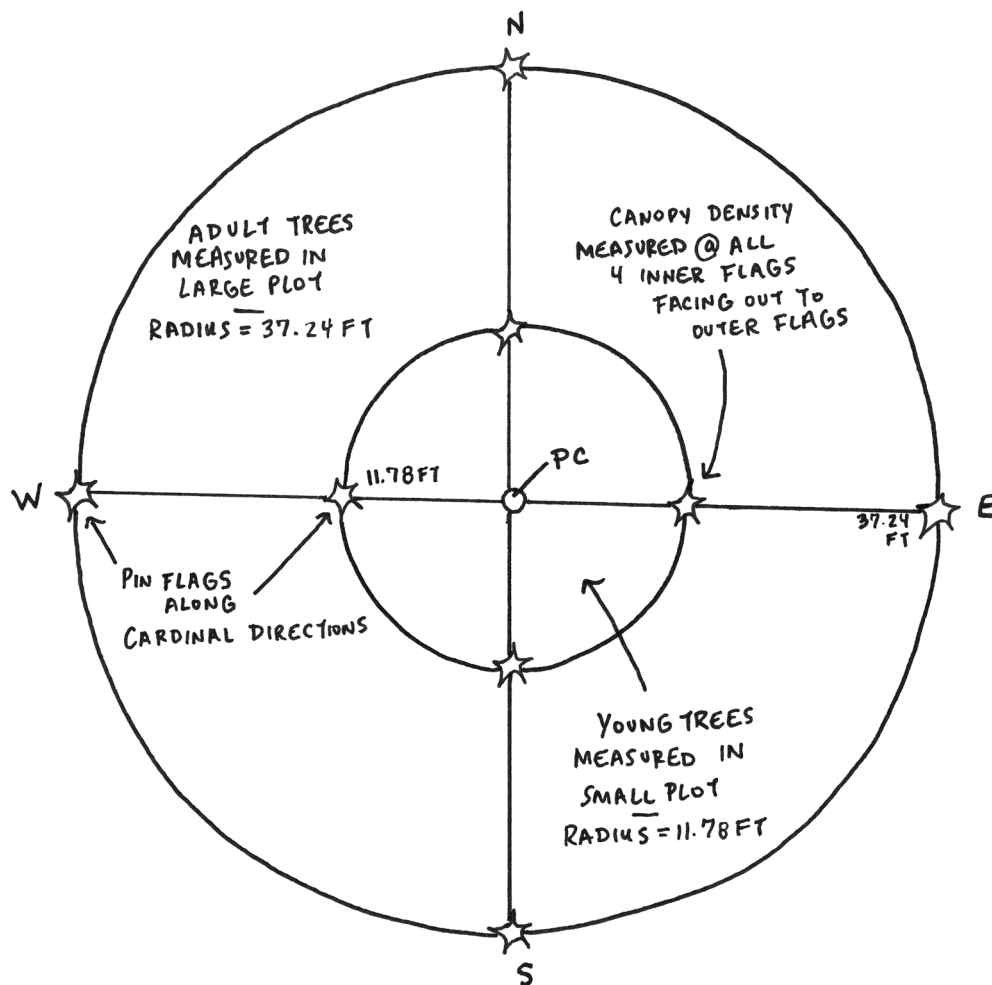


Figure 1. Plot Layout. Diagram by Meredith Prentice

TREE REGENERATION

SEEDLINGS : < 4.5 FT TALL

OR

SAPLINGS : ≥ 4.5 FT TALL
BUT < 1 IN. DBH

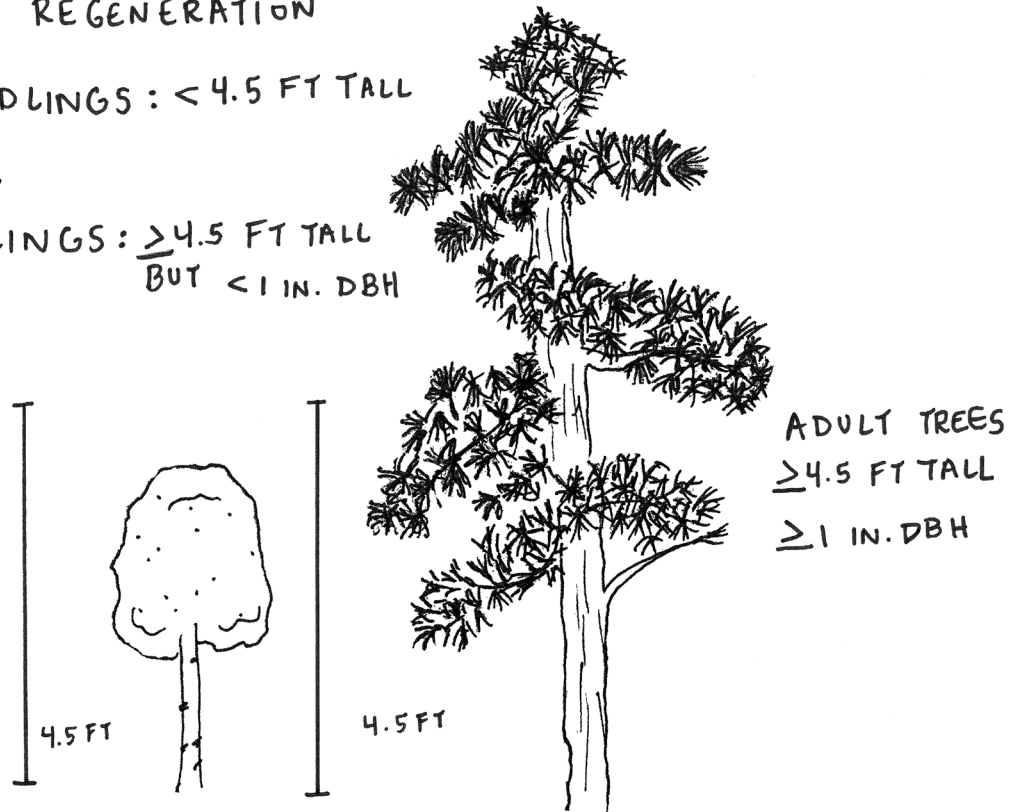


Figure 2. Tree Regeneration & Adult Trees Classifications. *Diagram by Zoe Ahrens & Meredith Prentice*

Fuels (Brown's Transects)

Dead woody biomass and forest floor depth are measured using a planar Brown's transect or transects. These transects may be at fixed or random azimuths. To select a random azimuth, one crew member spins a compass and another decides when to stop. Typically, in our protocol, a fiberglass or steel reel tape is run from the plot center stake out 75 ft and fuels are measured from 15 to 75 ft to account for the expected foot traffic disturbance around plot center. Rebar is installed at 75 ft to ensure accurate remeasurement in the future. If you have to offset the Brown's line rebar, be sure to make a note in the comments (e.g., Brown's line rebar placed at 76.5 ft due to rocks at 75 ft). Parameters measured include 1, 10, 100, and 1,000-hr fuels ("time-lag fuels"). Other lengths of transects, including variable lengths for each fuel size, may be used. Note that in our protocol, a piece of coarse woody debris (CWD) must be ≥ 3 inches in diameter and at least 3 ft long to count as a 1000-hour fuel; if it is >3 " in diameter, but under 3 ft long, we count it as a 100-hour fuel. Decay class (1 to 5), species, and sometimes length is collected for each 1000-hr fuel (See Figure 3).

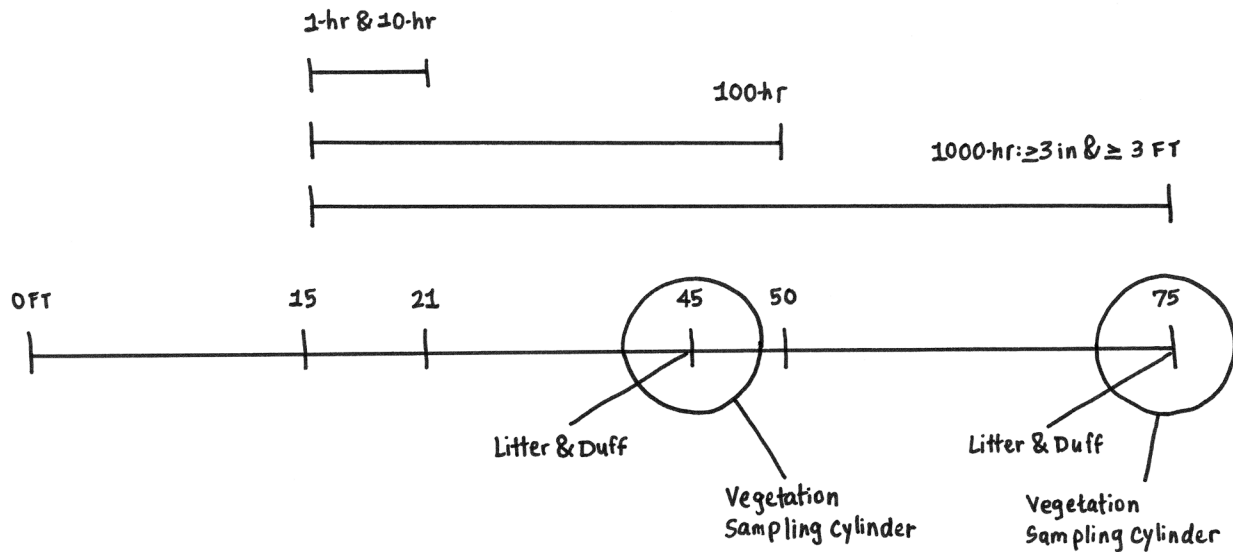


Figure 3. Fuels Transect. *Diagram by Meredith Prentice*

Percent cover and height of herbaceous live and dead (HL, HD) material percentage cover and height (up to 6 ft) of shrubby (woody) live (excluding boles of trees) and dead (SL, SD) material are estimated using 6-foot diameter cylinders per Brown's planar intersect method at 45 and 75 ft. Litter and duff depths are measured at 45 and 75 ft. The location, offset, and frequency of these measurements may be modified depending upon management objectives. For more information, see Brown 1974 and subsequent guidelines (https://www.fs.usda.gov/rm/pubs_int/int_gtr016.pdf) (See also Ch. 20).

Understory

Vegetation and ground cover are most often estimated within the nested 1/100th acre plot ("small plot"); other project managers may request these measurements be conducted across the entire 1/10th acre area. (See Figure 4). Vegetation measurements include aerial percent cover of seedling/saplings (tree regen), shrubs (woody species which are not trees, including cacti), graminoids (grasses and grass-like plants such as sedges, rushes), and forbs (flowering herbaceous plants which are not grass) and may not necessarily total 100%. Depending upon objectives and field crew skill levels, aerial percent cover may be further stratified by individual species greater than 1% cover. Ground cover measurements include percent cover of plant basal area (cacti is included in this category), boles (trunks of trees and shrubs, anything woody), litter, bare soil, rock, and gravel. Ground cover must logically total 100%. (See Chs, 3 and 18).

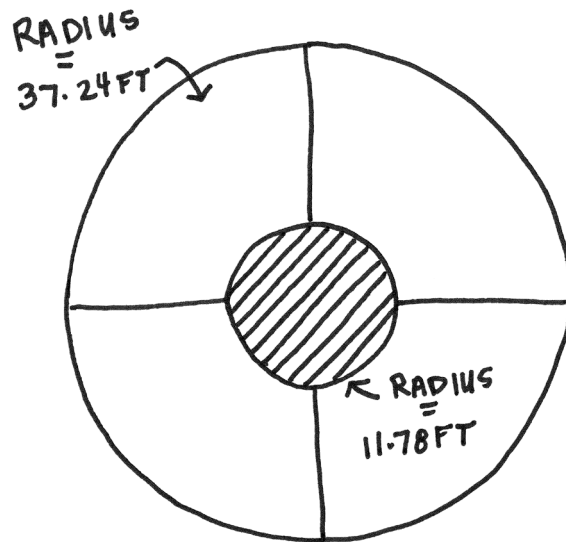


Figure 4. Understory in Small Plot. *Diagram by Meredith Prentice*

Data processing and reporting

At this time, we use Access, FFI software, Excel spreadsheets, SQL, and R to enter and analyze our data. FFI is able to export to FVS and FuelCalc. FFI software and User Guides are available for download (<https://www.frames.gov/partner-sites/ffi/software-and-manuals/>). Individual piñons, junipers, and oaks with more than two stems, or whose branch structure made access difficult were measured at DRC instead of DBH. We use DRC conversion equations developed by Chojnacky and Roger (1999) (https://www.usu.edu/beetle/documents/1999Chojnacky%20Rogers_Converting%20Tree%20Diam.pdf). All our results are typically reported to two significant digits, with exceptions for those metrics we know were measured with either more or less precision. NMFWRRI sample reports can be found on our website (<http://nmfwri.org/resources/restoration-information/cfrp/cfrp-long-term-monitoring/cfrp-long-term-monitoring>). (See more on data entry and analysis in Ch. 21).

General measurement quality standards for plots taken by our professional crews are as follows:

Measurement	Tolerance
Slope	+/- 5%
Azimuth and aspect	+/- 10°
Cover estimations	+/- 10%
Heights	+/- 0.5 ft
Diameters (DBH/DRC)	+/- 0.1in
Duff/litter depths	+/- 0.1in
Damage severity	+/- 10%
Decay Class	+/- 1 class
Seedling/sapling counts	+/- 20%
Species/status/tag #/plot #/etc	no tolerance

For most metrics, our expectation is that 95% or more of all measurements taken by our crews fall within these tolerances when compared against quality assurance checks. A detailed table of measurement quality objectives is available upon request.

WELCOME TO MONITORING

3.0 Terminology Used in Forest Monitoring

Acre (Ac) - Unit of measure for land area, 560 square ft; 10 square chains.

Aerial cover - % of ground covered when viewed from above.

Annual plant - A plant that completes its life cycle within one growing season (one year).

Aspect - The compass direction that a slope faces, expressed as, for example, “northern aspect”.

Basal area - A measurement of the cross-sectional area of trees at 4.5 ft (DBH height). Generally expressed in sq ft per acre (typically an open forest is 40-90 sqft/ac, while a dense forest is 100-160 sqft/ac or more).

Biennial plant - A plant that completes its life cycle within two growing seasons (two years).

Breakpoint diameter - Diameter above which trees become measured in detail; below which they are tallied.

Bole - Main trunk of tree or woody plant (see Figure 1 - pg. 27).

Brown’s transect - A protocol for monitoring surface fuel loads.

Caliper - A metal or wooden device consisting of an arm and two prongs, one of which is free to slide along a graduated scale on the arm. The prongs are placed against opposite sides of a tree to read its diameter on the scale.

Cactus - Succulent plant with a thick, fleshy stem; commonly with spines. Note: grouped with shrubs in all measurements except aerial cover estimations (see more detail in Ch 18).

Canopy - “Roof” of a forest formed by crowns of tall trees.

Chain - 66 ft.

Clinometer - An instrument used to measure slope and tree height.

Conifer - Trees with needle- or scale-like leaves that also produce cones; many are also evergreen and do not lose their needles every year.

Cool-season vegetation - Term used for grass species that grows better in cooler weather (e.g. early spring and fall); aka C3 vegetation.

Coarse Woody Debris (CWD) - Down woody debris including large branches, logs, snag boles leaning over 45 degrees (1000-hr fuels).

Crown - The part of the tree that includes branches and leaves (see Figure 1 - pg. 27).



Caliper. Photo by Taryn Schlosser

Diameter at Breast Height (DBH) - Measured at 4.5 ft, measured on the uphill slope of the tree.

Deciduous - Trees that lose leaves every year (e.g. apple, mountain mahogany).

Densiometer - A device with a spherical mirror used to estimate canopy cover.

Diameter tape - A measuring tape that has a scale calibrated to read a tree's diameter when wrapped around the tree's circumference; uses the value of pi.

Down Woody Debris (DWD) - The remains of fallen trees and branches on the forest floor; encompasses Fine Woody Debris and Coarse Woody Debris.

Diameter at Root Collar (DRC) - Measured close to the ground, above any swell from the roots.



Clinometer. Photo by Taryn Schlosser

Duff - A layer of partially decomposed organic material (e.g. leaves, needles, twigs) found between the mineral soil and the litter layer of the forest floor.

Fine Woody Debris (FWD) - Down woody debris including small pieces of woody material (e.g. twigs, branches) on the forest floor (1 hr – 100-hr fuels).

Foliage - Leaves of a tree or plant (see Figure 1 - pg. 27).

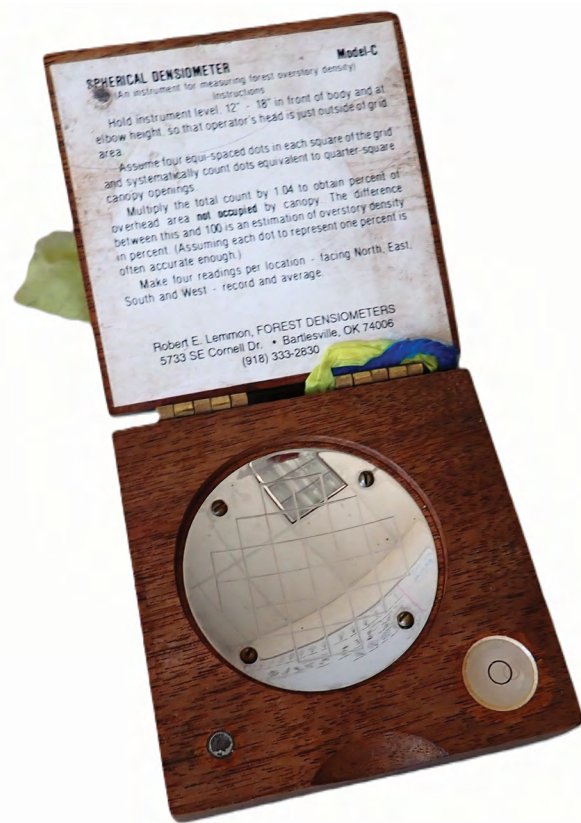
Forb - An herb, a flowering plant, other than grass (see Figure 3 - pg. 28).

Graminoid - grasses or grass-like plants (see Figure 3 - pg. 28).

Global Navigation Satellite System (GNSS) - this includes a range of international location providers such as Glonass, Galileo, and Beidou which are now incorporated into receivers such as Garmins, phones, tablets, and other devices.

Ground cover - % of ground covered by material at point of interception.

Herbaceous plants - Generally, plants with flexible stems (not woody), includes forbs and graminoids.



Densiometer. Photo by Taryn Schlosser

Hypsometer/Range Finder - Instrument used to measure tree height and distances.

Ladder fuels - Live and dead vegetation that allows fire to travel from the forest floor into the tree canopy. For example, smaller trees or shrubs growing immediately adjacent to taller ones; low branches; tall herbaceous vegetation.

Litter - Small dead plant material such as leaves, bark, and needles.

Live Crown Base Height (LiCrBht) - Distance from ground to start of live crown.

Overstory - Top layer of cover in a forest (see Figure 2 - pg. 28).

Perennial plant - A plant that lives more than two years.

Planar intercept method - A measurement of ladder fuels typically included as part of a Brown's transect.

Plant basal area - The area of the ground occupied by the base of the plant stem.

Sapling - An individual of a woody species with height over 4.5 ft but with a DBH or DRC (wherever it must be measured) is less than 1 in (this value may change depending upon objectives).

Seedling - An individual of a woody species with height less than 4.5 ft.

Shrub - A woody plant smaller than a tree at maturity; has several main stems arising at or near the ground (which plants are considered "shrubs" vs "trees" may depend upon monitoring objectives).

Slope - A measurement in percent of the steepness of a surface; (rise/run x 100); a slope of 45 degrees equals 100%.

Snag - A standing dead tree.



Diameter tape. Photo by Taryn Schlosser

Stand - A group of trees that are sufficiently the same in species composition and arrangement of age classes and condition so that they can be managed as a unit.

Surface Fuels - Vegetative materials near the ground that will carry fire.

Tree - A woody perennial plant; for measurement purposes, an individual that is over 4.5 ft tall and 1 in or over at DBH/DRC (definition may change depending upon monitoring objectives).

Trees per acre (TPA) - A way of quantifying the density of trees.

Understory - The area below the forest canopy that comprises shrubs, snags, and small trees (see Figure 2 - pg. 28).

Warm-season vegetation - Term used for grasses that grow during warmer periods; typically better at withstanding droughts; also known as C4 vegetation.

Woody - A plant containing secondary xylem (wood) as structural tissue; typically perennial.

3.0 Terminology Used in Forest Monitoring

Acronym, Abbreviation, or Term	Explanation or Definition as used by NMFWR I
AVE and AVG	Average
BA/AC	Basal area per acre
CWD	Course Woody Debris (1000 hr fuels)
DBH	Diameter at breast height (4.5 feet)
DIA	Diameter at root collar (used for woodland species e.g. <i>Juniperus</i>)
DRC	Diameter at root collar (used for woodland species e.g. <i>Juniperus</i>)
DWD	Down Woody Debris (surface fuels)
FWD	Fine Woody Debris (1-100 hr fuels)
HD	Herbaceous dead (dead non-woody species; herbs)
HL	Herbaceous live (live non-woody species; herbs)
HT	Height
LiCrBHt or LCBH	Live Crown Base Height, distance from ground to start of live crown
QMD	Quadratic mean diameter, always equal to or greater than mean DBH, always an average
SD	Standing dead (dead woody species)
SL	Standing live (live woody species)
TPA	Trees per acre (Trees/acre)

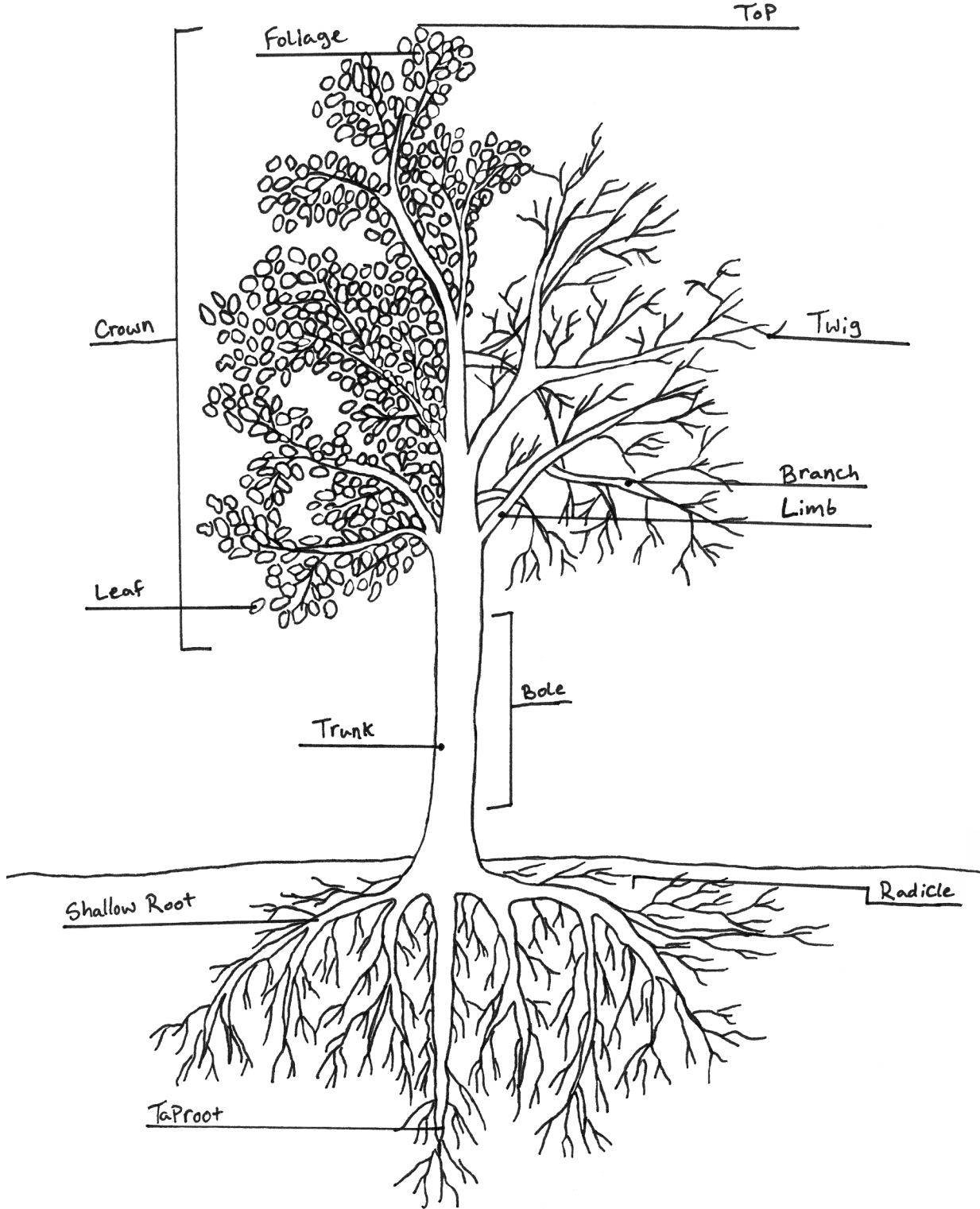


Figure 1. Tree terminology diagram. Diagram by Zoe Ahrens

3.0 Terminology Used in Forest Monitoring

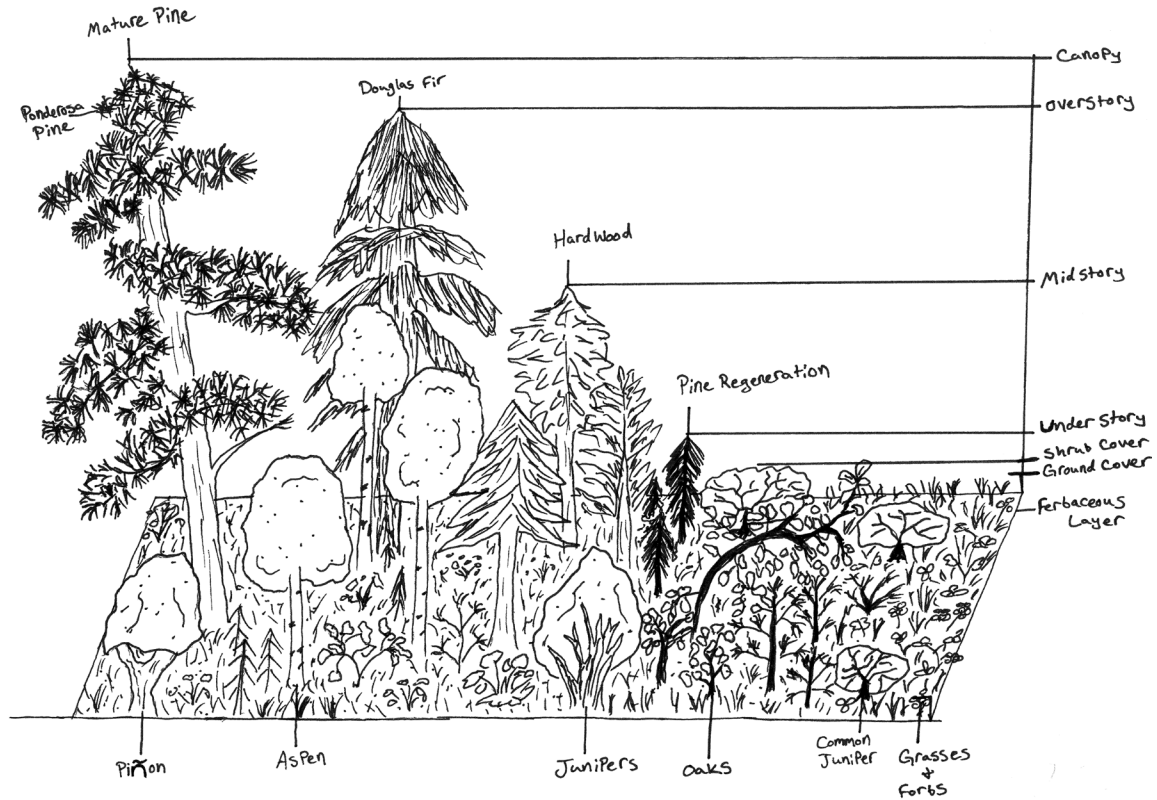


Figure 2. Forest Strata Levels. Diagram by Zoe Ahrens

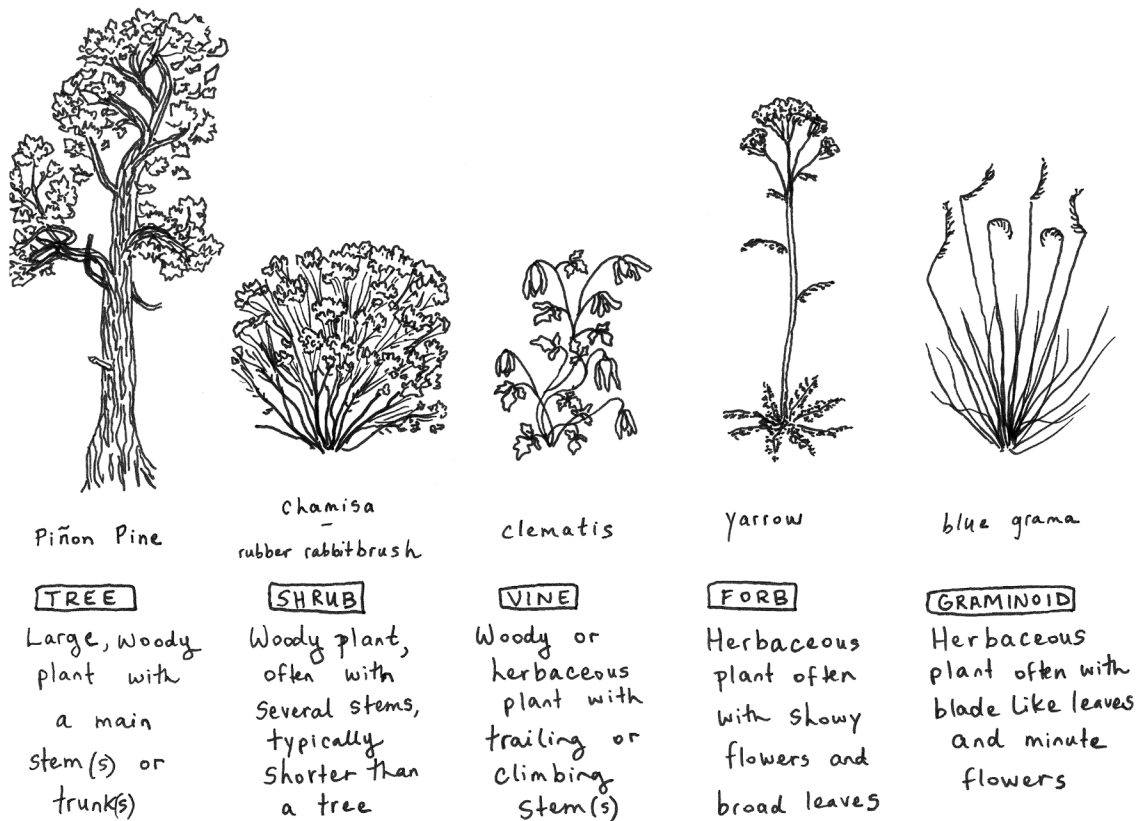


Figure 3. Vegetation Categories. Diagram by Meredith Prentice

WELCOME TO MONITORING

4.0 Field Safety

Always follow your general field procedures for safety. The section below provides a summary of specific hazards and mitigations to keep in mind while doing forestry field work. See NMFWRI Field Safety and Emergency Action Protocols (available upon request) for more detailed safety information.



Water crossings, steep drop-offs in the road, and signage stashed in trees are all hazards of traveling by vehicle.

Photos by Kathryn Mahan

Traveling by Vehicle

HAZARDS:

- Getting lost or getting the wrong directions
- Remoteness
- Poor access/degraded or impassable roads
- Mechanical problems

MITIGATIONS:

- Prioritize good communication prior to going into the field.
- Have an emergency action plan (EAP) worked out ahead of time, be sure everyone knows it, and keep it with you.
- Bring appropriate maps; ask questions about the route and terrain before heading out into the field.
- Create trigger points for turnarounds/knowing when not to pursue the project.
- Ensure drivers have defensive driving training.
- Follow standard 4WD protocols (FWRI staff have a detailed driving protocol to follow).
- Swap drivers regularly and/or as difficulty of travel demands.
- Use the buddy system and take two vehicles equipped with chains, tow straps, and chainsaws into very remote areas. Make sure you know if your organization requires chainsaw certifications and follow all related safety protocols.
- Communicate from the field if possible: use a radio, personal locator beacon (PLB), cell phone, etc. Keep everyone up to date if plans get changed.



Rocky terrain, steep slopes, downed logs, and body posture when taking transects are all potential hazards of working in the forest. *Photos by Kathryn Mahan*

Traversing and Working in the Forest

HAZARDS:

- Very steep terrain and/or cliffs on plot or encountered traveling between plots
- Traveling through dense understory/ areas with lots of downed trees
- Getting poked by limbs of trees trying to measure DBH
- Bending over for long periods of time for certain protocols
- Watching a GPS, map, or datasheet instead of watching the ground you're walking on, etc.

MITIGATIONS:

- Move slowly and cautiously.
- Maintain situational awareness.
- Use topographic maps.
- Wear sturdy boots and proper PPE (eye protection, long sleeves, gloves).
- Take breaks when travel is difficult.
- Maintain awareness of other field crew member to ensure you stay together. When traversing terrain with loose rocks or debris, maintain adequate spacing between crew members.
- Take turns switching up physically taxing tasks.
- Ensure crew members have first aid training and bring appropriate equipment, i.e. radios, first aid kit.



Incoming monsoon rains. Photos by Kathryn Mahan

Weather

HAZARDS:

- Lightning, monsoon, flooding, etc.
- Temperature extremes
- Hypothermia, hyperthermia, etc.

MITIGATIONS:

- Maintain good communication.
- Know the local area and weather patterns.
- Bring rain gear and other PPE suitable for wide variations in weather. Consider bringing a change of clothes and socks.
- Plan ahead; don't park in areas prone to flooding and depart from areas where roads/terrain may become impassable.
- Follow a lightning protocol (e.g. 30/30 rule, know the lightning position):
 - Pay attention to the sky, especially if you hear thunder/see lightning. If thunder follows 30 seconds or less after a lightning strike the thunderstorm poses danger. 5 seconds is equivalent to 1 mile, 30 seconds being equivalent to 6 miles.
 - The safest places to shelter during a thunderstorm are inside vehicles or fully enclosed buildings. If sheltering in a vehicle, keep the windows up. Plan your day accordingly based on weather patterns to ensure the vehicle is in close proximity to your monitoring plots.
 - If unable to seek shelter in a vehicle or building, practice the following safety tips:
 - ◆ Avoid exposed ridges, hilltops, and open fields.



Improvised rain gear!

4.0 Field Safety

- ♦ Avoid tall, isolated trees or other objects. Look for a uniform stand of trees to shelter in.
- ♦ Avoid bodies of water, metal objects or fences, and shallow caves.
- ♦ Spread out your group to reduce the risk of current traveling person to person.
- ♦ Assume lightning position: crouch down low to the ground with your feet together. Avoid laying flat on the ground, you want to minimize the amount of contact your body has with the ground. If a foam pad or backpack without metal wiring is available you can sit on top of that for greater comfort

Always seek shelter whenever possible. Following the safety tips listed above can help minimize the risk of being struck, but you are not safe if you are outdoors during a thunderstorm.



Snake under juniper. Photo by Kathryn Mahan

Wildlife

HAZARDS:

- Encounters with venomous snakes, spiders, etc.
- Rabid or aggressive animals
- Hantavirus infection
- Food motivated animals e.g., bears, javelinas

MITIGATIONS:

- Maintain situational awareness.
- Be familiar with local area.
- Secure your food.
- Specific to snakes: sweep under the tree with your caliper before crawling in; use snake chaps.
- Avoid caves, small enclosures, and old structures where mice and other small rodents might live (Hantavirus).



Plants like poison hemlock, cactus, and New Mexico locust all present hazards. *Photos by Kathryn Mahan*

Vegetation

HAZARDS:

- Spiny & sharp plants (e.g. cactus, New Mexico locust, Russian olive)
- Wild edibles: some good, some poisonous; sometimes taste is helpful for ID (e.g. PIEN vs PIPU)
- Skin irritation caused by plants (e.g. poison ivy, stinging nettles)

MITIGATIONS:

- Wear protective clothing.
- Wear eye protection.
- Have first aid kits & first aid training.
- Wear sturdy boots with heavy soles.
- Don't put it in your mouth or on your skin unless you're 100% positive about your identification.

Sharp and Spring-loaded Equipment

HAZARDS:

- Machetes, Spencer (spring-loaded metal-reel) diameter tapes with nails, metal clipboards, papers, etc.

MITIGATIONS:

- Wear personal protective equipment when appropriate (e.g. gloves) and use caution.

4.0 Field Safety



Use caution when working with sharp and spring-loaded equipment. *Photos by Kathryn Mahan*

- Be familiar with your equipment.
- Use two people to rewind a Spencer tape.

Burned Areas

HAZARDS:

- Very difficult travel in burned areas
- Risk of windthrow and/or falling dead trees and branches
- Ash is slippery, especially if wet
- Stump holes (sunken areas) may exist or appear
- Post-fire flooding



Stump holes and other hazards are present in burned areas. *Photos by Kathryn Mahan*

MITIGATIONS:

- Create a safety zone where you can get to in the event of high winds.
- Use proper PPE such as hard hats.
- Establish a wind cutoff and carry a kestrel to measure windspeed. NMFWR's wind cutoff protocol instructs field crews working in burned areas to wear hard hats when winds are over 15 mph. When there are sustained winds over 40 mph, crews do not work.
- Maintain good communication and regular check-ins.
- Check the weather.
- Proceed with caution.

Overnight Stays**HAZARDS:**

- Heavy backpacks, carrying lots of equipment, loading & unloading that equipment
- Front-country communications options may not work (e.g. no cell service)
- Improper campsite selection could result in exposure to high winds, lightning, flooding
- Increased chance for encounters with wildlife (importance of proper food storage)
- Importance of group and personal hygiene especially when getting water, preparing food, and using the restroom
- Team members face more challenges trying to stay warm and dry
- Distance to medical help makes prevention much more critical
- General hazards in kitchen and campsite (knives for food preparation, fire for cooking, guylines, etc.)
- Operating in the dark
- Emotional stresses intensify



Dinner at camp. Photo by Kathryn Mahan

MITIGATIONS:

- Ensure everyone in the group follows standards for hygiene, etc.
- Wear the proper PPE to avoid burns, cuts, sunburns, etc.
- Properly treat all drinking water (by boiling, Aqua Mira/chlorine treatment, iodine, etc).
- Pay attention to campsite selection and weather forecasts.

4.0 Field Safety

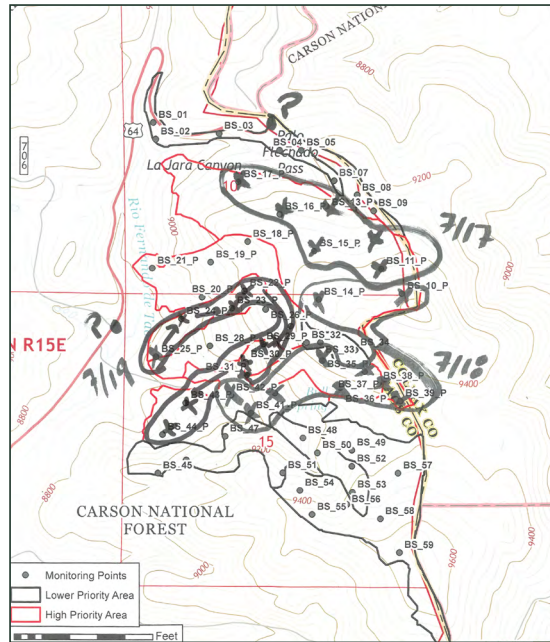


Heavy backpacks, wind impacting tents, extra equipment to load, and livestock at camp are all common hazards when staying overnight. *Photos by Kathryn Mahan*

- Keep all equipment in good condition and bring extra warm/dry clothes.
- Keep camp clean and secure food properly to reduce the draw for wildlife (in a locked car or trailer at night and when away from camp during the day).
- Ensure personal and collective gear is safely packed away and that your camps can withstand extreme weather conditions such as wind or rain (put away all equipment in tents or vehicles, zip up tents and rain flies, and thoroughly stake down tents when leaving camp).
- Prepare equipment beforehand to ensure nothing is left behind.
- When moving lots of heavy equipment, use proper posture and lift with a partner.
- Bring extra/backup batteries for field equipment and keep equipment in bags when there is risk of exposure to moisture. Sleep with batteries in your sleeping bag to keep them warm.
- Be courteous and communicate with team members. Be prepared to practice psychological first aid.

WELCOME TO MONITORING

5.0 Planning Your Day – Tips & Reminders



Example master map showing crew progress on project.
Credit: NMFWR Field Crew

- Begin each day with a plan for each crew:
 - What time they're heading out and returning.
 - How often they'll check in and with who.
 - ◆ We often use a radio check-in every 2 hours on the hour with the other crew in the area.
 - What plots they're covering and in what order.
 - ◆ Consider access, topography, skill, and speed of the crew.
 - What safety hazards they're watching for and what they'll do in case of emergency.
 - Be sure everyone goes through their checklists and has everything they need (equipment, food, raingear, first aid, etc.).
- At the end of each day:
 - Finalize QC and make sure all data was completed.
 - Take notes on the day and the project. For instance, did you learn anything about access to plots, or encounter any partners while working? Include in your notes anything that would benefit a future crew in working more safely and efficiently.
 - Record the route each crew took and what plots they finished that day on one master map. Be sure that map stays with the datasheets or project information. Having a master record of the sequence in which things happened allows for the data entry team to solve the mystery that may arise if a detail isn't recorded in the field.

WELCOME TO MONITORING

5.1 Sample Equipment Checklist

FIELD SUPPLIES – PER CREW

- SPOT device for check-ins (1 per crew or sat phone)
- Sat phone for emergencies (1 per crew or SPOT)
- Folder with emergency action plans (EAPs) and group medical history/confidential info
- Hypsometer (Rangefinder), packed carefully with extra battery & charger (1 per crew)
- Spherical densiometer with flagging tied around it (1 per crew)
- Handheld walkie-talkie radio with extra batteries and/or charger (1 per crew)
- Camera with space on memory card, spare charged batteries, spare memory card, & charger (1 per crew)
- Inverter (for car charging; 1 per crew)
- External GNSS receiver and tablet unit with points loaded & charger (1 per crew)
- Mini-Tripod for Geode (1 per crew)
- Samsung tablet for use with Geode with points loaded & charger (1 per crew)
- Tablet or Toughbook laptop with data entry software set up and charger/battery pack (if using; 1 per crew)
- Fiberglass 100 ft or longer tape (2 per crew)
- Pin flags (10+ per crew)
- Flag bags for carrying pin flags and/or rebar (1 per crew)
- Whiteboard, whiteboard markers, & whiteboard wipes (1 set per crew)
- Chaining Pins (2 per crew)
- Rebar cut to length & caps to match (number of plots needed + 5)
- Clipboard (1 regular and 1 waterproof per crew)
- Paperwork: emergency contacts, driving directions, driving maps, field maps, authority contacts, datasheets and EXTRA datasheets (including some on waterproof paper), plot photos, and data from previous trip
- Tree calipers (if using; 1 per crew)
- Fuels gage (min 1 per crew)
- Plant ID guides (e.g. Trees and Shrubs by Jack Carter)
- Training manual, tree codes, and protocol cheat sheets (min 1 per crew)
- Calculator (1 per crew)
- Field plant press (1 per group) and blank voucher collection sheets

- Metal detector & spare batteries (if using, 1 per group)
- Scribes (if using, 1 per crew)
- Kestrel and fire weather kit (1 per group)
- Tree tagging machine + tagging kit (extra metal tape reels, nails, hammer, pocket knife, etc) (1 per crew)

FIELD SUPPLIES – PER PERSON

- Field packs (1 per person)
- Compass (1 per person)
- Clinometer & case (1 per person)
- Garmin GPS with extra AA batteries and points loaded (1 per person)
- Diameter tape (logger's tape) (1 per person)
- Arctic Vinyl orange glo heavy duty flagging (1 roll per person)
- Pencil, pen, & Sharpie (min. 1 each per person)
- First aid kit (1 per person)
- Angle gauge (if using; 1 per person – do not share)
- Field vests (optional; 1 per person)
- Rattlesnake chaps (optional)
- Hardhats (if working in windy or burned areas) (1 per person)
- Field notebook (1 per person)
- Hand lens (1 per person)
- Safety sunglasses (1 per person)
- Sun hat (1 per person)
- Leather gloves (1 per person)
- Bandanas (min 1 per person)
- Lunch & snacks (mandatory per person)
- Raincoat & rain pants (1 set per person)
- Small flashlight or headlamp with extra batteries (1 per person)
- Durable watch with alarm setting – NOT cell phone (1 per person)
- Sturdy hiking or wildland fire boots – no tennis shoes or sandals when doing fieldwork (1 per person)
- More water & Gatorade than you think you will drink (recommended 10 L/day/person)
- Toiletries – toilet paper/trowel/hand sanitizer, sunscreen, etc. (1 kit per person)
- Tree codes & protocol cheatsheets
- Pack cover or contractor trash bag

VEGETATION OF NEW MEXICO

6.0 Species Code Cheat Sheet

Common Upland Tree Codes

Code	Scientific Name	Common Name
ABCO	<i>Abies concolor</i>	white fir
ABLAA	<i>Abies lasiocarpa</i> var. <i>arizonica</i>	corkbark fir
JUCO6	<i>Juniperus communis</i>	common juniper
JUDE2	<i>Juniperus deppeana</i>	alligator juniper
JUMO	<i>Juniper monosperma</i>	one-seed juniper
JUSC2	<i>Juniperus scopulorum</i>	Rocky Mountain juniper
PIAR	<i>Pinus aristata</i>	bristlecone pine
PIED	<i>Pinus edulis</i>	two-needle piñon <i>piñon pine*</i>
PIEN	<i>Picea engelmannii</i>	Engelmann spruce
PIFL2	<i>Pinus flexilis</i>	limber pine
PIPO	<i>Pinus ponderosa</i>	ponderosa pine
PIPU	<i>Picea pungens</i>	blue spruce
POTR5	<i>Populus tremuloides</i>	quaking aspen
PSME	<i>Pseudotsuga menziesii</i>	Douglas-fir
QUGA	<i>Quercus gambelii</i>	Gambel oak
QUGR3	<i>Quercus grisea</i>	gray oak
QUPA4	<i>Quercus pauciloba</i>	wavyleaf oak
QUTU2	<i>Quercus turbinella</i>	Sonoran scrub oak <i>desert scrub oak*</i>

Common Riparian Codes

Code	Scientific Name	Common Name
AIAL	<i>Ailanthus altissima</i>	tree of heaven
ACGL	<i>Acer glabrum</i>	Rocky Mountain maple
ACNE2	<i>Acer negundo</i>	boxelder
BASA4	<i>Baccharis salicifolia</i>	seepwillow <i>mule-fat*</i>

Code	Scientific Name	Common Name
COSE16	<i>Cornus sericea</i>	redosier dogwood
ELAN	<i>Elaeagnus angustifolia</i>	Russian olive
FOPU2	<i>Forestiera pubescens</i>	stretchberry New Mexico olive*
PODEW	<i>Populus deltoides ssp. wislizeni</i>	Rio Grande cottonwood
PRVI	<i>Prunus virginiana</i>	chokecherry
SAEX	<i>Salix exigua</i>	narrowleaf willow coyote willow*
TAMAR2	<i>Tamarix sp</i>	tamarisk salt cedar*, species unknown
ULPU	<i>Ulmus pumila</i>	Siberian elm

Common Cacti Codes

Code	Scientific Name	Common Name
CYIM2	<i>Cylindropuntia imbricata</i>	tree cholla
CYLIN2	<i>Cylindropuntia sp.</i>	cholla, species unknown
OPEN3	<i>Opuntia engelmannii</i>	cactus apple desert prickly pear*
OPPH	<i>Opuntia phaeacantha</i>	tulip prickly pear
OPUNT	<i>Opuntia sp.</i>	prickly pear, species unknown

Common Upland Shrub Codes

Code	Scientific Name	Common Name
AMCA6	<i>Amorpha canescens</i>	lead-plant
AMFR	<i>Amorpha fruitcosa</i>	false indigo bush
ARTR2	<i>Artemisia tridentata</i>	big sagebrush
ARPU5	<i>Arctostaphylos pungens</i>	point-leaf manzanita
ARUV	<i>Arctostaphylos uva-ursi</i>	kinnickinnick
ATCA2	<i>Atriplex canescens</i>	fourwing saltbush
CEFE	<i>Ceanothus fendleri</i>	Fendler's ceanothus
CEMO2	<i>Cercocarpus montanus</i>	alderleaf mountain mahogany

6.0 Species Code Cheat Sheet

Code	Scientific Name	Common Name
DAFR6	<i>Dasiphora fruticosa</i>	shrubby cinquefoil
ERNA10	<i>Ericameria nauseosa</i>	rubber rabbitbrush
FAPA	<i>Fallugia paradoxa</i>	Apache plume
FOPU2	<i>Forestiera pubescens</i>	stretchberry <i>desert olive*</i>
FRVE2	<i>Fraxinus velutina</i>	velvet ash
GUSA2	<i>Gutierrezia sarothrae</i>	broom snakeweed
KRLA2	<i>Krascheninnikovia lanata</i>	winterfat
MARE11	<i>Mahonia repens</i>	creeping barberry
NOGR5	<i>Nolina greenei</i>	woodland beargrass <i>Greene's beargrass*</i>
PAMY	<i>Paxistima myrsinites</i>	Oregon boxleaf <i>mountain-lover *</i>
RHTR	<i>Rhus trilobata</i>	skunkbush sumac <i>three-leaved sumac *</i>
RIBES	<i>Ribes sp.</i>	currant, species unknown
RICE	<i>Ribes cereum</i>	wax currant
RIIN2	<i>Ribes inerme</i>	whitestem gooseberry
RONE	<i>Robinia neomexicana</i>	New Mexico locust
ROWO	<i>Rosa woodsii</i>	Woods' rose
RUID	<i>Rubus idaeus</i>	American red raspberry
SHCA	<i>Shepherdia canadensis</i>	russet buffaloberry
SYAL	<i>Symphoricarpos albus</i>	white snowberry
SYMPH	<i>Symphoricarpos sp.</i>	snowberry, species unknown
SYRO	<i>Symphoricarpos rotundifolius</i>	roundleaf snowberry
VAMY2	<i>Vaccinium myrtillus</i>	whortleberry
YUBA	<i>Yucca baccata</i>	banana yucca
YUCCA	<i>Yucca sp.</i>	yucca, species unknown

**Italic common name* represents an alternative common name that differs from the common name found in the USDA plant database.

VEGETATION OF NEW MEXICO

7.0 Forest Types of New Mexico

Forest Type – A designation or name given to a forest based on the most abundant tree type or types in the stand.

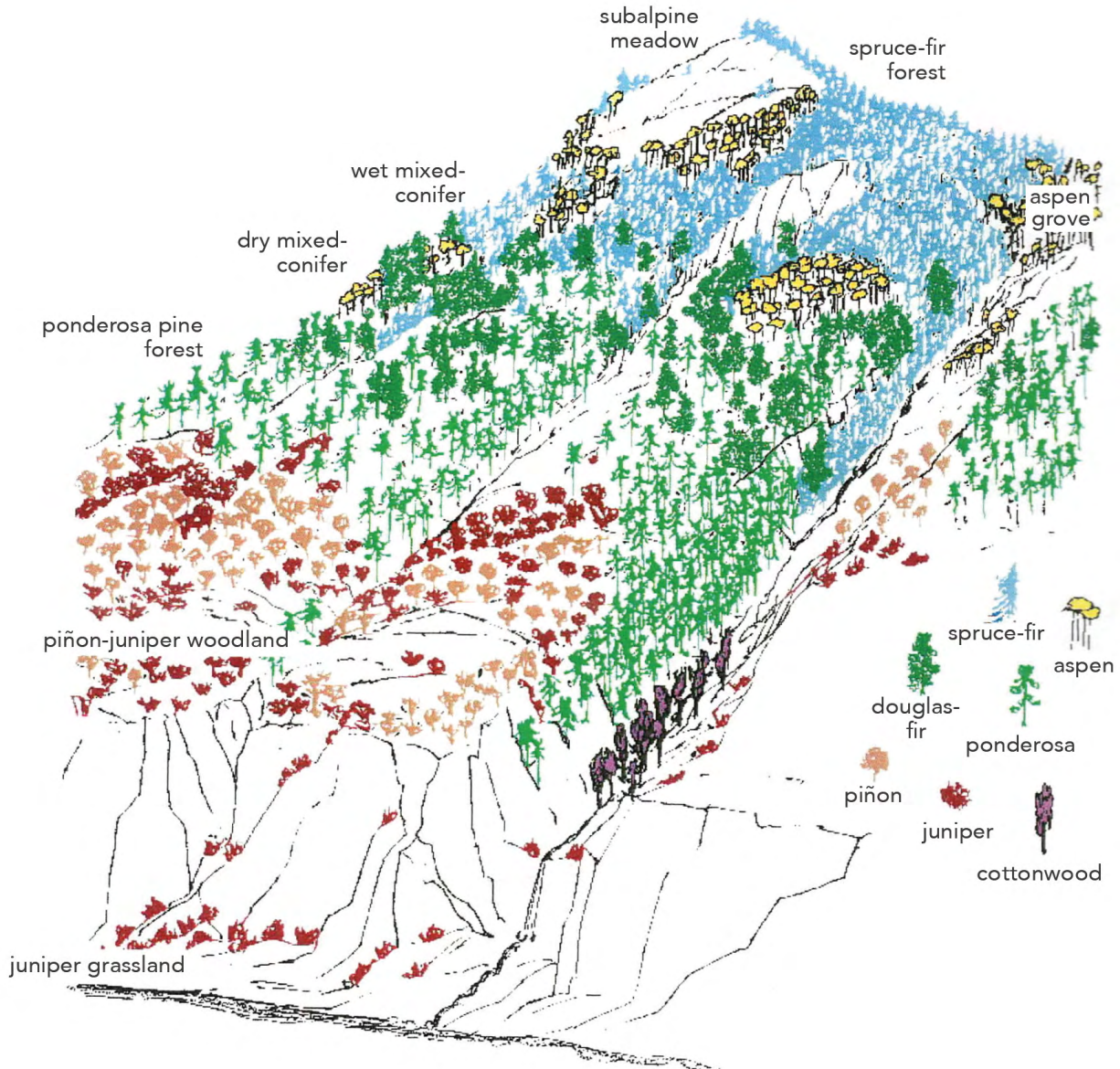


Figure 1. Illustration of changes in forest type by elevation and aspect (adapted from LANL 2011).
Diagram credit: Rocky Mountain Research Station, USDA Forest Service
(https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fseprd610012.pdf)



Photo by Carolina May

1. **Piñon-Juniper** – Forest type consisting mainly of piñon and juniper species, often one-seed juniper and/or rocky mountain juniper. Generally found in elevations ranging from 4,000 to 8,000 ft.



Photo by Carolina May

2. **Bosque/Riparian Forest** – Bosque is dominated by cottonwoods and willows, as well as non-natives such as salt cedar and Russian olive. Typically, found below 6,000 ft, at higher elevations smaller willows/shrubby/high-elevation species dominate.



Photo by Carolina May

- 3. Ponderosa** – Forest type consisting mainly of ponderosa pine (more than 26% of total tree species by NMFWR definition). Other trees species found in ponderosa pine forests in New Mexico includes oak, juniper, and piñon. Understory composition includes numerous bunchgrass, forb, and shrub species. Common from 7,000 to 9,000 ft.



Photo by Kathryn Mahan

- 4. Dry Mixed-Conifer** – Forest that is dominated by ponderosa pine but with a large component of Douglas-fir, limber pine, aspen, and occasionally white fir and blue spruce. Dry mixed-conifer forests are found in the drier, warmer, and lower elevations of mixed-conifer forest types. Generally, occurs from 5,000 to 9,500 ft.



Photo by Carolina May

5. **Wet Mixed-Conifer** – Forest type consisting of an assortment of species including Douglas-fir, limber pine, white fir, blue spruce, and aspen. Occurs from 5,500 to 10,000 ft.



Photo by Carolina May

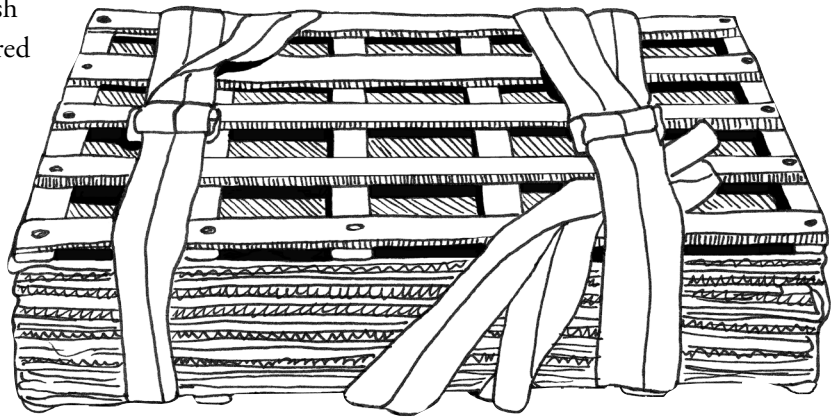
6. **Spruce-fir** – Forest dominated by Engelmann spruce, Douglas-fir, aspen, corkbark or subalpine fir. Usually occurs from 8,000 to 12,000 ft.

VEGETATION OF NEW MEXICO

8.0 Herbarium Voucher Collection Protocol

Purpose

Plant collections are used to establish physical records of plants encountered in the field and to aid in the identification of unknown species. A specimen collected in the field is known as a voucher. Along with collecting a voucher, photographs and observations of the plant and its habitat are documented to provide pertinent details that aid in identification and contribute to generalized knowledge of the species.



Field plant press. *Diagram by Meredith Prentice*

Main Steps

1. Photographing & Collecting
2. Pressing & Preserving
3. Mounting & Labeling
4. Filing

1. Collecting

Collection Materials:

- ♦ Hand lens
- ♦ Identification keys and field guides
- ♦ Clippers
- ♦ Gloves
- ♦ Soil knife and/or trowel
- ♦ Wooden plant press with newsprint, blotting paper, cardboard ventilators, and press straps
- ♦ Paper bags
- ♦ Gallon Ziploc bags
- ♦ Envelopes
- ♦ Field press bag
- ♦ Paper string tags
- ♦ Voucher datasheets
- ♦ Sharpie/pen/pencil
- ♦ Camera

Cactus Specific Materials (in addition to materials above):

- ♦ Knife
- ♦ Large paper bags
- ♦ 95% ethanol solution
- ♦ Small cooler
- ♦ Tongs
- ♦ First aid kit equipped with i.e. tweezers, ultra-sticky heavy-duty tape, and Elmer's glue

Ecological and Cultural Considerations:

Be familiar with any rare or endangered species in the area you are collecting from. Do not collect any species with a sensitive conservation status. Collecting threatened, endangered, or rare plants may be illegal depending on local laws. It is recommended to carry a list of rare, threatened, endangered, etc. plants for a field site you are traveling to. If there is a chance the plant you are thinking of collecting may be rare or endangered, be sure to identify first to confirm the species. If not 100% certain about the identification and there is a chance the species might be rare, err on the side of caution and don't collect. Take detailed observation notes and photographs. A list of rare plants in New Mexico can be found at <https://nmrareplants.unm.edu/rarelist.php>. or <https://www.emnrd.nm.gov/sfd/rare-plants/state-rare-plant-list/>.

Plant collections may or may not be permitted on certain land depending on the jurisdiction, i.e. tribal, federal, state or private. Be aware of restrictions on making collections and obtain any necessary permits ahead of time. Any permits obtained will need to be carried with you out into the field.

Many plants are culturally and medicinally important for the Indigenous and Nuevomexicano communities that have deep ancestral relationships to the land. Educate yourself about the land you are working in and peoples who call that land home. To learn more about indigenous territories, Native Land Digital has an online interactive map that can be found here: <https://native-land.ca/>.



Photo by Meredith Prentice

Scientific collections played a significant role in the colonial and imperialist practices of objectification, extraction, commodification, and expansion. The taxonomic system used to categorize and divide all of life arose from Carolus Linnaeus, a 18th century Swedish botanist. Linnaeus was inspired by Aristotle's "Great Chain of Being", a conceptual framework that ranked matter according to its perceived evolutionary advancement. Linnaeus adopted a hierarchical approach to categorizing life to organize his classification system. Linnaeus's classification schema was also used to categorize and rank human communities. His work influenced



Photos by Meredith Prentice

scientific racism, perpetuating the oppressive regimes of colonial genocide, slavery, and the eugenics movement.

Though the current educational and research aims of many herbariums differ from the original intentions of early colonialists, imperialists, and scientists, we can easily perpetuate harmful ways of perceiving and interacting with the land and the peoples who call that land home if we don't examine our positionality. Plants, and the ecosystems they reside in, have an inherent right to exist outside their benefit to humans and science. We can begin to untangle and rewrite our relationship to plants and the land at large by learning their stories and various names, by learning about the people who have close ties to them, and approaching them with respect, integrity, and curiosity.

This is by no means an exhaustive list, but before collecting, think through the following considerations:

- ♦ What is the conservation status of the plant I am considering collecting?
- ♦ Is collecting permitted? Do I have a copy of the permit with me?
- ♦ What is the cultural or ecological importance of this plant or the site it is growing in?
- ♦ Would a photograph suffice in place of a collection?
- ♦ Is the plant population stable? (Minimum of 20-30 plants for herbaceous plants, i.e. forbs and grasses)
- ♦ Is this plant already in the herbarium? If it is, does this particular plant display interesting morphological features or immaturities useful for education and training purposes?

Special Considerations for Non-native Plants:

Collection of common non-native plants are useful for education and training purposes. However, these types of plants should be handled with care and caution to avoid dispersal of seeds. Keep fragment bags handy to capture seeds that may become loose during the collection and pressing process. Clean collection equipment after collection of non-natives. There are laws at the federal, state, and local level regulating the transportation and possession of plants considered to be noxious. Be aware of regional regulations before handling and transplanting certain plants that may fall into this category.

What to Look for in a Voucher:

Vouchers should be as complete as possible, meaning the collected plant has leaves, flowers and/or fruits depending on the phenology. Depending on the purpose of a plant collection, vouchers may or may not need to include roots. Certain considerations to think through on whether to include roots or not include:

- ♦ Are roots needed for identification?
- ♦ Is the plant annual or perennial? Just taking an above ground clipping of a perennial allows the plant to survive
- ♦ What is the size of the plant population?

Regardless of whether the roots are collected or not, make sure to collect enough of the plant so that the voucher includes the necessary anatomical features needed for identification. A good voucher is healthy and representative of typical plant morphology. There are some cases in which immature or atypical plants would be desirable for collection. For monitoring purposes, it is helpful to have samples of common tree or shrubs in their seedling stage to aid identification in the field. Unhealthy or atypical plants may also be collected to display morphology impacted by forest pathogens.

Vouchers should ideally fill a good portion of the herbarium sheet (29 x 43 cm). If you are unable to identify the species in the field, collect two vouchers. One will be used for identification and the other will be the primary mounted specimen. If a plant encountered on plot is needed or desirable for collection, make sure to collect the plant from outside of the plot boundaries. Collecting inside the plot can impact species richness counts.



Photo by Meredith Prentice

What to Collect: Photographs + Voucher + Field Observations

Photographing

Always photograph a plant before collecting. This can aid in identification and capture details of the plant, i.e. size and color that usually become obscured in the pressing process.

Several photographs of the plant should be taken to capture enough details. Photograph the plant from a reasonable distance to capture the entirety of the plant. Additionally, take close up photos of the leaves, flowers, fruits, etc. Close up photos capture the smaller details of the plant needed for identification.

To indicate the size of these certain features its recommended to include an object next to the leaf, flowers, etc. to show scale. Use tapes, rulers, or commonly known objects such as coins.

Make sure photographs are in focus with nothing obscuring the plant. If collecting a plant voucher associated with a certain plot, take photos of the plant after all other plot photos have been taken. Record the photo number on the voucher collection datasheet and the plot description photo order section.

Small Plants (grasses, forbs, etc.):

Ensure there are at least 20-30 plants in the area. Include the leaves, flowers, and/or fruits, and potentially the underground structure. If the plant is small, collect a couple vouchers (as long as they all come from one population and the population is big enough). If collecting the roots, carefully dig them up and remove as much dirt as possible.

Bryophytes (liverworts, hornworts, and mosses) & Lichen:

Use your best judgment on whether you should collect certain species or not, considering conservation status and population size. If you are not seeing a lot of the species in the general area, opt to take pictures, sketches, and extensive notes. With these types of plants, you don't need to fill a whole herbarium sheet. Collect the whole specimen, grabbing enough plant material to fill the palm of your hand. Be careful not to include other species that may grow interspersed with the desired sample. When collecting bryophytes, collect specimens that include sporophytes if possible, as it is often needed for proper identification. If the plant is growing on a tree, additionally collect some of the outer bark it's growing on and include the tree species in observation notes. When collecting bark be careful not to damage the cambium layer located underneath the outer/inner bark layers. Before collecting lichen, if the specimen is dry or brittle, spray or dab some water on it to avoid damaging the voucher. These types of plants are air dried, so they can be placed in paper bags or envelopes right away when collecting.



Photo by Meredith Prentice

Trees, Shrubs, & Vines:

When whole plants cannot be collected, collect the essential features; leaves, twigs, flowers, bark (from either trunk or ground, being careful not to expose the cambium; or snap a close-up photo), and fruit as a cutting. Use clippers to make a clean cut through the stem approximately one foot back from the tip. To minimize danger to the parent plant, twigs should be cut off cleanly with a pruner and not torn. The stem should be cut diagonally to display the color of the wood and the pith. If the stem is very thick it can be sliced lengthwise to reduce its bulkiness.

Cactus:

Many cactus species are rare or illegal to collect. Be certain of an ID before collecting. Assuming the cactus is allowed to be collected, be certain that a voucher is actually needed or necessary. Include flowers and fruits of cactus as this is often necessary for identification. Using gloves and a sharp tool, cut off a section of the plant. For *Opuntia* species (prickly pear) this could mean several cladodes or pads depending on the size of the plant. Flowers should be collected when the tepals are completely opened. Be aware that cuttings will shrink after



Photo by Meredith Prentice

processing. Cacti hold a significant amount of water and thus can be challenging to dry. Cactus cladodes will need to be processed in the herbarium. Place the voucher in a larger paper bag for temporary storage. Flowers should be pressed immediately.

Labeling:

Collections will need to be assigned a collection number. Follow this format when establishing a collection number: Site_Year_#. Numbers should start with 001 and increase in consecutive order with each new collection. Record the collection number on a paper tag and attach that to plant (if collecting two samples make sure each sample has a label and additionally indicates which plant is 1 of 2 and 2 of 2). Also write the collection number on the newsprint or bag that plant is stored in, in case the tag is lost.

Field Observations:

In addition to collecting the voucher sample, we will also need to collect pertinent information about the plant and the specifics of its habitat. It's important to record any features of the plant that could be obscured after the pressing and mounting process. This includes features such as flower color, texture, scent, height, the presence of latex (i.e. usually located in the stem; examples include *Apocynum* and *Asclepias* species), type of bark, stickiness, etc.

Fill out a voucher datasheet to record the following information:

- ♦ Collection No.
- ♦ Associated Plot ID
- ♦ Collection date
- ♦ Collectors' name
- ♦ Identifier's name
- ♦ Location:
 - Country
 - State

County

Locality: e.g. distance and direction from nearest town or other landmark, hwy intersection, National forest or name of land, etc. in drainage along FS road 252, in Santa Fe National Forest, San Miguel, County, New Mexico)

- ♦ Latitude and longitude or UTM's
- ♦ Elevation
- ♦ Scientific name
- ♦ USDA Plants symbol
- ♦ Common name(s)
- ♦ Family
- ♦ Lifeform (forb, shrub, graminoid, tree, bryophyte)
- ♦ Plant description:

Height, flower color, texture, smell, habit (annual, biennial, perennial), etc. Any features likely to be obscured in the pressing/ drying process. The more details the better.

- ♦ Habitat:

Slope

Aspect

Type of habitat (prairie, marsh, piñon-juniper woodland, associated plants in the area. For epiphytes include the type of substrate: rock, log, tree, etc.)

Soil type or parent material

Extent of species population



Photo by Meredith Prentice

2. Pressing

The keys to achieving well-pressed plants are:

- Pressing them quickly;
- Attending to the specimens as they dry and not allowing them to mold under moist conditions.

Pressing is the process of applying pressure to a plant specimen to dry and preserve it. Ideally plants are pressed directly into the wooden plant press to reduce the amount of handling vouchers receive. There may be certain situations where you don't have immediate access to the wooden press and may store samples temporarily in a field press bag with cardboard, newsprint, and blotter paper or in a plastic bag/water bottle with a small amount of water to keep the sample moist. Vouchers will not press properly in the field press and will come out wrinkly. It is crucial to transfer the voucher to the wooden press as soon as possible.

As mentioned before, if you have an unknown plant you will collect two vouchers. One of these will be used for identification. It is best to try to identify the plant while plant material is still fresh. If you anticipate being able to identify a plant in the field, you can temporarily store the plant in a plastic bag with a small amount of moisture until you are able to identify it. If you do not anticipate being able to identify the plant in the field, press both samples and label them clearly.

Using the Plant Press:

1. Place the plant in between a sheet of newsprint. The sample should not hang over edges of the newsprint. If necessary, fold the specimen so it will fit on the sheet. Some specimens, such as grasses, sedges, and certain forbs can be arranged into a zigzag to fit onto the newsprint. If needed cut the specimen in half and press it in two separate sheets of newsprint. It is better to cut or fold the specimen rather than bending to achieve the proper size. Cutting and folding are more noticeable and indicate that the shape of the specimen was altered during the pressing process. Arrange the plants in a way that displays both the front and backside of the leaves. Flowers should be arranged to display a front, back, and side profile. If a voucher was too large to fit on a single sheet of newsprint or multiple smaller samples were collected for a voucher, make sure all samples have labels and note the total numbers of samples per voucher (i.e. 1 out of 2, 2 out of 2).
2. Once the plant is folded in the newsprint, place the newsprint in between two sheets of blotting paper. The blotting paper helps to absorb the moisture from the specimen. Place the blotting paper, newsprint, plant, newsprint, blotting paper arrangement between two sheets of ventilated cardboard. Using ventilated cardboard allows for air to flow through the press. If you are utilizing the field press bag without a wooden press, secure the field press in the field bag until you are able to transfer the collection to the wooden press. Before you place the collected voucher into the wooden field press, it is a good idea to reposition the sample if need be (the sample may have moved around during the day in the field press).
3. Make sure the sample:
 - a. Is spread out flat and fully on the newsprint.
 - b. Both the bottom and front sides of leaves are displayed.
 - c. Has some of the flowers pressed open and some flat.
 - d. Will fit on the mounting card when dry, remembering to leave space in the bottom right hand corner for the label.
 - e. Is not crowding the sheet; if you need to you can snip off some of the leaves, just make sure you leave part of the petiole so it is evident you removed the leaves.
4. Once checked, place the stack of collected vouchers (cardboard ventilators, blotting paper, newsprint, plant, newsprint, blotting paper, cardboard ventilator sandwich) in between the top and bottom lattices of the wooden field press.
5. Wrap the straps around the press. While applying pressure to the press, tie or fasten the straps so the press is compressed. The press should be evenly compressed so that specimens dry quickly and press flat. Specimens with bulky parts may require thick folds of newspaper around the bulky parts so that pressure is transferred to the less-bulky leaves and flowers. Vouchers should be arranged in the press so

that the bulky parts of the vouchers are alternating in orientation so as not to disproportionately make one side or corner of the press dramatically larger than the rest.

6. Make sure the datasheet is filled out correctly and fully and is stored nearby the samples for safe keeping.

Pressing Considerations:

Specimens typically take one to two weeks to dry depending on temperature, humidity and the dampness and/or succulence of the plants. Presses should be kept in a warm, dry location with good air circulation while drying.

Check vouchers regularly to ensure potential moisture, insect, and fungal spore build up is avoided. Checking the specimens regularly also provides the chance to reposition the sample if need be. Please refer to the positioning guidelines mentioned above to

ensure the plant is drying in a desirable manner. In the Southwest it is rarely necessary to replace the newsprint or blotting paper during the drying process. Specimens that are fleshy or contain a lot of water may need to be checked on and placed within fresh newsprint or blotting paper. Be sure to handle samples with care, as the plant continues to dry it will become more fragile and more likely to break. If any piece of the voucher breaks off, save and store the fragments in an envelope to be stored next to the voucher. Label this envelope in case it happens to be separated from the voucher.

Pressing Cactus:

Collections placed in a large paper bag can be stored for two to four days. Store in the bag in a dark place in the interim. It is best to process samples within one to two days after collecting. Once the collected sample is ready to be pressed, it is cut with a knife lengthwise. If the cactus species is especially thick, it may be necessary to cut lengthwise three to four times. *Opuntia* species (prickly pear) should be cut through the middle lengthwise. For *Cylindropuntia* species (cholla), slice through the joints lengthwise to preserve the branching pattern.

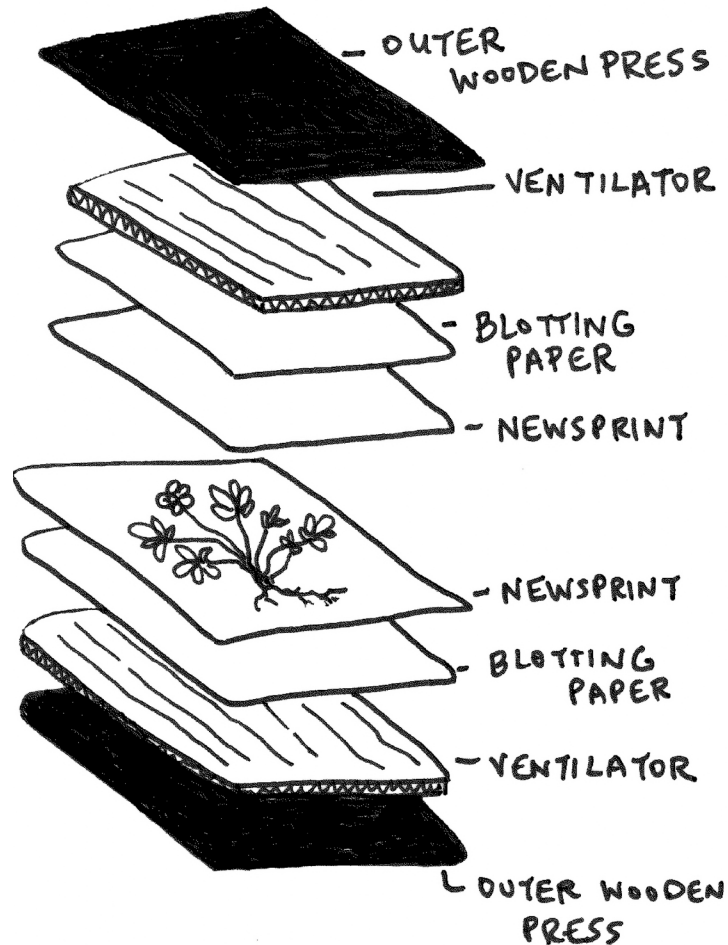


Diagram by Meredith Prentice



Plant press. Photos by Meredith Prentice

To aid in the cutting process, wear gloves and press cardboard or a piece of wood against the sample while you cut. After cutting, scoop out the parenchyma (fleshy inside) of the plant. Place the sample in a 95% ethanol solution for eight to twenty-four hours in a sealed container such as a cooler. Weigh down the sample with a heavy object to ensure it is totally submerged. This will also help with keeping the sample flat. Cacti can be removed from the ethanol bath when the parenchyma tissue has shrunk back from the vasculature. Time in the ethanol bath will differ depending on the size of the

sample and type of cactus. *Echinocactus* species (barrel) take around twenty-four hours, whereas *Opuntia* species will take around eight hours.

Flowers should be pressed immediately as they deteriorate more rapidly and lose their color quickly. Cut the flowers longitudinally and make small incisions in the ovary wall to aid in drying the sample. Make sure flowers stored in the press are assigned the sample collection number as the cladode or pad portion of the voucher.



Once the sample is ready, place the voucher in the wooden press. Place a sheet of parchment or wax paper on the side of the cactus pad or flower that was cut. This helps to ensure the plant material doesn't stick to the newsprint. Place the sample and the parchment paper inside a sheet of newsprint. Place the newsprint in between two sheets of blotter paper and ventilated cardboard. When tightening the press straps apply enough pressure so that cactus spines lay flat but not too much pressure to avoid damage to the soft tissue. Newsprint and blotting paper may need to be changed periodically depending of the thickness of the sample.

3. Mounting

Collections should be stored in the freezer for at least 48 hours before being mounted. Freezing specimens reduces the introduction of pests into the herbarium. Samples should be stored in the newsprint sheet and staked flat in the freezer.

After freezing, the pressed voucher is mounted on a 29 x 43 cm archival quality (acid free) white mounting card. It is best to mount several vouchers

(15-20) in the same session as set up/cleanup is time consuming.

Guidance on NMFWR I mounting technique was provided by the University of New Mexico Herbarium located at the Museum of Southwestern Biology. For more detailed information about mounting, reference “Mounting Specimens at the UNM Herbarium.”

Mounting Materials:

- ♦ Voucher
- ♦ Voucher datasheet
- ♦ Voucher label
- ♦ Pen (archival ink)
- ♦ Acid free herbarium glue
- ♦ Paper towels
- ♦ Flat surface to spread out glue, i.e. glass plate/lunch tray
- ♦ Plastic containers w/ lid (for watered down herbarium glue)
- ♦ Foam paint brush (various sizes)
- ♦ Forceps
- ♦ Acid free herbarium mounting paper (29 x 43 cm)
- ♦ Foam squares
- ♦ Wax squares
- ♦ Cardboard ventilators
- ♦ Heavy objects/books for weights
- ♦ Metal washers



CSC-2015-035	
No. _____	Herbarium <u>NMFWR I</u>
Scientific Name: <u>Teucrium laciniatum</u>	
Common Name: <u>cutleaf germander</u>	
Family: <u>Lamiaceae</u>	
Location: <u>Mora County - by office</u>	
Altitude: <u>6832 ft.</u>	
UTMs: <u>E-495559</u> / <u>N-3965759</u>	
Collected By: <u>C. Briones</u>	Date: <u>6/19/2015</u>
Identified By: <u>C. Briones</u>	
<small>Publication: Supply Co. Botanical MT, USA, 811-548-9531 (fax) 402/944-0711 (fax) 402/954-1554</small>	

Photo by Meredith Prentice

Arranging the specimen:

- ♦ Vouchers should be arranged and mounted in portrait orientation (vertical).
- ♦ Center the voucher on the mounting card, placing it vertically or diagonally across the paper.
- ♦ If there are multiple small plants collected for a voucher, arrange them in evenly spaced rows across the mounting paper.
- ♦ Placement of the voucher should reflect its growth habit, i.e. flowers at the top and roots the bottom.
- ♦ Make sure morphological characteristics are showcased (both sides of leaves displayed, some flowers open, some closed) and that specimen lies flat on the mounting card.
- ♦ Leave a 1 cm border around the edge of the mounting card to allow space for holding or picking up voucher.

- ♦ Leave space in the lower right-hand corner of the mounting card for the voucher label.
- ♦ Leave space in the upper left-hand corner if a fragment envelope needs to be glued to the mounting card.

Gluing & Attaching the Specimen:

1. Prepare a workspace by laying down used newspaper and gathering the supplies listed above.
2. Create a diluted glue mixture containing water and herbarium glue. The mixture is mostly glue. It should be a runny consistency that will easily spread over the working surface. Add water little by little to achieve the desired consistency.
3. Pour the diluted mixture on the surface of a plate/tray and spread the mixture around with a large foam brush. The surface of the plate should be semi-translucent. Too much glue and it will seep out the bottom of the specimen and label card.
4. Carefully dip the backside of the plant into the glue to ensure all parts of the plant have contacted the glue. It may be necessary to dip the plant from several angles to ensure total coverage. Use a small paintbrush to dab glue on areas not initially covered.
5. Place specimen in predetermined orientation on the mounting card. Dab away any excess glue that may seep out after attaching it to the paper.
6. Use heavy metal washers to hold down bulky plant materials that do not lie flat or do not stay in place. Place a small sheet of wax paper between the plant and the washer to ensure the washer doesn't stick to the plant. Certain plants may be too delicate to dip directly into glue. For these types of plants dab and /or brush glue on the backside.

Fragment Envelopes:

As mentioned previously, any loose seeds or plant parts that broke off during the drying/mounting process are kept in a fragment envelope. Fragment envelopes should be labeled with the voucher ID number of the specimen it is associated with. Don't place fragment parts in the envelope until they are completely dry. Brush the diluted glue mixture on the backside of the envelope and attach it to the mounting card in the top left-hand corner. Use metal washers to hold the envelope down until it is dry.

Labels:

After the specimen has been glued to the mounting card, fill out and glue the voucher label. Make sure hand writing is legible and written in archival ink for long-term preservation. NMFWRI uses Micron pens to fill out labels.

Labels include the following information:

- ♦ No. (ex. SITE_YEAR_#)
- ♦ Herbarium (NMFWRI)
- ♦ Scientific Name i.e. *Pinus ponderosa* Lawson
or Pinus ponderosa Lawson
- ♦ Common Name
- ♦ Family
- ♦ Location (include collection site, habitat, state, county, UTM's, elevation, etc.)
- ♦ Collected By
- ♦ Date
- ♦ Identified By

Brush glue on the backside of the label (glue should be thinner than the glue used for the plant specimen and fragment envelope). Make sure all corners and edges are covered with glue. Place in the lower right-hand corner of the mounting card. The label should be one cm from the bottom and righthand edges of the mounting paper. Smooth out any wrinkles or air bubbles that may form and wipe away any excess glue. Hold down the label with metal washers until dry.

Stacking & Drying:

Ten to 15 vouchers can be easily stacked in a pile to dry after gluing. After the voucher and label have been glued to the mounting paper, place a sheet of wax paper on top of the mounting card. Place a sheet of foam on top of the wax paper. Next, place a sheet of cardboard on top of the foam. Build up the stack with the additional mounting cards in this order. After building the stack, place a plywood square on top weighted down with heavy books or sandbags. Place a sticky note on the stack indicating the name of person who mounted the specimens and the date mounted. Allow to dry for at least 48 hours.

Remove specimens from the stack one by one, handling carefully. If any major parts of the plant did not successfully attach with the initial mounting, repeat the process above again to glue them down. Not every leaf or small section of the plant needs to be glued down, just ensure the main parts of the plant are attached to ensure they don't get lost.

4. Filing

Once the voucher is completely dry, place it in a clear voucher envelope. This sealed envelope will be filed in the herbarium cabinet. The cabinet is arranged in alphabetical order by family and then by genus. Each letter has its own shelf. Within the shelf, there are folders organized by genus. If the voucher collected belongs to a genus that doesn't currently have an existing folder, establish a folder and label the folder with the genus in the right-hand corner.

Vouchers should be handled delicately to ensure their longevity.

They should always remain in a horizontal flat position with the specimen facing towards the ceiling. Use both hands to pick up and move the voucher. Never turn them upside down or flip them over like pages of a book.



Herbarium cabinet. Photo by Meredith Prentice

VEGETATION OF NEW MEXICO

8.1 Mushroom Collection Protocol

Safety

Mushroom collection should not be scary! Mushrooms are not dangerous to touch or pick up. That said, some mushrooms are very poisonous if ingested, and caution should be exercised. Gloves are not needed to collect mushrooms because mycotoxins cannot be absorbed through skin, but touching the face or eating while handling mushrooms should be avoided, in case of micro-mycotoxin or bacterial transfer to the mouth. Always wash your hands with soap and water (not hand sanitizer) after handling mushrooms. Even if the mushrooms are not poisonous, pathogenic bacteria can live on them. Never eat a mushroom unless it has been properly identified and is a known edible. There is no one specific trait to determine if a mushroom is edible or poisonous, and many mushrooms have look-a-likes with different traits. If an edible mushroom is identified, always cook wild picked mushrooms. It is not necessary to wash edible mushrooms before cooking them, unless they are particularly dirty, because washing them may make them slimy and the heat from cooking them will kill any bacteria. Also note, do not eat wild mushrooms looking for a psychedelic trip. *Amanita muscaria* (fly agaric) is poisonous and is a native psilocybe species (magic mushrooms) which have many toxic look-a-likes. Edible, poisonous, or anything in between, mushroom collecting, and identification should be fun!

A brief introduction on fungi

Mushroom classification gets complicated. There are over 100,000 types of fungi described, with thousands more yet to be discovered. There are seven phyla of fungi: Chytridiomycota, Blastocladiomycota, Neocallimastigomycota, Microsporidia, Glomeromycota, Ascomycota, and Basidiomycota, with the latter two groups being lumped together in a subkingdom called dikarya, or higher fungi, and these kingdoms are the only two mushroom-producing phyla. Even dikarya can be broken down into microscopic and macroscopic groups. Microscopic fungi are comprised of yeasts, molds, etc. and macroscopic fungi are usually mushrooms. Fungi can also be grouped by ecological roles, which span across the seven phyla. The three major ecological roles are saprobic, which are decomposers, mycorrhizae, which are symbiotes, usually plant mutualists, and pathogens, which tend to be parasitic.

Mushrooms are the fruiting bodies of the underground mycelium, and the mycelium is the main body of the fungus made up of microfilament networks called hyphae. Mushrooms are the apparatus that spreads the spores of the fungus and they can last only hours up to many months. The mycelium, hidden underground, can last much longer and can sometimes regrow mushrooms for years. The mycelium, hidden underground, can last much longer and can sometimes regrow mushrooms for years. Mushroom anatomy starts with the mycelium underground, which sprouts an egg-shaped cup (volva) that will become the base of a mature mushroom. The stem/stalk (stipe) grows from the cup, with the cap (pileus) being the top of the mushroom. On or under the cap there can be gills (lamellae), pores, ridges, teeth, or more, all of which produce the spores. Some mushrooms also have a ring (annulus) around the stem or a veil around the gills.

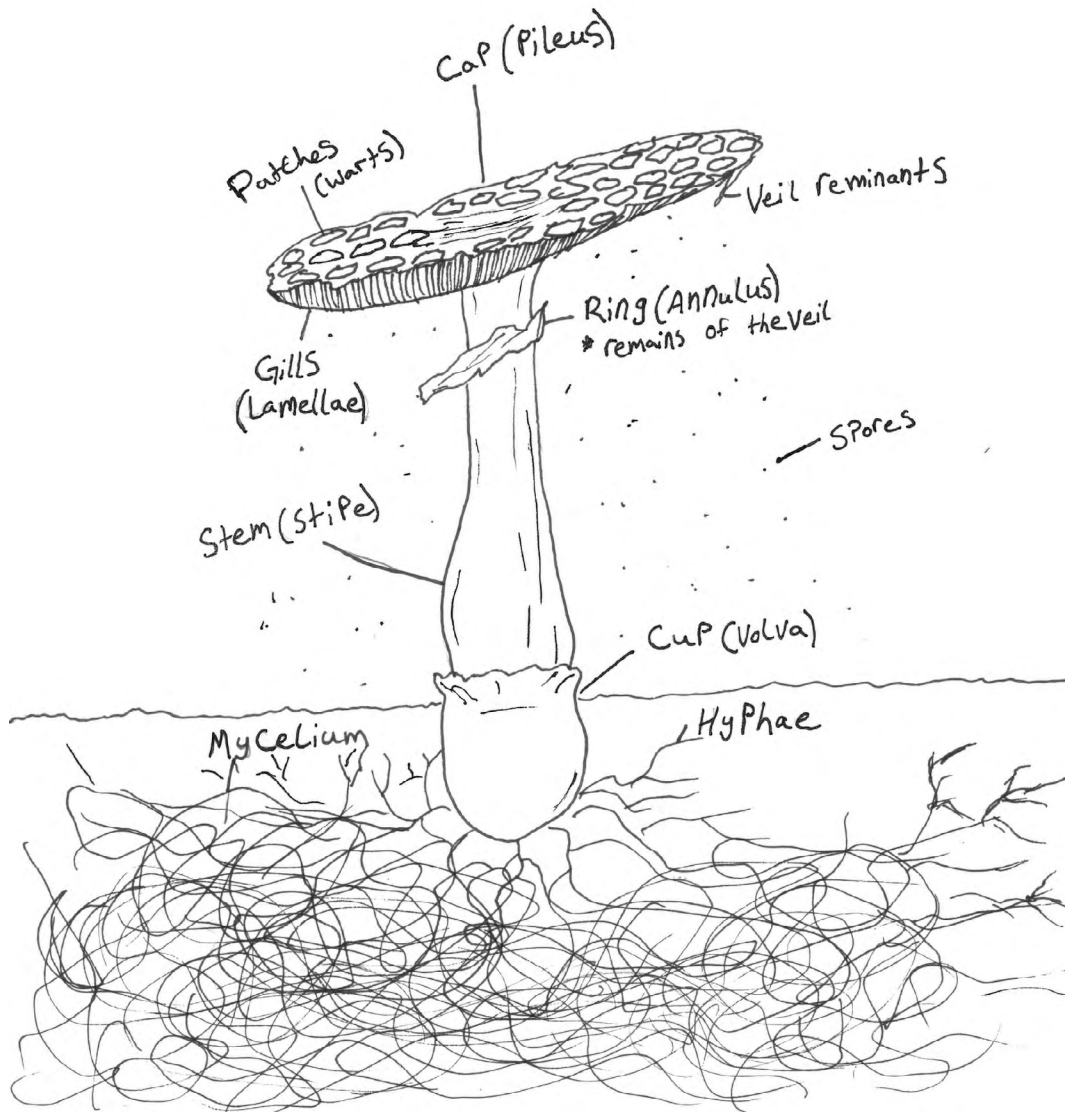


Diagram by Zoe Ahrens

To collect samples, you will need

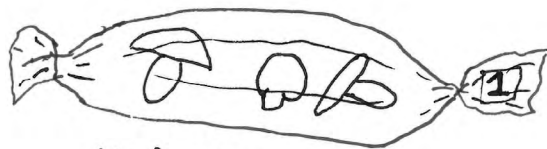
- ♦ Pen and notepad
- ♦ Mushroom ID book
- ♦ Camera
- ♦ Pocketknife with brush
- ♦ A basket, empty tackle box, cooler, large mesh bag or burlap sack
- ♦ Wax paper, paper sack, small mesh bags or plastic bags with paper towel
- ♦ Tin foil, white paper or spore print paper
- ♦ A plastic box with a lid or bowl
- ♦ Magnifying glass
- ♦ Ruler

Where to find mushrooms

Though mushrooms can be found virtually anywhere there is warmth, water, and plants, usually the best way to find mushrooms is after a steady rain in the summer near dead and living trees. Mushrooms of different species can grow in the Rocky Mountains year-round and from semi-arid grasslands to alpine regions. Many species grow on living trees, such as cottonwood trees by streams, pine tree roots in the shade, and aspen trees high up on their trunks. Other mushrooms survive on dead things, and many can be found on the underside of rotten logs, growing from the branches of snags, and in patches of litter. You can also find them in grassy fields, recently burned areas, flowerpots, in animal dung, growing out of a dead insect, really, anywhere!

How to collect mushrooms

Since mushrooms are so fleeting and sometimes difficult to preserve, take or draw lots of pictures. Take a picture of where it was found before collecting it. Take a photo of the side profile, and the top. Later, remove the cap and take a picture of the underside of it, then take photos specifically of the cap, stem and ring if present, and the cup. Cut the mushroom in half vertically and photograph the transect and take a picture of the spore print if that is successfully collected.



Wrap specimens of
The same species
from the same area
in wax paper and
twist ends. Place in
basket & label.

Diagram by Zoe Ahrens

If you find a mushroom on a stalk growing in the soil, use a knife to cut around the soil around the cup and scoop up the whole mushroom. Avoid breaking the stem from the base as the entire shape of the stem is sometimes important to the identification. The cup is usually just slightly buried in the soil, so it should not be necessary to dig very deep in the soil.

If you find a mushroom attached to a live tree, cut the mushroom closest to the wood without cutting the bark.

You can do the same for a mushroom attached to a dead tree; though you can try to cut it out of the wood, it can sometimes be gently pulled off the log or branch. Mushrooms like puffballs can be gently picked up, with little attachment to the ground.

Try to collect multiple of the same species if there are more than one in the same area, especially if there are some varying in age. If multiple specimens can be found, try to collect three, unless they are the only three you see, then only collect the best one. If three of the same species can be found, then keep the best one to preserve, use one with a good cap to take a spore print, and cut one in half to see what it looks like internally for identification. Avoid collecting endangered species, or over collecting a species, as some mushrooms don't grow back if picked. Try to collect complete samples that are not too old, broken or missing parts.

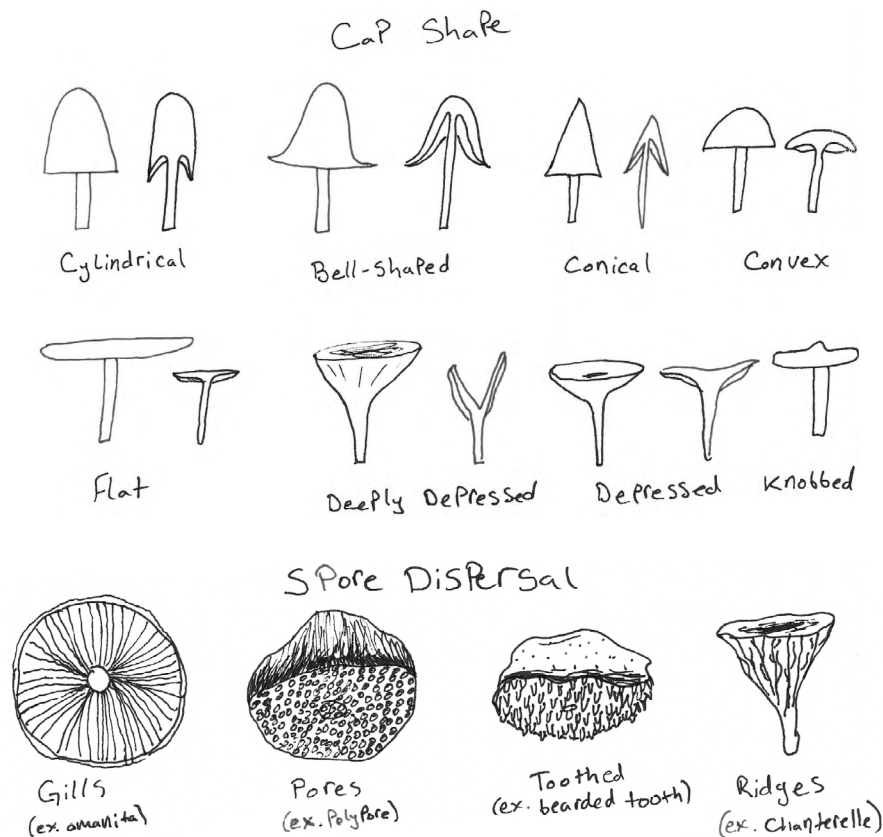
Take note of where your mushroom was found. Write down the date collected, the geographical location (ex. The Jemez Mts, NM; bonus points for coordinates and elevation), the ecological description (ex. montane, mixed coniferous forest, near a creek), and where the mushroom was growing (ex. on a rotten log, in the grass that was part of a fairy ring, next to a cottonwood, on a recently burned hillside) and it may help to even record the weather, as some species only grow in specific conditions, such as rain and shade.

When a specimen is collected, wrap it individually—or multiple of the same species collected from the same

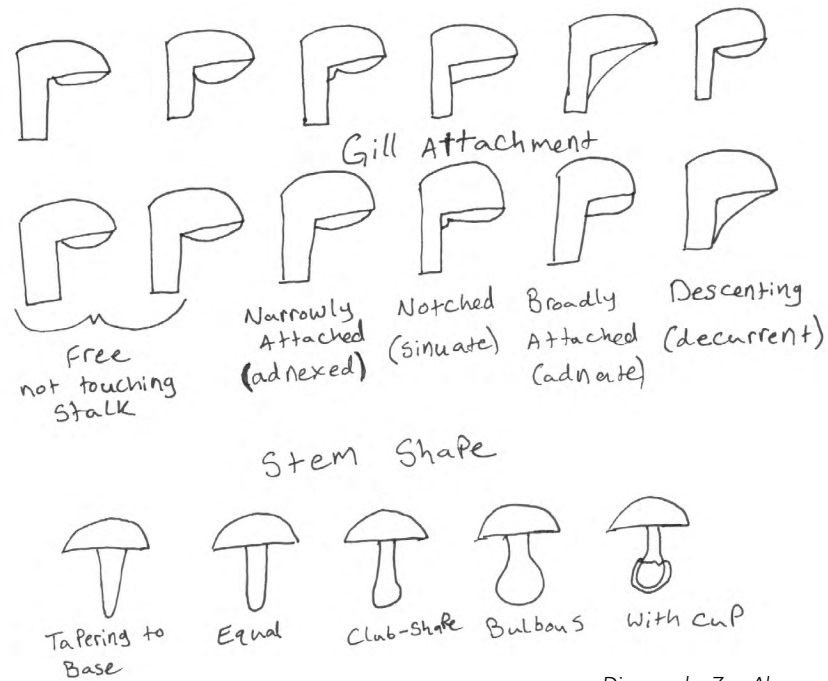
area together—in wax paper and twist the ends of the paper around the mushroom leaving some air around the mushroom and taking care not to squish them. Label the wax paper, even if it is a corresponding number to the note of where it was found on a notepad, then gently place the mushrooms collected into a basket or burlap sack. This is better than plastic to prevent the mushrooms from getting slimy. Plastic bags can work, but it is best to add some air and paper towels to absorb moisture and avoid keeping them in plastic for long periods of time. It is best to keep them in a cool dry place, such as a cooler, for longer transportation. It is best to identify them within the same day of collection.

After the mushroom hunt, examine the collections one at a time within a few hours of collection. Record as much detail of each specimen as possible.

- ♦ Smell, (ex. sweet, rotten, earthy, fishy, medicinal, nutty, anise like, corn like)
- ♦ Texture (ex. fuzzy, slimy, smooth, scaly, dry, waxy, spiny, hairy, firm, soft, spongy)
- ♦ Size (measure total height, length of stem, width of cap, width of stem)
- ♦ Anatomy (are there multiple parts or one, is there a cup, stalk, ring, cap, warts, veil?)
- ♦ Shape (typical, round, wrinkly, phallic, coral-like, star shaped, shelf-like)
- ♦ Color (brown, white, colorful, different colors, spots, gradient, staining)
- ♦ Cap shape (flat, bell, knobbed, conical, cylindrical, convex, concave, depressed)
- ♦ Stalk shape (thin, fat, tapering towards base or cap, equal, club shaped, bulbous, with cup)
- ♦ Gill type/attachment to stalk (pores, ridges, teeth, gills/free, narrowly attached, broadly attached, notched, descending, veiled)



Diagrams by Zoe Ahrens



Sample 1

09/08/22

Found near Cuchara, CO. 8,000 ft elevation. Mixed coniferous, hilly, found in a damp, shaded area near lake, one solitary mushroom found in litter near many downed decomposing trees. Sunny 63° F, recent rain.

Large, dark purple mushroom. Cap 4" diameter, convex, dark purple, dry almost velvety. Total height 5", stalk bulbous, 1" diameter, and pink at

base, fibrous, cream color, brown staining. Gills present, fleshy, yellowish white to brown, free from stalk. Inner flesh white, spongy, not hollow. No cup or ring present. Lightly fishy smelling. Orange spore print.

ID'd as Shrimp Russula (*Russula xerampelina*)

Great edible, but many poisonous look alikes.

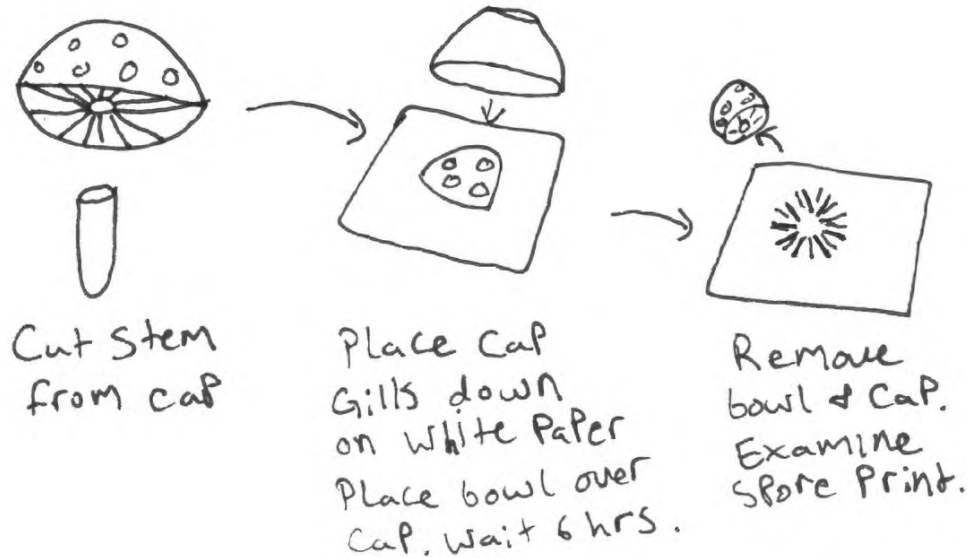


Diagram by Zoe Ahrens

- ♦ Spore print (pattern, color; white, grey, black, brown, pink, purple, yellow, green, etc.)
- ♦ Spore shape under a microscope (circular, smooth, ridged, pointed)
- ♦ Taste *not recommended for beginners* taste a small amount raw, and spit out (spicy, fishy, earthy, bitter, mild)

How to collect a spore print

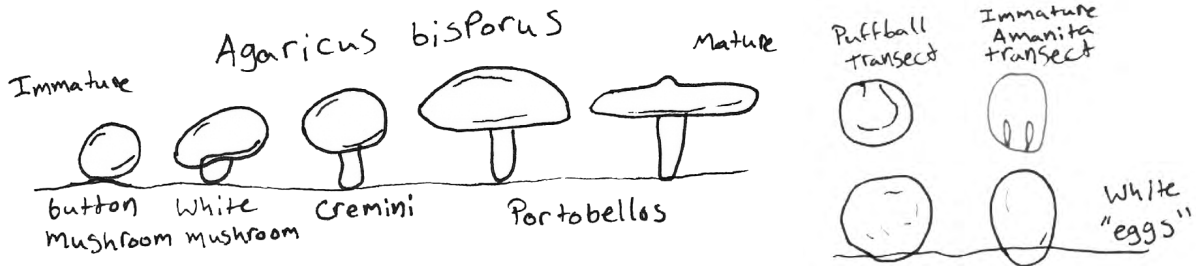
When the mushroom is fresh, cut the stem from the cap so that the cap can sit flat, gills facing down. Place the cap, gills down, on a piece of foil or white paper (even alternating black and white striped paper to be fancy). Place the cap and paper in a plastic box and cover with a lid or place a bowl over the cap on the paper on a table. Leave it alone for 2-24 hours (6 hours is a good target wait time), and carefully remove the mushroom from the paper to reveal the spore print. A mushroom may not provide a spore print if it is too young, or old, sits too long, doesn't have gills, or air blows the spores away. The color and pattern of the spore print is often vital to identifying a species or at least can help to determine if it is poisonous or edible. The spore print can also be preserved when covered with plastic and kept with the description label and photographs or drawings. The spores are also important to collect to view under a microscope to aid in identification. Some species cannot be properly identified without using a microscope to determine the spore shape. Sometimes the spores can also be used later for cultivation of some species.

How to dry mushrooms

Carefully clean dirt or debris from the mushroom using a brush. If it is still dirty, then a paper towel or cloth can be used, using very little, if any, water. If it is small, it can be dried whole. If it is large, it may need to be cut in half lengthwise or quartered to allow a better view and to dry faster. It is best to use a dehydrator but a mushroom can potentially be dried out in a warm dry room with adequate airflow over a few days. Keep track of the mushrooms while they are being dried by making sure a label is near them. Do not press the mushrooms; it will not preserve them. Place the dried mushrooms in plastic baggies or boxes, ideally with a silica packet, and keep them dry and free of pests. Keep a logbook with the dried sample and/or spore print labeled with a number corresponding to a notebook and/or computer spreadsheet with the location and physical description.

Identification challenges

All this information is vital to identification because mushrooms can vary so widely in color, shape, and age within their own species. The fly agaric mushroom is usually red and white around most of the northern hemisphere, except in Washington and Montana where it is yellow and white. Mushrooms also have many look-a-likes that can be from entirely different genus' with very different ecological characteristics that can't be obviously seen. A golden morel can vary in color and shape enough to easily be mistaken for a false morel, but a true morel can be identified by its hollow stalk. Age plays a huge part in identification too because a new mushroom of many species, called a button, looks like a white egg and can easily be mistaken for a puff ball unless cut in half. Common mushrooms in grocery stores, such as button mushrooms, white mushrooms, creminis, and portobellos are actually all the same species, *Agaricus bisporus*, they are just at different levels of maturity. Multiple identification books, talking to other more experienced mycophiles and lots of practice is the best way to become proficient in mushroom identification.



Other types of mushrooms



Diagrams by Zoe Ahrens

VEGETATION OF NEW MEXICO

9.0 Common Trees of New Mexico



Photo by Carolina May

JUNIPERS

- Juniperus deppeana*, alligator juniper
- Juniperus monosperma*, one-seed juniper
- Juniperus osteosperma*, Utah juniper
- Juniperus scopulorum*, Rocky Mountain juniper

PINES

- Pinus aristata*, bristlecone pine
- Pinus edulis*, two-needle piñon
- Pinus flexilis*, limber pine
- Pinus ponderosa*, ponderosa pine

FIRS

- Abies concolor*, white fir
- Abies lasiocarpa* var. *arizonica*, corkbark fir
- Pseudotsuga menziesii*, Douglas-fir

SPRUCE

- Picea engelmannii*, Engelmann spruce
- Picea pungens*, blue spruce

POPLARS

- Populus tremuloides*, quaking aspen

OAKS

- Quercus gambelii*, Gambel oak
- Quercus grisea*, gray oak
- Quercus turbinella*, desert scrub oak
- Quercus* × *pauciloba*, wavyleaf oak

ASSORTED

- Acer glabrum*, Rocky Mountain maple
- Alnus incana* ssp. *tenuifolia*, thinleaf alder

JUNIPERS

Juniperus deppeana, alligator juniper



Photo by Carolina May



Center photo and above by Grace McCarthy

Juniperus deppeana

Common Name: alligator juniper

Family: Cupressaceae or cypress

USDA PLANTS Code: JUDE2

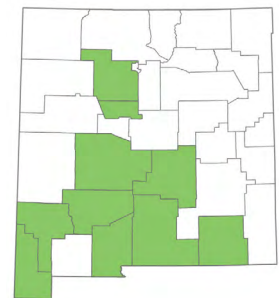
Habitat: Dry, rocky slopes. Grows in association with piñon pine, oaks, and ponderosa pine. Throughout most of the state, most commonly found in central and southern New Mexico.

Elevation: 6,000 to 8,000 ft

ID: 20-40 ft in height, occasionally taller. Typically, single stem. Platy, grayish bark resembles alligator skin.

Leaves: Blue-green, scale-like, 1-4 mm long, glandular.

Fruits: Pollen and seed cones on separate trees. Pollen cones 3 mm long, seed cones are 8-15 mm long. Reddish brown-bluish, bearing 3-6 seeds per cone.



Map by USDA PLANTS

JUNIPERS

Juniperus monosperma, one-seed juniper



Photo by Carolina May

Juniperus monosperma

Common Name: one-seed juniper

Family: Cupressaceae or cypress

USDA PLANTS Code: JUMO

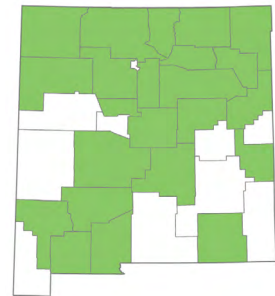
Habitat: Dry, rocky slopes. Grows in association with piñon pine and ponderosa pine. Very widespread throughout New Mexico.

Elevation: 4,000 to 8,000 ft

ID: 7-23 ft in height. Typically, with a rounded crown and multiple stems. Bark is grayish-brown, shreddy in appearance.

Leaves: 1-3 mm long, bright green. Scale like, elongate, glandular.

Fruits: Pollen and seed cones on different plants. Pollen cones are 3-4 mm long, seed cones are 4-7 mm long. Seed cones typically bare 1 seed per cone, occasionally bearing 2 or 3 seeds. Dark blue, glaucous.



Map by USDA PLANTS

JUNIPERS

Juniperus osteosperma, Utah juniper



Photos by Wendy McCrady, (<https://inaturalist.nz/observations/124210218>), licensed by CC-BY (<https://creativecommons.org/licenses/by/4.0/>)

Juniperus osteosperma

Common Name: Utah juniper

Family: Cupressaceae or cypress

USDA PLANTS Code: JUOS

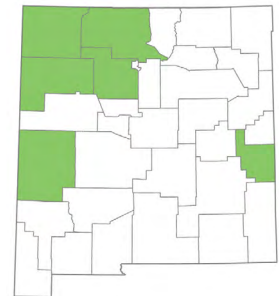
Habitat: Rocky slopes and hills. Found in western and northwestern New Mexico.

Elevation: 6,200 to 7,500 ft

ID: 20-30 ft in height. Typically single-stemmed, can have multiple stems. Rounded or conical crown. Shreddy, gray bark.

Leaves: Scale-like. Bright yellow-green. 1-2 mm long. Glandular.

Fruits: Pollen and seed cones on same plant. Pollen cones 2-3 mm, seed cones 6-12 mm long. Brownish-blue, glaucous. Typically contains 1 seed per cone.



Map by USDA PLANTS

JUNIPERS

Juniperus scopulorum, Rocky Mountain juniper



Photo by Carolina May



Photo by Grace McCartha

Juniperus scopulorum

Common Name: Rocky Mountain juniper

Family: Cupressaceae or cypress

USDA PLANTS Code: JUSC2

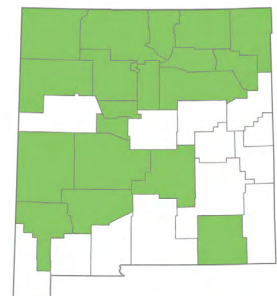
Habitat: Mixed conifer forests, dry slopes. Common throughout New Mexico. Found at higher elevations than *Juniperus monosperma* (one-seed juniper).

Elevation: 5,700 to 9,000 ft

ID: 10-35 ft in height. Most commonly with a single trunk. Has a "lacy" or "droopy" appearance. Bark is reddish-brown or grayish-brown, shreddy.

Leaves: Blue-green, scale-like, 1-4 mm long, and glandular.

Fruits: Pollen and seed cones on separate plants. Seed cones 4-6 mm in diameter, typically bearing 2 seeds. Bluish-purple.



Map by USDA PLANTS

PINES

Pinus aristata, bristlecone pine



Photo above and center by Carolina May



Photo by Kathryn Mahan

Pinus aristata

Common Name: bristlecone pine

Family: Pinaceae or pine

USDA PLANTS Code: PIAR

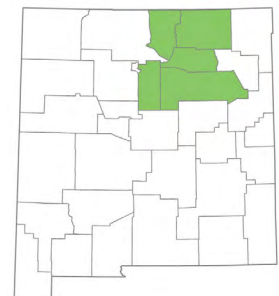
Habitat: High elevation mixed conifer to subalpine. Mountainous areas in northern New Mexico.

Elevation: 9,000 to 12,500 ft

ID: 40-50 ft in height. Needles on branches are bottlebrush in appearance. Mature trees have shallowly furrowed bark, reddish-brown in coloration.

Leaves: 4 cm long, 5 needles per fascicle, sticky, and curved.

Fruits: Pollen and seed cones on same plant. Pollen cones are 1 cm long. Seed cones 5-9 cm long. Scales bearing curved prickles.



Map by USDA PLANTS

PINES

Pinus edulis, two-needle piñon



Photos by Carolina May

Pinus edulis

Common Name: two-needle piñon

Family: Pinaceae or pine

USDA PLANTS Code: PIED

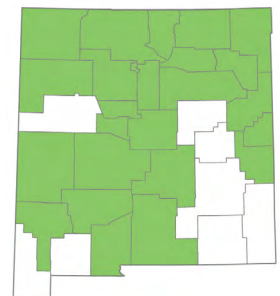
Habitat: Dry slopes, mesas, grows in association with juniper, oaks, and ponderosa pine. Common throughout New Mexico.

Elevation: 4,500 to 7,500 ft

ID: 15-60 ft in height. Yellowish-brown bark, irregularly fissured, and resinous.

Leaves: Two needles per fascicle, 2-4 cm long. Slightly curved upwards. Stomatal lines on both surfaces.

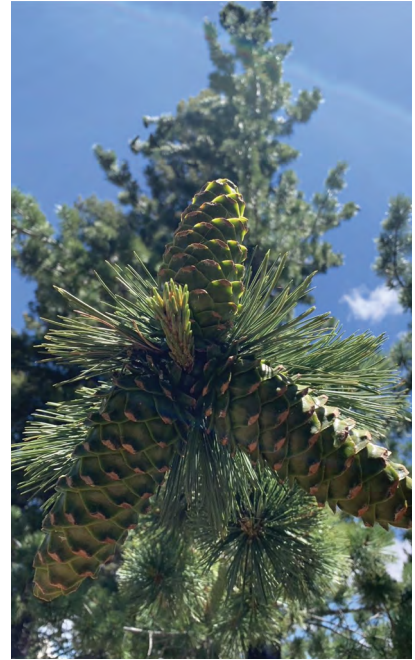
Fruits: Pollen and seed cones on the same tree. Seed cones 3.5-5 cm long. Golden, yellowish-brown in coloration. Spherical, stout in shape.



Map by USDA PLANTS

PINES

Pinus flexilis, limber pine



Photos above and center by C. Rothfels (<https://inaturalist.nz/observations/131156876>), licensed by CC-BY(<https://creativecommons.org/licenses/by/4.0/>)

Photo by Carmen Melendez

Pinus flexilis

Common Name: limber pine

Family: Pinaceae or pine

USDA PLANTS Code: PIFL2

Habitat: Mixed conifer forests to subalpine. Mountainous areas in northern New Mexico.

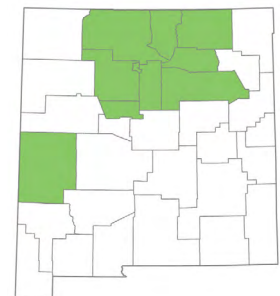
Elevation: 7,500 to 12,000 ft

ID: 26-85 ft in height. Spreading to ascending branches. Brownish-gray bark forms scaly plates with maturity.

Leaves: 3-7 cm long. 5 needles per fascicle. Stomatal lines on both needle surfaces but more distinct on upper surface of needle.

Fruits: Pollen and seed cones on same tree. Seed cones 7-15 cm long, slightly reflexed, and truncate at the apex. Unarmed. Wider and shorter than *Pinus strobiformis* (southwestern white pine).

Note: *Pinus strobiformis* looks very similar to *flexilis*. Has been known to hybridize. *Strobiformis* only has stomatal lines on upper needle surface. *Strobiformis* seed cones are 15-25 cm long and recurved.



Map by USDA PLANTS

PINES

Pinus ponderosa, ponderosa pine



Photo by Carolina May



Photo by Meredith Prentice

Pinus ponderosa

Common Name: ponderosa pine

Family: Pinaceae or pine

USDA PLANTS Code: PIPO

Habitat: Mid to high elevation forests. Common throughout New Mexico in mountainous regions.

Elevation: 5,000 to 9,500 ft

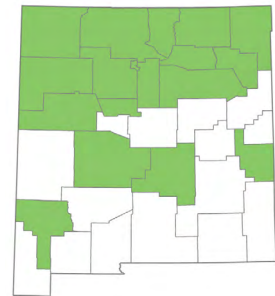
ID: 20-100 ft in height, can be taller. Bark puzzle piece shaped. Referred to as "blackjacks" when young due to grayish-black or brown coloration of bark. With maturity bark takes on golden-brown coloration and is referred to as "yellow bellies".

Leaves: 10-20 cm long, 3 needles per fascicle. Bright yellow-green. All needle surfaces have stomatal lines.

Fruits: Pollen and seed cones on same tree. Seed cones 5-15 cm long, ovoid to elliptic. Reddish-brown in coloration, scales tipped with sharp prickle.



Photo by Carolina May



Map by USDA PLANTS

FIRS

Abies concolor, white fir



This photo and left by Carolina May



Photo by Kathryn Mahan



Photo by Carmen Melendez

Abies concolor

Common Name: white fir

Family: Pinaceae or pine

USDA PLANTS Code: ABCO

Habitat: Mixed conifer forests, common throughout mountainous regions of New Mexico.

Elevation: 7,000 to 9,000 ft

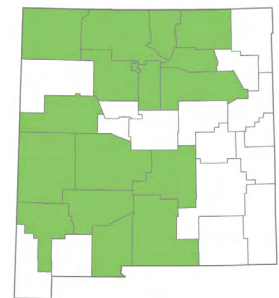
ID: 30-100 ft tall or more. Bluish-green in coloration. Symmetrical conical shape. Branches perpendicular to trunk. Bark is whitish-gray and smooth on young trees, dark gray and furrowed with maturity.

Leaves: Needles are 3 cm or more long. Spiraled upwards.

Fruits: Seed cones grayish, 7-12 cm long. Fall apart at maturity/ before they drop to the ground.



Photo by Kathryn Mahan

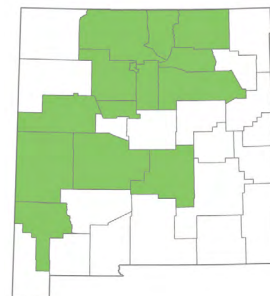


Map by USDA PLANTS

FIRS

***Abies lasiocarpa* var. *arizonica*,
corkbark fir**

Photos by Claire Gentry

Abies lasiocarpa var. *arizonica***Common Name:** corkbark fir**Family:** Pinaceae or pine**USDA PLANTS Code:** ABLA**Habitat:** Subalpine mixed conifer forests throughout mountainous regions in New Mexico.**Elevation:** 8,500 to 12,000 ft**ID:** Up to 65 ft in height. Bark is smooth, grayish-white, with resin blisters. Spongy upon touch, resembling a corkboard in texture.**Leaves:** 1.8-3 cm long. Flattened and typically turned upward. Bluish-green and waxy on upper surface.**Fruits:** Seed cones erect. Dark purple, 6-12 cm long, and 2-4 cm wide. Seed cone bracts.

Map by USDA PLANTS

FIRS

Pseudotsuga menziesii, Douglas-fir



Photos by Carolina May

Pseudotsuga menziesii

Common Name: Douglas-fir

Family: Pinaceae or pine

USDA PLANTS Code: PSME

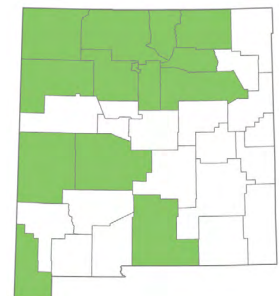
Habitat: Foothills, mixed coniferous forests. Common throughout New Mexico.

Elevation: 6,500 ft to treeline

ID: Up to 200 ft in height. Bark is dark brown, deeply furrowed. Crown shape conical to rounded.

Leaves: Flat, 2-4 cm long, tapering to a short petiole. Two stomatal lines on the underside. Needles form an angle at the point of attachment with the twig, shaped like a hockey stick.

Fruits: Seed cones 5-9 cm long. 3 pointed bracts extend out past the scales, resembling a mouse tail.



Map by USDA PLANTS

SPRUCE

Picea engelmannii, Engelmann spruce



Picea engelmannii

Common Name: Engelmann spruce

Family: Pinaceae or pine

USDA PLANTS Code: PIEN

Habitat: Mixed conifer, subalpine forests to treeline. Typically, found at elevations higher than *Picea pungens*.

Elevation: Above 8,500 ft

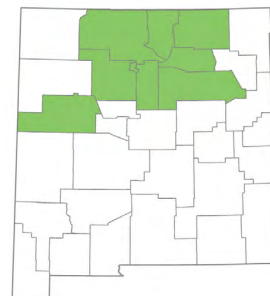
ID: Up to 190 ft in height. Bark is reddish-brown, scaly. Branches typically horizontal to somewhat drooping.

Leaves: 1.6-3.5 cm long. Typically, 4-sided or square. Borne singly from all side of the twig, 4-angled. Needles and pegs acutely attached to twig. Somewhat flexible, not spine-tipped, and not as sharp to the touch as *Picea pungens*. Stems pubescent on new growth.

Fruits: Seed cones are 6 cm long or less. Papery and flexible. Ellipsoid.



Photos by Grace McCartha



Map by USDA PLANTS

SPRUCE

Picea pungens, blue spruce



Photo by Carolina May



Photo by Claire Gentry



Photo by Carolina May



Photo by Claire Gentry

Picea pungens

Common Name: blue spruce

Family: Pinaceae or pine

USDA PLANTS Code: PIPU

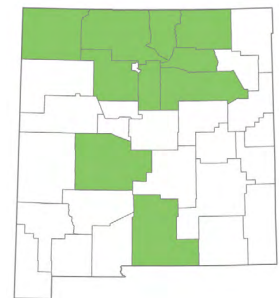
Habitat: Drainage, moist canyons. Foothills, mixed conifer, and subalpine forests in mountainous regions throughout New Mexico.

Elevation: 7,500 to 10,500 ft

ID: Up to 160 ft in height. Whorled branches, slightly to strongly drooping. Bark is gray, brown, and more furrowed/ridged than scaly.

Leaves: 1.5-3 cm long, rigid and sharp to the touch. Typically 4-sided or square. Needles and pegs attached to twig at right angles.

Fruits: Seed cones are typically 6-8 cm long. Ellipsoid, scales elliptic to diamond-shaped.



Map by USDA PLANTS

POPLARS

Populus tremuloides, quaking aspen



Photo by Carolina May



Center photo and above by Kathryn Mahan

Populus tremuloides

Common Name: quaking aspen

Family: Salicaceae or willow

USDA PLANTS Code: POTR5

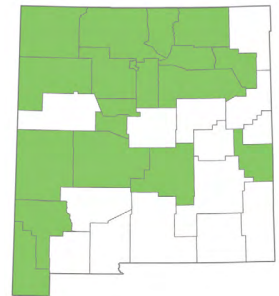
Habitat: Mountainous slopes and valleys throughout New Mexico.

Elevation: 6,500 to 10,500 ft

ID: 16-100 ft in height. Bark is white, smooth, and powdery to the touch. Bark around base becomes grayish-black and furrowed with maturity.

Leaves: 4-6 cm long. Ovate to nearly round. Margins have small, rounded teeth. Long, flattened petiole. Dark green and shiny above, pale green below.

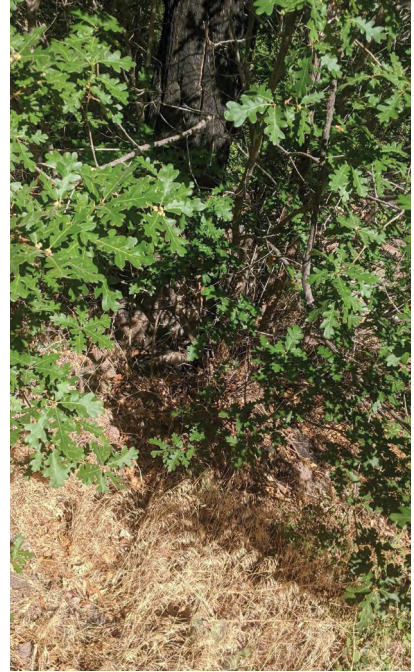
Fruits: Narrowly ovoid to flask-shaped capsules. 5-7 mm long. Seeds 2 mm long, each with a tuft of long, silky white hairs.



Map by USDA PLANTS

OAKS

Quercus gambelii, Gambel oak



Quercus gambelii

Common Name: Gambel oak

Family: Fagaceae or beech

USDA PLANTS Code: QUGA

Habitat: Grows in association with piñon-juniper woodlands, ponderosa pine forests, and dry mixed conifer forest. Hills, canyons, and mountain slopes. Common throughout New Mexico.

Elevation: 6,000 to 8,500 ft

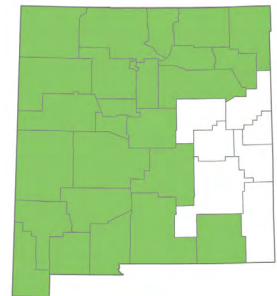
ID: Up to 60 ft in height. Growth form can also be shrubby.

Leaves: 3-15 cm long, with 5-9 lobes. Lobes rounded to obtuse. Bright green upper surface, dull green and tomentose on underside. Elliptic.

Fruits: Acorns 8-20 mm. Acorns grow solitary or borne in clusters of 2 or 3. Cup covers one-third to one-half of the total length of the acorn.



Photos by Carolina May

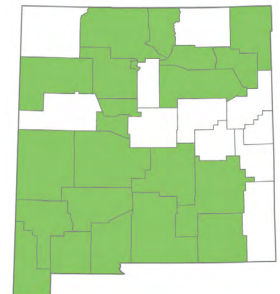


Map by USDA PLANTS

OAKS

***Quercus grisea*,**
gray oak

Photo by Grace McCartha

Photo by CK Kelly, <https://www.inaturalist.org/observations/77524775>, licensed by CC-BY (<https://creativecommons.org/licenses/by/4.0>)*Quercus grisea***Common Name:** gray oak**Family:** Fagaceae or beech**USDA PLANTS Code:** QUGR3**Habitat:** Piñon-juniper woodlands, ponderosa pine forests, and savanna. Common throughout New Mexico.**Elevation:** 4,700 to 7,200 ft**ID:** Up to 32 ft in height. Can be shrubby in appearance.**Leaves:** 1.5-5.5 cm long, 9-30 mm wide. Margins slightly revolute to dentate. Leaf tip rounded to pointed, base cordate to rounded. Pubescent on both the upper and lower surface. Gray-green, elliptic to ovate.**Fruits:** Acorn solitary or borne in pairs. 1-1.2 cm long. Cup covers about one-third to one-half of the total length of the acorn. Peduncle, if present, 30 mm.

Map by USDA PLANTS

OAKS

Quercus turbinella, desert scrub oak



Photo by Grace McCartha



Photo by Michael Tidwell, (<https://www.inaturalist.org/observations/172600835>), licensed by CC-BY (<https://creativecommons.org/licenses/by/4.0>)

Quercus turbinella

Common Name: desert scrub oak

Family: Fagaceae or beech

USDA PLANTS Code: QUTU2

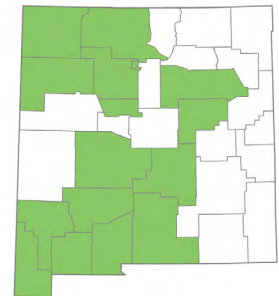
Habitat: Grassland, deserts, and piñon-juniper woodlands.
Common throughout New Mexico.

Elevation: 4,000 to 8,000 ft

ID: Up to 13 ft in height.

Leaves: 1.5-3 cm long and 5-30 mm wide. Spinose margins, 3-7 spines per side of the leaf. Thick and leathery, ovate to elliptic, oblong. Base cordate to rounded.

Fruits: Acorns 1-3.5 cm long. Cup covers one-fourth to one-half of total acorn. Peduncles 10 mm.



Map by USDA PLANTS

OAKS

Quercus × pauciloba, wavyleaf oak



Photo by Grace McCartha



Photo by CK Kelly, (<https://www.inaturalist.org/observations/34744058>), licensed by CC-BY (<https://creativecommons.org/licenses/by/4.0>)

Quercus × pauciloba

Common Name: wavyleaf oak

Family: Fagaceae or beech

USDA PLANTS Code: QUPA4

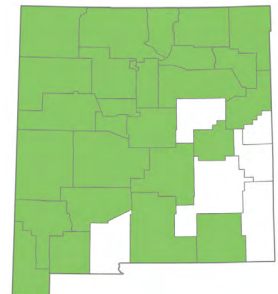
Habitat: Dry slopes and canyons, common throughout New Mexico.

Elevation: 5,500 to 8,500 ft

ID: Typically low growing 3-5 ft in height, up to 22 ft.

Leaves: 1.5-6.5 cm long, 0.6-3 cm wide, margins coarsely toothed. Shallow, pointed lobes. Pubescent surfaces.

Fruits: Acorns less than 2.5 cm long.



Map by USDA PLANTS

ASSORTED

Acer glabrum, Rocky Mountain maple



Photo by Carolina May



Photo by Aaron Gunnar, (<https://www.inaturalist.org/observations/181249758>), licensed by CC-BY (<https://creativecommons.org/licenses/by/4.0>)



Photo by Lindsey Salmonson, (<https://www.inaturalist.org/observations/48583464>), licensed by CC-BY (<https://creativecommons.org/licenses/by/4.0>)

Acer glabrum

Common Name: Rocky Mountain Maple

Family: Aceraceae or Acer

USDA PLANTS Code: ACGL

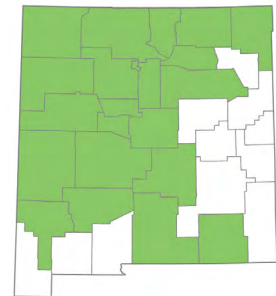
Habitat: Streams and canyons, foothills, mixed conifer, and subalpine forests. Common throughout New Mexico.

Elevation: 7,000 to 9,500 ft

ID: Up to 26 ft in height, with numerous slender shoots. Bark is smooth and reddish-brown.

Leaves: 10 cm or less long, 7.5 cm wide. Trifoliate or palmately lobed, with 3-5 lobes. Toothed or serrated margins. Long red petioles. Shiny green above, paler below.

Fruits: Samaras (winged nutlets) arranged in pairs, 4-6 cm long. Tinted red with maturity.



Map by USDA PLANTS

ASSORTED

Alnus incana ssp. tenuifolia, thinleaf alder



Photo by Calvin Chan, (<https://www.inaturalist.org/observations/166974804>), licensed by CC-BY (<https://creativecommons.org/licenses/by/4.0>)



Photo by John Doyle, (<https://www.inaturalist.org/observations/1818050>), licensed by CC-BY (<https://creativecommons.org/licenses/by/4.0>)

Alnus incana ssp. tenuifolia

Common Name: thinleaf alder

Family: Betulaceae or Birch

USDA PLANTS Code: ALINT

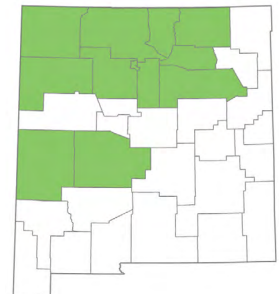
Habitat: Canyons and riparian areas. Common in mountainous regions throughout northern and western New Mexico.

Elevation: 6,500 to 8,500 ft

ID: Up to 32 ft in height. Bark smooth, grayish-brown to reddish-brown.

Leaves: 4-11 cm long, 2.5-7.5 cm wide. Margins doubly serrated, ovate to elliptic, oblong. Rounded or cordate at the leaf base.

Fruits: Catkins elliptic, arranged in clusters of 2-5, 1-2 cm long.



Map by USDA PLANTS

VEGETATION OF NEW MEXICO

10.0 Common Shrubs of New Mexico



Photo by Kathryn Mahan

What is a shrub?

A woody plant that is smaller than a tree and has several main stems arising at or near the ground.

NATIVE

Amelanchier alnifolia, Saskatoon service-berry

Amorpha canescens, leadplant

Amorpha fruticosa, indigo bush

Arctostaphylos pungens, pointleaf manzanita

Arctostaphylos uva-ursi, kinnikinnick

Artemisia tridentata, big sagebrush

Atriplex canescens, four-wing saltbush

Atriplex confertifolia, shadescale saltbush

Baccharis salicifolia, seepwillow

Ceanothus fendleri, Fendler's ceanothus

Cercocarpus montanus, mountain mahogany

Cornus sericea, redosier dogwood

Cylindropuntia imbricata, tree cholla

Dasiphora fruticosa, shrubby cinquefoil

Ephedra viridis, green ephedra

Ericameria nauseosa, rubber rabbitbrush

Fallugia paradoxa, Apache plume

Forestiera pubescens, New Mexico olive

Gutierrezia sarothrae, broom snakeweed

Hymenoxys richardsonii, pingue rubberweed

Jamesia americana, five-petal cliffbush

Juniperus communis, common juniper

Krascheninnikovia lanata, winterfat
Larrea tridentata, creosote bush
Lonicera involucrata, twinberry honeysuckle
Lycium pallidum, pale wolfberry
Mahonia repens, creeping Oregon-grape
Nolina greenei, Greene's beargrass
Opuntia engelmannii, cactus apple
Opuntia phaeacantha, tulip prickly pear cactus
Paxistima myrsinites, mountain-lover
Petradoria pumila, rock goldenrod
Physocarpus monogynus, mountain ninebark
Prunus virginiana, chokecherry
Psoralea scoparius, broom dalea
Purshia stansburyana, cliffrose
Rhus trilobata, skunkbush sumac
Ribes cereum, wax currant
Ribes inerme, whitestem gooseberry

Robinia neomexicana, New Mexico locust
Rosa woodsii, Woods' rose
Rubus armeniacus, Himalayan blackberry*
Rubus idaeus, red raspberry
Rubus parviflorus, thimbleberry
Salix exigua, coyote willow
Sambucus nigra ssp. caerulea, blue elderberry
Sambucus racemosa, red elderberry
Senegalia greggii, catclaw acacia
Shepherdia canadensis, russet buffaloberry
Sorbus dumosa, Arizona mountain-ash
Symphoricarpos rotundifolius, roundleaf snowberry
Tamarix spp., salt-cedar*
Vaccinium myrtillus, whortleberry
Yucca baccata, banana yucca

*non-native

Amelanchier alnifolia

Common Names: Saskatoon service-berry, service-berry, juneberry, shadbush

Family: Rosaceae or rose

USDA PLANTS Code: AMAL2

Habitat: Coniferous forests and wet meadows. Upper limits of piñon-juniper communities. Occurs in northern NM counties.

Elevation: 6,000 to 9,000 ft

Common/Similar Species:

Amelanchier utahensis (Utah serviceberry) has shorter leaves and typically occurs at lower elevations/ southern portion of New Mexico.

ID: Up to 22 ft tall. Forming thickets, mats, or clumps. Bark thin, light brown, and tinged with red. Smooth or shallowly fissured.

Leaves: Simple, alternate, ovate to nearly round. 2.5-6 cm long, 1.5-4.2 cm wide, with lateral, parallel veins in 8-13 pairs. Glabrous with age, margins coarsely serrate to dentate.



Photos by Carolina May

Flowers: Short, dense, 5-15 flowered, upright racemes. White petals, 1-2 cm long. Sepals with long hairs on the inside, reflexing in age. About 20 stamens, 5 styles, and ovary is persistently tomentose at the top. Flowers from May to June.

Fruits: 5-15 mm long. Smooth, purple-black, slightly gray-blue waxy. Pulp fleshy and sweet. 4-10 seeds.

Amorpha canescens

Common Names: leadplant, leadplant amorpha, downy indigobush, prairie shoestrings, buffalo bellows

Family: Fabaceae or pea

USDA PLANTS Code: AMCA6

Habitat: Dry grasslands, sandy, hillsides, roadsides, open woodlands, and distributed areas. Primarily found in northeastern and eastern New Mexico.

Elevation: 4,000 to 6,000 ft

Common/Similar Species: *Amorpha fruticosa* (indigo bush) is a larger plant as a whole and leaflets are larger. Fewer leaflets per leaf. Typically occurs in central, western, and southern New Mexico.

ID: Erect, up to 3.3 ft tall. Woody at base.

Leaves: Pinnately compound. 4-10 cm long with 15-47 leaflets. Lanceolate to elliptic or oblong. Leaflets 7-15 mm long and 3-6 mm wide. Stems and leaf underside densely woolly.



Photos by Grace McCarthy

Flowers: Tiny purple flowers, grouped in several terminal spikes. Florescence is 6-10 cm long. Single petal is about 4-5 mm long. Flowers June to August.

Fruits: Densely woolly, about 4 mm long. Seeds are orange-brown, elliptic.

Amorpha fruticosa

Common Names: false indigo bush, desert false indigo, river-locust, false indigo, indigo amorpha, indigobush

Family: Fabaceae or pea

USDA PLANTS Code: AMFR

Habitat: Open woods, canyons, and stream margins. Found in central, western, and southern New Mexico.

Elevation: 4,500 to 6,000 ft

Common/Similar Species: Similar to *Amorpha canescens* (leadplant) which has smaller leaves and more leaflets per leaf. *Amorpha canescens* is typically found more in the eastern portion of New Mexico.

ID: Height between 3-10 ft

Leaves: Compound leaves, 7-20 cm long. Leaflets 2-4.5 cm long, 9-25 per leaf, ovate to oblong. Shape of leaf and pubescence can be highly variable.

Flowers: Purplish-blue with orange anthers. Upright spikes 7-15 cm long. Flowers May to June.

Fruits: Curved, containing 1-2 seeds. Glabrous or slightly hairy.



Photos by Claire Gentry

Arctostaphylos pungens

Common Names: pointleaf manzanita, Mexican manzanita

Family: Ericaceae or heath

USDA PLANTS Code: ARPU5

Habitat: Pine-oak woodlands, piñon-juniper woodlands, chaparral, mixed conifer forests, foothills, canyons. Typically occurs in western and southwestern New Mexico.

Elevation: 4,500 to 8,000 ft

Common/Similar Species: May appear similar to *Arctostaphylos pringlei*, but *A. pringlei* has much more pubescence and is usually found in lower elevations in AZ/CA.

ID: Large, erect, reaching 3-10 ft. Bark is smooth, red to brown.

Leaves: Covered with fine hairs. Thick, leathery, oblong to elliptic, and pointed at the apex. 12-30 mm long, 10-20 mm wide.

Flowers: Raceme of perfect, urn-shaped, terminal flowers, roughly 6 mm long. Pink to white.



Photos by Carolina May

Flowers March to July.

Fruits: Smooth round berry, 5-8 mm in diameter. Red to brown. Contains several seeds.

Arctostaphylos uva-ursi

Common Names: kinnikinnick, bearberry

Family: Ericaceae or heath

USDA PLANTS Code: ARUV

Habitat: Dry mountain slopes in coniferous and subalpine forests. Typically found in northern and west central New Mexico.

Elevation: 6,500 to 10,000 ft

Common/Similar Species: Can get confused with *Paxistima myrsinites* (mountain-lover). *Paxistima myrsinites* leaves are opposite and toothed.

ID: Rarely exceeds 10 cm in height, typically grows in dense mats sending out trailing stems.

Leaves: Glossy dark green, reddish in the winter. Alternate, simple, entire, and obovate. Roughly 2 cm long.

Flowers: Shaped like an urn. White and pink. 5 petals and sepals, 10 stamens. Flowers from April to July.

Fruits: Bright red, glabrous, drupes. 6-12 mm in diameter. Contains 1 to 5 seeds. Stays attached to plant into early winter.



Top left photo by Carmen Melendez, top right and above by Claire Gentry

Artemisia tridentata

Common Names: big sagebrush

Family: Asteraceae or aster

USDA PLANTS Code: ARTR2

Habitat: Open, dry plains, hills, slopes, mesas, or rocky areas with deep soils. Often grows in cold desert shrub or piñon-juniper woodlands. Most commonly found in western/ northwestern New Mexico.

Elevation: 4,500 to 8,500 ft

Common/Similar Species: Many *Artemisia* species.

ID: 2-13 ft tall, spreading branches with numerous main stems.

Leaves: Blue-gray to blue-green due to dense gray hairs. Typically, cuneate (wedge-shaped, triangular, and gradually tapering to the base) or flabelliform (fan shaped). 0.5-5 cm long, 3 lobed, sometimes 5. Spirally arranged with internodes making the leaves very dense.

Flowers: 5- 12 flowers per head. Arranged in panicle. Flowers July to October. Very aromatic with the smell being described as bitter, pungent to pleasant.



Top right photo by Carolina May
all others by Claire Gentry

Atriplex canescens

Common Names: fourwing saltbush, chamize, chamise, chamiso, white greasewood, fourwing shadescale, bushy atriplex

Family: Chenopodiaceae or goosefoot

USDA PLANTS Code: ATCA2

Habitat: Salt-desert scrub, alkali bottoms, sand dunes, piñon-juniper woodlands, sandy to gravelly soil. Common throughout the entirety of New Mexico.

Elevation: 3,000 to 6,800 ft

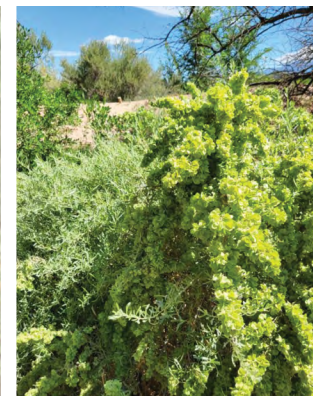
Common/Similar Species: highly variable in appearance; may hybridize with *A. confertifolia* in NM

ID: Multi-branched stems that are stout and whitish in appearance. Mature plants up to 8 ft in height.

Leaves: Simple, alternate, entire, sessile, linear-spatulate to narrowly oblong, canescent (covered with fine whiteish hairs). 1-4 cm long and 3-8 mm wide.

Flowers: Yellow, brown, or cream colored flowers arranged in small clusters. Panicles 3-15 cm long. Flowers May to September.

Fruits: Bracts have four flat, entire, or fringed wings from which the plant gets its name.



Photos by Grace McCartha

Atriplex confertifolia

Common Names: shadscale saltbush, spiny saltbush

Family: Chenopodiaceae or goosefoot

USDA PLANTS Code: ATCO

Habitat: Can be found in warm and cold desert shrub-steppe environments. Populations occur in low valleys, foothills, and mesas. Can also be found in sagebrush and piñon-juniper communities. Found in western and northwestern portions of New Mexico.

Elevation: 4,500 to 7,000 ft

ID: 1-3 ft tall with spine-tipped branches.

Leaves: Gray-green, ovate, alternate. 10-20 mm long. Typically width is equal to length. Sessile or attached by short petiole.

Flowers: The staminate flowers are yellow and gathered in clusters or spikes. Perianth divided into 5 parts. Flowering date varies.

Fruits: Two-winged, small utricle (inflated, dry fruit). 4-12 mm long and wide that typically bears one seed.



Photos by Bobby McCabe,
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Baccharis salicifolia

Common Names: seepwillow, mule fat

Family: Asteraceae or aster

USDA PLANTS Code: BASA4

Habitat: Found along streams and drainages, disturbed sites, dry washes. Typically found in southeastern New Mexico and a small portion of the state in the northeast.

Elevation: 3,500 to 5,000 ft

Common/Similar Species: May resemble true willows, but is not a member of the willow family.

ID: 3-10 ft in height. Woody at base. Stems subtly hairy.

Leaves: Margins entire to coarsely toothed. 3-nerved. 3- 15 cm long, 3-20 mm wide. Linear-lanceolate to oblong- obovate. Apex tapering to a point.

Flowers: Inflorescence is a round, large, terminal corymb. Phyllaries 2-4 mm long. Flowers March to October.

Fruits: Achenes 0.8-1.5 mm in length, glabrous, 5 nerved on short petiole.



Photos by Guillermo Debandi,
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Ceanothus fendleri

Common Names:

Fendler's ceanothus,
Fendler's buckbrush

Family: Rhamnaceae or
buckthorn

USDA PLANTS Code: CEFE

Habitat: Coniferous forests.
Common throughout
New Mexico.

Elevation: 5,000 to 9,500 ft

ID: Spreading to erect shrub.
Rarely exceeds 3 ft in height.
Thorny. Often can form dense
thickets.

Leaves: Alternate, simple,
margins typically entire.
3 prominent veins. Green to grayish green, pubescent
on the upper surface. Lower surface white-tomentose.
Oblong, elliptic, oblanceolate. Roughly 2 cm long.

Flowers: Inflorescence borne in dense panicle. White
flowers with 5 sepals, 5 petals, and 5 stamens. Style



Photos by Jackson Irvin,
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3-lobed. Flowers April to October.

Fruits: Small, 3-lobed dry capsule.

Cercocarpus montanus

Common Names: mountain
mahogany, alderleaf mountain
mahogany, silverleaf mountain
mahogany

Family: Rosaceae or rose

USDA PLANTS Code: CEMO2

Habitat: Rocky hillsides, cliffs,
open woods, mesas, piñon-
juniper woodlands, coniferous
forests. Most commonly found
in northern New Mexico but
has a wide range throughout
the state.

Elevation: 5,500 to 8,500 ft

Common/Similar Species: *Cercocarpus ledifolius* (curl-
leaf mountain mahogany) leaves are linear to elliptic.
Found in the northwest corner of New Mexico.

ID: Up to 15 ft in height. Erect growth habit with
numerous branches.

Leaves: Simple, alternate, ovate to obovate. Crenate to



Photo by Grace McCartha



Photo by Carolina May

dentate margins. Deep venation. 2-4 cm in length,
1.5-3 cm in width.

Flowers: Can be in clusters (2-3) or solitary.
No petals. 5 sepals, stamens 20 or more, 1 pistil.
Flowers May to July.

Fruits: Achene 4-8 cm in length. Tapers to a slight
spiral, covered in white hairs.

Cornus sericea

Common Names: redosier dogwood, American dogwood, red willow, redstem dogwood

Family: Cornaceae or dogwood

USDA PLANTS Code: COSE16

Habitat: Edges of lake, ponds, within wetlands, along streams. Prefer soils that are saturated for at least a portion of the growing season. Found throughout New Mexico generally excluding the eastern and central portion of the state.

Elevation: 5,500 to 9,000 ft

ID: Generally, 4.6-20 ft tall. Bark and twigs are reddish to purple and smooth from autumn to spring after leaves have fallen. Bark and twigs green in spring and summer.

Leaves: Simple, opposite, 2-4 in long, dark green above and hairy and lighter-colored below. Smooth margins, rounded bases, pointed tips, falsely parallel veins.

Flowers: Cyme inflorescence of small white to cream-colored flower. Four petals, four stamens. Flowers May to July.



Photos by Claire Gentry

Fruits: White berries with smooth exterior faces and furrowed interiors.

Cylindropuntia imbricata* var. *imbricata

Common Names: tree cholla, walking stick cholla, rope pear, cane cholla

Family: Cactaceae or cactus

USDA PLANTS Code: CYIM2

Habitat: Grassland, scrubland, woodland, and hillsides. Common throughout New Mexico.

Elevation: 3,600 to 7,500 ft

Common/Similar Species: Varieties include *imbricata* and *spiniosior*. *Spiniosior* has smaller tubercles (mound/enlarged leaf base), more tubercles per row. Typically found in the southeastern portion of New Mexico.

ID: 4 ft or taller in height. Several stems arising from one to several main trunks.

Leaves: Tubercles 2 cm long. 3 to 4 rows visible on one side of the stem. Areoles (area of cactus bearing spines and/or flowers) contain 10-20 spines, roughly 15-18 mm long.

Flowers: Pink to magenta. Flowers May to June.

Fruits: Yellow when mature. With 18-20 areoles.



Photos by Grace McCartha

Dasiphora fruticosa

Common Names: shrubby cinquefoil, golden hardhack, potentilla

Family: Rosaceae or rose

USDA PLANTS Code: DAFR6

Habitat: Open forests, moist meadows, subalpine. Most likely found in north central, northwestern, and western portions of New Mexico.

Elevation: 6,000 to 11,000 ft

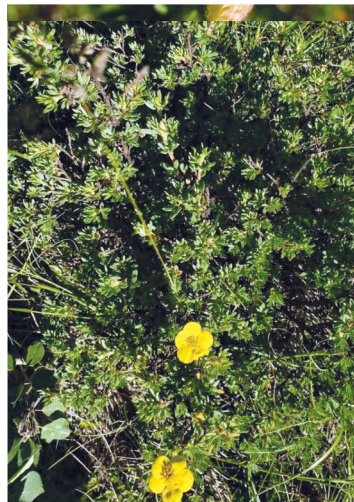
Common/Similar Species: There are many cultivars used in landscaping.

ID: Typically 3 ft in height. Dense, upright. Shredding bark is reddish brown.

Leaves: 3 to 7 leaflets per leaf. Compound, alternate. Leaflets obovate to lanceolate. Margins entirely, slightly revolute.

Flowers: Perfect. Yellow. Five petals, five sepals, 20-25 stamens. Flowers June to July.

Fruits: Long, hairy brown achene, not showy. Roughly 1-2 mm in length.



Photos by Grace McCartha

Ephedra viridis

Common Names: green ephedra, Mormon tea, jointfir

Family: Ephedraceae or ephedra

USDA PLANTS Code: EPVI

Habitat: Rocky or sandy slopes and plains. Piñon-juniper woodland, sagebrush desert, and desert grasslands. Can occur throughout many regions, most typically northwestern and southwestern New Mexico.

Elevation: 3,000 to 7,000 ft

Common/Similar Species: Many *Ephedra* species. Evidence of hybridization between species. Mostly similar in appearance to *Ephedra cutleri* (sticky joint fir) but the twigs are not sticky.

ID: Typically, about 3 ft in height. Branches green and irregularly fissured, practically leafless.

Leaves: Scale-like, 0.2-0.3 cm long, bases and middle portion conspicuously dark brown, the rest light green. Tends to be membranous.



Photos by Carolina May

Flowers: On staminate plants, flowers are yellow clusters of pollen sacs. Pollen cones are spheroidal and 0.3-0.4 mm in diameter. Pollen sacs are 0.5 mm long and 0.5-0.6 mm broad, practically lacking stalks.

Fruits: Cones of 2 to several present at nodes. 6-10 mm long. Either sessile or on short peduncles.

Ericameria nauseosa

Common Names: rubber rabbitbrush, gray rabbitbrush, golden rabbitbrush, chamisa, chamiso blanco

Family: Asteraceae or aster

USDA PLANTS Code: ERNA10

Habitat: Dry, open areas on plains, valley bottoms, foothills, and mountains. Common throughout New Mexico.

Elevation: 4,000 to 8,000 ft

ID: 1-8 ft tall. Rounded crown with stems originating from its base. Stems and leaves covered with dense white hairs.

Leaves: Bluish green, gray. Alternate, linear to spatula shaped with entire margins. 2-10 cm long and 1-6 mm wide. Commonly covered in felt like hairs.

Flowers: Arranged in cymes or corymbs. Involucre 6-11 mm. Heads typically contain 5-6 tubular flowers. Phyllaries in 4-5 series. No ray flowers. Flower July to October.

Fruits: Achenes topped with a pappus.



Photos by Grace McCartha

Fallugia paradoxa

Common Names: Apache plume

Family: Rosaceae or rose

USDA PLANTS Code: FAPA

Habitat: Dry/ rocky slopes, arroyos. Common throughout New Mexico.

Elevation: 3,000 to 8,000 ft

Common/Similar Species: *Purshia stansburiana* (cliffrose), flowers are less than 1.5 cm in diameter. 5-10 pistils per flower. More common in western half of New Mexico.

ID: Grows up to 6 ft.

Leaves: Alternate, 3- 7 lobes. 0.6-1.4 cm long. Lower surface covered in white tomentose hairs. Some leaves are fascicled, revolute.

Flowers: Perfect, white. Over 2 cm in diameter. 20 carpels or more, with slender pistils, numerous stamens. Flowers April to October.

Fruits: Achene with exserted style. Red, feathery. 2.5-5 cm in length.



Top photo and bottom right by Kathryn Mahan
Bottom left photo by Michele Jones,
(<https://inaturalist.nz/observations/127441522>),
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Forestiera pubescens

Common Names: New Mexico olive, stretchberry, New Mexico privet, New Mexico forestiera, desert olive

Family: Oleaceae or olive

USDA PLANTS Code: FOPU2

Habitat: Along streams, moist valleys, hillsides, and mesas. Common throughout New Mexico.

Elevation: 3,000 to 7,000 ft

Common/Similar Species: *Forestiera neomexicana* is a synonym of *Forestiera pubescens*. Sometimes get separated out as two species.

ID: Multi-stemmed, typically 6 ft in height. Occasionally reaching a mature height of 12-15 ft. Capable of sprouting from the base.

Leaves: Light green to grayish green oblong, simple, opposite. Rounded at both base and leaf apex. Attached to stem by short petiole. 1.4-5.5 cm long and 0.5-2 cm wide.

Flowers: Cluster of inconspicuous yellow flowers are borne along bare stem. Typically, in bloom before the leaves are present. Petals are absent from flowers.



Photos above left by Grace McCartha, right by Claire Gentry

Four to six small sepals. Flowers April to June.

Fruits: Dark bluish black to black, round to oblong drupe. 5-7 mm long.

Gutierrezia sarothrae

Common Names: broom snakeweed, snakeweed, stinkweed, turpentine weed

Family: Asteraceae or aster

USDA PLANTS Code: GUSA2

Habitat: Open, dry plains and upland sites, disturbed areas or areas with overgrazing. Common throughout New Mexico.

Elevation: 3,000 to 8,000 ft

Common/Similar Species: Often gets confused with *Ericameria nauseosa* (rubber rabbitbrush). *Gutierrezia sarothrae* is smaller. Also gets mixed up with *Hymenoxys richardsonii* (pingue rubberweed), *richardsonii* flowers are significantly bigger. *Gutierrezia microcephala* (thread-leaf snakeweed) can be difficult to distinguish. In the past it has been grouped into the same species as *Gutierrezia sarothrae* and treated as a variety. *Microcephala* flowers are more tightly clustered, and involucre are typically less than 1.5 mm in diameter.

ID: Up to 3 ft tall. Stems are bushy and branch upwards from woody base. Non-woody stems range from smooth to having some short hairs. Stems may



Photos by Grace McCartha

be resinous and sticky.

Leaves: Alternate, linear, and threadlike in shape. 0.5-7 cm long and 1-4 mm wide. Gland dotted.

Flowers: Bright golden yellow with sticky resin. 3-8 ray and disk florets per cluster. Involucre typically 2-3 mm in diameter. Bracts are narrow and green in color at apex and along mid-nerve.

Fruits: Achenes have a modified calyx consisting of 8-10 acute scales. The acute scales of the ray achenes are about one-half as long as those of the disk achenes.

Hymenoxys richardsonii

Common Names: pingue rubberweed

Family: Asteraceae or aster

USDA PLANTS Code: HYRI

Habitat: Ponderosa pine and piñon-juniper forests, upland sites. Common throughout New Mexico.

Elevation: 3,000 to 8,000 ft

Common/Similar Species: Often gets confused with *Gutierrezia sarothrae* (broom snakeweed), which has smaller flowerheads and lacks distinctive basal rosette.

ID: Roughly 1-1.5 ft in height. Erect with numerous stems. Woody caudex.

Leaves: Alternate, both basal and cauline. Simple or lobed (3-7). Gland dotted, glabrous to slightly pubescent. Linear. Tufts of soft hair located at leaf base axis.

Flowers: Corymbs of yellow flowers with both ray and disk flowers. 7-9 ray flowers, 7-15 mm long. Disk flowers 25-50, 3-4 mm long. Phyllaries arranged in two series, the outer phyllaries keeled.

Fruits: Pubescent achene, 2 mm long.



Photos by Bobby McCabe,
(<https://www.inaturalist.org/observations/92153066>),
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Jamesia americana

Common Names: five-petal cliffbush, cliffbush, cliff Jamesia, waxflower

Family: Hydrangeaceae or hydrangea

USDA PLANTS Code: JAAM

Habitat: Moist, sunny canyons and forests. Common throughout mountainous regions across New Mexico.

Elevation: 6,500 to 9,500 ft

Common/Similar Species: When trying to identify can key out to several species of *Viburnum*. These are found in the southeast and require more moisture than what's typically available in the Southwest.

ID: Up to 6 ft in height. Peeling reddish bark.

Leaves: Margins serrate, crenate, or dentate. Green above, underside is white tomentose. Deep venation. Ovate to elliptic. 7- 40 mm long, 6-32 mm wide.

Flowers: Arranged in a small cyme, with white, hairy flowers. Five sepals, five petals, with typically about 10 stamens. Ovary half inferior. Flowers June to July.

Fruits: Capsule.



Photos by Claire Gentry

Juniperus communis

Common Names: common juniper

Family: Cupressaceae or cypress

USDA PLANTS Code: JUCO6

Habitat: Wide habitat range. Typically, found in mixed conifer forests. Northwest and southwest New Mexico.

Elevation: 7,000 to 11,500 ft

Common/Similar Species: none

ID: Typically, grows to about 3-5 ft in height. Sometimes taller depending on location. Dense, spreading. Bark is shreddy, peels into thin strips.

Leaves: Awl-shaped. Simple. 5-15 mm long. Whorl arrangement.

Fruits: Cones are fleshy, berry-like, contain 1 to 3 seeds. Less than 1.5 cm in diameter.



Top photo by Carolina May, bottom by Grace McCartha

Krascheninnikovia lanata

Common Names: winterfat, white sage, winter-sage, feather-sage, sweet sage, lambstail

Family: Chenopodiaceae or goosefoot

USDA PLANTS Code: KRLA2

Habitat: Occurs in salt desert shrub, piñon-juniper woodlands, sagebrush grass and near the edges of some forest plant communities. Found in every county in New Mexico.

Elevation: 4,700 to 6,500 ft.

ID: Erect to spreading, low-growing. Up to 3 ft in height, sometimes taller. Woolly and branched.

Leaves: Simple, alternate, mostly linear, and revolute margins (rolled back from the margin). 1-4 cm long and 5 mm or less wide.

Flowers: Inflorescence is a spike. Plants are monoecious with staminate flowers above the pistillate ones or occasionally they are dioecious. Perianth is 4 parted with 4 stamens on staminate flowers. Flowers from May to July.

Fruits: Seed is an utricle. Seed coat is thin and covered



Top left photo by Carolina May, top right by Grace McCartha, bottom photos by Carmen Melendez

with fine white, silky pilose hairs. About 1 cm long.

Larrea tridentata

Common Names: creosote bush, greasewood, chapparal

Family: Zygophyllaceae or caltrop

USDA PLANTS Code: LATR2

Habitat: Well-drained slopes and plains, particularly those with a layer of caliche. Central and southern portions of New Mexico.

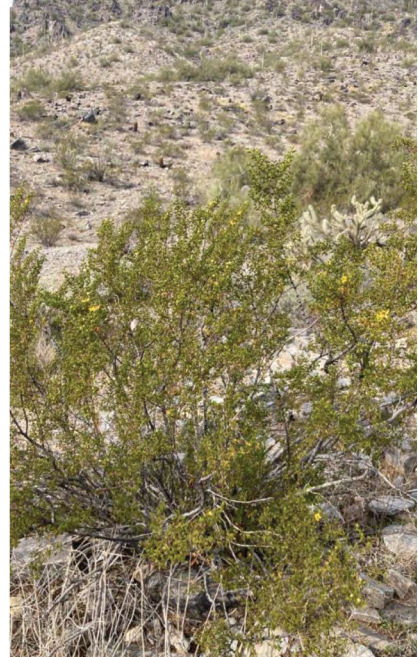
Elevation: 3,000 to 5,500 ft

ID: Typically, 6 ft in height. Mature bark gray. Dark swollen nodes persist along the stems.

Leaves: Thick, resinous, waxy. Bifoliate, with two small leaflets. Opposite.

Flowers: Yellow, solitary. 5 petals and sepals, 10 stamens. Flowers April to June.

Fruits: Hairy capsule with 1 seed. 4.5 mm wide.



Photos by Meredith Prentice

Lonicera involucrata

Common Names: twinberry honeysuckle, bearberry honeysuckle, twinberry, black twinberry, bush honeysuckle, bracted honeysuckle

Family: Caprifoliaceae or honeysuckle

USDA PLANTS Code: LOIN5

Habitat: Moist or wet soils, open woods, riparian. Mostly found in shaded areas in the mountainous regions throughout New Mexico.

Elevation: 7,500 to 10,500 ft

ID: Typically, 6 ft in height, sometimes taller.

Leaves: Arranged in opposite pairs along the stem. Egg or broadly lance shaped, pointed, and often hairy beneath. 5-15 cm long.

Flowers: Tubular, yellow. Solitary or borne in twos or threes in the leaf axis. Flowers June to July.



Photos by Carolina May

Fruits: Grows two, "twin" black, shiny berries. Cupped by purplish-red bracts.

Lycium pallidum

Common Names: pale wolfberry, pale-desert thorn, boxthorn, rabbit thorn

Family: Solanaceae or nightshade

USDA PLANTS Code: LYPA

Habitat: Piñon-juniper woodlands, riparian zones, savannah, desert grasslands, ruins. High salinity soils. Common throughout New Mexico.

Elevation: 2,000 to 7,000 ft

Common/Similar Species: Can get confused with *Lycium torreyi* (Torrey's wolfberry). *Torreyi* has shorter flowers, 1.6 cm long or less, usually found along river drainages.

ID: Dense, thorny shrub, up to 3-9 ft tall. Typically, erect. Mature branches reddish-brown.

Leaves: Pale green, hence, the name. Alternately arranged along the branch. Oblanceolate to spatulate, waxy and glabrous. Apex can be acute to rounded. 1-4 cm long and 4-15 cm wide.

Flowers: Solitary or arranged in 2-3. Funnel shaped flowers can be creamy-yellow, yellow-green, or



Photos by Carolina May

creamy-green. Sometimes can present with a tinge of purple. Fragrant. Roughly 2 cm long or longer. Flowers May to June.

Fruits: Resemble tiny tomatoes. Shiny, oval shaped bright red berries. Can contain up to 50 seeds.

Mahonia repens

Common Names: creeping Oregon-grape, creeping mahonia, truckee barberry, ash barberry, creeping holly grape, holly grape, mountain holly, creeping western barberry

Family: Berberidaceae or barberry

USDA PLANTS Code: MARE11

Habitat: Primarily found in high elevation coniferous forests. Dry, open woods and hills. Common throughout New Mexico.

Elevation: 6,200 to 10,000 ft

Common/Similar Species: *Mahonia aquifolium* (Oregon grape) can grow to height of 9 ft. *Mahonia repens* can take on appearance of *aquifolium* and grow taller if water resources are more abundant. *Aquifolium* has 5 – 9 leaflets per leaf.

ID: Less than 1 ft in height.

Leaves: Alternate, leaflets 3 – 7 per leaf. Toothed margins. Blue green above, grayish green on the underside.



Photo by Carolina May



Photo by Grace McCartha

Flowers: Yellow, arranged in racemes. Flowers April to July.

Fruits: Bluish-black berries, 6-10 mm.

Nolina greenei

Common Names: Greene's beargrass, woodland beargrass

Family: Liliaceae or lily

USDA PLANTS Code: NOGR

Habitat: On rocky limestone slopes, over lava flows, piñon-juniper woodlands and grasslands. Most commonly found in central New Mexico.

Elevation: 4,000 to 6,500 ft

Common/Similar Species: Has been synonymous with *Nolina texana* (Texas beargrass) in the past.

ID: Typically, 3 ft in height. Rosette forming plant.

Leaves: Long and narrow, up to 100 cm long, up to 1 cm wide. Toothed margins, sometimes entire.

Flowers: Panicle of white flowers with purple midveins. Up to 20 cm in length.

Fruits: Dry, inflated capsule, 5 mm in diameter.



Photos by Teresa Mayfield,
(<https://inaturalist.nz/observations/145721978>), licensed by CC-BY
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Opuntia engelmannii

Common Names: Engelmann prickly pear, cactus apple

Family: Cactaceae or cactus

USDA PLANTS Code: OPEN3

Habitat: Sandy soils, plains, arroyos, deserts, grasslands. Found in central and southwestern New Mexico.

Elevation: 3,000 to 7,000 ft

Common/Similar Species: *Opuntia phaeacantha* (tulip prickly pear) has a lower spine that is longer than the others. Pads 10-25 cm long.

ID: Up to 6 ft in height.

Leaves: Mature spines white or light gray, reddish at base. 1-5 spines per areole, 2-5 cm long. Pads 20-40 cm long, usually longer than wide. Orbicular to elliptic.

Flowers: Yellow, sometimes pink or orange. Flowers April to July.

Fruits: Purple-red, 3.5-9 cm long. Obovoid.



Photos by Theo Summer,
(<https://inaturalist.nz/observations/146664036>),
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Opuntia phaeacantha

Common Names: tulip prickly pear cactus, dark-spined prickly pear, desert prickly pear

Family: Cactaceae or cactus

USDA PLANTS Code: OPPH

Habitat: Found on sandy to rocky soils. Found throughout the entirety of New Mexico.

Elevation: 3,000 to 7,500 ft

Common/Similar Species: *Opuntia engelmannii* (cactus) spines are all the same length. Pads 20-40 cm long.

ID: Up to 3 ft in height. Stems sprawling to flat on the ground.

Leaves: Reddish brown or dark yellow-red spines. Often lighter at the tip. 3-8 cm long. Three to eight spines per areole. One single lower spine longer than the other. Pads obovate to circular, 10-25 cm long.

Flowers: Yellow, rarely pink or red. Flowers April to July.

Fruits: Wine color to purple.



Photos by Grace McCartha

Paxistima myrsinites

Common Names: mountain-lover, Oregon boxleaf

Family: Celastraceae or bittersweet

USDA PLANTS Code: PAMY

Habitat: Coniferous forests; piñon-juniper to spruce fir. Primarily found in north central and northwest New Mexico. Range extends to southern border.

Elevation: 6,000 to 10,000 ft

Common/Similar Species: Can get confused with *Arctostaphylos uva-ursi* (kinnikinnick), kinnikinnick has alternate leaves, leaves entire.

ID: Up to 20 cm in height. Growth form spreading to upright.

Leaves: Opposite, toothed above middle portion of leaf. Elliptic to obovate. Dark green, leathery.

Flowers: Red to reddish brown. Solitary or groups of 2-3 cymes. 4 petals. Flowers May to July.

Fruits: 2-celled dehiscent capsule. Sessile in leaf axis.



Top photo by Aaron Gunnar, (<https://www.inaturalist.org/observations/178345428>), licensed by CC-BY (<https://creativecommons.org/licenses/by/4.0/>)

Bottom photos by Ken-ichi Ueda, (<https://www.inaturalist.org/observations/1303042>), licensed by CC-BY (<https://creativecommons.org/licenses/by/4.0/>)

Physocarpus monogynus

Common Names: mountain ninebark

Family: Rosaceae or rose

USDA PLANTS Code: PHMO4

Habitat: Dry, rocky slopes in the mountain, open woods. Can be found across New Mexico in high elevation to subalpine mixed coniferous forests.

Elevation: 6,500 to 10,000 ft

Common/Similar Species: Looks like *Ribes* spp., *Ribes* spp. flowers are tubular shaped.

ID: Typically, 3 ft or taller. Bark often shreddy.

Leaves: Three lobed, arranged alternately. 2.5-4.5 cm long. Margins double crenate.

Flowers: Nine-25 white flowers arranged in a corymb. Five petals, five sepals. Petals 2-4 mm long. Flowers June to July.

Fruits: Inflated capsule with 2-3 carpels. 3-4 mm long. Reddish brown.



Photos by Christine Laney, (<https://www.inaturalist.org/observations/84453509>), licensed by CC-BY (<https://creativecommons.org/licenses/by/4.0/>)

Petradoria pumila

Common Names: rock goldenrod

Family: Asteraceae or aster

USDA PLANTS Code: PEPU7

Habitat: Piñon-juniper woodlands, open woods, roadsides.

Elevation: 4,500 to 8,000 ft

Common/Similar Species: Looks like *Gutierrezia sarothrae* (broom snakeweed) and *Hymenoxys richardsonii* (pingue rubberweed), *richardsonii* flowers are significantly bigger. *Pumila* leaves are wider than *Gutierrezia sarothrae*.

ID: Less than 1 ft in height. Base of plant typically has dead leaves from previous years still attached.

Leaves: 7-12 mm long, 4-7 mm wide. Bright green. Primarily grow at base. Margins entire.

Flowers: Dense, flat-topped cluster, yellow. Phyllaries arranged in vertical lines, light yellow to brownish. Slightly darker towards the tips. 2-3 pistillate ray florets, 2-4 staminate ray florets. Flowers May to August.

Fruits: Pappus of capillary bristles. Glabrous seeds.



Photos by Jim Morefield, (<https://www.inaturalist.org/observations/146098285>), licensed by CC-BY (<https://creativecommons.org/licenses/by/4.0/>)

Prunus virginiana

Common Names: chokecherry, common chokecherry, black chokecherry, red chokecherry, California chokecherry, Virginia chokecherry, eastern chokecherry, western chokecherry, rum chokecherry, whiskey chokecherry, wild cherry, wild blackcherry, bird cherry, jamcherry, chokeberry, cabinet cherry, chuckleyplum, sloe tree, bitter-berry, capulin

Family: Rosaceae or rose

USDA PLANTS Code: PRVI

Habitat: Moist forests and canyons, along streamsid es. Common throughout New Mexico.

Elevation: 5,500 to 8,000 ft

Common/Similar Species: There are 3 recognized varieties of *Prunus virginiana*. *Prunus virginiana* var. *demissa* (western chokecherry) produces dark red fruit. *Prunus virginiana* var. *melanocarpa* produces black fruit. *Prunus virginiana* var. *virginiana* produces crimson to deep red fruit. This variety can be found in two forms, one with red and one with white fruit.

ID: Up to 25 ft. Stems numerous and slender. Bark gray to reddish brown when young, turning darker brownish



Left photo by Will McFarland, (<https://inaturalist.nz/observations/133760478>), licensed by CC-BY (<https://creativecommons.org/licenses/by/4.0/>)
Right photo by Carolina May

black and furrowed with maturity. Distinctly marked with horizontal rows of lenticels (raised air pores).

Leaves: Alternate, simple, glabrous, oval to broadly elliptic in shape, 4-12 cm long. Margins toothed. Dark green and glossy above, paler below.

Flowers: Perfect, aromatic, five white petals. Arranged in cylindrical racemes, 7-15 cm long. Start appearing before leaves are fully developed. Flowers April to June.

Fruits: Spherical drupes with 1 seed. Dark red or purple to almost black.

Psoralethamnus scoparius

Common Names: broom dalea, feather dalea, broom smokebush

Family: Fabaceae or pea

USDA PLANTS Code: PSSC6

Habitat: Sandy soils, arroyos. Can be found throughout New Mexico, mostly the central portion of the state.

Elevation: 3,500 to 5,300 ft

Common/Similar Species: Other *Psoralethamnus* spp., other species less shrubby, contain spines, or can be more pinnately compound.

ID: Broom shaped shrub, growing up to 3 ft tall. Stems yellowish green, with amber colored glands.

Leaves: Linear, alternate, sparsely arranged along stems. 1 mm wide, 0.5-1.9 cm long. Row of glands grow along the leaf margins. Leaves are sometimes, but rarely tri-foliate.

Flowers: Dark purple and blue. 1 cm wide, growing at



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the tip of the branches. Typical pea flower morphology; 5 hairy sepals fused together forming a tube. Flowers July to September.

Fruits: Legume, obovate, gland dotted and pubescent, less than 0.5 cm long.

Purshia stansburyana

Common Names: cliffrose, Stansbury cliffrose

Family: Rosaceae or rose

USDA PLANTS Code: PUST

Habitat: Dry, rocky slopes, grasslands, piñon-juniper woodlands. Found in western New Mexico.

Elevation: 3,000 to 8,000 ft

Common/Similar Species: *Fallugia paradoxa* (Apache plume) flowers are more than 2 cm in diameter, with 20 carpels per flower. Styles are reddish.

ID: Up to 6 ft in height.

Leaves: Alternate, simple, pinnately lobed with 3-9 lobes per leaf. Think, resinous, margins rolled under. Dark green, glandular above, white tomentose below.

Flowers: Solitary. Yellow or cream color. Less than 1.5 in diameter. Five petals, 5-10 carpels per flower. Flowers April to July.

Fruits: Achenes 4-7. Silvery, pubescent, feather like styles.



Photos by Rachel Stringham (<https://inaturalist.nz/observations/149382208>) licensed by CC-BY (<https://creativecommons.org/licenses/by/4.0/>)

Rhus trilobata

Common Names: skunkbush sumac, skunkbrush, polecat bush, stinking sumac, ill-scented sumac, quailbush, basketbush, lemonade sumac, three-lobed sumac, three-leaved sumac, lemita

Family: Anacardiaceae or sumac

USDA PLANTS Code: RHTR

Habitat: Prairies to shrublands and oak woodlands and in a variety of sites including dry rocky slopes, streamsides, seasonal drainages, canyon bottoms, sand dunes and sandhills, pastures, and roadsides. Widespread throughout New Mexico.

Elevation: 5,000 to 7,500 ft

Common/Similar Species: Sometimes treated as a variety of *Rhus aromatica* (fragrant sumac). There seems to be regional distinctions when it comes to the classification. Historically, *Rhus trilobata* has been in the classification used in western states and *Rhus aromatica* has been the classification used in the east.

ID: Up to 8 ft tall. Rounded, mound-like, or upright thicket growth form.

Leaves: Alternate, compound with three leaflets,



Photos by Grace McCartha



Photo by Claire Gentry

variable in size and shape. Margins crenate, usually shiny-glabrous above. Terminal leaflet 3-6.5 cm long. Green in summer, becoming orange to reddish in fall.

Flowers: Pale yellow or a soft cream color. Dense clusters on short lateral shoots. Bisexual and unisexual, both types borne on the same plant. Flowers April to July.

Fruits: 5-7 mm in diameter. Red at maturity and sparsely hairy, each fruit containing a single nutlet.

Common name derived from odor of the leaves, especially when bruised.

Ribes cereum

Common Names: wax currant, wild wax currant, Western red currant

Family: Grossulariaceae or currant

USDA PLANTS Code: RICE

Habitat: Pine forests, wood openings, dry slopes, ridges, rocky places, and forest edges. Common throughout New Mexico.

Elevation: 6,000 to 9,000 ft

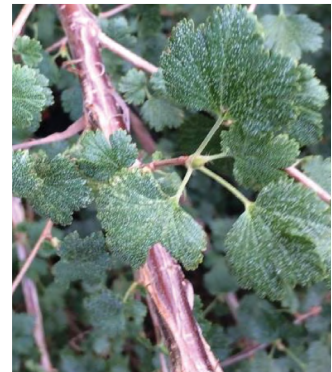
ID: Typically, 3-6 ft in height. Erect to spreading. Unarmed, lacking spines.

Leaves: Alternate, 3-5 lobes, crenate. Length and width roughly equal. Glandular, pubescent.

Flowers: Tubular, pink, pubescent. 6-8 mm long. Anthers have a cup shaped gland at the apex. Flowers May to July.

Fruits: Bright red or orange-red berry containing several seeds. 5-12 mm. Stipulate- glandular or spiny.

***Ribes cereum* has a noticeable "spicy" odor.**



Left photos by Grace McCartha, right photos by Claire Gentry

Ribes inerme

Common Names: whitestem gooseberry, klamath gooseberry

Family: Grossulariaceae or currant

USDA PLANTS Code: RIIN2

Habitat: Moist, often in shaded places, in woodland. In riparian, grassy meadows, under willows, and cool, rocky seeps. Found in mountainous regions throughout New Mexico.

Elevation: 6,000 to 10,500 ft

ID: Can reach height of 9 ft. Can be armed with 3 spines at the node or unarmed. Younger bark has smooth, whitish stems with black, sessile glands. When spines present 1-12 mm long.

Leaves: Deeply lobed, 1.5-6 cm wide. Glabrous to sparsely pubescent. Petiole equal or longer than leaf blade.

Flowers: Arranged in raceme of up to 5 flowers. Green to greenish-purple, shorter than the sepals which are reflexed. Anther lacks cup shaped gland at apex. Stamens two times longer than the petals. Style

pubescent. Hypanthium 2-3.5 mm long. Flowers April to May.

Fruits: Glabrous, greenish purple to black, roughly 7-8 mm in diameter.



Photos by Don Loarie, (<https://inaturalist.nz/observations/3981182>), licensed by CC-BY (<https://creativecommons.org/licenses/by/4.0/>)

Robinia neomexicana

Common Names: New Mexico locust, southwestern locust, hojalito

Family: Fabaceae or pea

USDA PLANTS Code: RONE

Habitat: Arroyos, stream banks, canyons. Widespread throughout New Mexico.

Elevation: 5,500 to 9,500 ft

Common/Similar Species: none

ID: Can reach up to height of 25 ft. Pair of spines present at base of each leaf node. Bark reddish brown, turning gray with maturity.

Leaves: Pinnately compound, 8-20 cm long. Leaflets, 9-21 per leaf, 1.5-3 cm long. Elliptic to oval. Margins entire.

Flowers: Raceme of pink- pinkish purple flowers. Covered in gland tip hairs. Flowers May to July.

Fruits: Flat legume pod, brown, 6-10 cm long, covered in gland tipped hairs. Contains 4-8 seeds.



Photos by Rachel Stringham,
(<https://inaturalist.nz/observations/121054463>), licensed by CC-BY
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Rosa woodsii

Common Names: Woods' rose, wild rose, common wild rose, mountain rose

Family: Rosaceae or rose

USDA PLANTS Code: ROWO

Habitat: Riparian and wetland sites, disturbed sites, especially along roadsides and south-facing cutbanks. Bluffs, dry grassy slopes, prairie sandhills, in clearings in boreal and subalpine forests. Ponderosa pine, cottonwood, and Douglas-fir dominated forests. Common throughout New Mexico.

Elevation: 4,500 to 9,500 ft

Common/Similar Species: Can be distinguished from other species of rose by its shrubby, thicket-forming habit, stems with straight prickles, and leaves and sepals without glands.

ID: 0.5-9 ft tall. Can form dense thickets. Stems reddish-brown to gray, with straight or slightly curved prickles.

Leaves: Alternate, odd-pinnately compound, leaflets 5-11 cm long, obovate to ovate or elliptic. Finely toothed.

Flowers: Can grow in clusters at the stem tip or less;



Photos by Claire Gentry

commonly grow solitary. Five petals, 15-25 mm long, pink to lilac-pink or lavender. Sepals lanceolate, 1-2 cm long, erect or usually persistent, tomentose on the margins and inner surface. Flowers June to September.

Fruits: Fleshly, red, globose to ellipsoid "hip", 5-12 mm wide, derived from the base of the sepals and petals. Nutlets 15-25, 3-4 mm long.

Rubus armeniacus

Common Names: Himalayan blackberry, Himalaya-berry, Armenian blackberry

Family: Rosaceae or rose

USDA PLANTS Code: RUAR9

Habitat: Grows in open weedy sites, stream sides, and along roadsides.

Elevation: 2,700 to 6,000 ft

ID: Canes (mature stems) arching, may be up to 32 ft long. Thorns are typically reddish color later in the summer and may be up to 20 mm long. Canes can intertwine forming dense thickets as tall as 6 ft.

Leaves: Compound leaves with 3-5 leaflets. Underside is white. Roughly oval shaped, with toothed margins and a pointed apex. All leaflets attached to a common point.

Flowers: Flowers perfect. Five white or pale pink petals. Borne in loose clusters. Roughly 2 cm in diameter.

Fruits: Drupe, consistently of 15-40 tiny drupelets. Dark blue at maturity. Each drupelet contains one seed.



Photo by Sam Beaumont
(<https://inaturalist.nz/observations/136975993>),
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Rubus idaeus

Common Names: American red raspberry, raspberry, grayleaf red raspberry, red raspberry

Family: Rosaceae or rose

USDA PLANTS Code: RUID

Habitat: Edges of swamps and bogs, especially common after burnings, clearings, or other disturbances. Common throughout New Mexico.

Elevation: 6,500 to 10,000 ft

ID: Grows up to 5 ft tall. Slender. Covered in sharp hairs.

Leaves: Pinnately compound with three to five leaflets. White tomentose on the underside. Terminal leaflet 5-7 cm long, ovate. Toothed margins.

Flowers: Five white petals, five sepals, numerous stamen and carpels. Sepals covered with gland tipped hairs. Flowers May to July.

Fruits: Red to white rounded, aggregate. 2 cm long and broad. Maturing between July to September.



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Rubus parviflorus

Common Names: thimbleberry, western thimbleberry

Family: Rosaceae or rose

USDA PLANTS Code: RUPA

Habitat: Forest edges and stream banks. Found in mountains across New Mexico.

Elevation: 7,000 to 10,000 ft

ID: 3-6 ft in height. Erect, slender. Older bark shreddy. Unarmed.

Leaves: Alternate, large, palmately lobed. Three to five lobes per leaf. 9-30 cm wide, roughly as long as wide. Long, hairy, petioles, 2- 11 cm. Deep palmate venation. Margins irregularly serrated. Bright green above, paler below.

Flowers: White, borne in cymose. Typically, three to seven flowers per cluster. Five petals, five sepals. Sepals are reflexed and spreading. Glabrous styles. Flowers June to August.

Fruits: Red, aggregate, 2-3 cm wide. Drupelets numerous.



Photos by Carolina May

Salix exigua

Common Names: coyote willow, sandbar willow, gray willow, narrow-leaved willow, dusky willow, pussywillow

Family: Salicaceae or willow

USDA PLANTS Code: SAEX

Habitat: Near water, wetlands, alluvial bottomlands, streambanks, riparian forest, stabilized gravel bars. Common throughout New Mexico.

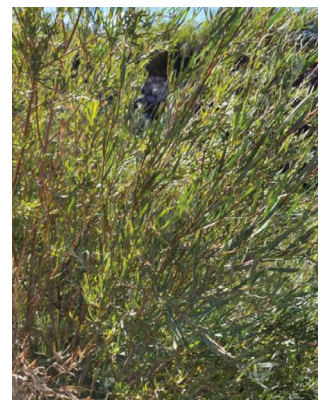
Elevation: 3,500 to 7,500 ft

ID: Up to 20 ft tall. Spreads clonally by root-sprouting.

Leaves: Mature blades are 3-16 cm long, 2-10.2 mm wide, linear, with an acuminate leaf top or either a serrate or entire leaf edge. Petioles 2-10 mm long.

Flowers: Catkins inflorescence appears with or after the leaves in the spring. Staminate (male) flowers 0.9-9 cm long, two stamens, yellow anthers, hairy filaments. Carpellate (female) flowers 2-9 cm long. Flowers March to July.

Fruits: 4-8 mm long, glabrous capsule.



Photos by Carolina May

Sambucus nigra ssp. caerulea

Common Names: blue elderberry, blueberry elder, elder, blue elder, Arizona elderberry, American elder, sweet elder, wild elder, flor sauco, tree of music, Danewort, Walewort, New Mexican elderberry, velvet-leaf elder, hair blue elderberry, dwarf elder

Family: Caprifoliaceae or honeysuckle

USDA PLANTS Code: SANIC5

Habitat: Common along stream banks, riverbanks, and open places in riparian zones and forested ecosystems.

Elevation: 7,000 ft to 9,000 ft

Common/Similar Species: Other *Sambucus* spp., can look like *Juglans* spp., and *Fraxinus* spp. *Sambucus caerulea* is synonymous with *Sambucus nigra ssp. caerulea*. Note that the spelling *cerulea* in some sources is synonymous.

ID: Height ranges from 6 to 26 ft. Multiple stems sprouting from base. Bark typically grayish to brown with ridges.

Leaves: Opposite, odd pinnate. Leaves about 15-35 cm long, made up of 3- 9 serrated leaflets about 2-15 cm long. Distinctive scent.



Photo by Joe Rojas-Burke, (<https://inaturalist.nz/observations/137883640>), licensed by CC-BY (<https://creativecommons.org/licenses/by/4.0/>)

Flowers: Flat-topped clusters of tiny, creamy white scented flowers. Inflorescence is 4-30 cm across, broader than high. Bisexual flowers have five lobed corollas. Flowers May to July.

Fruits: Dark bluish-purple berries that hang in large clusters from September-October. 5-6 mm wide. Contains 3-5 nutlets.

Sambucus racemosa

Common Names: red elderberry, scarlet elder, stinking elderberry, stinking elder, red-berried elder, bunchberry elder, and red elder

Family: Caprifoliaceae or honeysuckle

USDA PLANTS Code: SARA2

Habitat: Streambanks, ravines, swamps, moist forest clearings and higher ground near wetlands. Shade tolerant but prefers a sunny exposure. Found in northern, central, and western New Mexico.

Elevation: 7,000 to 12,000 ft

Common/Similar Species: Other *Sambucus* spp.

ID: Grows to height of 10-20 ft tall. Broad arching form. Twigs are pithy, dark red or purple to reddish-brown in color, covered with numerous small bumps (raised pores).

Leaves: Opposite, compound, 5-7 leaflets. Oval to oblong or lance shaped, 5-10 cm long. Finely toothed margins. Foliage has strong distinctive odor.

Flowers: Conical or pyramidal shaped clusters of small, creamy white flowers. Flowers April to July.



Photos by Grace McCartha

Fruits: Arranged in clusters of small bright red, fleshy berries, bearing 2-5 seeds per fruit. Fruits in summer.

Senegalia greggii

Common Names: catclaw acacia, catclaw, devilsclaw, Gregg acacia, Gregg catclaw, long-flower catclaw, Texas catclaw, wait-a-minute bush

Family: Fabaceae or pea

USDA PLANTS Code: SEGR4

Habitat: Chaparral communities, flats, along streams, stream banks and washes. Found in southern New Mexico.

Elevation: 3,500 to 5,500 ft

ID: Can reach height of 22 ft with curved/ hooked spines, rarely reaching 4 cm in length.

Leaves: Alternate, compound; bipinnate. Leaves less than 5 cm long, leaflets 3-6 mm long.

Flowers: Cream to pale yellow, dense, fragrant, cylindrical spike. Flowers April to September.

Fruits: Twisted, legume pod. 1.2-1.8 cm wide and 4-10 cm long.



Photos by Alex Wentworth,
(<https://inaturalist.nz/observations/147926410>),
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Shepherdia canadensis

Common Names: russet buffaloberry, buffaloberry, soapberry, russet red buffaloberry, Canadian buffalo-berry

Family: Elaeagnaceae or oleaster

USDA PLANTS Code: SHCA

Habitat: Dry to moist open woods and thickets from lowlands to mid-elevation forests. Generally found on rocky, sandy, or gravelly soil. Found in northcentral New Mexico.

Elevation: 8,000-9,800 ft

Common/Similar Species: *Shepherdia argentea* (silver buffaloberry) has silvery leaves on both sides with stellate scales. Twigs are also thorny.

ID: Reaches 3-6 ft in height. Branches stellate-hairy. Not armed.

Leaves: Opposite, oval to elliptic. Green, slightly pubescent on upper surface, undersides rusty, scaly, with brown spots. 2-6 cm long, 1-2.5 cm wide.

Flowers: Small, yellowish or brownish, male and female flowers on separate shrubs. Arranged in raceme of a



Photos by Kathryn Mahan

few to several flowers. Flowers May to June.

Fruits: Drupelike, red or yellowish, 4-6 mm long. Ovoid achenes.

Sorbus dumosa

Common Names: Arizona mountain ash

Family: Rosaceae or rose

USDA PLANTS Code: SODU2

Habitat: Moist coniferous forests. Found in western and northwestern New Mexico.

Elevation: 7,500 to 10,000 ft

Common/Similar Species: *Sorbus scopulina* (cascade mountain ash) has leaves and leaflets that are longer (leaves: 10-25 cm, leaflets: 35-70 mm). Rachis (stems) only slightly hairy as opposed to *dumosa* which is densely hairy.

ID: Up to 16 ft. Bark reddish to gray, densely white pubescent, smooth with maturity.

Leaves: Odd-pinnate leaves, 7-15 cm long. Leaflets 9-15 per leaf, oval to lanceolate, 4-45 mm long, serrated leaf margins. Dark green, glabrous above, paler, glabrous to pubescent on the underside.

Flowers: Cyme of numerous small, white flowers (10-40). 5 petals (1-2 mm long), 5 sepals (1-2 mm long). Flowers May to June.

Fruits: Small, red, berry-like pome (an apple-like



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fruit), arranged in terminal clusters, each 8-10 mm in diameter.

Symphoricarpos rotundifolius

Common Names: roundleaf snowberry

Family: Caprifoliaceae or honeysuckle

USDA PLANTS Code: SYRO

Habitat: On ridges, slopes, open places in woods. Found in western and northern New Mexico.

Elevation: 6,000 to 10,000 ft

Common/Similar Species: *Symphoricarpos oreophilus* (mountain snowberry) is a synonym of *Symphoricarpos rotundifolius* (roundleaf snowberry). *Symphoricarpos albus* (white snowberry) and *Symphoricarpos occidentalis* (western snowberry) are uncommon, only found in north central and northeastern New Mexico. Corollas on both species are bell shaped, corolla lobes are equal to or longer than the corolla tubes.

ID: 1-6 ft in height. Erect to arching.

Leaves: Opposite, entire, oval to ovate. 1-3 cm long. Bright green, paler on the underside. Petioles 1-3 mm long.

Flowers: Arranged in pairs or separately. White to pink. Tubular flowers. Corolla lobes one-third or less



Photos by Claire Genty

compared to length of corolla tube. Corolla 8-25 mm long. Flowers May to June.

Fruits: Drupe, white to pink.

Tamarix spp.

Common Names: salt-cedar, tamarisk

Family: Tamaricaceae or tamarisk

USDA PLANTS Code: TAMAR2

Habitat: Dunes, scrub, wetlands, rivers, desert washes. Non-native. Common throughout New Mexico.

Elevation: 3,000 to 5,500 ft

Common/Similar Species: Species in New Mexico include *Tamarix parviflora* (small-flowered tamarisk), *Tamarix gallica* (French tamarisk), and *Tamarix chiensis* (salt-cedar). These species are known to hybridize so identification to species can be problematic.

ID: Up to 26 ft in height. Reddish bark when immature.

Leaves: Alternate, green, scale-like. Rarely more than 1 mm long.

Flowers: Raceme of white or pink flowers. 5 sepals, 4-5 petals, 5-10 stamens, Superior ovary with 2-5 united carpels. Flowers April to October.

Fruits: Capsule with numerous hairy seeds. Capsules 3-4 mm long.



Photos by Adriana Nelly Correa Sandoval, (<https://inaturalist.nz/observations/139171161>), licensed by CC-BY (<https://creativecommons.org/licenses/by/4.0/>)

Vaccinium myrtillus

Common Names: whortleberry, myrtle whortleberry, dwarf bilberry, bilberry, wimberr, European blueberry, blueberry, whinberry

Family: Ericaceae or heath

USDA PLANTS Code: VAMY2

Habitat: Found in coniferous forests. Found in northcentral and western New Mexico.

Elevation: 8,000 to 11,500 ft

Common/Similar Species: *Vaccinium scoparium* (grouse whortleberry) and *Vaccinium myrtillus* (whortleberry) have been known to hybridize. *Scoparium* berries are smaller in diameter, 3.5-6 mm. Branches are also broom-like, numerous, and glabrous. Leaves are 0.7-1.2 cm long and 4-6 mm wide. Most commonly found in tundra ecosystems.

ID: Up to 1.5 ft in height. Slender and spreading. Twigs are green and sharply angled. Grooves of branches typically puberulent. Rhizomatous; usually occurs in colonies.

Leaves: Alternate, 1.9-2.8 cm long, 7-12 mm wide. Serrated margins. Bright green, elliptic to lanceolate. Broadest from the middle of the leaf to the base.

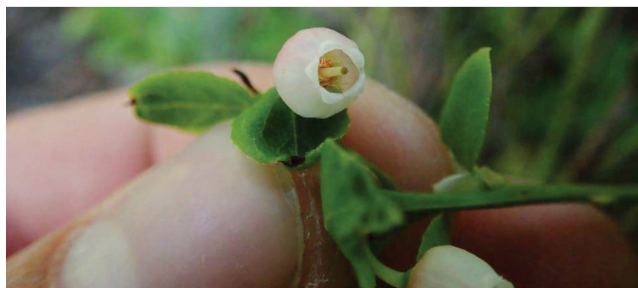


Photo Credits: Mitch Van Dyke, (<https://inaturalist.nz/observations/50600171>), licensed by CC-BY (<https://creativecommons.org/licenses/by/4.0/>)

Flowers: Pink, cream or greenish white urn-shaped flowers. 3-5 mm long.

Fruits: Deep purple, purplish-black, to bluish black berry. 7-9 mm in diameter.

Yucca baccata

Common Names: banana yucca, blue yucca, fleshy-fruited yucca, datil

Family: Asparagaceae or asparagus

USDA PLANTS Code: YUBA

Habitat: Dry plains; hilly grasslands, in piñon-juniper, sagebrush and ponderosa pine forests. Common throughout New Mexico.

Elevation: 3,500 to 7,500 ft

ID: Up to 8 ft in height. Grows in colonies.

Leaves: Forms basal rosettes. 30-100 cm long, more than 2 cm wide at widest point. Margins produce fiber strings. Spine tipped apex, 1.5-7 mm long.

Flowers: Creamy colored tepals with hints of purple. 4.5-13 cm long. Inflorescence a panicle, usually somewhat tucked within the basal rosette, 130 cm long. Flowers April to May.

Fruits: Indehiscent, fleshy, succulent type fruit. Roughly 12 cm or more long. Seeds are black, obovate.



Left photo by Carolina May, right photos by Grace McCartha

VEGETATION OF NEW MEXICO

11.0 Poisonous Plants of New Mexico



Photo by Nick Kleinschmidt
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POISONOUS PLANTS

Conium maculatum, poison hemlock

Toxicodendron rydbergii, western poison ivy

Urtica dioica, stinging nettle

POISONOUS PLANTS

Conium maculatum



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Conium maculatum

Common Name: poison hemlock, hemlock, wild hemlock

Family: Apiaceae or carrot

USDA PLANTS Code: COMA2

Habitat: Moist areas, streams, roadsides, ditches, and disturbed areas.

Elevation: 5,000 to 7,500 ft

Common/Similar Species: *Ligusticum porteri* (oshá) looks very similar to poison hemlock. Oshá has a distinct spicy-celery smell while poison hemlock is reported to have a musty smell. Oshá tends to not grow in excessively moist soil due to the plant's relationship with mycorrhizal fungi, thus it is never found growing in standing water.

ID: 3-7 ft tall. Stalks are hollow, glabrous, and dotted with purple spots or stripes.

Leaves: 3-4 times pinnately compound, triangular. Bright green and toothed, resembling a fern.

Fruits: Green, ribbed, ovoid, and 2-2.5 cm long.

Interaction: **VERY TOXIC.** All plant parts are poisonous, and toxins can be absorbed into the skin. If working in area where its presence is confirmed or suspected, wear gloves. Wash your hands with soap and avoid contact with your mouth if touched. Ingestion can result in the following symptoms: dilated pupils, salivation, rapid weak pulse, dizziness, ataxia, and shaking or trembling. May result in depression of the central nervous systems, respiration rhabdomyolysis, acute renal failure, and even death.

POISONOUS PLANTS

Toxicodendron rydbergii



Photos by Quinten Wiegiersma,
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Toxicodendron rydbergii

Common Name: western poison ivy, poison ivy, poison oak

Family: Anacardiaceae or Sumac

USDA PLANTS Code: TORY

Habitat: Widespread throughout disturbed sites, woodlands and forests, rocky slopes, wetland/riparian areas, and canyon bottoms.

Elevation: 4,500 to 8,500 ft

Common/Similar Species: Looks similar to *Toxicodendron radicans* (eastern poison ivy), which generally grows as a vine in the east. *Radicans* and *rydbergii* can hybridize where their ranges overlap.

ID: Low growing shrub/subshrub. Occasionally grows as a vine. Typically, up to 3 ft in height.

Leaves: Alternate, compound leaves. Each leaf has 3 leaflets (trifoliate). Leaves are longer than wide, measuring 3-15 cm long and 2-11 cm wide. Prominent mid vein. Leaf margins are broadly toothed or serrated, with an acute apex. Glabrous on both sides.

Flowers: Inflorescence arranged in a panicle. Greenish sepals are deltoid in shape. The 5 petals are creamy white to yellowish, oblanceolate in shape. Flowers May to September.

Fruits: Yellowish-white drupes, arranged in an axillary panicle. Glabrous.

Interaction: Can result in painful itching, rashes, blistering, and swelling. The chemical urushiol, the cause of the reaction, is located throughout the plant. Confident ID and avoidance help to prevent contact. If contact occurs or is suspected, thoroughly wash objects or parts of body that came into contact with the plant with liquid dish soap.

POISONOUS PLANTS

Conium maculatum



Photos by Nick Kleinschmidt
(<https://inaturalist.nz/observations/145109744>)
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Conium maculatum

Common Name: stinging nettle, California nettle, slender nettle, tall nettle

Family: Urticaceae or nettle

USDA PLANTS Code: URDI

Habitat: Moist areas, streams, and meadows. Disturbed sites.

Elevation: Up to 10,000 ft

Common/Similar Species: Other *Urtica* species.

ID: Low growing shrub/ subshrub. Occasionally grows as a vine. Typically up to 3 ft in height.

Leaves: Opposite arrangement with 2 leaves per node. Margins serrated or doubled serrated. Elliptic, lanceolate, to ovate. Apex acute, base rounded or cordate. 7-20 cm long, 2.5-6.5 cm wide. Stem relatively square. Covered in stinging hairs.

Flowers: Arranged in a panicle, sprouting throughout the length of the stem near the leaf axils and atop stem tip. White to green in coloration.

Fruits: Ovoid, flattened achene, and 1-1.4 mm in length and width.

Interaction: Contact with the plant results in rash and burning/ stinging sensation. Wash irritated area with soap and water. Can apply a cold compress for pain relief. In certain cases, contact may result in an allergic reaction.

TOOLS

12.0 Using GNSS/GPS Devices

Global Positioning System (GPS) is a satellite-based navigation system made of at least 24 satellites. It works in various weather conditions, 24 hours a day. Global Navigation Satellite System (GNSS) includes a range of international location providers (such as Glonass, Galileo, Beidou) and is incorporated into receivers (such as Garmins, phones, tablets, etc).

The following guidelines are for Garmin handheld receivers, which NMFWRI and many partners commonly use. Please note that specific instructions will vary by device.

Calibrating GPS Units

Most GPS units need to be calibrated on occasion. On Garmin units, navigate to the compass, select 'Menu', and then select 'Calibrate Compass'. Follow instructions on screen.

Navigating to a Pre-loaded Point

On Garmin units, select 'Find' and then 'Waypoints'. Scroll until the waypoint of interest is located.

Navigating to GPS Coordinates

On Garmin units, select 'Find' and then 'Coordinates'. Type in GPS coordinates in decimal degrees.

Recording a Waypoint

On Garmin units, select 'Mark'. Use up and down arrows to input point name and notes. Use a standardized point naming system to avoid confusion (i.e. Plot Name).

GPS Tips & Troubleshooting

- Ensure all necessary GPS points are loaded onto all GPS devices before heading into the field.
- In deep canyons, GPS access to satellites may be obscured. GPS units need a clear view of the sky to be used with accuracy.
- Satellite locations will vary throughout the day, and therefore GPS accuracy will vary.
- Low battery warnings are frequent on Garmin GPS units, but often battery life will continue long after low battery warnings. Always bring plenty of spare batteries along.

TOOLS

13.0 Using a Compass

Getting set up

For each project, you must know the declination for the area where you are working. Make sure everyone on your crew sets their compasses to the same declination. You may use any style of compass for your work. Most of the following instructions and photos use Silva Ranger compasses. *See 13.1 Compass Declination*

Walking a line



Photo by Carolina May

1. To walk a straight line, for instance, to the West, turn the dial on the top of your compass so the “W” is lined up with the center mark.
2. Next, rotate yourself and your entire compass so that the red arrow lines up with the painted red lines. See photo above. Be sure you are not holding any metal near the compass.
3. Hold the compass level. Keep the red arrow aligned and look through the sights at either the top of the cover or at the base until you find an object you can recognize. In the picture on the next page, we can see a tree through the sights.
4. Walk toward this object, keeping the red arrow aligned with the painted lines at all times. You can continue looking through the viewer or look at the real-life object. One other option is to walk every step with your eyes on your compass needle, and make sure it stays aligned.



Photo by Carolina May

5. Walk out the appropriate distance (bring your tape along) and stop.
6. Turn around and use the sights on the compass to look back at where you came from. This time, the WHITE arrow should line up with the red lines (you are looking backwards). Step right or left as needed until the alignment is perfect.
7. To double-check yourself, have someone stand where you started and sight to you with their own compass. If your declination was set the same, you should both agree on the right position.

Common errors and troubleshooting

1. If you are sighting with one eye open and one eye closed, it does make a difference, depending on which eye is dominant for you. Be sure you know this for yourself, or sight with both eyes open.
2. Be sure you are holding your compass level while sighting with it.
3. If you are holding something metal such as pin flags or a metal tape, these will attract the compass needle and your line will be off.
4. If you are consistently off, double-check your declination setting. These tic marks are very hard to read, so it is easy to make a mistake initially.
5. In very dense stands, have someone stand at plot center (PC) and guide you around trees and brush.
6. Try to keep your compass protected from extreme temperatures or rapid changes in elevation to reduce the chance of getting bubbles in the liquid inside. These bubbles, if they are large enough, can make the compass very difficult to use.
7. If compass liquid is gone, large bubbles are present, or if needle is spinning loosely, the compass is unusable.

TOOLS

13.1 Compass Declination

Declination is the difference between magnetic north and true north. Declination changes over time and differs depending on location, so it is important to know the current declination of your monitoring site. We must correct for this difference when working from a map or when re-taking plots over time so that, for instance, the “north” photo of the plot remains in the same location.

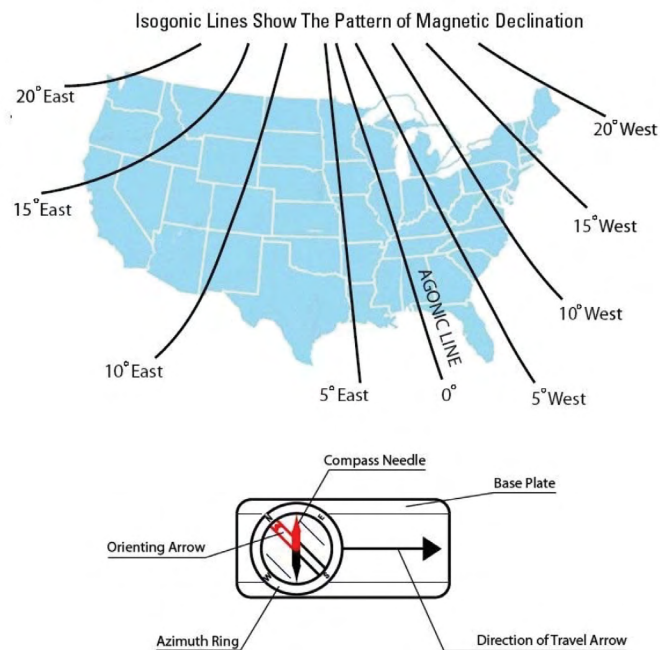


Diagram by USGS Educational Resources

Looking Up Declination

To look up the declination for your area, this link to the NOAA website is useful: <https://www.ngdc.noaa.gov/geomag/calculators/magcalc.shtml>. You will need to know the latitude and longitude of your monitoring site to look up the declination.

Correcting for Declination – Method 1

One way of correcting for declination is to set the wheel on your compass.

1. Locate the small metal key included along your lanyard.
2. Turn your compass over.
3. Insert the metal key into the adjustment screw on the wheel on the back of your compass to set the declination on your compass.

4. Turn the screw until the declination indicator matches the declination you looked up for your area of work (make sure you are going the correct direction - east or west!).
5. Make sure everyone on your crew sets their compasses to the same declination and test this by sighting a line.

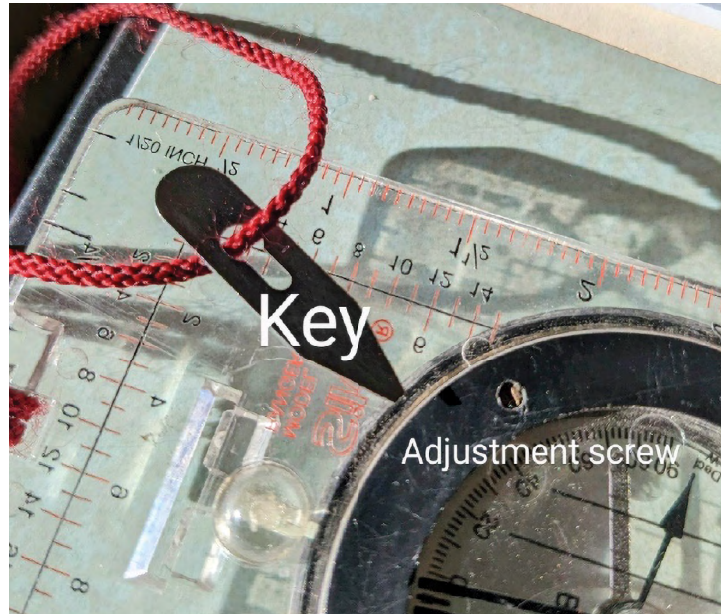


Photo by Carolina May

Correcting for Declination – Method 2

If you do not have a compass with adjustable declination, you can adjust with addition and subtraction. One method is to use the formulas:

$$\text{True reading} - \text{east declination} = \text{magnetic reading}$$

$$\text{True reading} + \text{west declination} = \text{magnetic reading}$$

So, for example, if your declination is 10 degrees East and you want to walk a line north for your plot:

$$\text{True reading} - \text{east declination} = \text{magnetic reading}$$

$360 - 10 = 350$, so you would need to set your compass for 350 degrees to get a true north line.

TOOLS

14.0 Reading Tape Measures

Many kinds of tape measures may be used on a plot. It's very important to pay attention to what each tape is, and how to read it.

Caution! Tapes built with a hook on the end are designed to be read only if the hook is attached to something and the tape is pulled taut. The end of the tape is NOT zero. Zero is at the end of the hook.



All Photos in this chapter by NMFWR Field Crew



Types of Tapes

1. Fiberglass/Reel Tapes

Sometimes these tapes have one side, and sometimes two. Read the tape to know what units it uses (see pictures below). For instance:



This tape is in feet and tenths. You know this because it only counts to 10 (you only see numbers up to 9).



This tape is the same, but the tenths are marked with a decimal point.



This tape, however, is marked in feet and inches. Notice how it has twelve divisions (you see numbers up to 11).

Note: it's common to find fiberglass tapes with both a metric side and a side with inches. Typically, the sides are two different colors.

2. Diameter/Logger Tapes

If you use a Spencer tape, it is commonly also two-sided. For example:



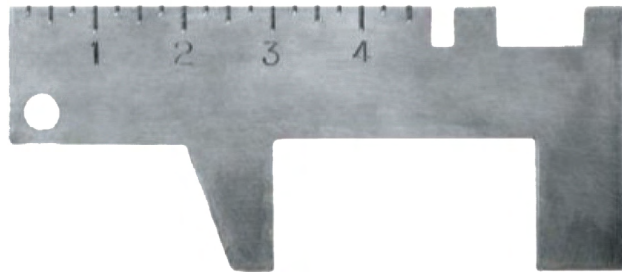
Side 1 – in feet and tenths, designed to be read from the end of the hook. This side is useful for measuring length of logs or measuring your distance from a tree when measuring height by clinometer and laying out the East and South lines of your plot.



Side 2 – in inches and tenths BUT adjusted for the value of pi. This side is meant to be read when measuring the diameter of a tree or 1000-hour fuel. It is read where the number and the zero-mark line up (see more detail on reading this side of the tape in *19.31 Rules for Measuring DBH*).

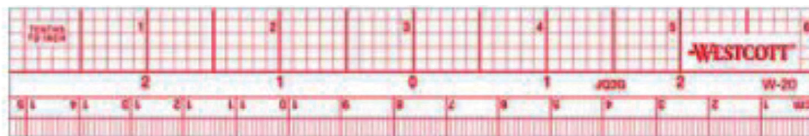
3. Fuels gauge

Some go/no-go fuels gauges also come with a measuring side. This is useful for measuring litter and duff depth. This one is marked in inches and quarter inches, so each small mark represents 0.25 inches.



4. Flat tape/ruler

Sometimes rulers are also used, especially if your fuels gauge doesn't have a ruler, or if you are checking plant ID by measuring the lengths of parts of the plant. Be sure you check your units.



Abbreviating Measurements

Remember, there are standard abbreviations for inches and feet. Always indicate what units you're using on your datasheets and be careful not to confuse inches and tenths of feet!

Unit	Inches	Feet
Acceptable ways to record	2.1 in, 2.1 inches, 2.1"	6 ft, 6 feet, 6'

For example, the datasheet below uses both kinds of abbreviations for inches and feet. Both forms are acceptable.

Similarly, both decimal and fractions are acceptable (e.g. ½ inch or 0.5 inches) as long as they can be clearly and easily read.

Transect	Sample Location	Litter Depth	Duff Depth	Veg Item	% Veg Cover	Veg Hgt (d.d')	Surface Fuels-Vegetation Item Code and Description																												
1	45'	0.1 in	0 in	HD	0.5	1.0ft	HD dead non-woody vegetation																												
				HL	3.0	0.5ft	HL Live non-woody vegetation																												
				SD	0	-	SD Dead woody vegetation																												
				SL	0	-	SL Live woody vegetation																												
1	75'	1.5 in	0.2 in	HD	0.5	0.5ft	<table border="1"> <thead> <tr> <th colspan="2">% Veg cover</th> </tr> <tr> <th>Code</th> <th>Cover</th> </tr> </thead> <tbody> <tr> <td>0</td> <td>No cover</td> </tr> <tr> <td>0.5</td> <td>>0-1 % cover</td> </tr> <tr> <td>3</td> <td>>1-5 % cover</td> </tr> <tr> <td>10</td> <td>>5-15 % cover</td> </tr> <tr> <td>20</td> <td>>15-25 % cover</td> </tr> <tr> <td>30</td> <td>>25-35 % cover</td> </tr> <tr> <td>40</td> <td>>35-45 % cover</td> </tr> <tr> <td>50</td> <td>>45-55 % cover</td> </tr> <tr> <td>60</td> <td>>55-65 % cover</td> </tr> <tr> <td>70</td> <td>>65-75 % cover</td> </tr> <tr> <td>80</td> <td>>75-85 % cover</td> </tr> <tr> <td>90</td> <td>>85-95 % cover</td> </tr> </tbody> </table>	% Veg cover		Code	Cover	0	No cover	0.5	>0-1 % cover	3	>1-5 % cover	10	>5-15 % cover	20	>15-25 % cover	30	>25-35 % cover	40	>35-45 % cover	50	>45-55 % cover	60	>55-65 % cover	70	>65-75 % cover	80	>75-85 % cover	90	>85-95 % cover
				% Veg cover																															
				Code	Cover																														
				0	No cover																														
0.5	>0-1 % cover																																		
3	>1-5 % cover																																		
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80	>75-85 % cover																																		
90	>85-95 % cover																																		
HL	3.0	1.0ft																																	
SD	0	-																																	
SL	0	-																																	
2	45'			HD																															
				HL																															
				SD																															
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2	75'			HD																															
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3	75'			HD			Comments:																												
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				SD																															
				SL																															

TOOLS

14.1 Measuring by Tenths of a Foot

1. Place your tape measure on a flat surface where you can clearly read it.
2. Reading from left to right, you will see your tape measure has the numbers 1 through 9 (in black). Each one of the nine vertical dashes (in black) between the foot marks (in red) represent 1/10th of a foot (or 0.10 feet).
3. Remember that if your tape begins with a hook or loop, it is designed to be read **from** a stake (see the picture below).

For example, if the measurement from the stake to the pin flag (below) comes out to 1 foot (red) with 2 black numbers after the 1 foot mark, then your measurement would be 1.2 feet.



Photo by Ernesto Sandoval

Example 1 (above): The measurement from stake to pin flag is 1.2 feet.

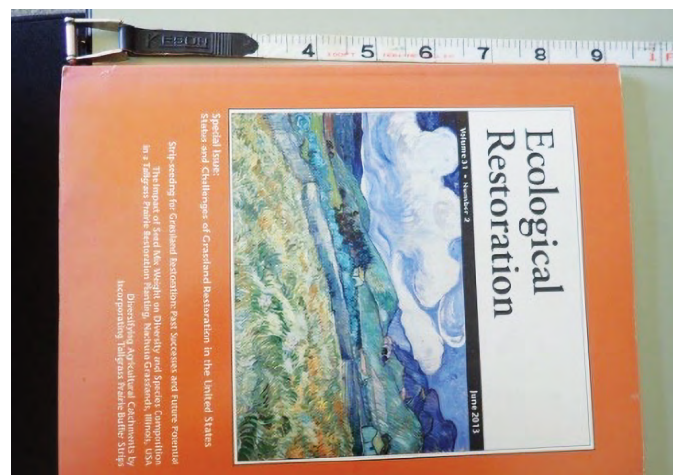


Photo by Ernesto Sandoval

Example 2 (above): The measurement of the book is 0.9 feet (we round to the nearest tenth of a foot or 0.10).

PLOT METHODS

15.0 Plot Layout & Description



Setting up a plot. Photo by NMFWRI Field Crew

1. Use GPS to locate plot center (PC).
2. At PC, drive rebar into ground at a height of 4-6" and add a mushroom cap.
3. Run tape in each cardinal direction to 37.24 ft. Have another crew member direct you from PC with a compass to ensure your line matches the correct azimuth.
4. Use pin flags to mark smaller diameter circle at 11.78 ft and larger circle at 37.24 ft (pin flags correspond to stars in the image below).
5. Run a tape at the specified azimuth for the Brown's line(s). Again, have another crew member direct you with a compass, and use photos of the previous Brown's line to get the tape as close as possible to the previous tape layout.
6. Drive another rebar into the ground at the end of the Brown's line (75') and add a mushroom cap. If you have to offset the Brown's line rebar, be sure to make a note in the comments. (i.e., Brown's line rebar placed at 76.5 ft due to rocks at 75 ft)
7. Record the information found in the highlighted boxes of your datasheet, following page.

Observer: The initials of people calling out data.

Recorder: The initials of the person recording the data on the datasheet.

Latitude, Longitude, and Elevation: Record from your high-precision GNSS receiver in the appropriate format. Be sure to indicate units for elevation.

Administrative Unit: Landowner or Land Manager (i.e. Santa Fe National Forest, New Mexico State Land Office).

Project Unit: Name of the sub-unit of the project.

Macroplot: Number of the plot.

Date: Date monitored.

Time: Time you begin working on the plot.

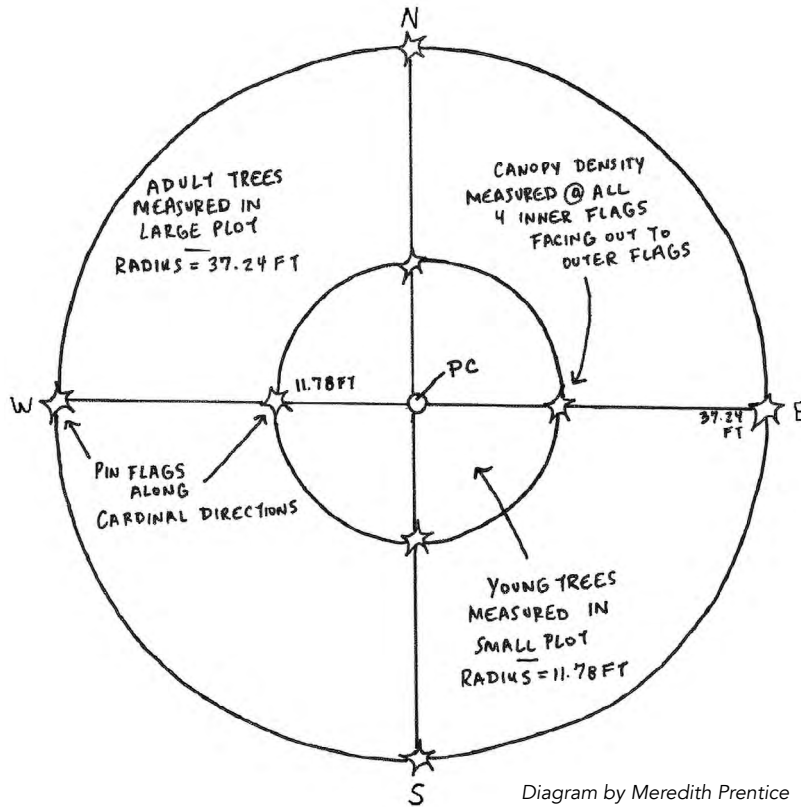
Hill Slope: % slope wherever it is steepest within your plot (at least 37.24 ft distance). *See also Ch 15.1*

Aspect: Overall orientation/ direction of the plot (N, E, S W). *See also Ch 15.2*

Aspect azimuth: The direction of the aspect in degrees.

Magnetic declination: The amount you adjusted your compass to account for the difference between true north and magnetic north. *See more Ch 13.1*

Plot comments: Include information useful for finding the plot again, a description of conditions at the site, and any other pertinent information about the collection of data.



Plot Description

Observer: <u>KM, ES, RP, PD</u>	Administrative Unit: <u>USFS</u>
Recorder: <u>CB</u>	Project Unit: <u>9neqo.1</u>
Latitude (dd.dxxxx): <u>35.7373926</u>	Macroplot: <u>06</u>
Longitude (ddd.dxxxx): <u>105.38561700</u>	Date (MM/DD/YYYY): <u>4/10/18</u>
Elevation: <u>7931 ft</u>	Time: <u>11:48</u>
Photo: <small>(1) of whiteboard at PC. (2) from 75 feet N looking south to PC (4) from PC in all four cardinal directions; (3) from each Brown's transect looking toward PC.</small>	Hill Slope (% where steepest): <u>28</u> %
ORDER TAKEN: <u>PC, B0, C, B270, B135,</u> <u>NESW</u>	Aspect (circle one): <u>N (E) S W</u>
	Aspect azimuth (degrees): <u>70</u> °
	Mag Declination: <u>8</u> °

Comments: Many many mulein, burned a while back, some fire killed, a few snags. large woody debris, open Ponderosa Pine forest, a few ABCO & PSME Dead QuBA seedlings fire-killed.

PLOT METHODS

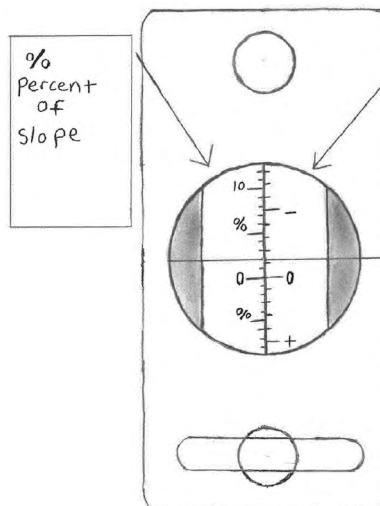
15.1 Slope with a Clinometer

Choosing a Clinometer

Clinometers are tools that can be used for measuring slopes, angles, or heights of objects, including trees. There are many different scales available, such as secant, percent, degree, topographic, 15- and 20-meter, and more. Each clinometer comes with two scales. We recommended using a percent and topographic clinometer, also known as PM5/1:66, when measuring plot slopes and tree heights, because this allows you to take height measurements from a chain away. The following instructions are based on Suunto clinometers.

Using a Clinometer:

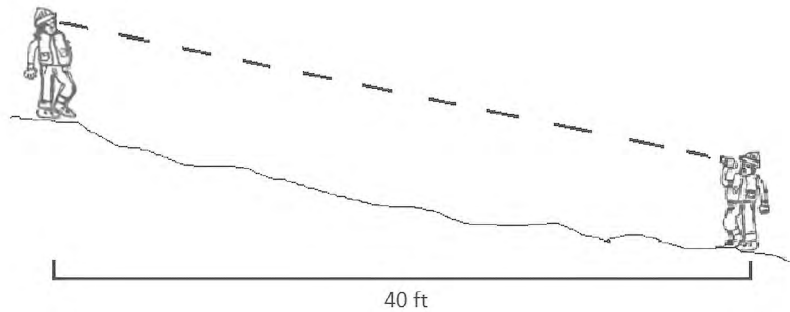
1. Hold the clinometer to your eye. Generally, the recommendation is to look with both eyes open, one eye looking through the lens at the wheel and the other looking at the object or landscape. For some people, however, it may be necessary to close one eye.
2. Aim the red dot at the target and imagine a horizontal sighting line from the lens wheel to the object you are measuring.
3. Raise or lower the clinometer by tilting your head until the imaginary sighting line crosses the wheel like a target.
4. Read the number closest to the sighting line on the correct side of the wheel - remember that two scales appear through the clinometer lens. If you forget which side to read, look at the wheel on the side of the clinometer to see the units, or look through the lens and tip the wheel until you can see symbols. On a PM5/1:66 clinometer, the scale on the left indicates percent slope (rise/run x 100), while the scale on the right measures height in feet if you are 66 feet away from your target.



Use the scale on the left for percent slope measurements. *Diagram by Raymundo Melendez*

Taking plot slope:

- Find a partner and establish where your eye level falls on them.
- Stand at least 37.24 ft apart on the steepest part of the plot. The slope measurement does not need to pass through plot center but it can.
- Raise or lower the clinometer to the point you established as eye level on your partner. The number at the sighting line is your percent slope.



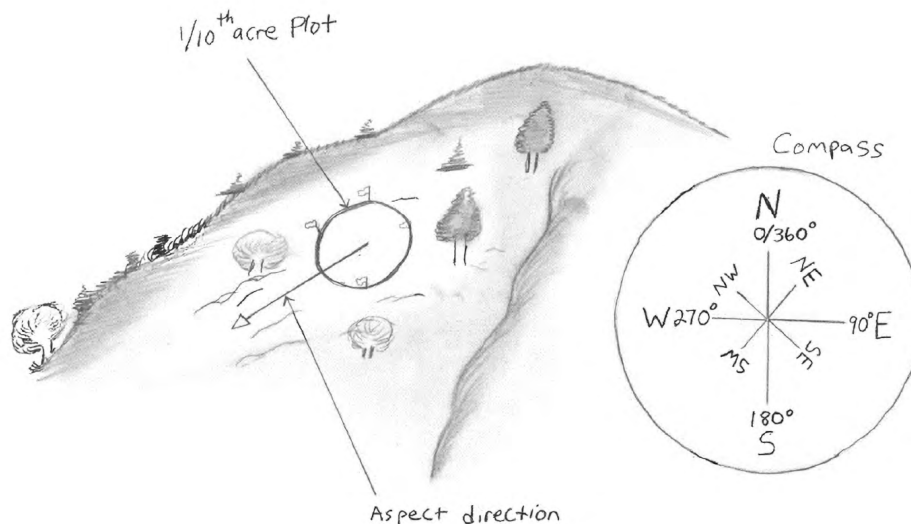
The technician on the right measures slope uphill by angling the clinometer to eye level on their partner. *Diagram by Raymundo Melendez and Carolina May*

PLOT METHODS

15.2 Aspect with a Compass

Aspect is the general orientation or direction of your plot. To determine aspect, it's helpful to conceptualize which direction water would flow through your plot. For each plot, aspect is recorded with a specific azimuth (degrees) and a cardinal direction (N, E, S, W).

1. Stand at plot center and hold the compass facing up with the sights facing away from you.
2. Hold the compass flat and parallel to the ground.
3. Turn your body so that you aim the sights of the compass in the direction the slope is facing. (Another way to visualize this is to position yourself as if you were downhill skiing the fastest route off your plot).
4. Without moving yourself or or the main body of your compass any more, turn the round dial to align the painted red lines with the red needle.
5. Read the number that now aligns with the sights.
6. Record this number exactly as you see it (aspect azimuth) and also as whatever cardinal direction it is closest to (aspect). For example: 230 degrees, West.



The plot shown on the hillside has an aspect azimuth of 230 degrees. Aspect direction would be listed as West. *Diagram by Raymundo Melendez*

PLOT METHODS

16.0 Taking Photos



Crew member taking photo from plot center (PC). *Photo by Kathryn Mahan*

Plot Photo Points

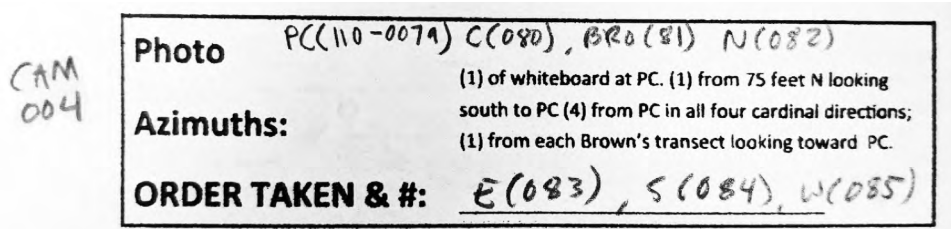
Plot photos are an important aspect of ecological monitoring. Photos are powerful visual tools for documenting change over time. Photos are included in reports and professional publications meant for diverse audiences including land managers and the public.

Seven photo points are taken per plot. If more than one Brown's transect is collected, additional photographs are taken in the same format. Typically, a white board with marker is used to tag each photo. The first photo taken at each plot is of the white board on the ground at plot center (PC). This ensures the data technicians are able to read the plot name and number and correctly identify the photos that follow. It is helpful if the camera used can record GPS coordinates.

Additional photos include:

- “C,” (center) taken from 75 ft along the North azimuth looking at a crew member holding the white board at plot center.
- Brown's transect photo, “BR_degrees” taken from the 75 ft mark of each fuels azimuth looking towards a crew member holding the white board at plot center.
- “N,” “E,” “S,” and “W” photos taken from plot center facing a crew member holding the white board 37.24 ft away at each of the four cardinal azimuth flags. Additional photographs may be taken, but we recommend these be taken after the mandatory seven plot photos, and noted on the data sheets, so that there is no confusion for the data technicians.

The photo order must be recorded for each plot, for example, PC, C, N, BR75, E, S, W. If photos are being re-taken from a previous year, it is critical to bring along copies of the previous photographs to be sure the frames and landmarks match up. In addition to recording the order of the photo points, record the camera number/model and photo numbers to aid in photo labeling. For example: CAMER001, PC (100-0434), C (100-0435), N (100-0436), etc.



Recording photo numbers. Photo by NMFWR I Field Crew

Taking Photos – Tips & Reminders

- Be sure GPS tracking is enabled on your camera (if available).
- Do NOT turn the camera vertically.
- Do NOT zoom in or out at all.
- Try to use the same kind of camera that was used before (aspect ratio/frame should match).
- If previous photos were taken from a different azimuth than you measured (i.e., azimuth was incorrectly recorded in previous measurements, or declination was not set perfectly), match the photos to the previous azimuth (i.e, make a perfect visual match). Make notes of major deviations from the previously identified azimuth. If the azimuth was off for the initial picture, after retaking the photo to match the previous year's, take a photo of what the correct orientation should be. Be sure to label which photo is which when jotting down the order.
- If you are taking photos on a plot for the first time, do so after flagging your witness tree, and try to have a landmark in every photo if it's easy to do so.
- Center the frame on the person with the whiteboard (right-to-left). The person holding the whiteboard should hold the board directly in front of their body, to take up as little space in the photo as possible. If a tree or obstacle is in the way, try to hold the board in a way that it is visible.
- All crew members should wear proper clothing and PPE in photos and appear professional.
- You may not be able to center on the person up-and-down because you will always keep your camera level (even if shooting on steep slopes).
- If you take extra photos of “cool stuff” or unknown plants, try to do this after you have completed the series required for your plot, and be sure to document these extras on your datasheet.
- Double-check your photos by using the playback function on your camera before you leave the plot.

- When you're looking through them, remember that photos should NOT:
 - be blurry or include fingers over photo.
 - include vehicles.
 - include highly visible backpacks/gear or other crew members.
 - include tapes that are “wiggly” – straighten them up or remove them!

Sample Photos:



Griego Unit 1 Plot 6 PC



Griego Unit 1 Plot 6 Center



Griego Unit 1 Plot 6 Brown's 0



Griego Unit 1 Plot 6 Brown's 270



Griego Unit 1 Plot 6 Brown's 135



Griego Unit 1 Plot 6 North



Griego Unit 1 Plot 6 East



Griego Unit 1 Plot 6 South



Griego Unit 1 Plot 6 West

PLOT METHODS

17.0 Canopy Cover with a Densiometer

Spherical densimeters are tools developed for estimating overstory canopy density in forests. They are available with concave and convex mirrors; NMFWRI crews use the concave models. You should be aware that, in addition to the methods described below, there are a number of other ways to use spherical densimeters, such as the Strickler modification, that you may encounter in other monitoring protocols or jobs.

When working on plot, the tree canopy cover for each plot will be an average of four measurements, collected while standing at each inner plot flag (North, East, South, West), facing out to the outer plot flag.

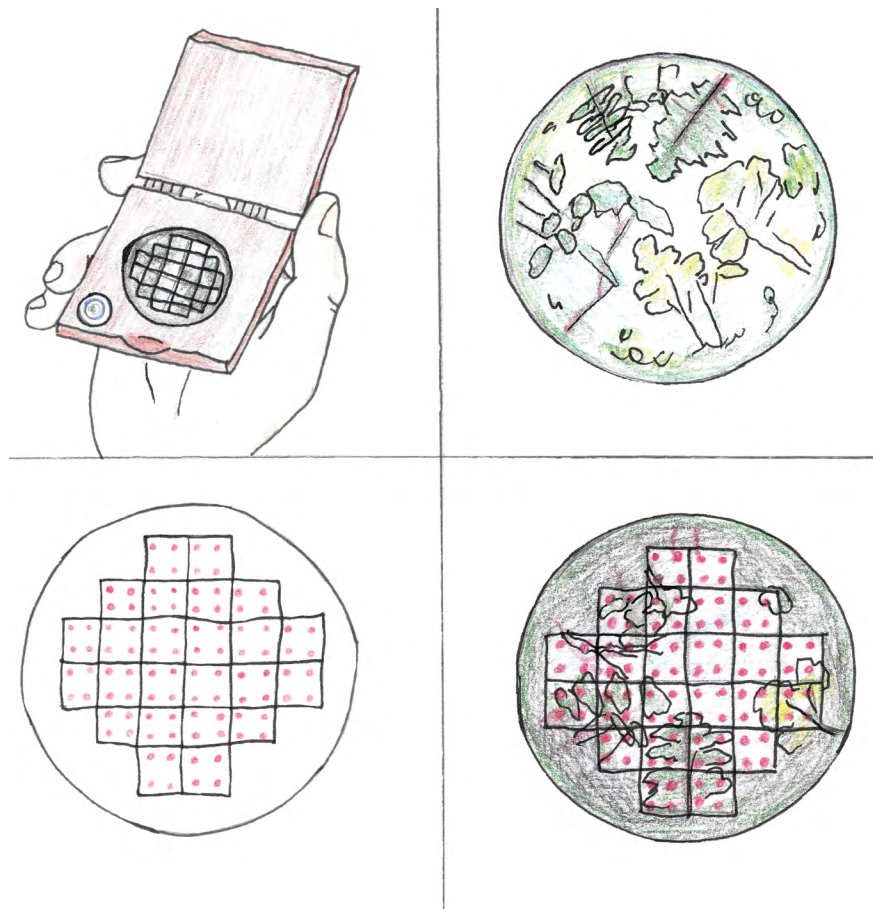


Diagram by Zoe Ahrens

To begin,

1. Stand at your first flag.
2. Open the densimeter and hold it about waist high, level, and just far enough away from your body so that you cannot see yourself in it. Typically, your elbow should be pressed against your waist.

3. To ensure the densiometer is level, make sure the bubble is centered in the black circle in the lower right corner.
4. Proceed, using either the Squares or Dots methods outlined below.

Squares Method:

- In the mirror, you will see 24 engraved squares.
- Count the number of squares which are NOT occupied by canopy. Half squares can be combined within a single measurement, but each measurement should be reported in a whole number of squares.
- Subtract the number of open squares from 24 to get the number of covered squares.
- Record this number and move on to the next measurement. Repeat this process until you have four numbers from each inner flag. Record each measurement on your datasheet individually for each cardinal direction.
- In the analysis, the four measurements will be added together and multiplied by 1.04 to obtain percent canopy cover.

Square Method Example:

North Inner Flag: 6 squares were open.

$$24 - 6 = 18 = \text{canopy}$$

East Inner Flag: 18 squares were open.

$$24 - 18 = 6 = \text{canopy}$$

South Inner Flag: 0 squares were open.

$$24 - 0 = 24 = \text{canopy}$$

West Inner Flag: 11 squares were open.

$$24 - 11 = 13 = \text{canopy}$$

Next, I add up my numbers

$$18 + 6 + 24 + 13 = 61$$

Next, I multiply by 1.04 to correct for only having a total of 96 squares (24 x 4).

$$61 * 1.04 = 63.44 = 63$$

So, I have an average of 63% canopy cover on my plot.

Dots Method:

- In the mirror, you will see 24 engraved squares. Mentally, you can add 4 dots per square, for a total of 96 dots. (See diagram on previous page for an illustration of these dots.)
- Count the number of dots which are NOT occupied by canopy.
- Subtract the number of open dots from 96 to get the number of covered dots.
- Record this number and move on to the next measurement. Repeat this process until you have four numbers from each inner flag. Record each measurement on your datasheet individually.
- In the analysis, the four measurements will be averaged and multiplied by 1.04 to obtain percent canopy cover.

Dot Method Example:

North Inner Flag: 44 dots were open.

$$96 - 44 = 52 = \text{canopy}$$

East Inner Flag: 32 dots were open.

$$96 - 32 = 64 = \text{canopy}$$

South Inner Flag: 70 dots were open.

$$96 - 70 = 26 = \text{canopy}$$

West Inner Flag: 51 dots were open.

$$96 - 51 = 45 = \text{canopy}$$

Next, I add up my numbers

$$52 + 64 + 26 + 45 = 187$$

Then, I divide by 4, since I took 4 measurements

$$187 / 4 = 46.75$$

Finally, I multiply by 1.04 to correct for only having 96 dots.

$$46.75 * 1.04 = 48.62 = 49$$

So, I have an average of 49% canopy cover on my plot.

Special Cases:

Cliff/Ground providing cover in measurement on steep slopes:

- Include this as “cover” but leave a note estimating the percent coverage that was ground/rock rather than canopy.

Burned/dead canopy:

- Squares with dead branches without leaves can make for difficult canopy estimations as it is not always clear how many dots would actually be covered by thin branches. In these cases, estimate the amount of sky visible in each square (I.e. 50% sky and 50% coverage would be half a square or 2 dots of coverage).

Calibration/Troubleshooting:

- Crew members using the densiometer can come up with a wide variation in readings. To become consistent, it's important to agree upon a method (dots vs squares) and to spend time practicing with all crew members taking the same readings from the same point and comparing readings. Always record the method you are using, and use the same method across the entire project. As a crew, you will need to calibrate yourselves so you can share the same judgment in counting dots and squares, especially with small, irregular openings. Have the same crew member measure all four directions within one plot.
- When working in forests with deciduous trees, such as riparian areas, you need to make sure you are taking canopy readings during the same season each time as leaf-off will impact readings.
- Sunglasses are recommended when using the instrument in open canopy on sunny days.

PLOT METHODS

18.0 Small Plot Measurements

Aerial cover and ground cover are estimated within the nested 1/100th acre plot along with tallies of seedlings, saplings, and shrubs. Some project managers may request that these measurements are conducted across the entire 1/10th acre area.

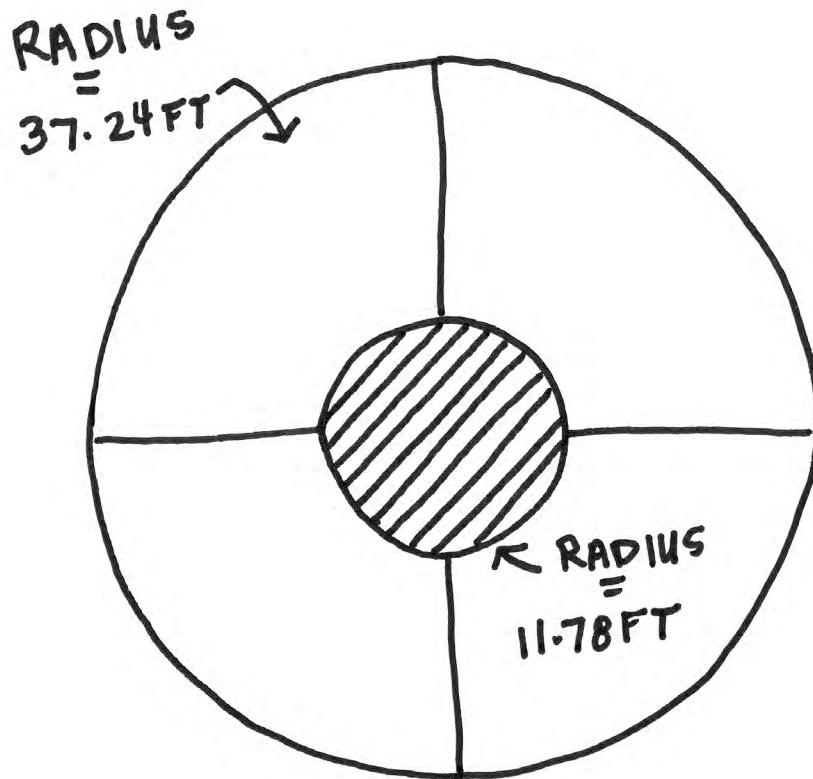


Diagram by Meredith Prentice

PLOT METHODS

18.1 Estimating Aerial Cover

Aerial cover refers to cover as viewed from above. Aerial cover includes the percentage of the ground covered by perimeter of leaves/ branches/ etc., from a viewpoint above the plot. In our protocol, aerial cover is for ocular estimations of the cover of seedling/saplings (“tree regen”), shrubs, graminoids, and forbs, and may not necessarily total 100%. When vegetation overlaps, cover values greater than 100% are possible. When vegetation is sparse, aerial cover may be much less than 100%. Depending upon objectives, aerial percent cover may be further stratified by individual species greater than 1% cover and/or by growth habit.

Aerial cover (%) (1/100th acre plot)			
Tree regen.	Shrubs	Graminoids	Forbs
35	0	65	18

Photo by NMFWR Field Crew

Terms:

- **Aerial cover** - Percent of ground covered when viewed from above.
- **Tree regen** - A term covering, for our purposes, all individuals meeting the definition of seedling (<4.5 ft tall) and sapling (≥4.5 ft tall but under the breakpoint diameter at DBH).
- **Shrub** - A woody plant smaller than a tree at maturity; has several main stems arising at or near the ground (which plants are considered “shrubs” vs “trees” may depend upon monitoring objectives); cacti are lumped into the shrub category for aerial cover.
- **Graminoids** - Grasses or grass-like plants.
- **Forb** - An herb, a flowering plant, other than grass.

Steps:

1. Be sure all four flags of your inner circle/small plot are in place.
2. Visualize the circle you are estimating for; walk around it and look up and down.
3. Imagine you are looking down from above at your inner circle.
4. Estimate the percentage of your circle covered by each item in the table. Break the circle down into quadrants and sum up the cover in each quadrant if needed. Consult with others if you are unsure.
5. To stay consistent, have the same person do the estimation for all plots in a project.

PLOT METHODS

18.2 Estimating Ground Cover

Ground cover measurements include percent cover of plant basal (including cacti), bole, litter, bare soil, rock, and gravel, and **must total 100%**.

Ground cover (%) (1/100th acre plot) (total 100 %)						
Plant basal	Bole	Litter	Bare soil	Rock (>2.5in)	Gravel (<2.5 in)	Total (%)
70	2	7	18	1	2	100

Photo by NMFWR I Field Crew

Terms:

- **Plant basal** - Area of the ground occupied by the base of the plant stem. Plant basal includes mosses, cactus, lichen, and cryptobiotic crust.
- **Bole** - Main trunk of tree or woody plant.
- **Litter** - Small dead plant material such as leaves, bark, and needles. For ground cover estimations, this also includes down woody debris (DWD) such as sticks and logs, and other non-living organic materials including ash.
- **Bare soil** - Exposed mineral soil.
- **Rock** - Material greater than or equal to 2.5 inches in diameter.
- **Gravel** - Material under 2.5 inches in diameter but larger than a grain of sand.

Steps:

1. For this estimation, imagine you cut off everything in your plot at less than an inch above the ground to estimate how the surface is covered.
2. Estimate the percentage of your circle covered by each item in the table. Sometimes it is easiest to divide your circle into quarters between the inner flags and PC. Remember that if something fills up an entire quarter, it would be 25%. It also may help to remember that 1% of your area is about the size of a large pizza.
3. To stay consistent, have the same person do the estimation for all plots in a project.
4. To begin with, estimate your plant basal area. This is basically the area where the plant stem intercepts the ground surface. So, for instance, if you estimated graminoids and forbs at a total of 83% in your

aerial cover table, you might expect the basal area to be less than this. This number does not include any part of the plant except what is right on the soil surface. The stems of cacti are included in basal area.

5. Next, do your bole estimation. A bole is the part of a woody stem (the main trunk) that goes into the ground. It doesn't include branches or twigs, and it doesn't include any pieces of wood that are not stuck into the ground. Cut stumps do count, however.
6. Your litter estimation will capture all needles, sticks, logs, loose pieces of dead grass, etc., that may be on your plot. Only include material that is in direct contact with the ground. For example, some logs may be partially in contact with the ground and partially suspended in the air.
7. Bare soil means an area is totally bare. Don't forget that gravel or pine needles are not bare soil.
8. Rock is a piece of solid mineral material ≥ 2.5 inches in diameter, while gravel is under 2.5 inches.
9. Use a calculator to check your total. Make sure your ground cover totals 100%.

PLOT METHODS

18.3 Tallying Seedlings, Saplings, and Shrubs

Tree regeneration (seedlings and saplings) is measured on the nested 1/100th acre circular plot (11.78 ft. radius). The species, condition, and height class (>0-0.5 ft; >0.5-1.5 ft; >1.5-2.5 ft; >2.5-3.5 ft; >3.5-4.5 ft) are recorded for each **seedling** or sprout. **Saplings** (≥ 4.5 ft but <1.0 in or other breakpoint diameter) at diameter at breast height (DBH) are also recorded in this way. **Shrubs** are measured on the same nested subplot and species, condition, and height/diameter class are recorded for each stem just as with tree species; we typically record **cacti** as well, since they were considered “shrubs” in the aerial cover measurements. Other cutoffs may be used for height and diameter classes depending upon project and monitoring objectives.

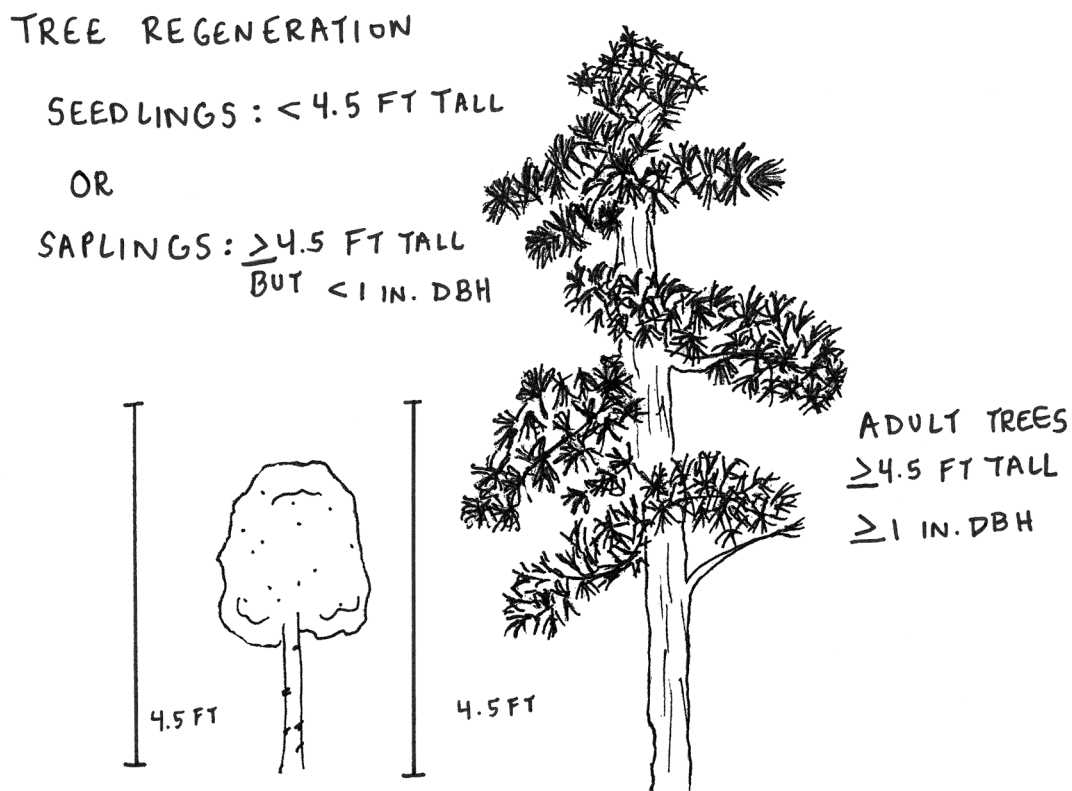


Diagram by Zoe Ahrens & Meredith Prentice

Taking the Measurements:

1. It is helpful to measure these cutoffs on your body, just as you did to find 4.5 feet for DBH. This way you can simply walk up to a seedling and know which height category it falls in.

18.3 Tallying Seedlings, Saplings, and Shrubs

2. In dense areas, it also helps to break up the small plot into quarters, and do one quarter at a time. Having a helper might also be a good idea.
3. If unsure if a seedling, sapling, or shrub is in the inner circle, pull the tape out from plot center.
4. Be careful to look for sprouts or very young seedlings that may be hiding in the brush or litter layer. Don't forget that subshrub species such as *Mahonia repens*, which is low-growing and small, also count. So do any cacti found on the plot.
5. For shrubs and seedlings prone to multistem growth or resprouting (such as oaks), count stems individually if the ground is visible between sprouts. List the status of each individual stem (live, dead, or sick).
6. For shrubs prone to creeping growth (i.e kinnikinnick), identify clumps with main rooting stems and count these as individuals.
7. Tally your seedlings by height class and condition, such as the example below. Multiple tally systems exist. Tally marks or dot and line tallies (aka Tukey tallies) may be used, but when the recording is complete, the final count should be recorded in Arabic numerals. This is to avoid confusion (for instance, 2 tally marks look similar to 11), and make data entry simpler. If tallies are present on the datasheet, circle the numerals of your final count. (See an example of this in Supplement D.)
8. Tally your saplings by diameter class. If you are only working with saplings under 1" (i.e. this is your breakpoint diameter), then you will only have one class of saplings. If there were no saplings found, place a line through the box. See the example below.

Species	Condition (Live, Dead, Sick)	Small Plot—Tree Regen & Shrubs				
		Height classes—Seedlings (<4.5', <1" dbh/drc)				
		> 0 - 0.5	> 0.5—1.5'	> 1.5' - 2.5'	> 2.5 - 3.5	> 3.5 - 4.5
Quga	D			25		
Quga	L			5		
Abco	D					1

Small Plot—Tree Regen & Shrubs		
Species	Condition (Live, Dead, Sick)	Saplings >4.5', < 1"
<hr/>		

Photo by NMFWR Field Crew

PLOT METHODS

19.0 Measuring Trees

Information about trees is captured for every plot in overstory measurements. There are many rules and parameters for what to record and how to properly take tree measurements (i.e. DBH, height, live crown base height, etc.)

19.1 What Trees to Record

All **trees and snags** are measured within the 1/10th acre circular, fixed-area sample plot (37.24 ft. radius).

By Diameter:

Trees and snags are recorded in the macroplot if they have one stem greater than or equal to the established breakpoint diameter for the protocol. In the following examples, we will use a 1" breakpoint diameter. If there is more than one stem per tree or snag you will collect multiple diameters if they meet certain criteria. (See Figure 1, below.) First determine what stem has the largest diameter. This is considered your main stem. Additional stems captured need to 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. See 19.33 *Measuring Multi-Stem Trees for information on defining multi-stem trees.*

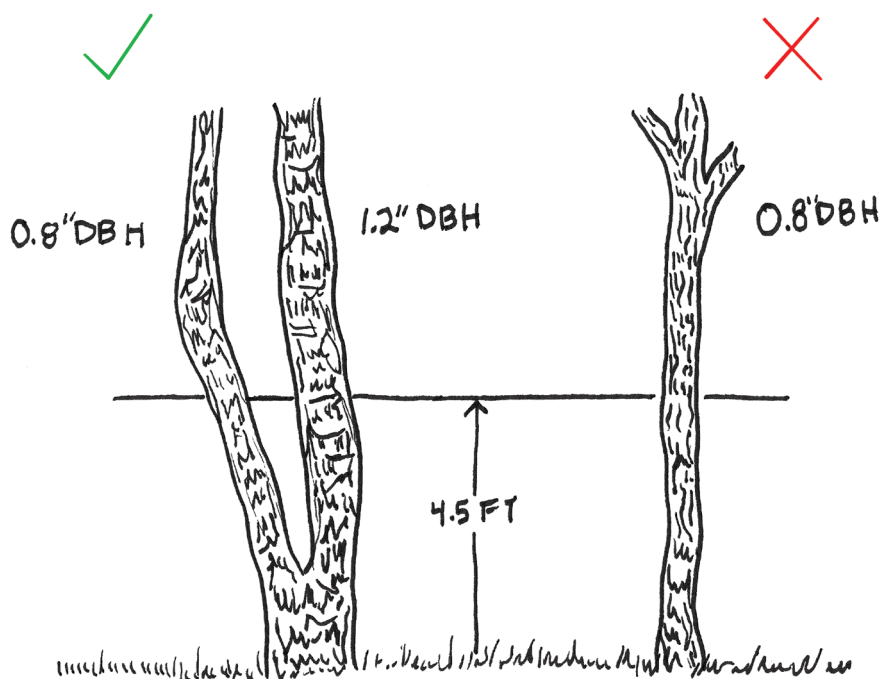


Figure 1. Record both stems of the tree on the left, as the main stem is over 1" DBH. Do not record the tree on the right as the diameter is below 1" DBH and it is not connected to any stems over 1". Diagram by Raymundo Melendez and Meredith Prentice

By Distance from PC:

All trees should be determined to be in or out of the plot by their horizontal distance from plot center (PC), not the slope distance. In a sloping plot, have a crew member help you hold the transect tape horizontally

while measuring tree distance from PC. For example, if the tree of interest is uphill from plot center you will have to raise the tape above DBH at plot center so that the tape is level when measuring if the tree is in. See 19.24 *Slope Corrections* for information on slope distance vs. horizontal distance.

Trees and snags are determined to be in or out of the plot by the location of the bole at DBH height (4.5 feet). See Figure 2. A tree or snag rooted in the plot that leans out of the plot at DBH should not be recorded and vice versa.

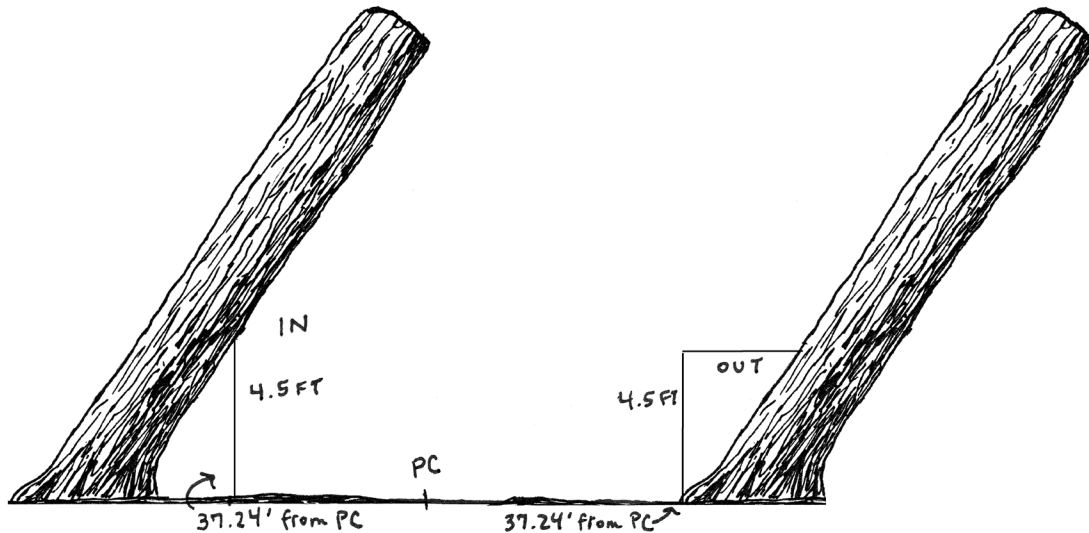


Figure 2. The tree on the left is rooted out of the plot, but leans into the plot at DBH height, and therefore should be recorded. The tree on the right is rooted in the plot, but leans out of the plot at DBH, and therefore should not be recorded. Diagram by Zoe Ahrens

By Angle:

Snags leaning at an angle greater than 45 degrees should not be recorded in the tree data, and instead will be captured in fuel measurements (Figure 3). Live or sick trees should be recorded regardless of angle (along with appropriate damage code/severity).

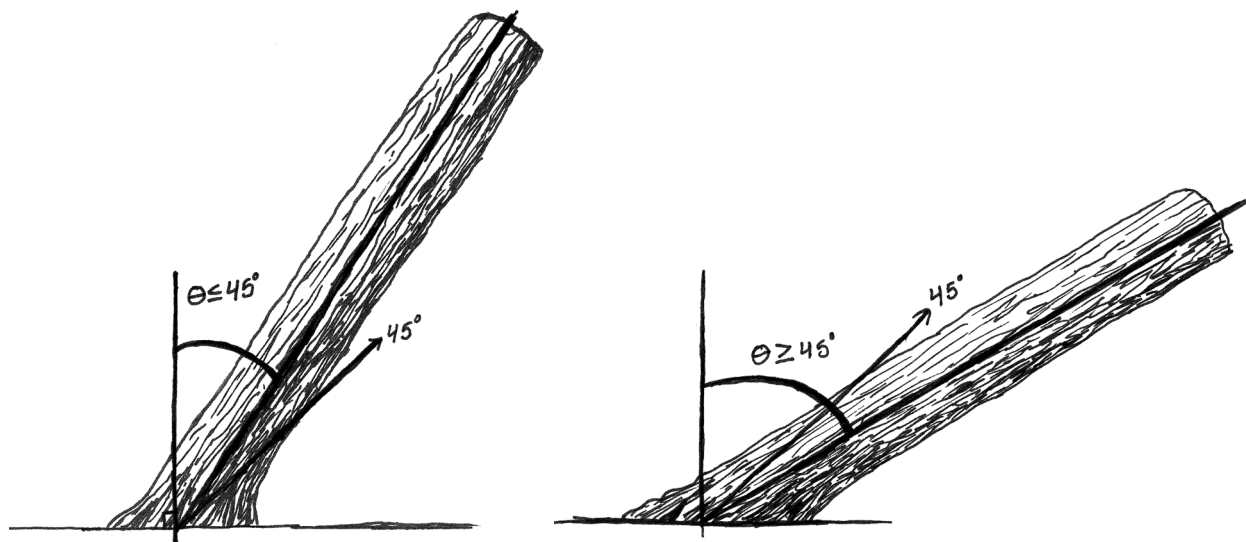


Figure 3. The snag on the left is leaning at an angle less than 45 degrees, and therefore should be recorded as a tree (with a lean noted as a damage code). The snag on the right is leaning at an angle greater than 45 degrees, and therefore should not be recorded as a tree, but instead be recorded in the fuel transect if applicable. Diagram by Zoe Ahrens.

PLOT METHODS

19.11 Recording Trees

Trees are recorded using their USDA PLANTS code, a four-letter code defined by the first two letters of the genus and first two letters of the species name (e.g. PIPO, ABCO, PIFL, PIED, JUDE, JUSC, QUGA, etc) *See Ch 6*. Trees are recorded starting from the north azimuth line and moving clockwise, like spokes of a wheel, from plot center. In dense stands, we find it helpful to flag the first tree measured to keep the crew oriented. If appropriate, this first tree may also serve as the witness tree. *See 19.13 Witness Trees for more details.*

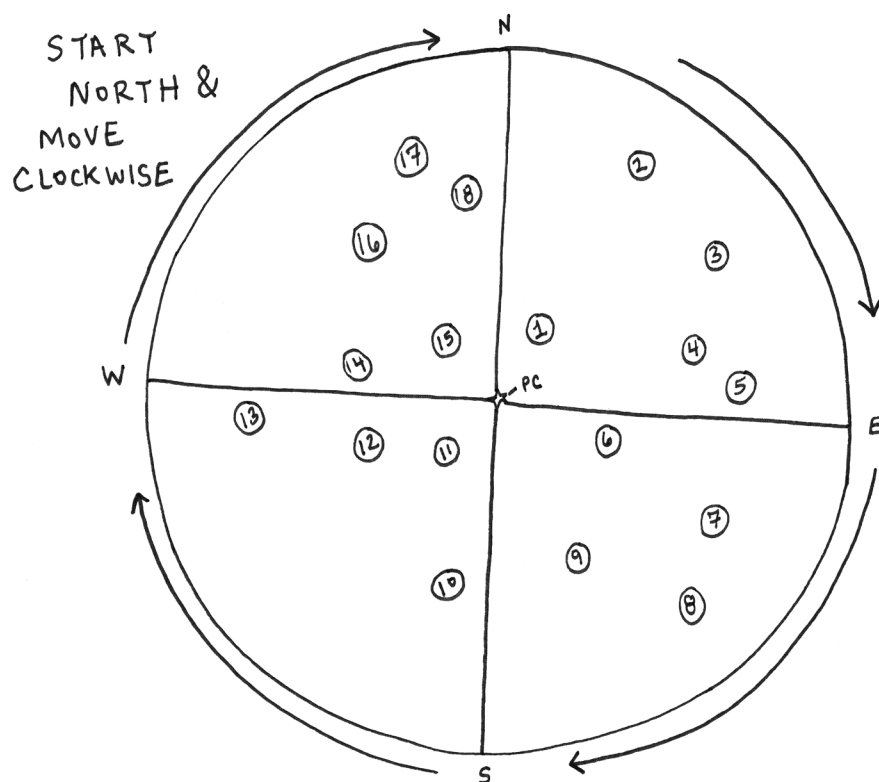


Diagram by Meredith Prentice

What Gets Recorded:

For each tree located within the plot collect the following:

- Species *See Ch 9*
- Condition (live, dead, or sick) *See Ch 19.4*
- DBH or DRC *See Ch 19.3*
- Number of stems *See Ch 19.33*
- Total height *See Ch 19.2*
- Live crown base height *See Ch 19.2*
- Damage codes and severity ratings *See Ch 19.4*
- Any comments—for information such as: details on damages/severities, estimation of how long the tree has been dead (i.e. needles gone, well-rotted, etc.) or anything unusual or interesting.

PLOT METHODS

19.12 Tagging Trees

Tagging trees with labeled aluminum or stainless-steel tags is recommended to increase consistency of measurements across time, assist with catching errors in the QC process, allow for tree growth analysis, and track tree-level pathology and mortality.

Tag Numbers/Devices:

During initial tagging, tag numbers should follow traditional numbering protocols as described in *19.11 Recording Trees* and *19.33 Measuring Multi-Stem Trees*. Trees should be tagged with consecutive numbers moving clockwise from north, with stems of the same tree starting with the same tag number. For example, if the 5th tree on plot has four stems, tags will read: 5.1, 5.2, 5.3, 5.4.

Considerations for working in areas likely to be thinned or harvested for fuelwood: If using stainless steel tags, make them as small as possible. Use aluminum nails rather than stainless steel to protect loggers and logging equipment. If working in juniper or other forest types where you are finding aluminum nails do not work well, 22-24 gauge wire may be a better option.

Tag Installation:

Install trees tags at DBH (4.5'), so that DBH measurements can be taken consistently just above the nail at each recurring measurement. Tags should be installed on the uphill side of the tree, where DBH is taken. If DBH is offset due to an abnormality, tag at whatever height the diameter was taken. Thread the tag through a long nail (at least 2.5-3") and hammer the nail until it is secure. Leave at least 1.5" of nail exposed to allow for tree growth before the next measurement period. Angle the nail down slightly towards the ground to allow the tag to easily slide away from the tree as it grows.

When remeasuring tagged trees, use the claw of a hammer to loosen and extend the nail to allow for further growth before the next measurement period.

Tagged Tree Remeasures:

When remeasuring plots with tagged trees, record fallen trees with visible tags in data notes. Be sure to check for trees that have grown into the tree class since the last measurement and add a tag with the next tree number available for this plot. Verify what the next tree number should be for your specific plot based on the previous dataset. Include in the comments: notes about the azimuth and/or which tree tags this tree occurs between to minimize confusion on the next remeasure.

If a tree is missing a tree tag but is large enough to have been present in the previous measure and is within the plot boundaries, tag the tree and make a note of this in the data so that additional quality control work can be done.

It is useful to bring a copy of previous data to the field during a remeasure to check that all previously tagged trees were either located, noted as fallen on the ground, or were plausibly removed by fire/thinning.

PLOT METHODS

19.13 Witness Trees

On every plot, a witness tree is established to aid in locating plot center for future measurements. Witness trees should be close to the plot center, should be expected to survive any future thinning, fire, or other disturbances, and ideally have some notable visual characteristics (i.e., yellowbelly, forked top, etc.). Witness trees are double flagged, noted in the overstory tree data comments, and described in plot description. Measure and record the distance and azimuth of the witness tree from the plot center.

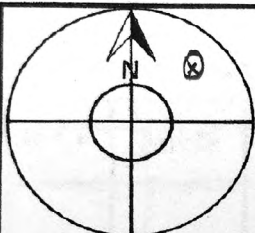
Plot Number G03-03

Page 4 of 1

Observer/Recorder: CJM, MJP Project/Site/Plot Gringo Date 11/2/2022

Record all woody species over breakpoint diameter/ seedling height for entire 1/20th ac plot

Tree #	Species	Tree cond. (L, D, S)	DBH (in)	No. stems	Total Tree Ht	LiCrBht	Char Height	Scorch Height	Comments damage/disease/severity, witness tree, etc.
1	PIPO	L	14.6	1	51.5	22.4	13.4	24.7	witness/
2	PIPO	L	1.1	1	6.0	1.5	0.8	5.5	1022g Sap
3	PIPO	S	10.4	1	46.7	23.4	1.0	—	Severe BIRD BEETLE
4	PIPO	L	13.5	1	49.8	24.5	—	—	—
5	PIPO	L	10.2	1	43.2	18.0	8.0	—	—
6	QUGA	D	2.9	1	9.0	—	0.5	—	Broken top 5%
7	PIPO	L	11.2	1	49.1	29.3	9.0	30.3	—



Describe Witness Tree(s):

PIPO DBH: 12.1
Ht: 45.6
LCrBht: 22.0

Distance: 24.3' Az: 43°

****Draw location of tree on plot****

Color of Flagging/Marker Used: orange

19.13 Witness Trees



Examples of witness tree flagging. *Photos by NMFWR Field Crew*

PLOT METHODS

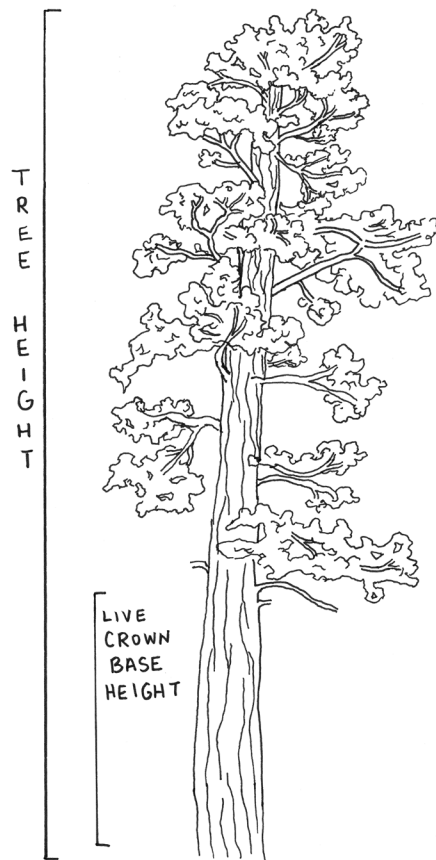
19.2 Tree Heights

The following sections explain how to take tree heights: the rules, tools, and methods we use.

19.21 Rules for Measuring Tree Heights

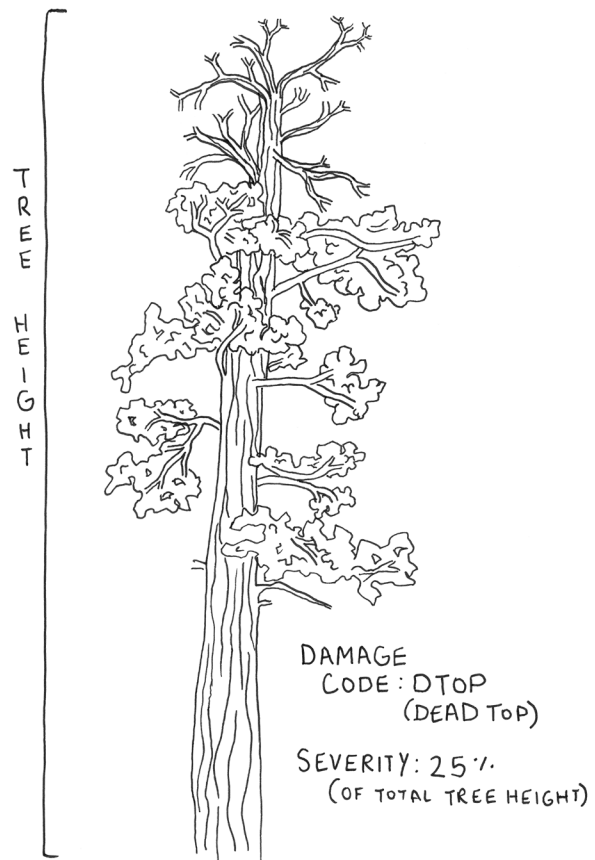
Rules for Measurements

- *Tree Height*: Record height from ground to highest part of the tree. For multi-stem trees with a Diameter at Breast Height (DBH) for each stem, record individual heights for each stem.
- *Live Crown Base Height (LiCrBht or LCBH)*: Record the height from the ground to the start of live foliage. For multi-stem trees with a DBH for each stem, record individual LCBH for each stem.
- *Leaners*: Measure from ground to highest point, even though the tree would measure taller if it were standing up straight.



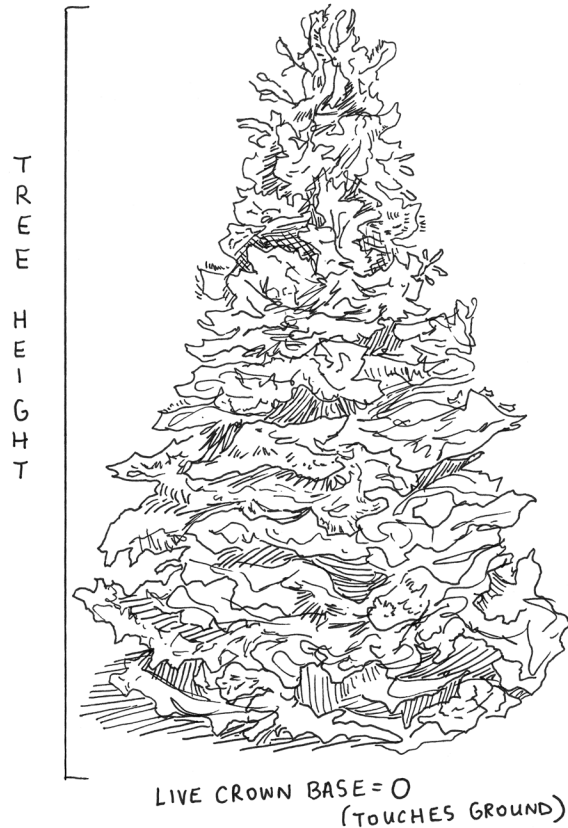
Example 1. Note that branch bends lower to ground a few feet out than it does where it connects to the tree. Use the distance from the ground to the lowest live foliage for your Live Crown Base Height measurement.

Diagram by Meredith Prentice.

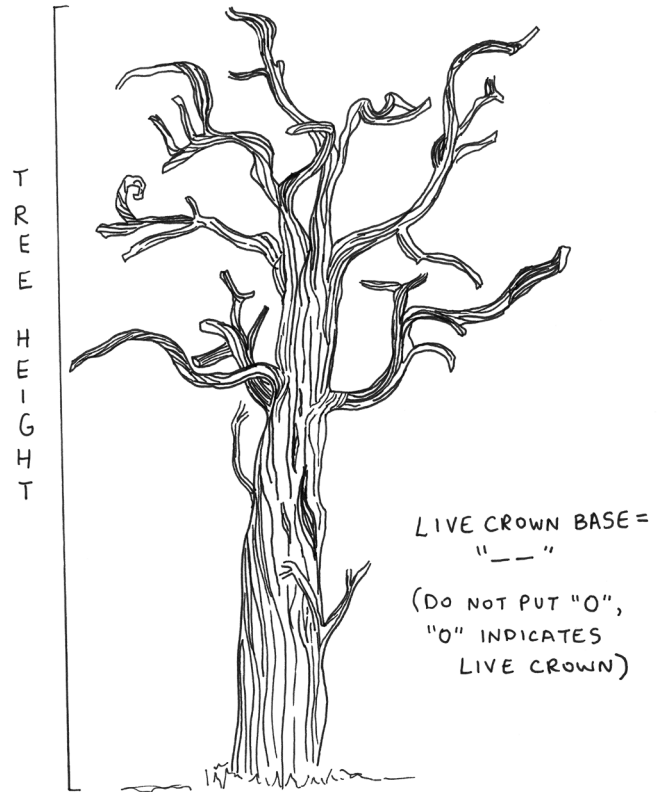


Example 2. The treetop is dead. However, for our Tree Height, we measure from the ground to the highest part of the tree. Remember to add a damage code and severity indicating the dead top.

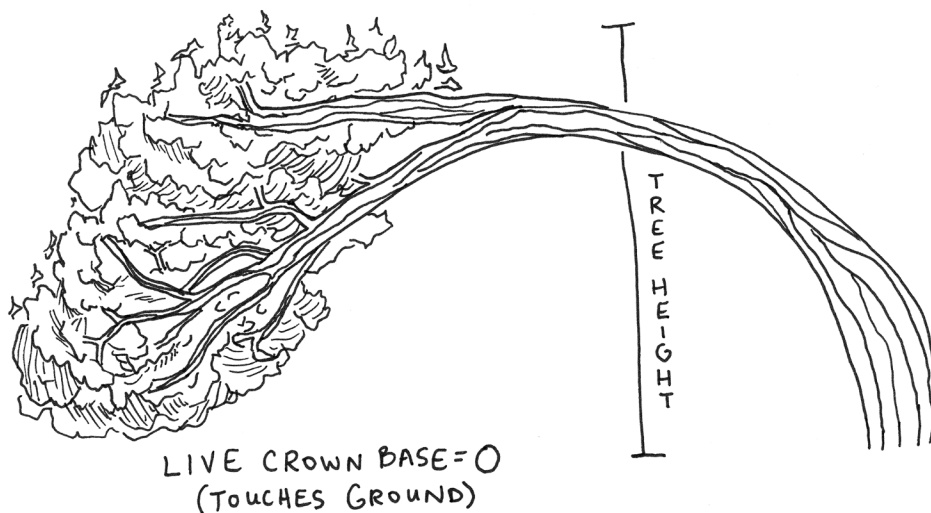
Diagram by Meredith Prentice.



Example 3. The live crown base height is 0, because the foliage touches the ground.
Diagram by Meredith Prentice.



Example 4. The tree is dead (a snag). For tree height, measure from the ground to the highest part of the tree. The tree's condition will be a "D" for dead. The Live Crown Base Height should be left blank for electronic data entry or recorded as "---" on the datasheet. Do NOT enter or record a "0" because a value of "0" indicates the crown is present and touching the ground. For absent live crown, always leave the field blank or use dashes.
Diagram by Meredith Prentice.



Example 5. The tree is bent over. For tree height, measure from the ground to the highest part of the tree. Since the crown touches the ground, record a live crown base height of 0. Also record a damage code and severity to indicate a lean.
Diagram by Meredith Prentice.

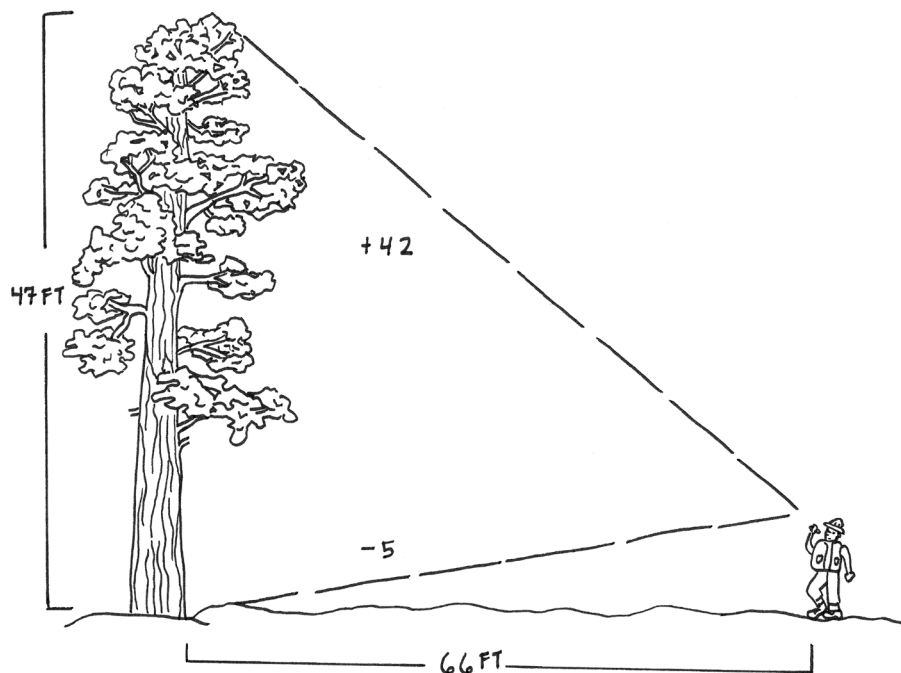
PLOT METHODS

19.22 Measuring Tree Heights Using a Hypsometer

A hypsometer (or rangefinder) is a tool that uses a laser to calculate height/distance of an object. In the case of this protocol, hypsometers are used to measure the height and live crown base height of trees. Laser hypsometers can make taking tree heights fast work, as they typically handle slope distance adjustment calculations for you and do not require you to stand a chain away from your target. Make sure the hypsometer your crew is using is accurate; many models operate outside the recommended ± 0.5 ft precision standard for height. One model NMFWR crews use is a TruPulse 360R.

Instructions:

1. Power on the hypsometer and ensure it has been recently calibrated.
2. Ensure the hypsometer is in the correct mode. Tree height measurements will be taken with a “3-point height routine”, which uses a horizontal distance, a base angle, and a top angle to calculate heights.
3. Stand at least 30 feet away from the tree you are measuring, until you are able to clearly see the top. Taller trees will need to be measured from a further distance.



Technician uses hypsometer to shoot 1) the distance to the bole of the tree, 2) the angle to the base of the tree, and 3) the angle to the top of the tree.
Diagram by Raymundo Melendez and Meredith Prentice

4. Look through the eyepiece and aim the crosshairs at eye level on the bole of the tree you are measuring. Press the button to activate the laser. You should see a distance value appear. If this number is unreasonably high or low, the bole may not have been hit by the laser.
5. Direct the crosshairs to the base of the tree. Activate the laser. An angle reading will appear.
6. Direct the crosshairs to the very top of the tree. Activate the laser. An angle reading will appear, followed by a height measurement for the tree.

Hypsometer Tips and Troubleshooting

- The hypsometer is not usable in rain or heavy fog, and can be challenging to use in windy conditions..
- Do not point the hypsometer into direct sunlight.
- Similarly to a compass, hypsometers are sensitive to magnetic materials and magnetic fields. Keep pin flags, nails, computers, spare batteries, etc. away from the hypsometer while in use.
- If height measurements seem incorrect, check:
 - Is the hypsometer in the correct mode for a 3-point height routine?
 - Is the measurement starting with horizontal distance?
 - Is the laser able to hit the bole of the tree, or is it hitting other vegetation in the way?
 - Is the user standing too close to see the true top of the tree?
 - Is the hypsometer low on battery?
 - Is the hypsometer properly calibrated? Calibration is key to keeping these sensitive instruments functioning as they should. See user manual for information on calibrating.

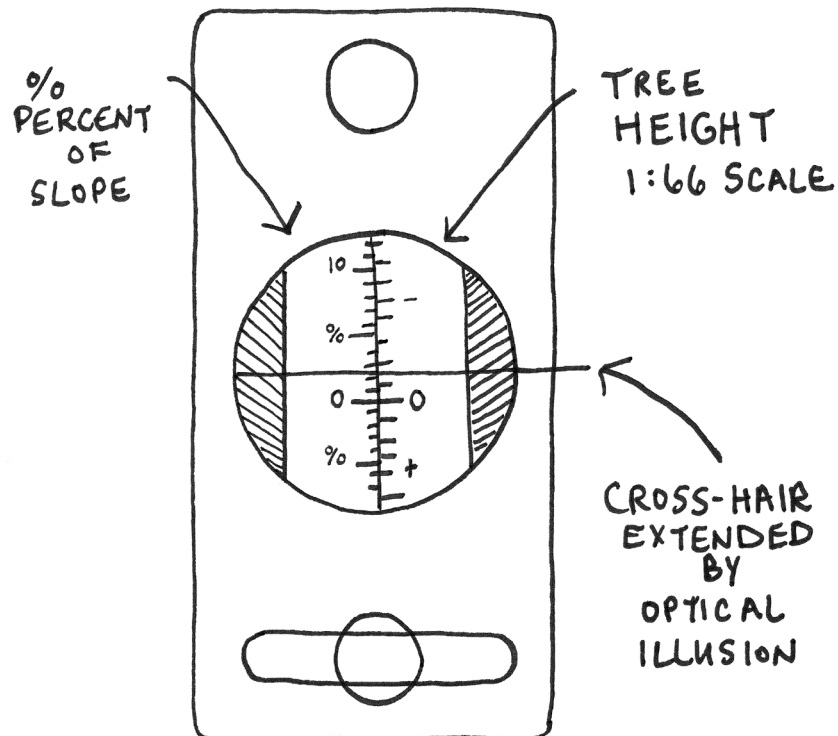
PLOT METHODS

19.23 Measuring Tree Heights Using a 1:66 Clinometer

A clinometer is an instrument commonly used in forestry to measure slope and heights. The instructions that follow are based on a Suunto clinometer.

Instructions:

1. Confirm your clinometer has a 1:66 scale. For 1:66 scale clinometers, % slope is on the left side and the 1:66 scale used to measure tree heights is on the right. If uncertain about which side of the scale to read, you can tilt your head back while looking through the clinometer and reference the unit labels at the bottom of the scale.

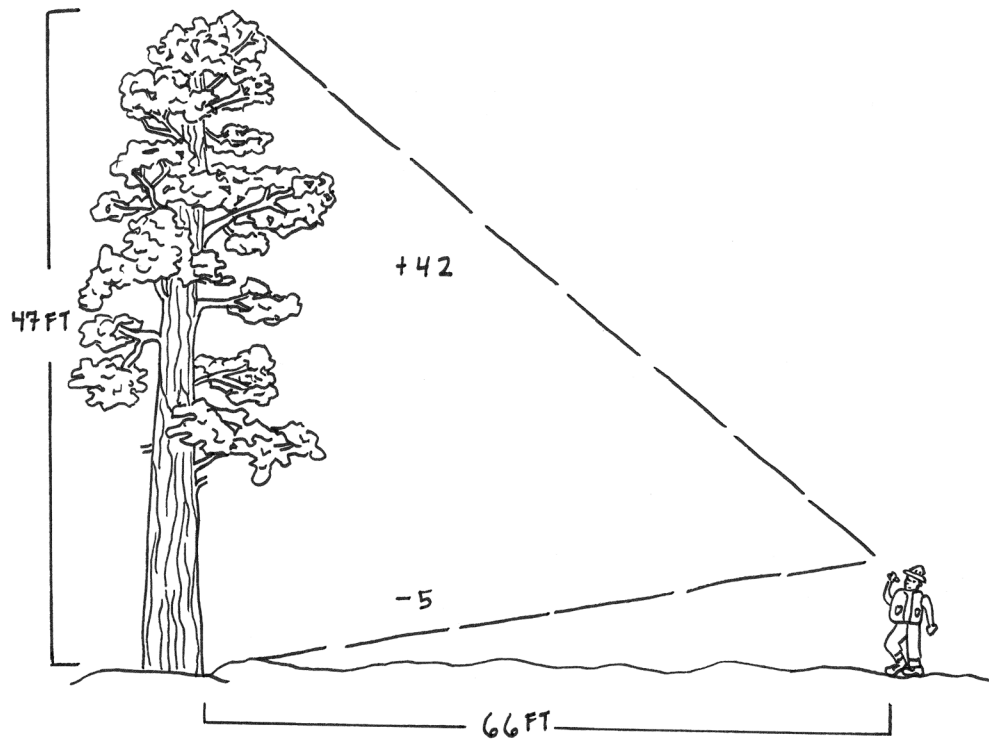


Use the scale on the left if you are measuring percent slope, and the scale on the right if you are measuring tree height.

Diagram by Raymundo Melendez and Meredith Prentice

2. Determine the tree you want to measure and move 66 feet away. You can either measure with a DBH tape (nail stuck in tree), or pace off a chain.
3. From 66 feet away, sight through the glass eyepiece of the clinometer with both eyes open to the very top of the tree. Remember to point the red dot at the tree; the dot represents your line of sight. Record this number and its sign (+ or -).

4. From exactly the same location, and while trying not to move your head, tilt the clinometer downward until the red dot is lined up with the base of the tree. Sight through the clinometer with both eyes open to the base. Record this number and its sign (+ or -).
5. You will now use the equation “top” – “bottom” to get tree heights. For example,
“top” – “bottom” = $42 - (-5) = 42 + 5 = 47$ ft tall
If you are on a very steep slope and your final answer is negative, only then can you drop the sign. (Obviously a tree cannot be -15 feet tall!) Remember, always: “top” – “bottom”



Example of using a clinometer to calculate tree height.
Diagram by Raymundo Melendez and Meredith Prentice

Chains

1 chain = 66 feet

80 chains = 1 mile

You can determine how many paces (one pace = two steps) your chain is by laying out a tape and counting the paces required to reach 66 ft. When determining your chain pace number, always take multiple (at least three) and average them.

How does the terrain change your pace?

- Shorter in tall vegetation than in short vegetation.
- Shorter walking uphill than walking downhill.

- Shorter walking on sloping ground than on flat ground.
- Shorter walking on soft ground than on hard ground.
- Level vs uphill vs downhill?
 - In general, when slope is >5%, your “level” pacing is no longer accurate.

Common sources of error when using the clinometer:

- The distance between you and the tree was not perfectly measured and/or paced. This is a common challenge in very dense or very steep areas. Remember that slope distance is not always the same as horizontal distance. *See 19.24 Slope Correction* for using a clinometer to measure tree heights in areas with slope.
- The tree is taller than 66 feet, which means using a 1:66 scale is less accurate.
 - Ideally the trees you measure should be less than 66 feet, or you should consider alternate scales. For example, you could use the percent (left) side of the clinometer if you were standing 100 feet away, since this is a 1:100 scale.
- Arithmetic errors, such as mixing up signs.
- You cannot see the top and bottom of the tree and are estimating. This is a common challenge in very dense areas.
 - Try moving to another area.
 - Do not move between sighting the top of the tree and the base.

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19.24 Slope Corrections

When using clinometers, it is sometimes necessary to correct the difference between slope distance and horizontal distance. Slope distance is always longer than horizontal distance. When possible, always try to walk the contour so that you are not going uphill or downhill from the tree you are measuring. Another option for slope correction would be to calculate the slope distance needed to reach one chain (66 ft) in horizontal distance.

Use this formula to calculate slope distance:

$$\text{Slope distance} = \text{horizontal distance} / \cos \alpha \text{ (slope in degrees)}$$

To convert your measured percent slope (grade) to degrees α , reference the conversion table provided on the back of your clinometer. Do not use percent slope in this equation. Horizontal distance will always equal 66 ft.

Grade	Angle	Grade	Angle	Grade	Angle	Grade	Angle	Grade	Angle
2%	1.15	22%	12.41	42%	22.78	62%	31.80	82%	39.35
4%	2.29	24%	13.50	44%	23.75	64%	32.62	84%	40.03
6%	3.43	26%	14.57	46%	24.70	66%	33.42	86%	40.70
8%	4.57	28%	15.64	48%	25.64	68%	34.22	88%	41.35
10%	5.71	30%	16.70	50%	26.57	70%	34.99	90%	41.99
12%	6.84	32%	17.74	52%	27.47	72%	35.75	92%	42.61
14%	7.97	34%	18.78	54%	28.37	74%	36.50	94%	43.23
16%	9.09	36%	19.80	56%	29.25	76%	37.23	96%	43.83
18%	10.20	38%	20.81	58%	30.11	78%	37.95	98%	44.42
20%	11.31	40%	21.80	60%	30.96	80%	38.66	100%	45.00

Example: A crew comes across a tree that can only be accurately and safely measured from uphill. First, slope percent is taken at 40%. Using a conversion table, this converts to 21.8 degrees. Using the formula below, a slope distance of 71.3 ft is calculated.

$$\text{Slope distance} = \text{horizontal distance} / \cos \alpha \text{ (slope in degrees)}$$

$$\text{Slope distance} = 66 \text{ ft} / \cos(21.8)$$

$$\text{Slope distance} = 71.3$$

Using a tape, the crew pulls out to 71.3 ft uphill (in the direction the slope was taken) from the bole of tree across the ground. Standing here, the technician is at a distance of 66 horizontal feet. To measure multiple trees occurring across the same slope, the technician could count and remember the number of paces required to reach 71.3 ft uphill and use this as a chain pacing for this plot.

Important Takeaways:

On this 40% slope, taping out 66 ft parallel to the slope does not result in a run (horizontal distance) of 66 ft. Measuring tree heights from a slope distance of 66 ft would result in an error of nearly 10 percent. Always calculate slope correction before using a clinometer to measure tree heights on a slope. Alternatively, pacing along the contour and maintaining the same elevation as the tree, or using a hypsometer, removes the need for this calculation.

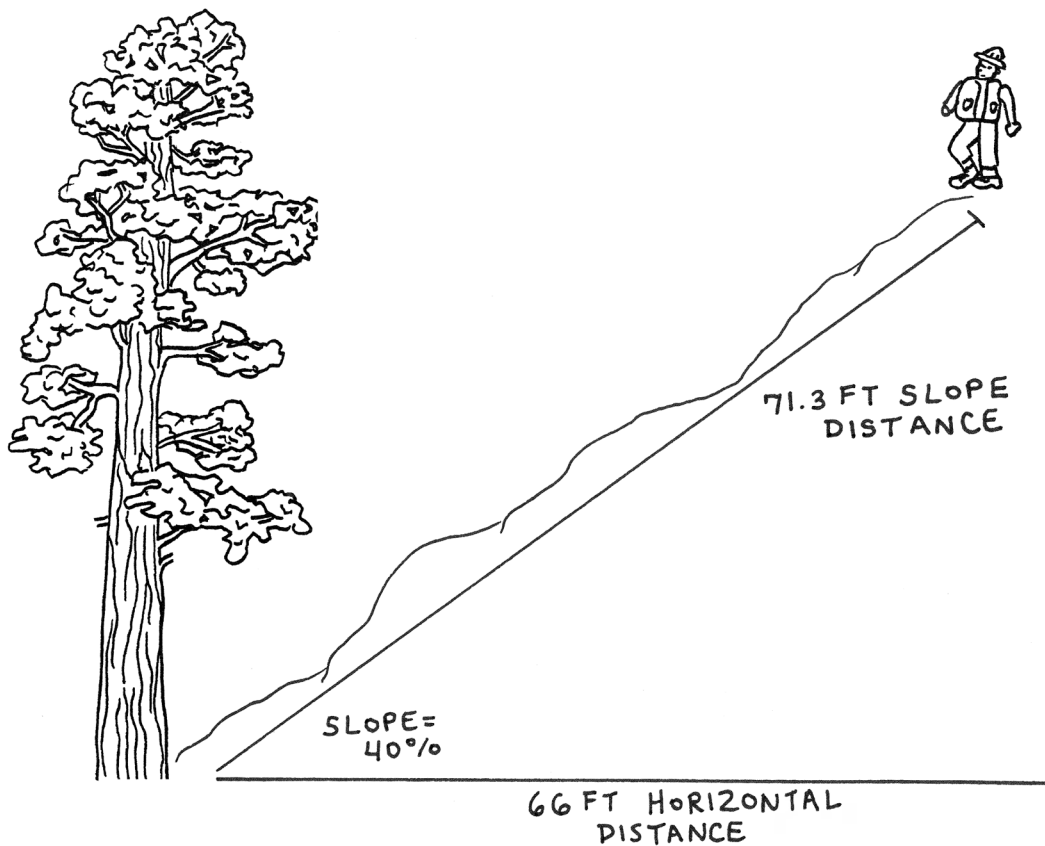


Diagram by Raymundo Melendez, Meredith Prentice, and Carolina May

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19.3 Tree Diameters

The following chapters outline methods of taking tree diameters: measuring a diameter at breast height, diameter at root crown, and how to handle multiple stems.

19.31 Rules for Measuring DBH

DBH, or diameter at breast height, is a standard measurement in forestry. This measurement is the diameter of a tree at 4.5 feet. It is important to measure all trees at the same height, to the extent possible, to keep forest inventory consistent. Diameter tapes (aka Logger's Tape or D-tape) are adjusted by the value of π to provide the diameter of the tree.

The Basics:

To measure DBH, first determine where 4.5 ft is on yourself. You will use this spot to determine where to take DBH on a tree. Remembering this position saves lots of time when you are taking DBH on numerous trees. If trees were previously tagged, measure DBH just above the nail to maintain consistency between measurements.

DBH is always taken on the uphill/ upslope side of the tree being measured. Make sure the tape is level and straight around the bole. Tapes can easily get twisted around the bole and the DBH can get inflated by a branch or burl. For larger DBH trees get someone to help you wrap the tape around the tree to ensure it is straight and taut. To read the tape, look at the number where the zero crosses. Round to the nearest 0.1 inch, as the diameter tape is in tenths. For example, the tape in the picture below on the right reads 45.7 inches.



Measure DBH on yourself. Photo by Kathryn Mahan



Diameter of 45.7 inches. Photo by Carolina May

Reminders & Special Situations

1. Always measure from the uphill side. See Figure 1, below.

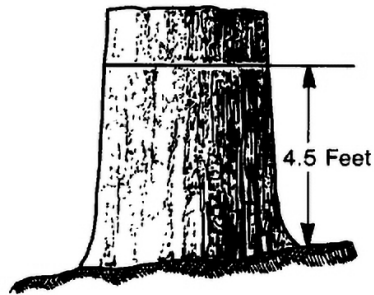


Figure 1. Measure from the uphill side.

*** Sketches from Forest Service Washington
FSH 2409.12 – Timber Cruising Handbook*

2. Always measure height to DBH vertically, not diagonally with the lean of the tree. If a tree leans so severely that it does not reach 4.5 feet vertically, it will not be measured as a tree in our protocol.
3. Once DBH height is established, measure diameter perpendicularly to the lean of the tree. See Figure 2, below.

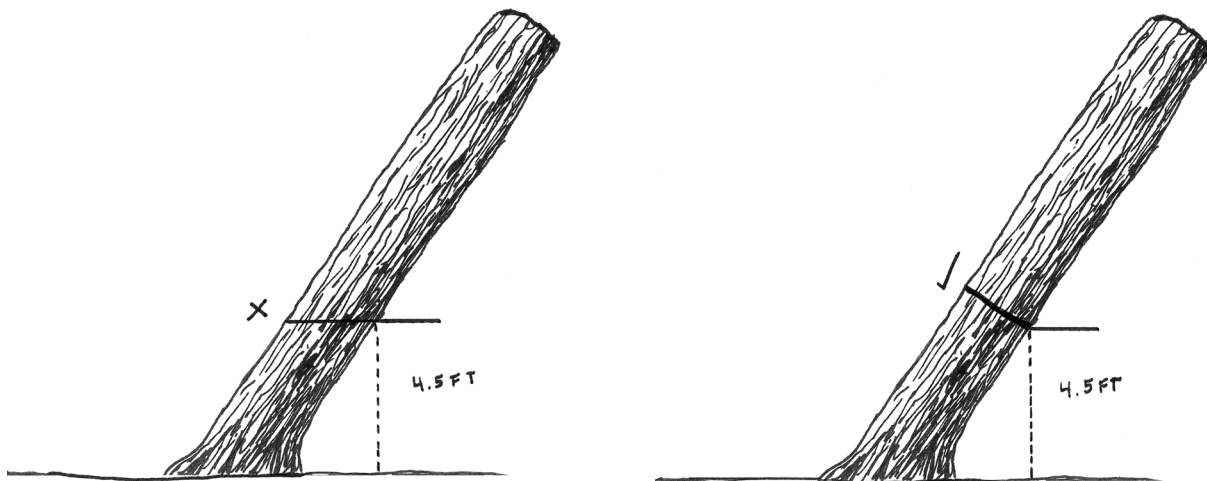


Figure 2. The tree on the left is not measured perpendicular to the lean of the tree, and therefore is measured incorrectly, overestimating the diameter. The tree on the right depicts the correct orientation of the DBH tape on a leaning tree.
Diagram by Zoe Ahrens

4. If the tree is forked below 4.5 feet but is determined to have common rootstock and a unified crown, record as a single tree with two stems. If unsure, apply the ankle-height rule. If there is light between the two stems at ankle height, record as two trees. If there is no light at the ankle, record as one tree with two stems and two DBH's with the same tag number. See *19.33 Measuring Multi-Stem Tree* for more information.

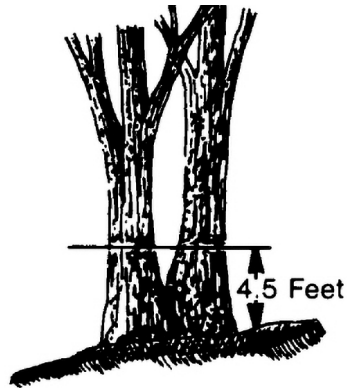


Figure 3. Fork occurs below 4.5 feet.

5. If a tree is forked above 4.5 feet, but the stems are together at DBH, measure it as one tree with one stem, and record one DBH. Record in the comments that the tree is forked and at what height, and what percentage of the total length of the bole is forked. See Figure 4.

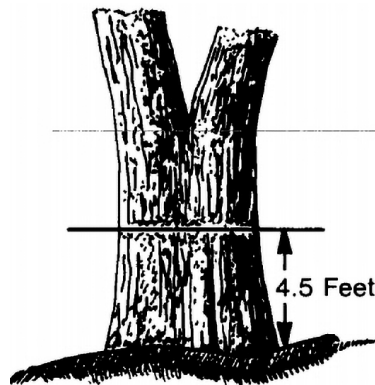


Figure 4. Fork occurs above 4.5 feet.

6. Abnormalities: For abnormalities, measure at the first place **above** 4.5 feet where the tree appears normal. Be sure you note where you measured DBH in the comments field on the datasheets. See Figure 5.

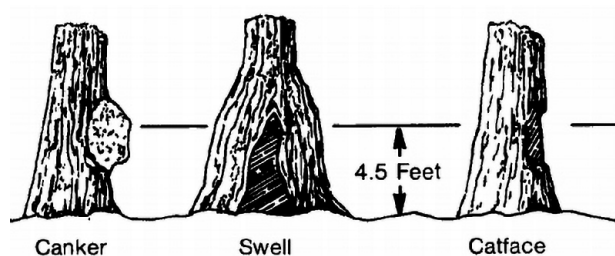


Figure 5. Abnormalities at 4.5 feet.

7. For trees growing on objects, measure at 4.5 feet from the root crown, not the forest floor. See Figure 6.

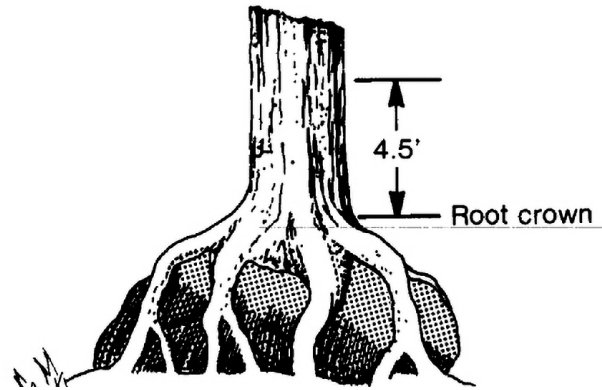


Figure 6. Measuring DBH on Trees Growing on Objects.

8. If DBH is at A, measure normally. If DBH is at B, measure just above on broken portion where tree appears normal, i.e. at C. Make note of the tree abnormality in the comments, but as the bole is vertical at the original DBH height, the 45 degree lean cutoff for dead trees is not a concern here. See Figure 7.

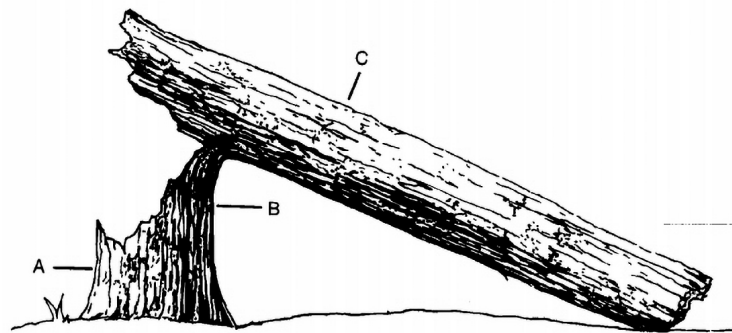


Figure 7. Measuring DBH on Broken Trees.

9. Unable to measure above: If it is not possible to measure at or above breast height because of the vertical extent of the irregularity, or because the top of the tree is missing entirely, then adjust the DBH measurement to better reflect the diameter of a regular bole: if 50% or more of the circumference of the bole is intact, reconstruct the diameter at DBH. If less of the bole is intact, record the measurement of the remaining bole and explain in the comments.

In Summary:

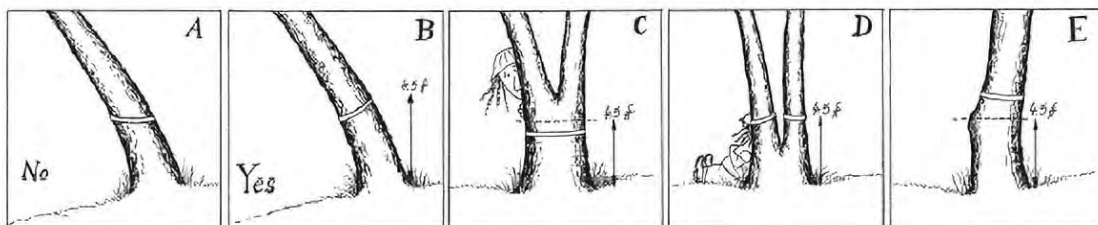


Figure 8. DBH measurements. A) Diameter tape is not perpendicular to the tree stem. B) Correct way to measure tree diameter is with tape perpendicular to tree stem. C) If the tree splits above breast height measure tree diameter below any swell caused by the separation. D) If the tree splits below breast height measure as two trees. E) Measure the most representative diameter above or below any deformity.

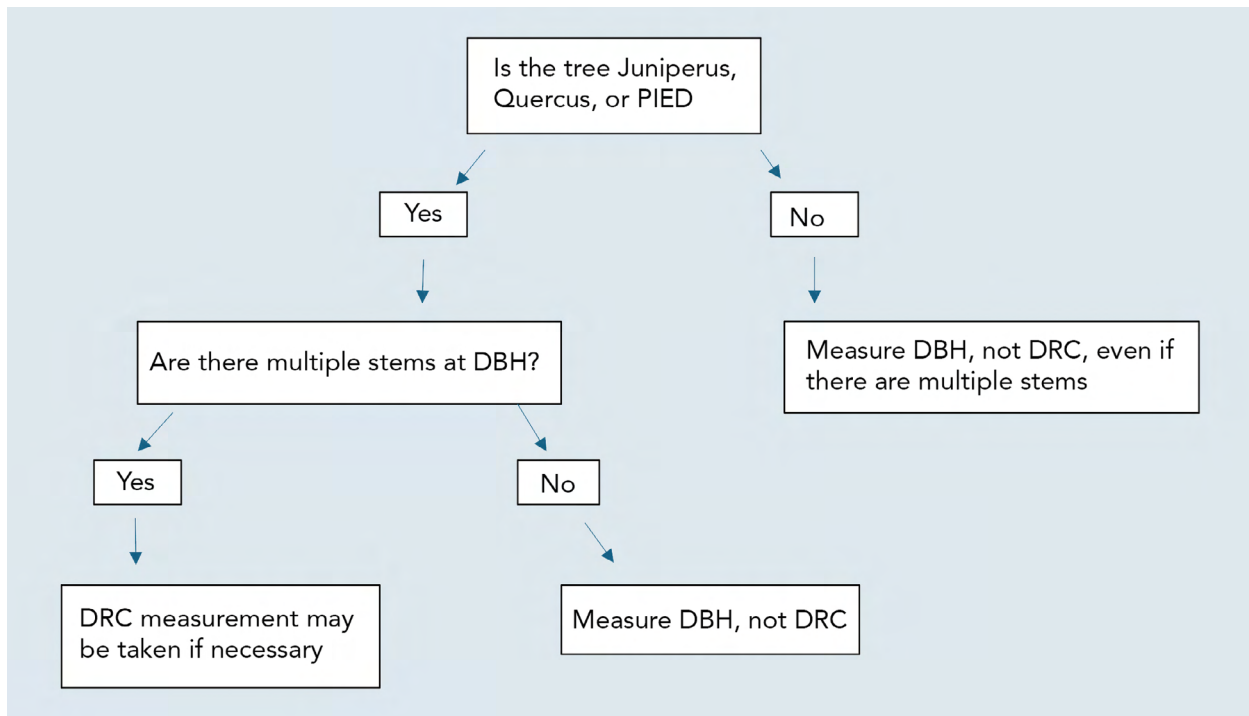
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19.32 Rules for When and How to Measure at DRC

When to take DRC measurements:

Measuring diameter of root collar (DRC) may be used for multi-stemmed trees in some situations. Measuring diameter at breast height (DBH) generally provides a better estimate of tree size than measuring DRC. Use DRC only in scenarios where taking DBH measurements of individual stems for all trees on a plot would be very prohibitive. Using the Chojnacky and Rogers conversions, DRC should only be taken on junipers, oaks, and piñon pine.

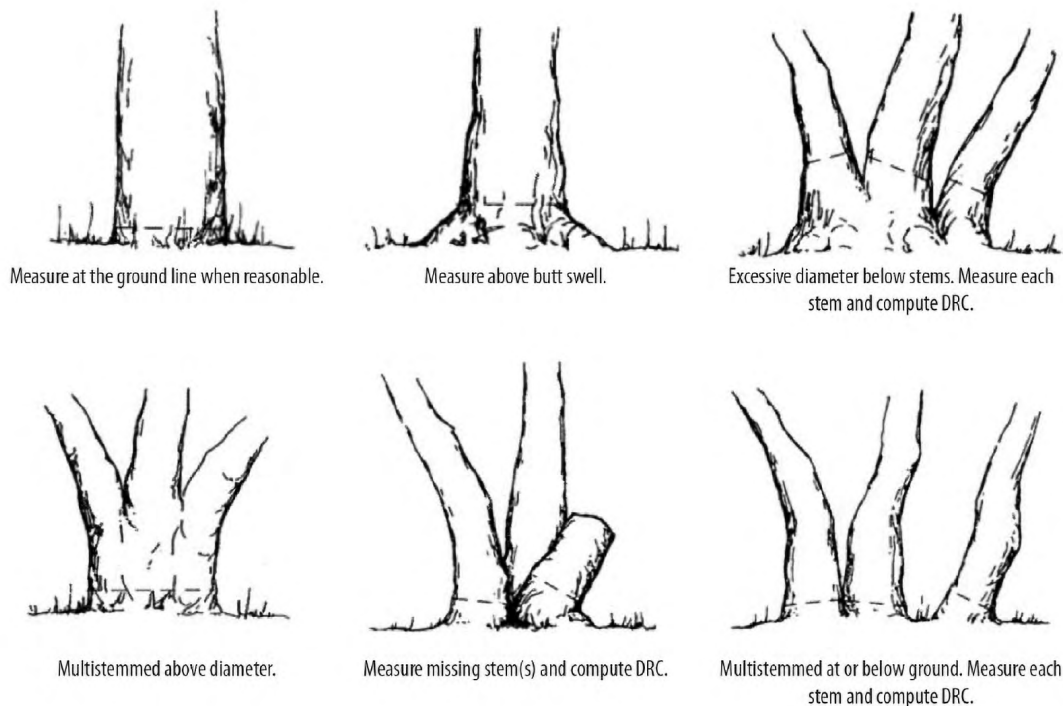
See the below flowchart for when DRC can be measured:



How to take DRC Measurements:

1. Remove loose material on the ground, but DO NOT remove mineral soil. Watch for snakes when reaching under trees.
2. Measure at ground line when *reasonable*.

3. Measure DRC just above any swells present.
4. Must be measured in a location that is a good representation of the volume in the stems.
5. If excessive diameter exists at the base, measure the stems occurring above the base individually.
6. If a tree has unified crown and common rootstock, but has several separate stem clumps with soil in between, take multiple DRC measurements for the same tree tag number. Do not include any soil or open spaces at ground level between stems in a single measurement.
7. If using tree tags, tag at the height DRC is taken. If re-measuring tagged trees, take DRC just above nail.



Credit: Bonfantine, K., J. Zebrowski, and Egan, A. (2011). *Guidelines and protocols for monitoring riparian forest restoration projects*. New Mexico Forest and Watershed Restoration Institute. https://nmfwri.org/wp-content/uploads/2020/07/Riparian_forest_monitoring_guidelines-1.pdf

Figure 1. Guidelines for taking DRC.

DRC/DBH conversion protocols:

DRC values must be converted to equivalent diameter DBH values for analysis. Table 2 below from Chojnacky & Rogers, 1999 shows established DRC to DBH conversion equations. These conversions are done after field data collection, and both the original DRC value and converted DBH value are reported.

Table 2 Parameters and equation¹ to convert drc to dbh for pinyon pine, Utah juniper, and Gambel oak

Measurement units	Parameter estimates						No. of trees	Fit statistics		
	β_0	β_1	β_2	β_3	β_4	β_5		β_6	R^2	CV (%)
English	-2.6843	1.0222	0.7433	0.7469	-0.0399	1.2244	-0.0689	224	0.98	13
Metric	-6.8180	1.0222	1.8879	1.8971	-0.0399	3.1100	-0.0689	224	0.98	13

¹ Conversion equation:

$$dbh = \beta_0 + \beta_1 drc + \beta_2 stm + \beta_3 Pied + \beta_4 drc_P + \beta_5 Quga + \beta_6 drc_Q$$

where

dbh = diameter at 1.3m above groundline of all live and dead stems 2.5 cm and larger (cm or in.)

drc = diameter at root collar above groundline of all live and dead stems 2.5 cm and larger (cm or in.)

$$diameter = \sqrt{\sum_{i=1}^n d_i^2}$$

n = number of live and dead stems at dbh or drc with diameter 2.5 cm or larger

d_i = stem diameter (cm or in.)

stm = 1 for trees with one stem (*n* = 1) at drc, 0 otherwise

Pied = 1 for pinyon pine species, 0 otherwise

drc_P = drc for pinyon pine species, 0 otherwise

Quga = 1 for Gambel oak species, 0 otherwise

drc_Q = drc for Gambel oak species, 0 otherwise

Figure 2. DRC to DBH conversion formulas from Chojnacky and Rogers, 1999.

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19.33 Measuring Multi-Stem Trees

What defines a single multi-stem tree vs. multiple trees?

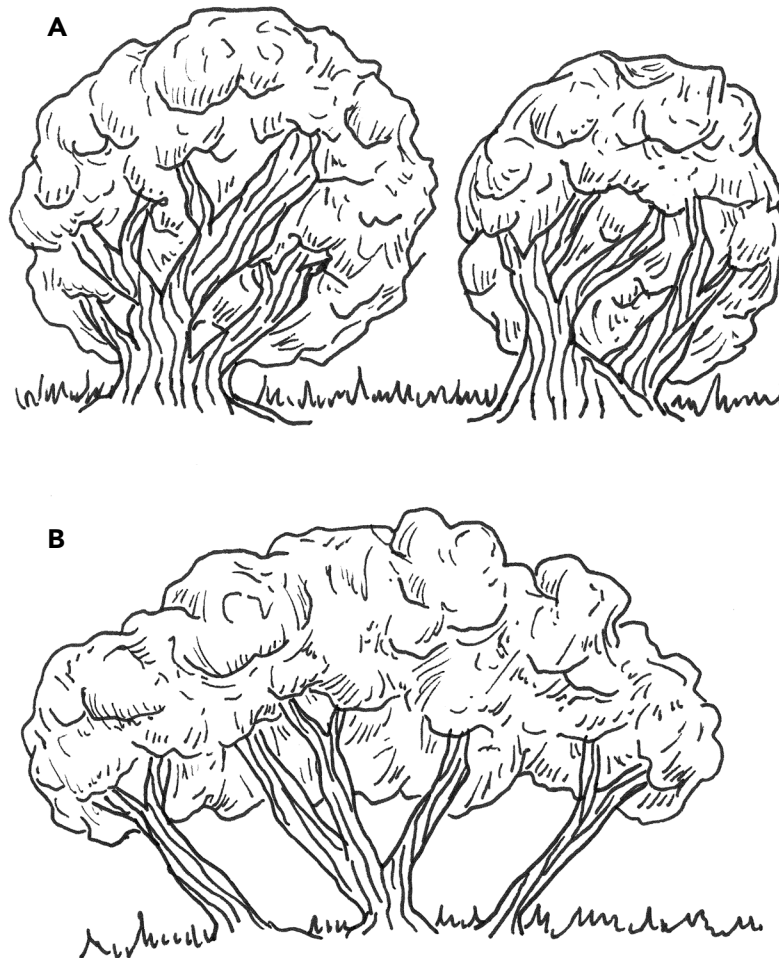


Figure 1A shows two trees with distinct crowns, which should be recorded as separate trees. **Figure 1B** shows a single tree with a unified crown and assumed common rootstock, which should be recorded as a single tree with multiple stems.

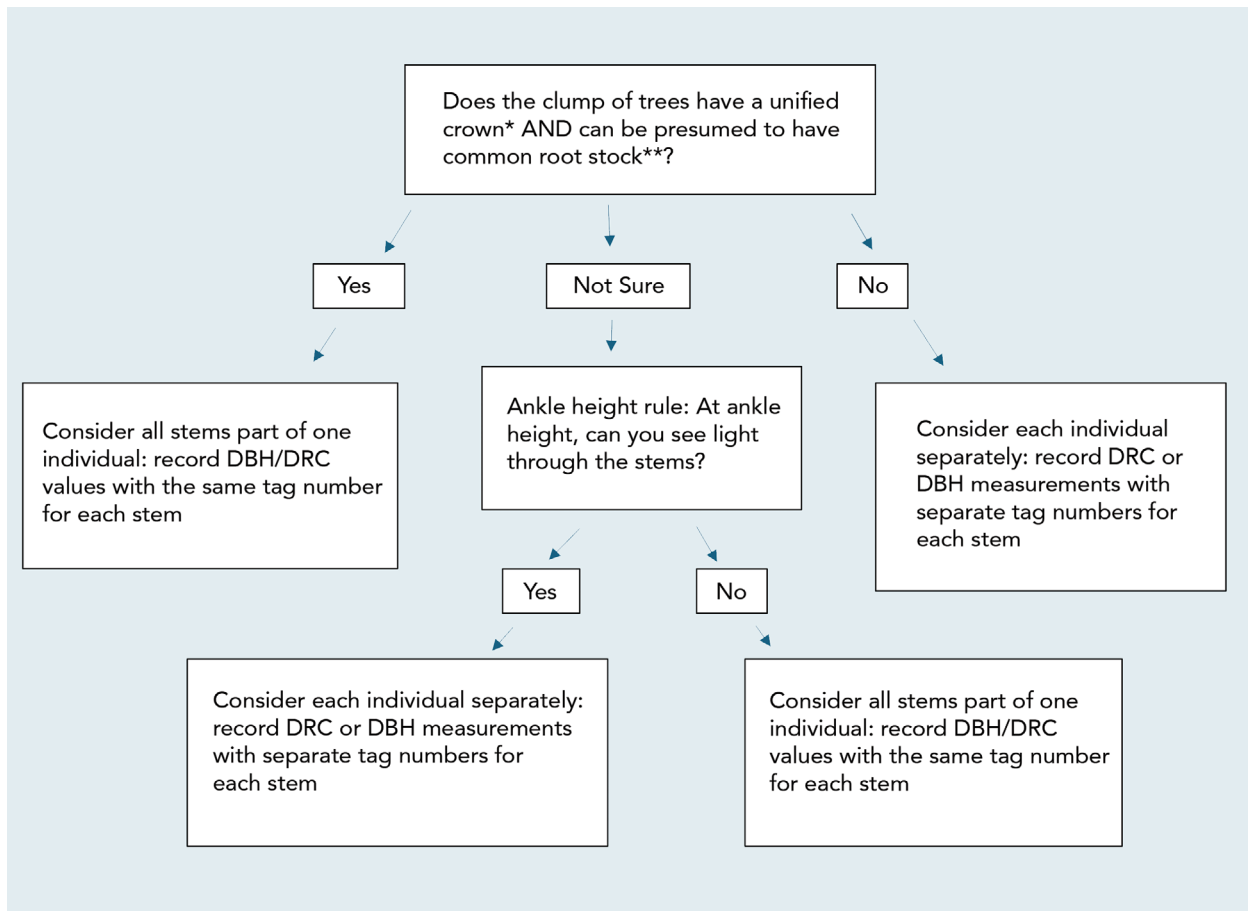
Diagram by Raymundo Melendez and Meredith Prentice

Definitions:

**Unified crown:* Stems come together to form a contiguous crown, often teardrop or vase shaped, without large gaps. See Figure 1B, above.

***Common rootstock:* A **rootstock** is part of a plant, often an underground part, from which new above-ground growth can be produced. Stems which are of the same species and originate from the same place in the ground can be considered to have common rootstock. See Figure 1B, above.

Flow Chart for Defining Multi-Stem Trees



What is a stem vs a branch?

- A stem generally grows in an upright position and contributes to the main structural support of a tree crown.
- In order to qualify as a stem, 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. See Figure 2.
 - Special case: Stump sprouts originate between ground level and 4.5 ft on the boles of trees that have died or been cut. Stump sprouts are handled the same as trees with multiple stems, 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 ft are measured at 4.5 ft from ground line. For multi-stemmed woodland species, treat all new sprouts as part of the same new tree.

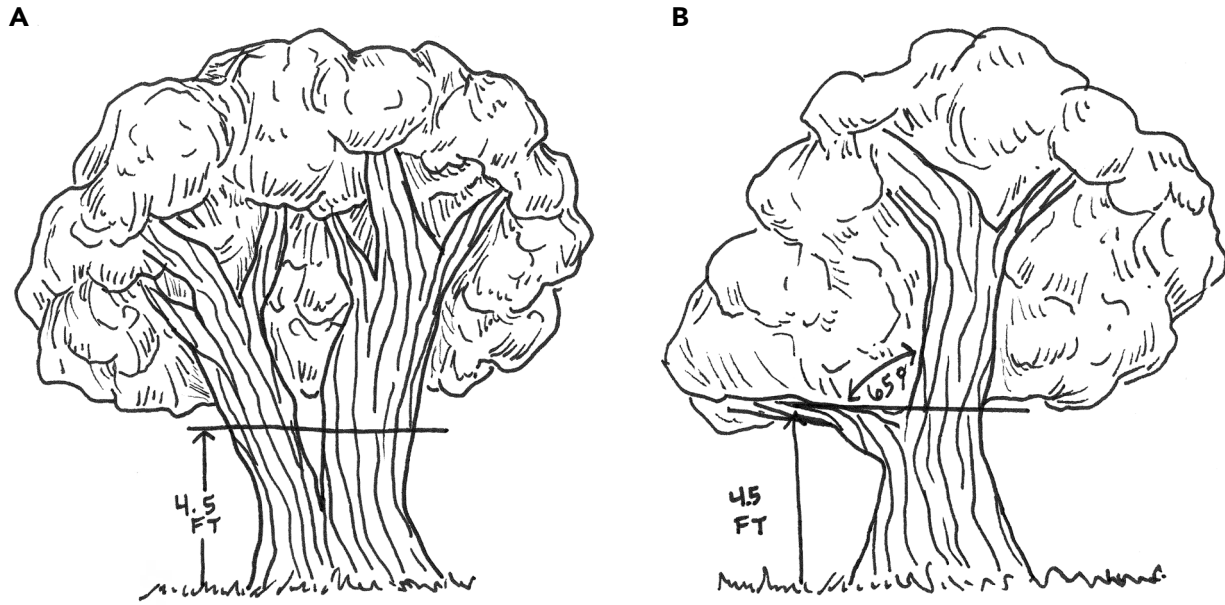


Figure 2A shows a tree with two stems at DBH, with the smaller stem greater than a 1/3 of the diameter of the main stem and branching at an angle of 45 degrees or less. **Figure 2B** shows a single stem tree with a branch. This branch is not considered a stem as it is less than 1/3 the diameter of the main stem at DBH, and it also branches at an angle greater than 45 degrees. *Diagram by Raymundo Melendez and Meredith Prentice*

Other recommendations for measuring trees with multiple stems

- Record each stem of a multi-stem tree as a separate line of data with an individual diameter, height, live crown base height, and condition status (live, dead, or sick). Multi-stem trees should start with the same tag number followed by a decimal and its respective consecutive number. Certain databases may not allow you to record tag numbers with decimals. In these cases indicate the specific tag numbers in the comment form. We recommend this method over the square-of-squares method for multi-stem trees. See example below.

Tree #	Species	Tree cond. (L, D, S)	DBH (in)	No. stems	Total Tree Ht	LiCrBHt
1.1	JUMO	L	12.1	3	17.5	2.5
1.2	JUMO	L	8.6	3	9.6	3.1
1.3	JUMO	D	5.7	3	8.8	—
2.1	PIED	L	3.6	2	9.5	4.0
2.2	PIED	L	4.5	2	8.5	2.2

Figure 3. Sample record of multi-stemmed trees. *Photo by NMFWR Field Crew*

19.33 Measuring Multi-Stem Trees

- Maintain the same clockwise progression within the multi-stemmed tree that is maintained in the plot as a whole while recording stems.
- Onion-shaped junipers are common, and getting past the outer branches of a large specimen to measure the stems at the root collar can be a challenge. The crew member doing this must wear eye protection and work gloves as protection from sharp branch stubs and watch for rattlesnakes.
- Multi-stemmed oaks are more often defined using the ankle-height rule, as common root stock and unified crown can be hard to determine.
- If trees were previously tagged, maintain the same stem definitions of previous crew for consistency over time. However, check for any new stems that may have grown into measurable size since the last measurement period and add tags as needed.

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19.4 Damage Codes and Statuses

Status:

Status denotes whether the trees, shrubs, saplings, or seedlings are live, dead, or sick.

Live (L):

Tree or shrub has green foliage, green or wet cambium when cut, and is healthy, with no severe damage or significant disease. Some dead stems or branches may be present, but there are more live stems than dead stems. If burned, the tree has greater than 30% live canopy remaining.

Dead (D):

Tree has no green foliage or sign of living tissue. Branches and twigs snap with no flexibility and do not have a green or wet cambium when cut. For *Quercus spp.* where the main stem is dead with resprouts from roots, record the status as dead and record “sprouts at base” in the comments.

Sick (S):

In general, sick trees have extensive biotic or abiotic damages that will ultimately cause death within 5-10 years (FIREMON). Designation of sick status is ultimately subjective as it may vary by management objectives, site conditions, and crew expertise with specific damage agents. For instance, in our practice, because research shows that most trees with less than 30% live crown remaining unscorched following fire are more likely to die than survive, we designate all these trees as sick when recording data immediately post-fire. Note that damage codes and severity should be recorded on any tree with damage agents present, even if the tree is not marked as sick. It is critical that any tree designated as sick must also have supporting documentation such as damage codes, severity, and any relevant comments recorded. For our reports, we find it more useful to analyze and report by damage agent/severity across growing stock (live + sick trees considered together) vs dead trees, because of the subjectivity of defining sick trees.

Damage Code Systems

Damage codes are used to record signs of illness, injury, and abnormalities in overstory trees. These codes can be entered directly into FFI or written into the comments of the tree data sheet.

NOTE: All damage codes should also be recorded with a severity measure (minor/severe or % damage).

Multiple code systems are available to record damage. We will cover and provide references for two of the most common systems. The table below includes common damages and how they are represented by each system. Where damage equivalencies exist between the two systems, codes are displayed side by side. In cases where no equivalencies exist, “--” will be displayed.

Letter-based system

The letter-based system, used by the National Park Service, uses 4-letter abbreviations to represent various damage codes. This system is easy to use for those new to monitoring but has a much smaller set of possibilities than the numeric system and is less commonly used. More comprehensive information on the

letter-based system can be found here:

<https://www.nps.gov/orgs/1965/upload/fire-effects-monitoring-handbook.pdf>

Number-based system

The number-based system, used by the United States Forest Service (USFS) and others, uses a 5-number system to indicate damage. The format is Category/Agent. The Damage Category is a 2-digit code (see table below), and the Damage Agent is a 3-digit code. (Note that some programs may combine the Damage Category/Agent code with Tree Part (letter code)/Severity(numeric) to create a single alphanumeric code, such as 10000BO1, where the severity is rating scale associated with specific degrees of damage. Our datasheets and FFI encourage separate entry of the Damage Category/Agent and the Severity, and we recommend using the severity assessment suggested in the table below. FFI includes a suggestion of the following minimum numeric Damage Category/Agent codes, shown in the table below, but it is possible to type in and use any of the Damage Category/Agent codes found in the expanded list. More comprehensive information on the number-based system can be found here:

https://www.fs.usda.gov/nrm/documents/fsveg/cse_user_guides/userguide_fsveg_apdx_k_damages.docx

The table below includes common damages encountered in the field. The letter and number-based systems have been grouped together to compare equivalencies. Severity codes listed for damages are based on the USFS number system. The most common damages also have photographic examples below the table.

USFS Damage Category	NPS Damage Code	Damage Description	Severity	Notes
10000	INSE	General Insects	<p>101 - Minor: bottlebrush or shortened leaders, 0-2 forks on stem, OR <20% of branches affected, OR <50% of bole with visible larval galleries</p> <p>OR</p> <p>102 - Severe: 3 or more forks on bole, OR 20% or more branches affected, OR terminal leader dead, OR 50% or more of bole with visible larval galleries</p>	Beetles, moths, sawflies, ants, wasps.
11000	---	Bark Beetles	<p>900: 0 – 9% affected</p> <p>901: 10 – 19% affected</p> <p>902: 20 – 29% affected</p> <p>903: 30 – 39% affected</p> <p>904: 40 – 49% affected</p> <p>905: 50 – 59% affected</p> <p>906: 60 – 69% affected</p> <p>907: 70 – 79% affected</p> <p>908: 80 – 89% affected</p> <p>909: 90 – 100% affected</p>	The presence of small holes, usually exuding frass and galleries (tunnels beneath bark).

USFS Damage Category	NPS Damage Code	Damage Description	Severity	Notes
17000	GALL	Gallmarker Insects	171 - Minor OR 172 - Severe	Abnormal growths on stems, roots, or leaves. Formed by pathogen/ parasitic infection.
19000	---	General Disease	191 - Minor OR 192 - Severe	Blister rust, etc.
21000	ROTT	Root/Butt Disease	900: 0 – 9% affected 901: 10 – 19% affected 902: 20 – 29% affected 903: 30 – 39% affected 904: 40 – 49% affected 905: 50 – 59% affected 906: 60 – 69% affected 907: 70 – 79% affected 908: 80 – 89% affected 909: 90 – 100% affected	The presence of fungi other than shelf-like fruiting bodies/ conks. Indicate specific fruiting body or its general morphology in the comments.
22000	CONK	Stem Decay/ Canker	220: 0-4% rotten 221: 5-15% rotten 222: 16-25% rotten 223: 26-35% rotten 224: 36-45% rotten 225: 46-55% rotten 226: 56-65% rotten 227: 66-75% rotten 228: 76-85% rotten 229: 86-100% rotten	The presence of shelf-like fruiting bodies/ conks. If not shelf-like fungus, use ROTT/2100. Specify presence of conk in the comments.
23000	--- OR EPIC/ LICH/	Parasitic/ Epiphytic Plants	900: 0 – 9% affected 901: 10 – 19% affected 902: 20 – 29% affected 903: 30 – 39% affected 904: 40 – 49% affected 905: 50 – 59% affected 906: 60 – 69% affected 907: 70 – 79% affected 908: 80 – 89% affected 909: 90 – 100% affected	Epiphytic plants: lichen Parasitic plants: dodder (<i>Cuscuta spp.</i>), pinedrop (<i>Pterospora andromedea</i>), bearcorn (<i>Conopholis americana</i>), pinesap (<i>Monotropa hypopitys</i>), etc. Make a note in the comments whether plant is an epiphyte or parasite and record the specific species if able to identify.

19.4 Damage Codes and Statuses

USFS Damage Category	NPS Damage Code	Damage Description	Severity	Notes
23001	MISL	Mistletoe	900: 0 – 9% affected 901: 10 – 19% affected 902: 20 – 29% affected 903: 30 – 39% affected 904: 40 – 49% affected 905: 50 – 59% affected 906: 60 – 69% affected 907: 70 – 79% affected 908: 80 – 89% affected 909: 90 – 100% affected	Parasitic plant that often forms a dense cluster of shoots. Can sprout from bole or branches. Affects PIPO, PIFL, PIED, PSME, PIEN, PIPU, JUxx.
25000	--- OR BROM	Foliage Diseases	251 - Minor: <20% of foliage affected or <20% of crown in brooms OR 252 - Severe: >20% of foliage affected or >20% of crown in brooms	Needle cast, needle blight, witches' broom. Note the specific damage in the comments.
25001	BLIG	Blight	251 - Minor: <20% of foliage affected or <20% of crown in brooms OR 252 - Severe: >20% of foliage affected or >20% of crown in brooms	Discoloration of needles, stunted growth. Needles stay attached to the tree in comparison to needle cast where they are shed.
27000	---	Broom Rusts	271 - Minor: <20% of crown in brooms OR 272 - Severe: >20% of crown in brooms	Dense cluster of growth. More yellow than brooms caused by mistletoe and lacks mistletoe shoots.
30000	FIRE	Fire	Maximum scorch height (foliage) & char height (bark)	No % or severity needed, assessed by recording the maximum height of scorch and char.
40000	MAMM	Animal Damage, Source Unknown	401 - Minor OR 402 - Severe	Bear claw marks, porcupine or beaver chewings, and deer/elk rubbings. Make a note in the comments about specific damage.

USFS Damage Category	NPS Damage Code	Damage Description	Severity	Notes
41010	BIRD	Woodpecker	411 - Minor: <20% of crown affected, bole damage is <50% circumference OR 412 - Severe: >20% of crown affected, bole damage is >50% circumference, upper 1/3 of crown is killed	Holes are larger, more chiseled than beetle holes. 41010 code indicates woodpecker, NPS letter code not as specific.
50000	-- OR OZON/ FRST	Abiotic Damage	501 - Minor: <20% of crown affected, bole damage is <50% of circumference OR 502 - Severe: >20% of crown affected, bole damage is >50% of circumference, upper 1/3 of crown is killed	Air pollutants, chemical damage, drought, frost. Note the specific damage in the comments.
50008	LIGT	Lightning Scar	501 - Minor: <20% of crown affected, bole damage is <50% circumference OR 502 - Severe: >20% of crown affected, bole damage is >50% circumference, upper 1/3 of crown is killed	Narrow vertical scar/wound running down the length of the bole.
70000	UMAN	Human Activities	701 - Minor OR 702 - Severe	Markings, girdling, cuttings, etc. Note the specific damage in the comments.
90000	---	Unknown	900: 0 – 9% affected 901: 10 – 19% affected 902: 20 – 29% affected 903: 30 – 39% affected 904: 40 – 49% affected 905: 50 – 59% affected 906: 60 – 69% affected 907: 70 – 79% affected 908: 80 – 89% affected 909: 90 – 100% affected	Used when damage cannot be identified.

19.4 Damage Codes and Statuses

USFS Damage Category	NPS Damage Code	Damage Description	Severity	Notes
99001	BROK	Broken Top	% of original height missing: 900: 0 – 9% affected 901: 10 – 19% affected 902: 20 – 29% affected 903: 30 – 39% affected 904: 40 – 49% affected 905: 50 – 59% affected 906: 60 – 69% affected 907: 70 – 79% affected 908: 80 – 89% affected 909: 90 – 100% affected	Live, sick, and dead trees can all have broken tops.
99002	DTOP	Dead Top	% of total tree height that is dead: 900: 0 – 9% affected 901: 10 – 19% affected 902: 20 – 29% affected 903: 30 – 39% affected 904: 40 – 49% affected 905: 50 – 59% affected 906: 60 – 69% affected 907: 70 – 79% affected 908: 80 – 89% affected 909: 90 – 100% affected	Only live and sick trees can have a dead top.
99004	FORK/ TWIN	Forked Top	% of total tree height above fork 900: 0 – 9% affected 901: 10 – 19% affected 902: 20 – 29% affected 903: 30 – 39% affected 904: 40 – 49% affected 905: 50 – 59% affected 906: 60 – 69% affected 907: 70 – 79% affected 908: 80 – 89% affected 909: 90 – 100% affected	Uncharacteristic, forked top (not applicable for POTR5, <i>Quercus spp.</i> , etc.). NPS letter codes use FORK for forking above DBH and TWIN is used for forking below DBH. Indicate whether fork is V-shaped or U-shaped in the comments in addition to recording the height of where the bole forks.

USFS Damage Category	NPS Damage Code	Damage Description	Severity	Notes
99006	CROK	Crook or Sweep	% of total tree height, which contains the crook or sweep 900: 0 – 9% affected 901: 10 – 19% affected 902: 20 – 29% affected 903: 30 – 39% affected 904: 40 – 49% affected 905: 50 – 59% affected 906: 60 – 69% affected 907: 70 – 79% affected 908: 80 – 89% affected 909: 90 – 100% affected	Use when crooked bole or sweep is uncharacteristic for tree species.
99016	SPAR	Foliage Loss	1 = Minor OR 2 = Severe	Unusually sparse foliage.
99026	WOND	Open Wound	% of bole affected: 900: 0 – 9% affected 901: 10 – 19% affected 902: 20 – 29% affected 903: 30 – 39% affected 904: 40 – 49% affected 905: 50 – 59% affected 906: 60 – 69% affected 907: 70 – 79% affected 908: 80 – 89% affected 909: 90 – 100% affected	Opening or cavity on bole with the outer bark missing.
99036	FIRE	Fire Scar	% of bole covered by fire scar	Scar that forms at the base of the tree, usually triangular in shape.
99037	LEAN	Leaning tree	% lean from vertical: 901: 10 – 19% affected 902: 20 – 29% affected 903: 30 – 39% affected 904: 40 – 49% affected 905: 50 – 59% affected 906: 60 – 69% affected 907: 70 – 79% affected 908: 80 – 89% affected 909: 90 – 100% affected	Should be greater than 15%, use 900 severity rating. In the comments, specify the exact %. Snags (dead trees) with a lean greater than 45 deg or 50% lean severity are not recorded as trees. They instead are recorded as CWD in the fuel measurements.

USFS Damage Category	NPS Damage Code	Damage Description	Severity	Notes
99000	--- OR ABGR/ BURL/ EPIC/ HOLW/ ROOT/ SRPT	Physical Effects	900: 0 – 9% affected 901: 10 – 19% affected 902: 20 – 29% affected 903: 30 – 39% affected 904: 40 – 49% affected 905: 50 – 59% affected 906: 60 – 69% affected 907: 70 – 79% affected 908: 80 – 89% affected 909: 90 – 100% affected	Large, exposed roots, hollowed out bole, abnormal growth pattern, burl, epicormic sprouts from bole/limbs, sprouts at base, etc. Make a note in the comments of the specific damage.
---	X	Not assessed	-1	

NMFWRI Damage Codes Reference Chart

(NMFWRI uses 900 percentage codes to indicate severity for several damage codes. Refer to “USFS Damage Code Reference Chart” in Supplement C to compare to the standardized USFS severity ratings.)

Damage Description & Photos

10000 General Insects

Insects to note include beetles, moths, ants, wasps, sawflies, etc. Depending on the insect, you might notice tree impacts such as pitch tubes, frass (insect excrement), or galleries. If insect signs can be identified to a beetle species, use 11000 (Bark Beetles).

11000 Bark Beetle

As the name indicates, these insects live in the bark of trees. Bark beetles bore small holes through the trunk, creating tunnels (egg galleries) where they lay eggs on the inner

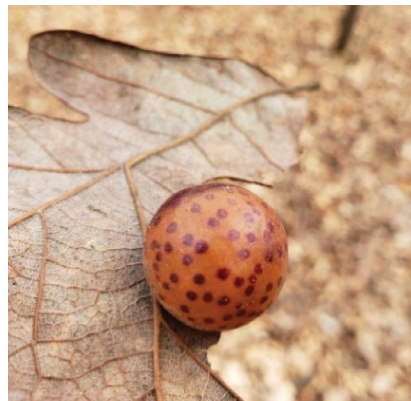


Insect damage on trees (10000/11000). Photos by Carolina May

surface of the bark. You will likely notice frass around the bore holes or at the base of the tree and pitch tubes. Advanced stages of infestation result in foliage discoloration, appearing yellow to reddish brown. Note that trees infested with bark beetle will have browning foliage from the top down, as opposed to fire scorch, which causes needle browning from the bottom up. Bark Beetle damage can be distinguished from bird damage as the holes are smaller. It is common to encounter trees with advanced bark beetle damage that also have bird damage. Bark beetles impact tree health by disrupting water and carbohydrate transport systems which can result in tree mortality. Bark beetles typically attack stressed, sick, or old trees.



Bark beetle damage (11000).
Photo by Carmen Melendez



Galls are abnormal growths (17000). Photos by Grace McCartha

17000 Gallmarker Insects

Galls are abnormal growths that form on plant branches, stems, roots, and vegetation. Infection caused by fungi, bacteria, insects, genetics, or environmental stress can result in the formation of galls. Galls come in many different shapes and sizes and it is often difficult to determine the specific cause of the growth. *Quercus spp.* often present with galls as they can host hundreds of insect species that can produce them. Most of the galls NMFWR encounters in the field are on *Quercus spp.*, thus we use the damage code 17000 (Gallmarker Insects) to record the damage.



Fungi on trees (21000). Photos by Grace McCartha

21000 Root/Butt Disease

The presence of fungi is indicated by the growth of the fruiting body/mushroom. Fungi enter trees through wounds or cracks or directly through the roots, causing rot. Fungi release enzymes that decay wood and weaken wood fibers. With advancing decay, impacted trees can start to lose branches and limbs and break. Use the 21000 (Root/Butt Disease) damage code to indicate the presence of fungi other than conks/cankers.



Conks (22000). Left and middle photos by Carolina May, above by Carmen Melendez

22000 Stem Decay/ Canker

Conks (polypores) are the shelf-like fruiting bodies of decay fungi. Some decay fungi attack the heartwood (inner dead core) of trees while the other types attack the sapwood (living wood). The presence of a conk typically indicates a tree in an advanced stage of decay. For our purposes it is not necessary to ID the kind of decay fungi or their fruiting bodies. For recording purposes, use the 22000 (Stem Decay/Canker) code and record conk in the comments.

23000 Parasitic/ Epiphytic Plants

Epiphytes

Epiphytes, often referred to as “air” plants, are photosynthetic. They obtain their water and nutrients directly from the atmosphere. Though they grow on other plants they are not parasitic. Lichens are a type of epiphyte.



Epiphytes/lichen (23000). Photos by Carolina May

Lichen

Lichens are symbiotic organisms comprised of both fungi and algae or cyanobacteria (blue-green algae). Contrary to popular opinion, lichen does not cause damage to the tree it lives on. An abundance of lichen can indicate poor tree growth, environmental stress, damage, etc. Lichen thrives with increased sun exposure.

Dead or declining trees open the forest canopy, increasing the amount of sunlight available. Use the damage code 23000 (Parasitic/ Epiphytic Plant) and recorded lichen in the comments.



Parasitic Plants

Parasitic plants lack chlorophyll, getting their water, nutrients, and carbohydrates from a host organism. Two types of parasitic plants are typically recognized. Heterotrophic plants, meaning “other feeding,” get their growth requirements directly from host plants. Mycotrophic plants, meaning “fungus feeding,” get their growth requirements from the mycorrhizal fungi that have a symbiotic relationship to host plants. Mycotrophic plants disrupt the mycorrhizal association by redirecting the carbon and nutrients that would have otherwise been exchanged between the fungi and the host plant. Use 23000 (Parasitic/ Epiphytic Plant) if a parasite is present and indicate that the specific damage is a parasite in the comments. If able to ID, indicate the type of parasite in the comments as well.



Parasitic plants, including pinesap, pinedrops, dodder, and cancer root (23000).

Top left photo by Carolina May, top right by Meredith Prentice, bottom right by Alina Martin, (<https://www.inaturalist.org/observations/189176588>), licensed by CC-BY (<https://creativecommons.org/licenses/by/4.0/>) bottom left by : Bob Nieman. (<https://www.inaturalist.org/observations/47023419>), licensed by CC-BY (<https://creativecommons.org/licenses/by/4.0/>)



Dwarf and true mistletoes (23001). Left and middle photos by Carolina May, right photo by Carmen Melendez

23001 Mistletoe

Mistletoes are parasitic plants that rely on woody hosts for most of their nutrients and water requirements. In NM we have both dwarf mistletoe, *Arceuthobium*, (found on coniferous trees) and true mistletoe, *Phoradendron*, (also call broadleaf or leafy mistletoe; found on deciduous trees). Mistletoe embeds its root system into the bark and wood tissue of trees. The size of mistletoe shoots can vary from 1/2 inch to 3 inches depending on the host tree. Colors range from yellowish orange to yellowish green. Mistletoe infection often results in the formation of witches' broom. Mistletoe infection can reduce tree growth; usually the tree height is more impacted than the diameter growth. Dwarf mistletoe has sticky seeds that are shot out from the plant and can land as far as 50 ft from the host tree. Birds also contribute to the dispersal of mistletoe seeds. After the tree is initially infected, it can take 3 to 4 years for the infection to reach maturity.

NM species susceptible to dwarf mistletoe: PIPO, PIFL, PIED, PSME, PIEN, PIPU, *Juniperus spp.*

NM species susceptible to true mistletoe: hardwoods such as cottonwoods, elms, ash, willows, oaks, and locusts

25000 Foliage Diseases

Foliage diseases include needlecast, blight, broom rusts, leaf spots, and blisters. Foliage diseases are caused by pathogens that penetrate the cuticle, epidermis, or stomates of the foliage. Foliage diseases impact conifers especially as they cannot re-foliate as easily or quickly as hardwoods. NMFWR I uses the general 25000 (Foliage Diseases) damage code when a tree has witches' broom(s). Indicate the specific kind of disease in the comments if known.

Witches' Broom

Witches' brooms are abnormal tree growths resulting in a dense spherical cluster of branches and twigs. Sometimes these clusters have lighter colored and smaller needles than the rest of the tree. The growth of brooms is a stress response caused by several diseases or pathogens including rusts, mistletoe, needle cast, insects, environmental conditions, etc. Witches' broom caused by mistletoe often form a few years after infection. Use damage code 25000 (Foliage Diseases) when witches' broom is present. Use codes 25000 and 23001 (Mistletoe) when both damages are present. Always make a note in the comment of witches' broom as the 25000 code indicates a non-specific foliage disease.



Examples of witches' broom (on left due to mistletoe) (25000) (23001).
Photos by Carmen Melendez

Needlecast

Needlecast is the premature “cast” or loss of needles. Prior to being cast, needles will brown. Discoloration can impact the entire length of the needle or just a portion. Most needlecast infections are caused by a specific family of fungi, Rhytismataceae, or pathogens belonging to phylum Ascomycota. There is one infection period annually. If needlecast is caused by fire scorch, use 30000 (Fire) code instead.



Foliage discoloration due to needlecast (in this case, from *Rhizosphaera*) (25000).

Photo by Forest Health Protection, Forest Service, USDA, Alaska Region (<https://www.flickr.com/photos/194703066@N07/51812376577/in/album-72177720296192422/>), licensed by PMD <https://creativecommons.org/publicdomain/mark/1.0/>

25001 Blight

Blight is a foliage disease that produces discoloration, stunted growth, wilting, rapid death, or dieback. Blight can be the result of a variety of rusts or canker diseases. In contrast to needlecast, dead needles caused by blight can remain attached to twigs. If discoloration is caused by fire scorch, use 30000 (Fire) code instead.



Blight (25001). Photo by Carolina May

25002 Broom Rust

Broom rust is a systematic disease caused by fungi. Similar to mistletoe, broom rust results in the formation of witches' broom. Witches' broom caused by broom rust can be distinguished from those caused by mistletoe because they are denser, more yellow, and lack mistletoe shoots. The yellow needles of broom rust are shorter and thicker than needles on unimpacted branches. Broom needles are shed during the fall and new yellow foliage is produced in the spring.



Broom rust (25002). Photo by Carolina May

Broom rust can also result in cankers, growth abnormalities, stunted growth (diameter and tree height), top-kill, and tree mortality. Trees impacted by broom rust are weakened and thus more susceptible to other pathogens or diseases.

Susceptible species: *Abies spp.*, *Picea spp.*

30000 Fire

Trees can be impacted by fire through radiant heat or direct burning. Fire is recorded by noting char (charring of the bole) and scorch (discolored/ dead needles) that may be present on the tree. We note the presence of char and scorch and the height of each to indicate the fire severity. Char can run up the entirety of the bole to the top of the tree. Scorch can also impact the entirety of the crown but should only be recorded if at least some dead needles are still present. If either or both situations occur, the char/scorch height would be the same as the tree height.



Fire impacts on trees (30000). Photos by Meredith Prentice

Note that post-fire needle browning that occurs *from the top down* with green needles at the base is caused by bark beetle impacts, not scorch.

40000 Animal Damage, Source Unknown

The most common animals that cause damage include elk, deer, beavers, porcupines, squirrels, and birds. Damage can appear as removal or alteration of wood, bark, vegetation, etc. Bird damage (woodpecker) can be differentiated from insect damage as the holes they produce are larger and appear chiseled. If woodpecker damage is detected, use the specific 41010 (Woodpecker) code. If the type of animal that caused the damage can be identified, make a note in the comments.



Animal damage (40000). Left photo by Carolina May, right by Carmen Melendez

41010 Woodpecker

Holes vary by type of bird. Woodpeckers usually create deep holes with jagged edges. Depth can vary from 1" to boring all the way through to the interior of the trunk. Woodpeckers, such as the Pileated Woodpecker, can bore through trees to forage on insects living inside the bole. Often you will find bird damage in conjunction with insect damage, indicating a potentially sick or dying tree.

Sapsuckers are a type of woodpecker that create numerous uniform horizontal rows of round to semi-round holes that are shallow. Indicated by the name, sapsuckers bore into trees to access insects attracted to sap secretions. Typically, the damage created by their boring isn't enough to weaken or kill trees unless the feeding is intensive, as the holes can act entry point to pathogens.



Damage caused by woodpecker (41010), note the deep irregular patterns of holes. Photos by Carmen Melendez

50008 Lightning Scar

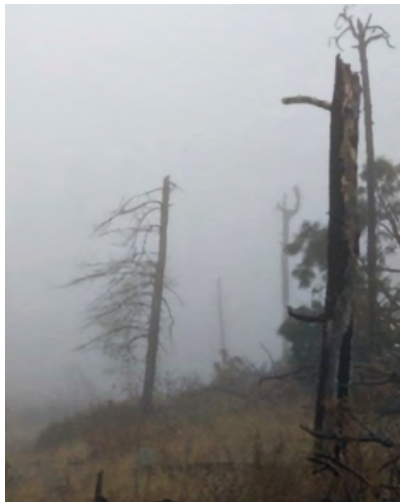
Lightning damage often presents as a long, narrow scar that runs down the length of the tree trunk, often curling around the bole. Often the scar can reach down into the soil. Sometimes lightning strikes result in the trees being blown apart. Damage caused by lightning can result in tree mortality, but more often the damage is slight. Lightning scars can encourage insects such as bark beetles and diseases to enter the tree.



Lightning Scar (50008). Photos by Carolina May

99001 Broken Top

Can be found on live, sick, or dead trees.



Broken Top (99001). Photo by Carolina May

99002 Dead Top

Noted for live trees. Foliage will appear brown or may be absent.



Dead Top (99002). Photo by Meredith Prentice

99004 Fork

Forks are splits in the tree bole, resulting in several leaders of vertical growth which are distinguishable from branches. For some species of trees, such as oaks, aspens, and junipers, the forking of the bole is characteristic of typical growth patterns.

When recording a fork, make a note of the height of where the bole forks in the tree comments and indicate whether the fork is V-shaped or U-shaped. U-shaped forks or “doglegs” are most often caused by injury or damage to the main stem when the tree was younger. They are generally considered to be stable. V-shaped forks often have two stems with no lateral connection, which are significantly more prone to splitting under stress (e.g. weight or wind). Noting the location of the fork is also relevant, as forks near the middle of the tree are more likely to result in breakage than a fork near the top of the crown.



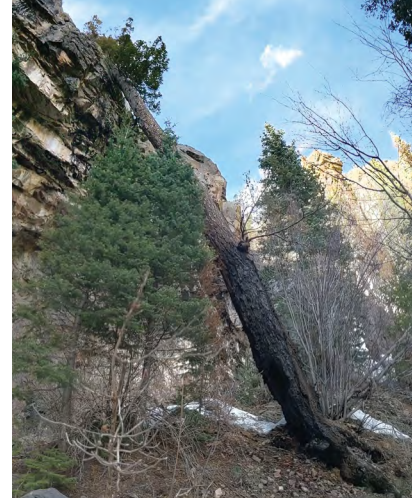
Fork (99004). Photo by Meredith Prentice



Crook or Sweep (99006).
Photo by Meredith Prentice



Fire Scar (99036). Photo by Carolina May



Leaning tree (99037).
Photo by Carolina May

99006 Crook or Sweep

Crooked or twisted boles are noted for species in which this growth form is uncharacteristic, such as PIPO or PIED.

99036 Fire Scar

Fire scars, often called catfaces, are the result of cambial death at the base of the bole. Trees respond to fire related injury by developing calloused edges around the edge of the wound. These callouses help to close the wound, thus helping to minimize vulnerability to infections.

99037 Leaning Tree

A leaning tree bole can result from a variety of factors including shading, crowding, poor soil structure, weather, or damage to the root structure. Leaning snags (dead trees) are hazards; be cautious around them. Snags with a lean greater than 45 degrees or 50% lean severity are not recorded as trees and are instead recorded as coarse woody debris (CWD) in the fuel measurements.



Foliage Loss (99016). Photo by Bryn,
(<https://www.inaturalist.org/observations/184732082>)
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99016 Foliage Loss

Loss of foliage or sparse foliage can be the symptom of many foliage diseases.

70000 Human Activities

Human-caused damage includes embedded objects such as nails or wire fencing, vandalism, inscriptions, etc. Trees are resilient and can survive a lot of instances of human-induced damage. In the case of embedded objects, the bole of a tree will often grow around the object. If damage is excessive or leads to infection, trees can sicken or eventually die. Indicate the specific kind of human-caused damage in the comments, if known.



Human activities (70000). Photo by Carolina May



Open Wound (99026). Left photo by Carmen Melendez, right by Carolina May

99026 Open Wound

Wounds and cracks secrete substances such as gums and resin to protect the wound from outside infections. Note the kind of substance, if any, that is being secreted from the wound or crack.



Examples of burls (99000). Left photo by Carmen Melendez, middle and right photos by Kathryn Mahan

99000 Physical Effects

Burl

A burl is a large, hard, woody abnormal growth presenting on the stem or branch of a tree. A burl can be caused by bacteria, insects, fungus, pathogens, or environmental stress. On some species of trees and shrubs, burls naturally develop. Since 99000 (Physical Effects) indicates general effects, indicate the presence of a burl in the comments.

Sprouts from bole/limb

Epicormic sprouts, also called adventitious shoots, are shoots that emerge in atypical places, typically the bole or branches. These shoots result from some kind of injury, stress, or disease (i.e., thinning, girdling, etc.), where the apical buds die or their dominance is impacted (apical buds are located at the tip of a shoot or stem). When they are dominant, the central leader of the tree is the longest. A helpful way to envision this concept is to consider the growth form that rises from trimming a basil plant to encourage the plant to develop a more bush-like shape). Epicormic branching is more common on some species, such as blue spruce, than others. Since 99000 (Physical Effects) indicates general effects, indicate the presence of sprouts in the comments.



Sprouts from bole (99000).
Photo by Carolina May



Hollowed out (99000). Left and middle photos by Carolina May, right photo by Caremen Melendez

Hollowed out

Hollows form when a tree's core rots out but remains surrounded by some amount of bark. Reoccurring fire can cause hollows. In most cases, evidence of char will also be present. Since 99000 (Physical Effects) indicates general effects, indicate that the tree is hollowed out in the comments.

Large, exposed roots

Tree roots can become exposed due to many factors including significant erosion, growth requirements, poor soil quality, or compaction. With roots exposed, there is an increased potential for wounds and thus infections. Since 99000 (Physical Effects) indicates general effects, indicate the presence of exposed roots in the comments.



Exposed roots (99000).
Photo by Taryn Schlosser

Sprouts at base

Certain trees such as *Quercus spp.* and POTR5 will have sprouts growing from the base. Since 99000 (Physical Effects) indicates general effects, indicate the presence of sprouts at base in the comments.



Sprouts at base (99000).
Photo by Carolina May

PLOT METHODS

20.0 Fuels Transects for Restoration Monitoring

We typically measure fuel loading along transects, also called “Brown’s transects.” The components sampled to estimate fuel loading include dead and down woody debris, depth of the duff and litter profile, and total live and dead vegetative cover. Down woody debris (DWD) is sampled using the planar intercept technique based on the methodology developed by Brown. Pieces of dead and down woody debris are tallied in the standard fire size classes: 1-hour (0 to 0.24 in.), 10-hour (0.25 to <1.0 in.), 100-hour (1.0 to <3.0 in.). Pieces 3 inches or greater in diameter and over 3 feet in length are recorded as 1000-hours and additional information is collected for those pieces on diameter and decay class. Duff and litter depth are measured at two points along each 60-foot sampling plane. Cover of live and dead vegetation is estimated at two points along each 60-foot sampling plane to gain an understanding of ladder fuel presence. Biomass of DWD, duff, litter, and vegetation can be calculated using computer software, or by hand using the calculation sheet in *21.3 Data Analysis Calculations*.

This chapter covers the methodology and rules that apply to sampling of these components. Because of the complexity of these protocols, we encourage you to keep this section nearby for reference when sampling in the field. Note that many sections and definitions of this chapter have been compiled from other reference materials; these are cited starting on page 223.

Why Measure Fuel Loading

It is generally recognized that down woody debris, which is dead material on the ground, is an important component of forest ecosystems. This debris is typically in various stages of decay, and quantifying them can help managers understand potential fire behavior, forest structural diversity, quality of wildlife habitat, carbon sequestration, nutrient cycles, and more.

Sampling Procedure

Monitoring for fuel loading requires 12 specific tasks for each sampling plane:

1. Layout the measuring tape, which defines the sampling plane.
2. Measure the slope of the sampling plane.
3. Count fine woody debris (FWD).
4. Measure coarse woody debris (CWD).
5. Measure depth of the litter.
6. Measure depth of the duff.
7. Estimate cover of live woody species.
8. Estimate cover of dead woody species.
9. Estimate average height of live and dead woody species.

10. Estimate cover of live non-woody species.
11. Estimate cover of dead non-woody species.
12. Estimate average height of live and dead non-woody species.

Transect Lengths and When to Consider Modifying

We suggest sampling over a 60-foot distance with an additional 15 feet of buffer from plot center to minimize the impact of disturbance from plot set-up. (In other words, the tape will go from plot center out to 75 feet, and sampling will occur from 15-75 feet.)

The 60-foot plane is the shortest recommended for sampling CWD; however, there are instances of high fuel loads, such as in slash, where shorter planes may be justified. Also, the field crew does not have to use the suggested locations of 45 feet and 75 feet for sampling duff/litter and vegetation. If they are thoughtfully placed, these measurements can be made elsewhere along the sampling plane.

DWD is sampled along a certain portion of the sampling plane based on the size of the piece (Figure 1). The 1-hour and 10-hour fuels are sampled from the 15-foot (5-meter) to the 21-foot (7-meter) marks, along the plane; the 100-hr fuels are sampled from the 15-foot (5-meter) to the 50-foot (10-meter) marks; and pieces 3 inches (8 cm) and larger are sampled between the 15-foot (5-meter) and 75-foot (25-meter) marks along the plane. The distances for sampling FWD are shorter than for CWD

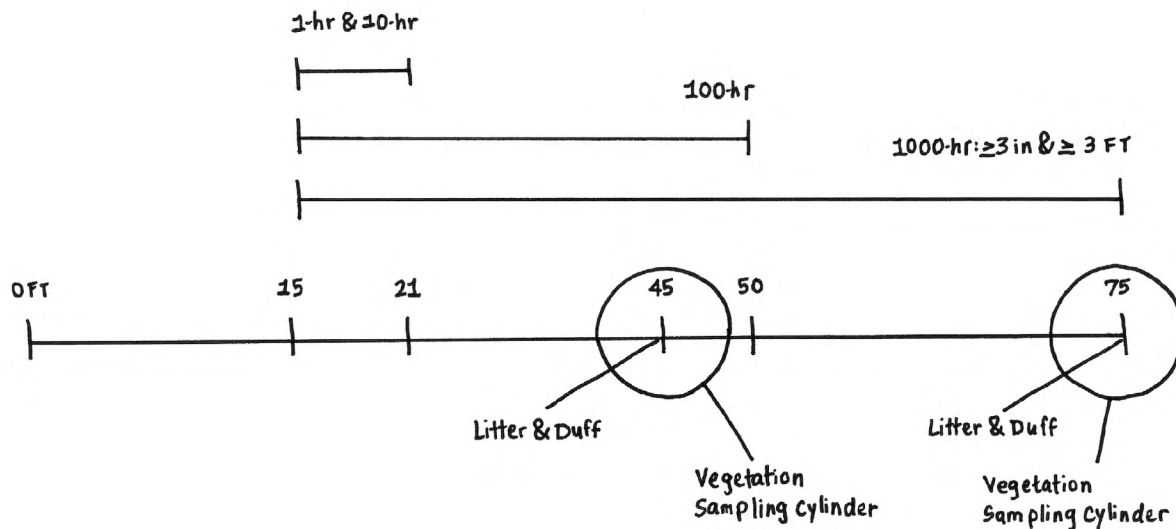


Figure 1. Dead fuels, duff/litter, and vegetation data are recorded at specific locations on or along each sampling plane. The 1-hour and 10-hour fuels are sampled from the 15-foot to the 21-foot marks along the plane, the 100-hr fuels are sampled from the 15-foot to the 50-foot marks and pieces 3 inches and larger are sampled between the 15-foot and 75-foot marks along the plane. Duff/litter measurements are made in a representative area within a 6-foot diameter circular area at the 45-foot and 75-foot marks. The cover of live and dead vegetation is estimated within an imaginary 6-foot diameter by 6-foot high sampling cylinder at the 45-foot and 75-foot marks. *Diagram by Meredith Prentice*

because pieces of FWD are more numerous, so a representative sample can be obtained with a shorter sampling distance. DWD is not measured along the first 15 feet (5 meters) of the tape because fuels are usually disturbed around plot center by the activity of the sampling crew. Record the number of sampling planes per plot.

Locating and Establishing Line Transects

The location of the transects depends on the protocol. In our standard protocol, we use one transect located at a random azimuth which will be remeasured at that same azimuth once established.

Another common arrangement is to use three transects that originate at the plot center and extend out 75 feet horizontal distance at azimuths of 0, 135, and 270 degrees. Using three transects can help 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.

Laying Out the Measuring Tape

A measuring tape laid close to the soil surface defines the sampling plane. The sampling plane extends from the top of the forest floor to a height of six feet. When laying out the tape, crew members need to step so that they minimize trampling and compacting fuels.

The process of laying out the tape is typically more difficult than it sounds because the tape needs to be straight (Figure 2). If the tape zigzags, the selection of pieces is biased, and remeasurement of transect lines and tally pieces for future change detection cannot be done properly. Take your time when laying out the tape.

Note: If photos of previous fuel transects are available, use these to align the measuring tape so that the photos match exactly (even if the azimuth on the compass appears to be slightly different).

Tips for getting the straightest tape:

Two crew members need compasses. One crew member can stand at plot center holding the zero end of the tape and the other can advance along the azimuth with the tape reel.

Before leaving plot center, the crew member with the tape should sight a bearing (see more in *13 Using a Compass*) to follow. The crew member remaining at plot center will also sight a bearing. The crew member with the tape will move away from plot center, following both their own bearing and the directions of the other crew member until they reach the 75-foot mark on the tape. At this point, they should be able to sight with their compass back to plot center and be exactly 180 degrees off their original mark. The crew member remaining at plot center will hold the zero end of the tape over plot center while the second crew member pulls the tape tight. Together, move the tape down as close to the ground as possible without struggling to get it so close to the ground that the debris to be measured is disturbed. In most cases, the tape will end up resting on some of the DWD and low vegetation but below the crowns of shrubs, seedlings, etc.

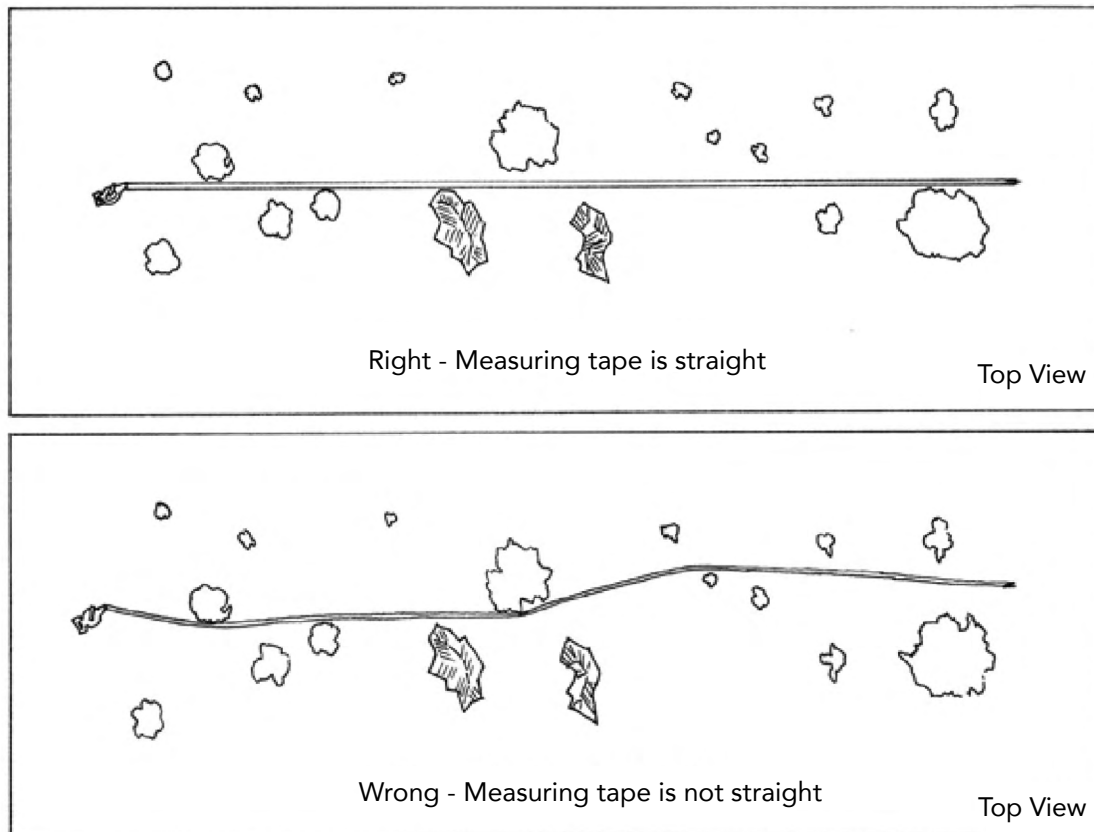


Figure 2. The measuring tape, which represents the lower portion of the sampling plane, should be as straight as possible. If the tape is not straight it needs to be offset left or right until it can be established without kinks or bends. *Image by FIREMON*

Once established, anchor the tape and do not move its position until all sampling is finished for the sampling plane. Most tapes have a loop on the zero end that can be anchored with the plot center rebar or a chaining pin to keep it anchored. A chaining pin through the handle on the other end can be placed through to keep it anchored, and a spike or stick through the handle on the other end of the tape will hold it in place. Roll-up tapes usually have a winding crank that can be flipped so that the knob points toward the reel. In this position, the knob will lock the reel so the tape won't unwind when it is pulled tight.

We recommend adding a piece of rebar to the 75-foot mark for reliable resurvey of the fuels transect.

Determining the Slope of the of the Measuring Tape

Once the tape has been secured, use a clinometer to measure the percent slope of the line. Aim the clinometer at the eye level of sampler at the other end of the line (Figure 3). If there is a height difference of the samplers, adjust the height where you are aiming so that the slope reading is accurate. (See more on taking slope in *15.1 Slope with a Clinometer*). Carefully, read the percent slope from the proper scale in the instrument and report to the data recorder.

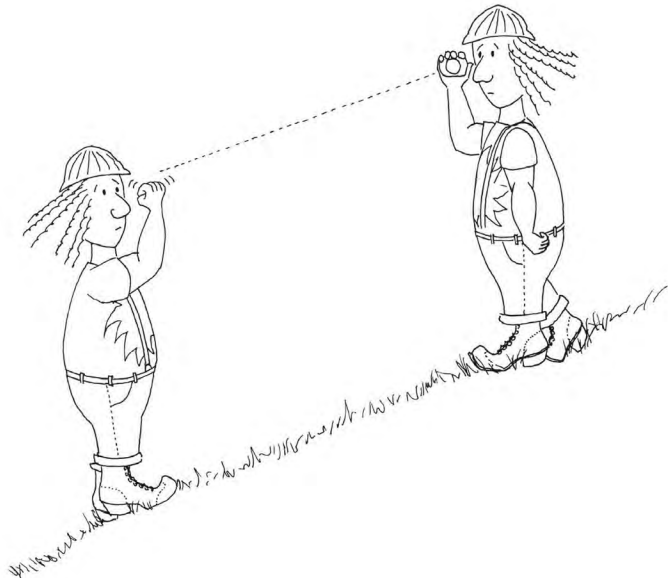


Figure 3. Measure the slope of each line by aiming the clinometer at eye level on the sampler at the opposite end of the measuring tape, then reading and recording the percent slope seen on the scale in the instrument.

Image by FIREMON

Measurement Quality Objectives

Use these standards when collecting data (Table 1).

Component	Standard
Slope	+/- 5 percent
FWD	+/- 3 percent
CWD diameter	+/- 0.5 in./1 cm
CWD decay class	+/- 1 class
Duff/litter depth	+/- 0.1 in./0.2 cm
Percent litter estimation	+/- 10 percent
Vegetation cover estimation	+/- 1 class
Vegetation height estimation	+/- 0.5 ft/0.2 m

Table 1. Precision guidelines for fuel loading (FL) sampling.

Definitions

When collecting data, the following definitions need to be understood so that data gathered is consistent between field crews.

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. Little decomposition has begun in this layer. Litter is defined as undecomposed or only partially decomposed organic material that can be readily identified (e.g., plant leaves, twigs, etc.). Litter is flash fuel – 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. 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.

Duff is the layer just below litter. It consists of decomposing leaves and other organic material. You should see no recognizable plant parts; the duff layer is usually dark decomposed organic matter. When moss is present, the top of the duff layer is just below the green portion of the moss. The bottom of this layer is the point where mineral soil (A horizon) begins. The duff (O horizon) is a soil layer dominated by organic material derived from the decomposition of plant and animal litter (pine straw, leaves, twigs, etc.) and deposited on either an organic or a mineral surface. As a general rule, duff depth should rarely exceed a few inches in Southwest US environments. Duff can easily weigh more than six times the litter.

Fuelbed is the accumulated mass of dead, woody material on the surface of the forest floor. It begins at the top of the duff layer, and includes litter, FWD, CWD, and dead woody shrubs. In this definition, the fuelbed does not include dead hanging branches from standing trees. We do not take a fuelbed measurement.

Woody refers to a plant with stems, branches or twigs that persist from year to year. (See more in *3.0 Terminology Used in Forest Monitoring*.) The structural parts support leaves, needles, cones, etc.; the structural components are tallied along the sampling plane.

Dead material has no live foliage, or is completely severed from the plant where it grew. Sampling deciduous species in the dormant season can be a challenge and should only be done by crews with the expertise to identify dormant vs. dead trees and shrubs. (See more tips on identifying dead vs live trees in *19.4 Damage Codes and Statuses*.) Note that it is possible for material to be considered “dead” even though it has green foliage attached because the rules consider any piece severed from the plant where it grew to be both “dead” and “down.” Fresh slash and broken branches are examples of green material considered “dead.”

Down Woody Materials/ Down Woody Debris

"Down" can include all snags that have their main stem lying on the ground, or are supported by branchwood. A tree is considered down if it is leaning more than 45 degrees from vertical, not self-supporting, and/or in contact with the ground.

Dead Woody Class		Piece Diameter (in.)	Piece Diameter (cm)
DWD	FWD	1-hr	0 to 0.24
		10-hr	0.25 to 0.99
		100-hr	1.0 to 2.99
	CWD	1000-hr and greater	3.0 and greater
			8.0 and greater

Table 2. Characterization of fine woody debris (FWD) and coarse woody debris (CWD).

Two specific components of dead woody fuel are measured: fine woody debris (FWD) and coarse woody debris (CWD). FWD are pieces less than 3 inches (8 cm) diameter, and include 1-hour, 10-hour, and 100-hour fuels. CWD includes pieces 3 inches (8 cm) or greater in diameter and at least 3 feet (1 m) in length, also called 1000-hour and greater fire fuels (Table 2). FWD and CWD function differently in forest ecosystems.

Fine Woody Debris - FWD includes downed, dead branches, twigs, and small woody boles that:

1. are not attached to the plant stems or tree boles where they grew and have fallen to the ground,
2. are not attached to the plant stems or tree boles where they grew but are supported above the ground by live or dead material, and
3. are attached to stems or boles of shrubs or trees that are themselves considered “dead” and “down.” 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. Piece angle of FWD is not critical in determining whether or not it is “down.”

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. Do not sample dead pieces that are still attached to dead (unless “down”) and live shrubs and trees, even if those pieces are hanging from the plant where they grew.
3. Dead foliage (i.e., pine or fir needles or leaf petioles) or cone scales.
4. Bark fragments or other non-woody pieces that are not an integral part of a branch, twig, or small bole. Do not tally needles, grass blades, cones, cone scales, bark pieces, etc., as they are not “woody.” This material is considered litter and is measured as part of the duff/litter profile.
5. Small pieces of decomposed wood (i.e., chunks of cubical rot).

Coarse Woody Debris – CWD includes downed dead tree and shrub boles, large limbs, and other woody pieces that are severed from their original source of growth and on the ground. CWD also includes dead trees

(either self-supported by roots, severed from roots, or uprooted) that are leaning > 45 degrees from vertical. Also included are non-machine processed round wood such as fence posts and cabin logs. For multi-stemmed woodland trees such as juniper, only tally stems that are dead, detached, and on the ground; or dead and leaning > 45 degrees from vertical (more on this later).

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.
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).

Sampling FWD

Because FWD is generally present in higher densities, a shorter transect will pick up an acceptable amount of tally. The transect begins at 15 feet from the subplot center and extends out 35 feet to capture 1-, 10-, and 100-hour fuels (see Table 3).

Category of FWD	Diameter range	Transect length (slope distance)	Transect location (slope distance)
1-hour	0 in to 0.24 in	6 feet	15 to 21 feet
10-hour	0.25 in to 0.9 in	6 feet	15 to 21 feet
100-hour	1.0 in to 2.9 in	35 feet	15 to 50 feet

Table 3. A shorter transect works to tally FWD.

Determining Piece Size

FWD is tallied within three size classes: 1-hour, 10-hour, or 100-hour. Often it will be clear at a glance what size class the pieces belong in.

The go/no-go gauge is a tool that can speed up the sampling process (Figure 4). The gaps in the tool correspond to the 1-hour and 10-hour fuel sizes and they allow quick assessment of fuel size.

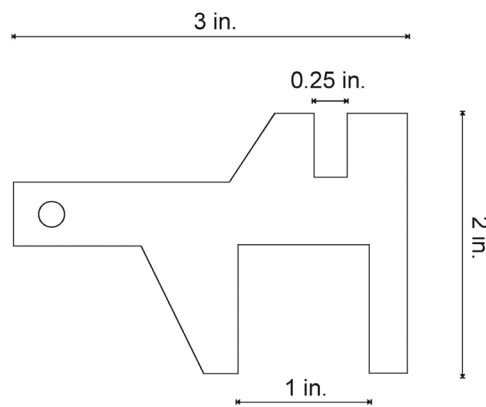


Figure 4. A go/no-go gauge can help samplers tally 1-hr, 10-hr and 100-hr fuels quickly and accurately. Image by FIREMON

Note that the FWD transects are slope distance, not horizontal distance. The formulas used to estimate biomass from the data contain an adjustment for slope.

Count the 1-hour and 10-hour fuels that pass through the sampling plane from the 15-foot to the 21-foot marks on the measuring tape. Remember the plane extends from the top of the litter layer vertically to a height of six feet. Each piece needs to be classified as 1-hour or 10-hour fuel by the diameter where it intercepts the sampling plane, defined by one edge of the measuring tape. Samplers should use the go/no-go gauge discussed earlier to classify fuels that are close to the size-class bounds. Often pieces above the ground will cover pieces below. It is important to locate all the pieces that intercept the plane in order to get accurate fuel load data (test yourself with Figure 5). Report the counts, or count out loud, to the data recorder who will enter them on the data sheet.

Use the same basic procedure to count the 100-hour fuels that pass through the sampling plane from the 15-foot (5-meter) to the 50-foot (10-meter) marks on the tape. Report the information to the data recorder.

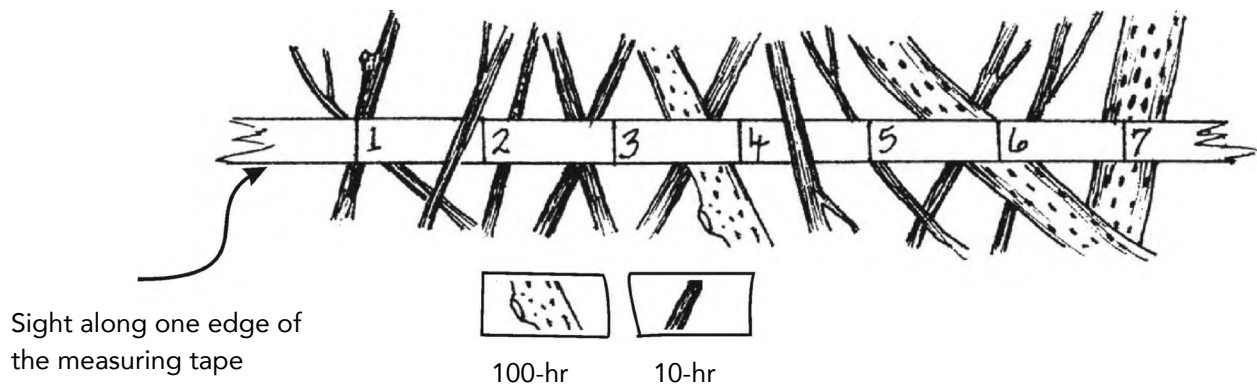


Figure 5. Tally pieces that intercept the sampling plane both above and below the measuring tape. Focus on one edge of the tape to make counting easier. Be sure to note any lower fuels that are hidden by pieces above. In this illustration there are 11 10-hour and three 100-hour fuels. Image by FIREMON

Main Points for Fine Woody Debris (FWD)

1. Only sample Fine Woody Debris (FWD) that intersects a plane from the ground to a height of 6 feet.
2. Individual diameters are not recorded for FWD.
3. Count a piece of FWD if it intersects the transect.
4. Only count a piece if the twig, branch, wood fragment, or shrub/tree bole are woody. Do not count pine or fir needles or cones, or non-woody parts of a tree or shrub.
5. 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.
6. If rocks, logs, or other obstructions are present along the transect, include any FWD that is present on top of these obstructions in the respective FWD counts.
7. If a residue pile intersects the FWD transect, do not measure FWD on this transect. It is too subjective to determine exact boundaries of the pile, and how they relate to the exact point on the transect line. Make a note in the Comment section, and take another transect.

Sampling CWD

The CWD sampling plane is 6 feet (2 meters) high and extends from the 15-foot (5-meter) mark to the 75-foot (25-meter) mark along the measuring tape. Sample CWD that intercepts the sampling plane and meets the dead, down, and woody requirements discussed above. In general, at least two fields are recorded for each piece of CWD: diameter and decay class. Proportion of char, log length, diameter of the large end, point of intersect, and estimations of volume lost to decay are additional data fields that may be collected for each piece of CWD. Diameter measurement and decay class are determined on each piece of CWD where its central axis passes through the sampling plane. Measure diameter perpendicular to the central axis of each piece to the nearest 0.1 inch (0.2 cm) (Figure 6). If a piece crosses through the sampling plane more than once, measure it at each intersection.

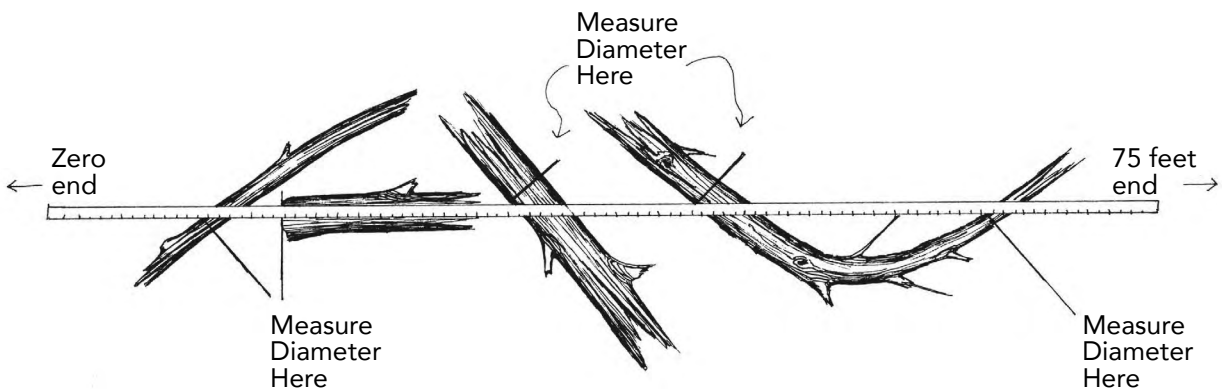


Figure 6. Measure the diameter of CWD crossing through the sampling plane perpendicular to the central axis of the piece. If a curved piece passes through the plane more than once, measure its diameter at each intersection. *Image by FIREMON*

The diameter is most commonly measured by wrapping a diameter tape around the bole if possible, or using calipers. For pieces that 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, and enter the average in the diameter field on the data sheet. This technique applies to intersect, small-end, and large-end diameters.

If the transect intersects the log at a splintered end, record the diameter at this location as the intersect diameter. If the splintered end appears to be two separate pieces (i.e., a major split located just at the end) treat it as one log and take a diameter around the end (take two measurements if it is oddly shaped).

The angle rule

CWD at an angle of greater than 45 degrees above horizontal where it passes through the sampling plane should only be considered “down” if it is the broken bole of a dead tree where at least one end of the bole is touching the ground (not supported by its own branches, or other live or dead vegetation). If CWD is at an angle of 45 degrees or less above horizontal where it passes through the sampling plane then it is “down” regardless of whether or not it is broken, uprooted, or supported in that position (Figures 7 and 8).

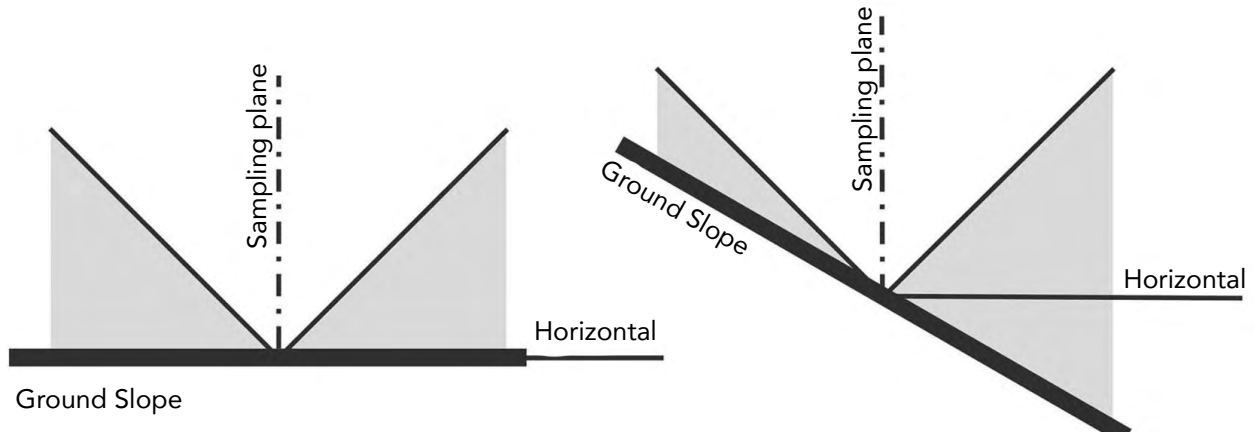


Figure 7. CWD pieces crossing through the sampling plane at an angle less than 45 degrees from horizontal (represented by the shaded areas in the figure) are always considered to be “down.” Some CWD leaning greater than 45 degrees may be considered “down.” See the text for details. *Image by FIREMON*

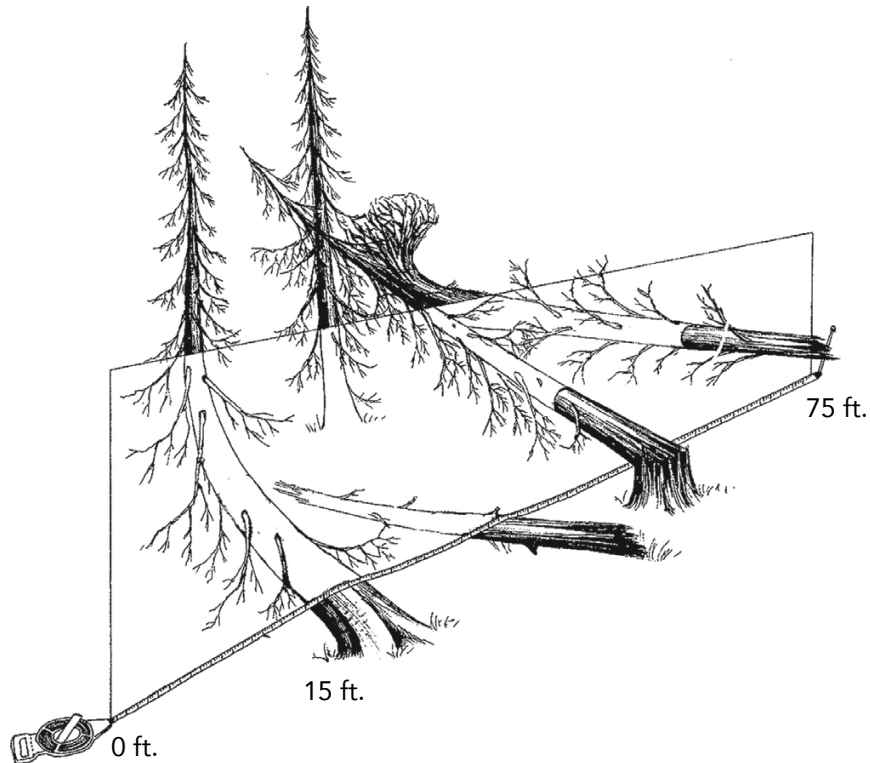


Figure 8. All of the pieces crossing through the sampling plane in this illustration would be considered “down.”

Do not sample a piece of CWD if you believe the central axis of the piece is lying in or below the duff layer where it passes under the sampling plane (Figure 9).

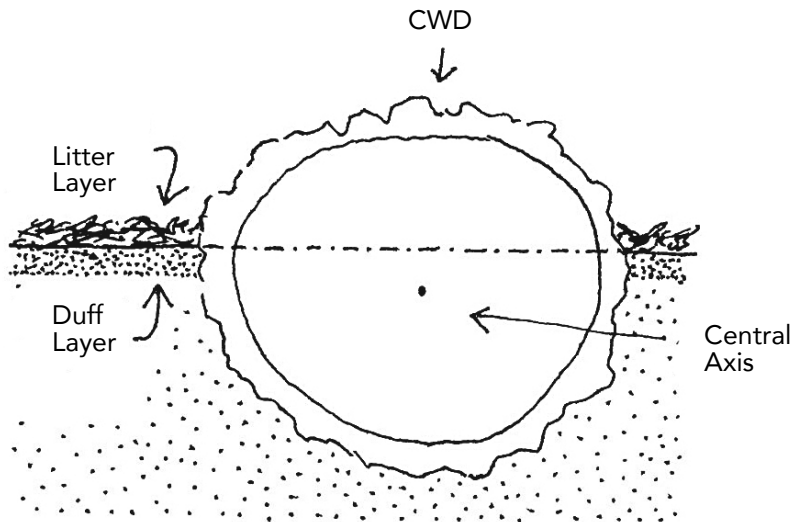


Figure 9. Do not sample CWD when the central axis of the piece lies in or below the duff layer. Image by FIREMON

Main Points for Coarse Woody Debris (CWD)

1. Tally a piece if its central longitudinal axis intersects the transect.
2. Tally dead trees that are leaning > 45 degrees from vertical. Do not tally live trees or standing dead trees and stumps that are still upright and leaning < 45 degrees from vertical. Most CWD will be lying on the ground.
3. The minimum length of any tally piece is 3.0 feet. When CWD pieces are close to 3 feet, measure the length to the nearest 0.1 foot to determine if it is ≥ 3.0 feet.
4. 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.
5. If the central longitudinal axis of a piece is intersected more than once on a transect line, or if it is intersected by two transect lines, tally the piece each time it is intersected (Figure 6).
6. 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.
7. 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 and length requirements.
8. 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 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 10).

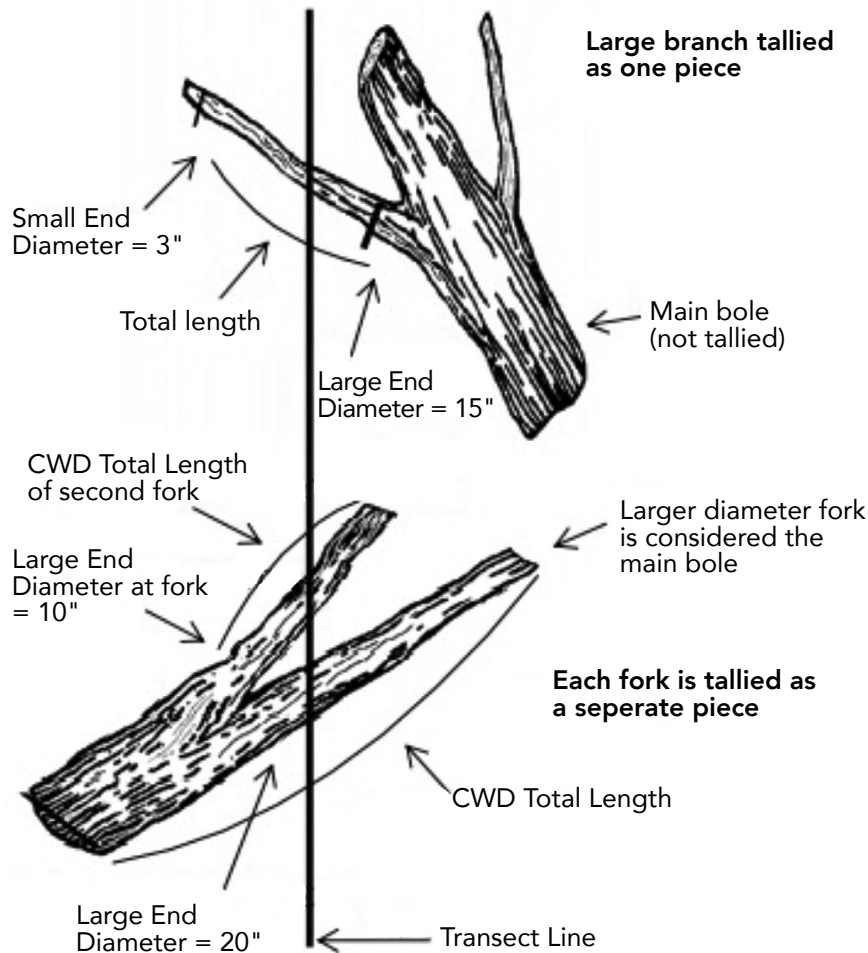


Figure 10. CWD tally rules for forked trees. Image by FIREMON

Decay Classes

Use the descriptions in Table 4 to determine the decay class for CWD at the same point where diameter measurement was made. Decay class can change dramatically from one end of a piece of CWD to the other and often the decay class at the point where the diameter measurement was taken does not reflect the overall decay class of the piece. However, by recording the decay class at the point where diameter was measured the field crew will collect a representative sample of decay classes along each sampling plane. The transect number, slope, sequential piece number (log number), diameter, and decay class for each piece are entered on the data sheet.

Decay Class	Description
1	All bark is intact and tight. All but the smallest twigs are attached. Old needles are probably still present. Solid, freshly fallen, intact logs, hard when kicked.
2	Some bark is missing (especially on fine twigs), as are many of the smaller branches. No old needles still on branches. Hard when kicked.
3	Most of the bark is missing. Most of the branches less than 1 in. in diameter also missing, but branch stubs will not pull out. Still hard when kicked, still supports its own weight, and heartwood is sound.
4	Looks like a class 3 log but the sapwood is rotten. Sounds hollow when kicked and you can probably remove wood from the outside with your boot. Pronounced sagging if suspended for even moderate distances. Branch stubs pull out.
5	Entire log is in contact with the ground. Easy to kick apart but most of the piece is above the general level of the adjacent ground. If the central axis of the piece lies in or below the duff layer then it should not be included in the CWD sampling as these pieces act more like duff than wood when burned.

Table 4. Use these descriptions to determine the decay class where the log crosses the sampling plane.

CWD decay class 5 pieces can be difficult to identify because they often blend into the duff and litter layers. They must still resemble a log; decomposed logs that are slightly elevated ‘humps’ on the ground are not tallied.

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).

Duff and Litter Depth Measurements

Duff and litter are two components of the fuel complex made up of small, woody, and non-woody pieces of debris that have fallen to the forest floor. The “duff/litter profile” is the cross-sectional view of the litter and duff layers. It extends vertically from the top of the mineral soil to the top of the litter layer. The depth of the duff layer, litter layer, and overall fuelbed are important components of fire models used to estimate fire behavior, fire spread, fire effects, and smoke production. The depth of the duff and litter are used to estimate the load of each component. These measurements are taken at the 45- and 75-foot locations on each transect.

Sampling Duff and Litter

The duff and litter layers lie below the sampling plane so they are not sampled using the planar intercept method. Instead, duff/litter measurements are made using a duff/litter profile at two points along each sampling plane. The goal is to develop a vertical cross-section of the litter and duff layers without compressing or disturbing the profile.

Duff/litter depth measurements are made at a point within 3 feet (1 meter) of the 45-foot (15-meter) and 75-foot

(25-meter) marks along the tape. Follow the same instructions for each duff/litter measurement. At each location, select a sampling point within a 3-foot (1-meter) radius circle that best represents the duff/litter characteristics inside the entire circle. Try to preserve the conditions of this location by walking around this point.

Samplers can make the profile using a trowel or boot heel. Carefully expose a shallow profile of the forest floor by digging out an area at the sample point using a knife, hatchet, or even your fingernails. As you dig the hole for this measurement, if you encounter a rock, root, or buried log, stop digging and take the measurements. If a boot is used, drive the heel down and drag it toward you. Mineral soil is usually lighter in color than the duff and coarser in composition, often sandy or gravelly. It is important to not disturb the profile by compacting it on successive scrapes. The profile that is exposed should allow an accurate measurement of duff/litter depth (Figure 11).

Use a plastic ruler to take separate measurements of the depths of the duff and litter to the nearest 0.1 in. (0.2 cm) (Figure 12). The height of the litter should be measured from the top of the loose material located at the sample point. Crews should be absolutely sure they are measuring deep duff depths, instead of mineral soil layers or parts of the litter layer. If unsure of the bottom of the duff layer, crews should feel the texture of the suspect material in their hand, and reject it if it feels like soil. Report the duff/litter depth measurements to the data recorder, who will enter the data on the field form.

Duff and litter measurements are most easily and accurately made on the vertical portion of the profile as long

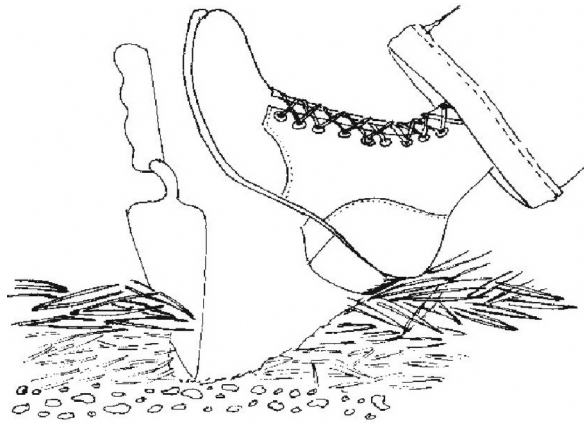


Figure 11. Use your boot to carefully pull the litter and duff layers away, until you are down to mineral soil. Image by FIREMON

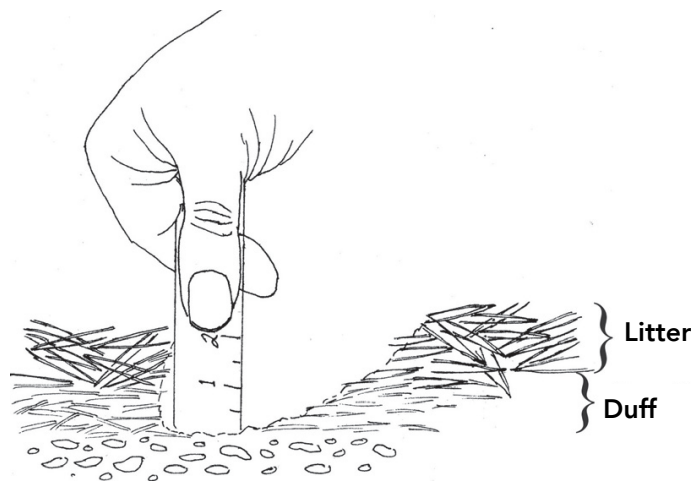


Figure 12. Use a clear plastic ruler to measure duff and litter depth. Here, both measurements are about 1 in. Image by FIREMON

as that portion of the profile is representative of the true duff/litter depth (i.e., it wasn't negatively impacted when the profile was developed). Sometimes the most vertical part is where the back of the trowel blade or boot heel went in, as depicted in Figures 11 and 12, and sometimes it is along one side of the profile.

Biomass of Understory Material (Planar Intercept Cylinders)

The final component of the total fuel loading on a plot to be sampled is the biomass of live and dead understory material, which is useful in approximating ladder fuels. A 6-foot diameter cylinder will be used to estimate the percent cover and height of live and dead shrubs, live and dead herbs (includes grasses), and litter.

Both trees and shrubs are woody species. They are easily identified because their stems persist and growth does not have to start at ground level each growing season. Trees generally have a single, unbranched stem near ground level. Shrubs, which include woody vines, generally have multiple stems near ground level.

Herbs are non-woody herbaceous plants, but also include ferns, mosses, lichens, sedges, and grasses. Although the aerial portions of many forbs and grasses die by the end the growing season, an estimate of live and dead biomass on a given date will help fire modelers predict the life stage of herbaceous material during the year, allowing them to estimate fire danger patterns across the landscape. One way to help identify non-woody plants is to remember that, in general, factors like wind, rain, snow, and so forth, collapse herb foliage and stems back to or near the ground between growing seasons.

Small trees, shrubs, and herbs influence fire behavior because their branches and foliage are suspended above the ground, allowing efficient heating and burning of these parts. Dense, suspended fuels can lead to fires that are difficult or impossible to control. By estimating the cover and heights of woody and non-woody vegetation, fire managers can estimate the volume, density, and biomass of vegetation. All three of the characteristics are strongly associated with fire behavior.

Sampling Vegetation Cover and Height

Estimate vegetation cover and height at the 45-foot and 75-foot marks on the measuring tape. Field crews will estimate the vertically projected cover of vegetation within a 6-foot tall by 6-foot diameter imaginary sampling cylinder. Use the marks on the measuring tape to help visualize the 6-foot diameter. For instance, when standing at the 45-foot mark, the 42-foot and 48-foot marks will identify the boundary of the cylinder along the tape. Use that measurement to get a good idea of the distance needed on each side, perpendicular to the tape, required to form the imaginary base of the cylinder. Most people have an arm's width spread that is about six feet. Each sampler should measure his or her arm span and use that measurement to help them visualize the sampling cylinder.

The cover of plants, especially of the foliage, is a function of the life stage of the plant. Early in the season many plants may not have completely leafed out, in mid-season plant cover reaches its maximum, and in late season plant material, especially herbaceous vegetation, moves from the live to dead class. Clearly, where herbaceous vegetation is concerned, it is important to sample at the same life stage when repeat monitoring, and this should be taken into account when starting a monitoring program. For example, in the Southwest, fires historically burned in May-June, so the best assessment of surface fuels, in terms of potential fire fuels, probably would be made during the fire season. However, other factors may keep monitoring crews

from working during fire season, making life stage only one of many factors considered in designing a monitoring program.

Eight attributes are measured at each vegetation sampling point. These values are four cover estimations for vegetation: 1) live woody species (trees and shrubs), 2) dead woody species, 3) live non-woody species (herbs) and 4) dead non-woody species; and the corresponding height measurements for each component. "Cover" is the vertically projected cover contributed by each of the four categories within the sampling cylinder.

For live fuels, estimate the percent of the microplot area that is covered by live plant material. Include whole plants that are entirely green (or alive) and the live branches on plants that are a mixture of live and dead plant parts. Include live branches or leaves that extend into the microplot area from a plant that is actually rooted outside of the microplot. Do not include material above 6 feet.

For dead fuels, estimate the percent cover using the same procedures as live fuels, but include plants that are entirely dead and branches or leaves that are dead but still attached to a live plant. Dead plant material must be clearly visible. Do not include dead material that has fallen to the ground. Cover estimates are made by visualizing an outline around the dead material and accumulating this across the microplot.

For both live and dead fuels, estimate cover by imagining a bright light above the microplot and casting shadows on the ground. The percent of the ground covered by the vegetation shadows inside the 6-foot (2-meter) diameter sampling area is being estimated. Do not include the cover of the cross-sectional area of upright stems in the live or dead woody cover estimate. Fire acts upon upright stems differently than it does upon the more horizontal fuels; thus, upright stems are not included in cover estimates.

%	Area (sq ft)	Diameter (ft)	Square (ft)
1	0.28	0.60	0.53
10	2.83	1.90	1.68
20	5.65	2.28	2.38
30	8.48	3.29	2.91
40	11.31	3.79	3.36
50	14.14	4.24	3.76
60	16.96	4.65	4.12
70	19.79	5.02	4.45
80	22.62	5.37	4.75
90	25.45	5.69	5.04
100	28.27	6.00	5.32

Table 5. Planar intercept cylinder (3 ft radius) Cover Estimation Guide (Tip: 8.5" x 11" = about 2.3% coverage)

Two conditions make cover estimations difficult and, frequently, inaccurate. First, the equations used to estimate biomass assume that all of the plant parts for each species are included in the cover and height estimation. In other words, when looking at the cover of a woody shrub species, samplers need to estimate the cover of all the parts, even things like the foliage, which are not “woody.” Second, estimating cover is not something people do very often; it is only with practice and experience that good estimations of plant cover can be made. Fortunately, the cover classes used here are typically 10 percent, so the precision of cover estimates are secondary to accuracy (Table 6).

Code	Cover
0	No cover
0.5	>0-1 percent cover
3	>1-5 percent cover
10	>5-15 percent cover
20	>15-25 percent cover
30	>25-35 percent cover
40	>35-45 percent cover
50	>45-55 percent cover
60	>55-65 percent cover
70	>65-75 percent cover
80	>75-85 percent cover
90	>85-95 percent cover
98	>95-100 percent cover

Table 6. Cover of each of the four vegetation categories is recorded in one of the following classes.

In addition to the cover estimates, samplers will make four height estimates at each vegetation sampling location—two for the average heights of the live and dead woody species and two for the average heights of the live and dead non-woody species. Make your height estimate by noting the maximum height of all the plants in the class and then recording the typical or average of all the maximum heights. Some people like to envision a piece of plastic covering just the plants in one class, then they estimate the average height of the plastic above the ground. A fast way to make accurate height assessments is for samplers to measure their ankle, knee and waist heights then estimate vegetation height based on those points. Estimate height to the nearest 0.1 foot (0.2 m). Maximum height is 6 feet.

Finishing Tasks

The most critical task before moving to the next sampling plane or plot is to make certain that all of the necessary data has been collected. This task is the responsibility of the data recorder. Just as with other protocols, the recorder should record any comments that might be useful. For instance, you might comment on some unique characteristic on or near the plot that will help samplers relocate the plot. Include notes about other plot characteristics such as, “evidence of deer browse” or, “deep litter and duff around trees.” Finally, collect the sampling equipment and move ahead to start sampling the next plane.

CLOSING THE ADAPTIVE MANAGEMENT LOOP

21.0 Using the Data

As we mentioned back in Chapter 1.1, the ultimate goal of most of our monitoring efforts is to provide critical information for the adaptive management, decision-making process. Not only can monitoring data help to understand a site's current conditions when considering a treatment, it can also be used to evaluate the impact and effectiveness of a particular treatment or disturbance and inform planning for the future. To support this goal, the following sections walk through ways to make sure the data collection and analysis processes are reliable, how to perform some common analyses, and a brief overview of what management implications may be drawn from those results.

21.1 Data Quality Assurance in the Field

Ensuring quality data collection requires taking steps to check data during collection and before leaving the plot. This practice applies to both paper datasheets and electronic data entry. Have two crew members look over the data to ensure completion and accuracy before removing flags and leaving the plot. Some best practices for on-plot quality assurance are listed below:

1) Is data being collected consistently?

- Ensure all technicians are following all established protocols (i.e., DBH is taken from the correct height; any trees located near the edge of a plot are carefully measured with a tape; fuels transects are laid out to match photos of previous transects).
- Training on practice plots and conducting an error analysis before collecting project data can highlight any areas of inconsistency where crew members need further practice. See Table 1 on the following page for the measurement quality objectives appropriate for a professional, experienced crew.

2) Are all protocols completed?

- If using paper datasheets, ensure every box is filled in. If no trees/seedlings/fuels were present, a line through the box or comment should indicate that this protocol was completed. Do not leave anything blank!
- If using computer/tablet data entry, ensure every protocol tab is filled out completely.
- Confirm all photos are present on the camera.
- Confirm GPS location is recorded on GPS unit and in datasheets/data entry forms.

3) Within protocols, are all required data present?

- Are the plot center coordinates and elevation recorded?

- Does the witness tree have distance and azimuth recorded?
- Do all trees have a height, DBH, and status recorded? Do all live trees have a crown base height?
- Are all tree damages recorded (char/scorch, diseases, abnormal growth) with appropriate severities?
- Do all 1000-hr fuels have a diameter listed?
- Are all surface vegetation coverage values recorded? Does each have a height? Has the slope of the fuel transect been recorded? Ensure there was no height entered if the aerial cover for that category was zero.
- On paper datasheets, are final tallies counted and circled?
- Is all plot description info filled in? Does anyone else on the crew have anything to add to the comments sections?

4) Scan through data. Do data values make sense?

- Do any live crown base heights exceed tree heights?
- Do ground cover percentages add up to 100?
- Do trees with small diameters have excessive heights listed? Do trees with large diameters, and no damages, have abnormally short heights?
- Are the appropriate units used and labeled for surface fuel vegetation heights, litter, duff depths, and other measurements?
- Is all written data legible?

General measurement quality standards for plots taken by our professional crews are as follows:

Measurement	Tolerance	MQO Standard %
Slope	+/- 5%	90%
Azimuth and aspect	+/- 10°	90%
Cover estimation	+/- 10%	90%
Heights	+/- 0.5 ft	90%
Diameters (DBH/DRC)	+/- 0.1in	95%
Duff/litter depths	+/- 0.1in	90%
Damage severity	+/- 10%	90%
Decay Class	+/- 1 class	90%
Seedling/sapling count	+/- 20%	90%
Species/status/tag #/plot #/etc	no tolerance	90-99%

Table 1. The MQO Standard % represents our expectation of what percentage of measurements taken by our crews fall within these tolerances when compared against quality assurance checks. Please note that these MQOs are intended for professional, experienced crews. We recommend taking the time to evaluate your own crew's performance against these or similar metrics before using your data for analysis and decision-making.

CLOSING THE ADAPTIVE MANAGEMENT LOOP

21.2 Data Quality Control

Following field quality assurance, quality control practices are necessary to ensure all data errors are corrected before analysis. There are multiple methods that can be employed in the quality-control process, and the most effective quality control employs a combination of these methods.

Quality control by visual review:

QC can be done by doing a visual review of data in the database, sorting by values, and comparing entered data to paper datasheets. Reviewers should check for missing data, data values that are unlikely or incompatible with other data, typos, and incorrect plot sizes/transect lengths. For example, a PIPO with a 1.5" DBH with a height of 60' would warrant additional review and checking paper datasheets. Likewise, a dead tree with a live crown base height listed indicates an error in either tree status or live crown base height.

An example of complete visual review QC checklist can be provided by NMFWRI upon request.

Quality control by script:

Programming languages can be used to write a script that detects potential errors in a dataset and flags them for review. Using a script allows for the efficient checking of all data for established errors, such as heights, DBH values, plot sizes, or transect lengths entered outside of set parameters. It can also detect errors that are harder to find with visual review, such as a damage code entered that does not match any established codes, or ground cover values that do not sum to 100%. However, not all error detection can be automated, and additional visual review is needed to detect errors such as incorrectly identified plant species or mis-entered sampling dates.

An example of a complete QC script can be provided by NMFWRI upon request.

Quality control by data analysis:

Data analysis can be a powerful tool for detecting potential errors missed in initial quality control. Large changes in data values across measurement periods that have no obvious ecological cause warrant additional investigation into the data. For example, a large drop in basal area or tree density following no treatments or fires may indicate missed trees or a plot size error. Plot photos can often be used to validate data trends or expose potential errors.

CLOSING THE ADAPTIVE MANAGEMENT LOOP

21.3 Data Analysis Calculations

This chapter intends to present some common analyses that can be done with the data collected on plots according to the protocols outlined in this manual. These are not all the analyses that can be done, and many programs will do this work for you. However, it may be helpful to understand the math and be able to perform the calculations by hand if needed.

Overstory and Regen Calculations

Mean height/live crown base height:

The mean height and live crown base height of trees may be reported at the plot or project level. When calculating mean heights (H_{plot}) at the plot level sum all individual tree heights (H_i) within a plot and divide by the number of trees in the plot (n) following equation 1. When reporting mean heights at the project level ($H_{project}$) we typically average the means of the plots by summing the mean heights across the plots and dividing by the number of project (p). Note that the taking the mean of the plot means may yield a different project level value when there different numbers of trees among the different plots (not shown).

$$H_{plot} = \frac{\sum_i^n H_i}{n} \quad \text{Equation 1}$$

$$H_{project} = \frac{\sum_i^p H_{plot}}{p} \quad \text{Equation 2}$$

Mean basal area:

Basal area represents the area of a forest that is covered by tree boles, and is calculated based on DBH (diameter at 4.5 ft off the ground). Typically, basal area is reported as the square feet of tree bole per acre of forest. To calculate the basal area for a plot we first calculate the basal area (in inches) of each tree (measured in inches) as the DBH squared times 0.005454 (equation 3). Then we sum basal area of trees within the plot, and divide by the area of the plot in acres – for reference the area of a 37' 3" plot radius is 0.1 acres. Finally, to get a project mean DBH we average across the plots (not shown).

$$\text{Basal Area} = DBH^2 * 0.005454 \quad \text{Equation 3}$$

Quadratic mean diameter:

The quadratic mean diameter (QMD) is meant to represent the average tree diameter and is used over an arithmetic mean for historical reasons (see: <https://www.fs.usda.gov/pnw/olympia/silv/publications/opt/436-CurtisMarshall2000.pdf>)

The QMD for a plot is calculated by summing the squared DBH values, dividing by the number of trees and taking the square root as in equation 4. To calculate the QMD at the project level we then take the arithmetic mean of the QMD for the plots (not shown).

$$QMD = \sqrt{\frac{\sum_i^n DBH_i}{n}} \quad \text{Equation 4}$$

Density (trees per acre):

The density of trees is generally reported as the number of trees per acre (TPA). This is first calculated at the plot level as the number of individual trees divided by the area of the plot in acres (equation 5). To calculate a project level mean the plot level TPA is averaged (not shown).

$$TPA = \frac{n}{area} \quad \text{Equation 5}$$

Species composition:

Species composition compares the abundance of different species within a forest. It is typically calculated based on either TPA or basal area of species, and could be graphed as a bar graph.

General notes on forest measurement metrics.

When comparing forest measurement metrics between projects or sampling periods it is important to understand the underlying methods that were used to collect and summarize the data. A few considerations are discussed here.

1. Breakpoint diameters that determine whether a tree is counted as a “tree” or “sapling” are an important part of a classification scheme. Two sampling protocols that use different breakpoints can end up having different values for these metrics because changing the breakpoint can change how trees are counted, and how many small trees effect the values like average height and QMD.
2. How multi-stem species are treated. When species have multiple stems, they are sometimes treated differently by different protocols. Sometimes the DBH of each stem is measured and reported as an individual tree, sometimes math is done so that one DBH is reported that corresponds to the basal area of both stems, and sometimes the diameter at the root collar (DRC) is measured and reported. These decisions can all effect summary metrics – and are particularly important in woodlands where multi-stem species are common. NMFWR I handles each stem separately when possible.
3. Averaging. At NMFWR I, to get project level averages, we typically average at the plot level and then average across plots. Metrics such as height, live crown base height, and QMD may also be reported as grand means at the project level. There is not a right and wrong way to do this but that the values of these two methods can differ so be aware of this when comparing to values collected on different protocols.

Fuel Load Calculations

Downed Woody Debris (from Brown 1974):

Formula for Computing Tons per Acre:

$$1, 10, 100\text{-hr size classes: } 0\text{-}3 \text{ in: (tons/acre)} = (11.64 * n * d^2 * s * a * c) / N_i$$

$$1000\text{-hr size classes: } 3\text{+ inches: (tons/acre)} = (11.64 * \sum d^2 * s * a * c) / N_i$$

Where:

c = slope correction factor

$$c = \sqrt{1 + \left(\frac{\text{Percent slope}}{100}\right)^2}$$

No slope correction is needed for samples taken using the Jacob's staff.

Table 1.--Slope correction factors for converting weight/acre on a slope basis to a horizontal basis

Slope	Correction factor	Slope	Correction factor
Percent	c	Percent	c
0	1.00	60	1.17
10	1.00	70	1.22
20	1.02	80	1.28
30	1.04	90	1.35
40	1.08	100	1.41
50	1.12	110	1.49

(From Brown 1974)

n = total number of intersections over all sample points (for each of the 1-hr, 10-hr and 100-hr samples), aka the number of pieces you tallied

d² = squared average diameters

- For 1, 10 and 100-hr fuels these have been measured in the field and constants for different species and systems have been derived. For our purposes, we use the following (nonslash composite values from Brown 1974):

Hour Category	1-hr	10-hr	100 -hr
Diameter class (inches)	0 – 0.25	0.25 - 1	1 - 3
d ² (inches ²):	0.0151	0.289	2.76

- For 1000-hr fuels (3+ in), the actual diameters of each piece are squared and added together to get $\sum d^2$

s = specific gravity of the materials

Approximate Specific gravities for conifers given by Brown (1974) were:

Hour Category	1-hr	10-hr	100 -hr	1000-hr sound	1000-hr rotten
Diameter class (inches)	0 – 0.25	0.25 - 1	1 - 3	3+, decay class 1, 2, or 3	3+, decay class 4 or 5
specific gravity	0.48	0.48	0.40	0.40	0.30

a = the nonhorizontal angle correction factors

- The correction factor adjusts weight estimates for the fact that all particles do not lie horizontally as assumed in the planar intersect theory.
- Brown provides the following:

0 to 3 inches: 1.13
3+ inches: 1.00

N_l = the total length of the sampling line

These lengths are different for different protocols. In our protocol:

Fuel Size Class	Length of Transect Sampled
1-hr	6ft
10-hr	6ft
100-hr	35ft
1000-hr	60ft

Litter and Duff:

Litter and Duff loadings are calculated by multiplying the average depth by the bulk density of litter (or duff). Use bulk density values of 2.75 lbs/ft³ for litter and 5.5 lbs/ft³ for duff. Note that you will need to convert to tons/acre.

Full formulas:

$$\text{Fuel loading } \left(\frac{\text{tons}}{\text{ac}}\right) = \text{avg. depth (in)} \times \text{bulk density} \left(\frac{\text{lb}}{\text{ft}^3}\right) \left(\frac{1\text{ft}}{12\text{in}}\right) \left(\frac{1\text{ton}}{2000\text{lb}}\right) \left(\frac{43560\text{ft}^2}{1\text{ac}}\right)$$

Or

$$\text{Fuel loading } \left(\frac{\text{tons}}{\text{ac}}\right) = \frac{\text{avg. depth (in)} \times \text{bulk density} \times 43560}{24000}$$

Or

$$\text{Fuel loading } \left(\frac{\text{tons}}{\text{ac}}\right) = \text{avg. depth (in)} \times \text{bulk density} \times 1.815$$

Calculate average depth in inches for your entire site.

Live and Dead Herbaceous and Woody Loads:

For each transect, average the planar intercept cylinder microplot estimates for live shrub cover, dead shrub cover, live herbaceous cover, and dead herbaceous cover. Find the average shrub height and average herbaceous height. Biomass of live and dead shrubs and biomass of live and dead herbaceous plants are calculated using the equation. Note that you may need to convert to metric units to be able to use this formula!

$$\mathbf{B=H*C*BD}$$

Where:

B = biomass (kg/sq. m)

H = height (m)

C = percent cover/100

BD = bulk density (kg/cu. m)

Bulk density used for the herbaceous and shrub components are 0.8 kg/m³ and 1.8 kg/m³, respectively.

CLOSING THE ADAPTIVE MANAGEMENT LOOP

21.4 Reporting & Ecological Management Implications

The final steps in the monitoring process are creating accessible summaries of the data, interpreting the results in the context of the project ecosystem, and discussing the implications of these results for adaptive management with those responsible for decision-making. In this section, we focus on discussing the management implications of monitoring results in an ecological context, but similar metrics are used in stands managed for timber production.

Reporting metrics

Mean height/live crown base height:

Mean tree height provides information on site quality, tree growth, and wildlife habitat. An increase in tree height can indicate growth, or when paired with a decrease in tree density following thinning or fire, can indicate selective retention of taller trees. Similarly, decreases in mean tree height may be caused by an increase in the number of small trees at the site.

Mean live crown base height provides information about the susceptibility of a stand to crown fire, and an increase in mean live crown base height can indicate decreased risk of crown fire in the measured project area, usually following treatments or fire. A decrease in live crown base height over time often indicates the ingrowth of smaller trees with lower live crown base heights drawing the overall stand mean lower.

Basal area:

Basal area incorporates stand density and tree diameters and can be used with other metrics to assess forest trends. For example, if basal area increases while tree density decreases five years after a fire, remaining trees can be assumed to be gaining diameter, likely due to decreased competition. Basal area values can be compared to historic ranges of variability to assess risk of high-severity fire, inform treatments, and assess treatment effectiveness.

Quadratic mean diameter (QMD):

Quadratic mean diameter provides information about the average tree size in a project and is directly related to basal area. An increase in quadratic mean diameter over time may indicate tree growth or the selective removal of smaller trees. As retaining fewer, larger trees is generally the target of thinning treatments, an increase in QMD immediately post-treatment is expected.

Density:

Tree density, reported as trees per acre, reflects the degree of tree crowding within a project area. It can be used to assess the level of tree competition, risk of high-severity fire, and vulnerability of insect and disease

outbreaks within a stand. Reporting tree density provides the number of trees per acre irrespective of size, so considering basal area alongside density gives further information on stand trends. High tree densities can be predictive of an increased risk of high-severity fire, insect or disease outbreaks, and stagnated growth. Similarly to basal area, tree density values can be compared to historic ranges of variability to inform treatments and assess outcomes.

Species composition:

Species composition, and changes in species composition over time, are important parameters to report to understand forest type classification, assess wildlife habitat factors, and determine impacts of treatments and fire on forest biodiversity. Shifting species dominance in a stand is often included in management goals when planning forest treatments. For example, a thinning treatment may target the removal of white fir to increase the dominance of ponderosa pine to reflect historic species compositions in the area or increase resilience to fire. Species compositions of the regeneration class can provide valuable information about the trajectory of the stand species composition over time.

Surface fuel loads:

Surface fuel loads, most often reported in tons/ac can tell you a lot about not only expected fire behavior but also forest structural diversity, quality of wildlife habitat, carbon sequestration, nutrient cycles, and more. Surface fuel loads typically increase after thinning, and decrease after fire. Very low fuel loads may suggest recent fire, and/or heavy fuelwood utilization. Paying attention to the distribution of 1000-hour fuel decay classes can give information on habitat diversity, fire history, and recruitment. For instance, if the majority of logs are decay classes 1-2 this would suggest they have been recently recruited (e.g. thinning, blowdown).

Ladder fuel loads:

Ladder fuel loads (approximated by the planar intercept cylinders) can be useful for predicting fire behavior. Increased biomass—for instance, in the standing dead categories—can indicate more ladder fuels on the landscape, which could increase the likelihood of crown fire. This can also tell us about the structural diversity of the forest – an absence of biomass in the planar intercept cylinders may be associated with an absence of understory shrubs/regeneration.

Best practices for reporting

Make reports accessible:

If reporting results for a general audience, avoid technical terms and jargon that may be inaccessible to the average reader. Define any acronyms or technical terms that are used. Create clear and simple figures that show data trends visually and refer to these figures when describing results. Provide a general summary of data trends and management implications at the beginning of the report. Try to integrate your understanding across the different types of data to create a common-language narrative of what is happening in the forest.

Provide context:

When reporting, it is important to make results relevant in the context of the history and geography of a project area. Provide maps of treatments, plots, and project boundaries. Include a timeline of treatments,

fires, and other disturbances, with details on the intended outcomes and goals of any treatments completed. Consider any other information needed to understand the report's results in an ecological context, and if reporting to a general audience, do not assume prior knowledge.

Note limitations:

When reporting monitoring results, always clearly describe any limitations in the data analysis or data quality. For example, if only a subset of monitoring plots were re-measured in a particular year, this could influence results and should be noted clearly in the report wherever applicable. If monitoring protocols changed over time, detail these changes and any effects they may have on data trends. Note where direct comparisons should not be made over time due to changing protocols or seasonal effects.

22.0 References

1.1 Why We Monitor

- NMFWRI. (2023). *CFRP long-term monitoring*. New Mexico Forest and Watershed Restoration Institute. <http://nmfwri.org/resources/restoration-information/cfrp/cfrp-long-term-monitoring/cfrp-long-term-monitoring>
- Der, T., McGrath, D., Estranda, V., Krasilovsky, E., and Evans, Z. (2008). *Monitoring the Longterm Ecological Impacts of New Mexico's Collaborative Forest Restoration Program*. New Mexico Forest Restoration Series Working Paper 5. New Mexico Forest and Watershed Restoration Institute. https://foreststewardsguild.org/wp-content/uploads/2019/06/NMFWRI05_Long_term_CFRP_monitoring.pdf
- NMFWRI. (2023). *GRGWA Projects Online Map*. New Mexico Forest and Watershed Restoration Institute. <https://www.arcgis.com/apps/webappviewer/index.html?id=9aae429929c145418a4d5bf9296f65d1&extent=-12013351.3984%2C4110609.7455%2C-11735426.3635%2C4381808.3219%2C102100>
- Mahan, K.M. and Reid, R. K. (2022). *Sustainability Analysis: Ecological Monitoring. Long-Term Ecological Impacts of the CFRP*. New Mexico Forest and Watershed Restoration Institute. https://nmfwri.org/wp-content/uploads/2022/02/CFRP_Sustainability-2021_report_final_draft_9_17_21.pdf
- SWCD. (2020). *NMFWRI Monitoring Work and Reports for GRGWA by SWCD*. New Mexico Forest and Watershed Restoration Institute. <https://nmfwri.org/collaboration/greater-rio-grande-watershed-alliance/monitoring-reports/>
- NMFWRI. (2020). *Monitoring Work Resources*. New Mexico Forest and Watershed Restoration Institute. <https://nmfwri.org/uncategorized/grgwa-resources/>
- NMFWRI. (2023). *NMFWRI Monitoring Work*. New Mexico Forest and Watershed Restoration Institute. <https://www.arcgis.com/apps/webappviewer/index.html?id=1ff53fe01cbd43d9a24657225a24386c&extent=-12406484.6521%2C3666886.861%2C-10850838.2524%2C4481399.8344%2C102100>
- NMFWRI. (2020). *Other Documents and Resources*. New Mexico Forest and Watershed Restoration Institute. <https://nmfwri.org/collaboration/greater-rio-grande-watershed-alliance/other-docs/>
- Williams, B.K., Szaro, R.C., and Shapiro, C.D. (2009). *Adaptive Management: The U.S. Department of the Interior Technical Guide*. Adaptive Management Working Group. U.S. Department of the Interior. <https://www.doi.gov/sites/doi.gov/files/uploads/TechGuide-WebOptimized-2.pdf>

1.2 Best Practices for Ecological Monitoring

- Burns, E., Lindenmayer, D., Tennant, P., Dickman, C., Green, P., Hanigan, I., Hoffmann, A., Keith, D., Metcalfe, D., Nolan, K., Russell-Smith, J., Wardle, G., Welsh, A., Williams, R., Yates, C. (2014). *Making ecological monitoring successful: Insights and lessons from the Long Term Ecological Research Network*. LTERN, Australia. https://openresearch-repository.anu.edu.au/bitstream/1885/130886/1/Making%20ecological%20monitoring%20successful_web.pdf
- Savage, M., Derr T., Schumann, M., Abrams, J., Moote, A., McCarthy, L., Lowe, K. (2006). *Monitoring ecological effects: Handbook four*. U.S. Department of Agriculture. Forest Service. Collaborative Forest Restoration Program. https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5345347.pdf

2.0 Summary of Plot Protocols

- Brown, J. K. (1974). *Handbook for inventorying downed and woody material*. (Gen. Tech. Rep. INT-16) Department of Agriculture. Forest Service. Intermountain Forest and Range Experimental Station. https://www.fs.usda.gov/rm/pubs_int/int_gtr016.pdf

- NMFWRI. (2023). *CFRP Long-term Monitoring*. New Mexico Forest and Watershed Restoration Institute. <http://nmfwri.org/resources/restoration-information/cfrp/cfrp-long-term-monitoring/cfrp-long-term-monitoring>
- Chojnacky, D.C, and Rogers, P. (1999). *Converting Tree Diameter Measured at Root Collar to Diameter at Breast Height*. U.S. Department of Agriculture. Forest Service. Rocky Mountain Research Station. https://www.usu.edu/beetle/documents2/1999Chojnacky%20Rogers_Converting%20Tree%20Diam.pdf
- Derr, T., McGrath, D., Estranda, V., Krasilovsky, E., and Evans, Z. (2008). *Monitoring the Longterm Ecological Impacts of New Mexico's Collaborative Forest Restoration Program*. New Mexico Forest Restoration Series Working Paper 5. New Mexico Forest and Watershed Restoration Institute. https://foreststewardsguild.org/wp-content/uploads/2019/06/NMFWRI05_Long_term_CFRP_monitoring.pdf
- FEAT-FIREMON Integrated. (2023). *FFI Manuals and Software*. FFI Ecological Monitoring Utilities. United States Department of Agriculture, United States Forest Service, National Parks Service, AXIOM IT Solutions, Fire Modeling Institute. <https://www.frames.gov/partner-sites/ffi/software-and-manuals/>
- FEAT-FIREMON Integrated. (2023). *FFI User Guide*. United States Department of Agriculture, United States Forest Service, National Parks Service, AXIOM IT Solutions, Fire Modeling Institute. https://www.frames.gov/sites/default/files/FFI/FFI_UG_Jan2023.pdf
- Forestry Suppliers. (2021). Using Forest Densiometers. https://www.forestry-suppliers.com/Documents/4283_msds.pdf
- United States Department of Agriculture. (2024). *PLANTS Database*. U.S. Department of Agriculture. Natural Resource Conservation Service. <https://plants.usda.gov/>

4.0 Field Safety

- NOAA. (2023). *Lightning Safety Facts*. NOAA, National Weather Service, NOLS. https://www.weather.gov/media/zhu/ZHU_Training_Page/lightning_stuff/lightning/lightning_facts.pdf
- Roeder. M. (2002). *Lightning Risk Management for Backcountry Campers and Hikers*. Weather.gov https://www.weather.gov/media/owlie/backcountry_lightning.pdf

6.0 Species Code Cheatsheet

- USDA. (2024). *PLANTS Database*. U.S. Department of Agriculture. Natural Resource Conservation Service. <https://plants.usda.gov/>

7.0 Forest Types of New Mexico

- Reynolds, Richard T.; Sánchez Meador, Andrew J.; Youtz, James A.; Nicolet, Tessa; Matonis, Megan S.; Jackson, Patrick L.; DeLorenzo, Donald G.; Graves, Andrew D. 2013. Restoring composition and structure in Southwestern frequent-fire forests: A science-based framework for improving ecosystem resiliency. Gen. Tech. Rep. RMRS-GTR-310. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 76 p. https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fseprd610012.pdf
- USDA. (2009). *Wet (Infrequent Fire) Mixed Conifer Forest Desired Conditions Operational Draft*. https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5181232.pdf
- USDA. (2010). *Dry (Frequent Fire) Mixed Conifer Forest Desired Conditions Operational Draft*. https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5409827.pdf

8.0 Herbarium Voucher Collection Protocol

- Bowles, J. M. (2004). *Guide to Plant Collection and Identification*. University of Western Ontario Dr. Laurie L. Consaul Herbarium. <https://www.uwo.ca/biology/pdfs/research/collectingguide.pdf>

- British Columbia Ministry of Forests. (1996). *Techniques and Procedures for Collecting, Preserving, Processing, and Storing Botanical Specimens*. Res. Br., B.C. Min. For., Victoria, B.C. Work. Pap. 18/1996. <https://www.for.gov.bc.ca/hfd/pubs/docs/wp/wp18.pdf>
- Caomhánach, N.P., & Bell, R. (2020). *Decolonizing Living Collections – Part 1*. Journal of the History of Ideas Blog. <https://www.jhiblog.org/2020/12/07/decolonizing-living-collections/>
- Center for Plants and Culture. *Imperial Taxonomy and Nomenclature*. <https://www.plantsandculture.org/imperialtaxonomy>
- Das, S., & Lowe, M. (2018). *Nature Red in Black and White: Decolonial Approaches to Interpreting Natural History Collections*. Journal of Natural History Collections, 6, 4-14. <https://natsca.org/sites/default/files/publications/JoNSC-Vol6-DasandLowe2018.pdf>
- DeWitt, R.I. (1986) *Flowering Plants of New Mexico: Second Edition*. Robert DeWitt Ivey.
- Florida Museum. (2023). *Preparation of Plant Specimens for Deposit as Herbarium Vouchers*. University of Florida Herbarium (FLAS). <https://www.floridamuseum.ufl.edu/herbarium/methods/vouchers/>
- Gray, R., & Sheikh, S. (2021, January 27). *The Coloniality of Planting: Legacies of Racism and Slavery in the Practice of Botany*. The Architectural Review. <https://www.architectural-review.com/essays/the-coloniality-of-planting>
- Kenyon-Flatt, B. (2012, March 19). *How Scientific Taxonomy Constructed the Myth of Race*. Sapiens. <https://www.sapiens.org/biology/race-scientific-taxonomy/>
- National Ecological Observatory Network. (2019, January 29). *NEON Standard Operating Procedure: Plant Pressing, Mounting, and Labeling (Herbarium Techniques)*. NEON. <https://data.neonscience.org/documents/10179/1883155/NEON.DOC.003564vD/d3bd9b35-f13f-2fcd-039b-6da5bf27e78c?version=1.0>
- Park, D.S., Feng, X., Akiyama, S., Ardiyani, M., Avendaño, N., Barina, Z., Bärtschi, B., Belgrano, M., Betancur, J., Bijmoer, R., Bogaerts, A., Cano, A., Danihelka, J., Garg, A., Giblin, D.E., Gogoi, R., Guggisberg, A., Hyvärinen, M., James, S.A., Ramagwai, J.S.,...Davis, C.C. (2023). *The Colonial Legacy of Herbaria*. Nature Human Behaviour, 7, 1059-1068 <https://doi.org/10.1038/s41562-023-01616-7>
- Reyes-Agüero, J.A., Carlin-Castelán, F., Aguirre R., J.R., & Hernández, H. M. (2007). *Preparation of Opuntia Herbarium Specimens*. Haseltonia, 13, 76-82. [https://doi.org/10.2985/1070-0048\(2007\)13\[76:POOHS\]2.0.CO;2](https://doi.org/10.2985/1070-0048(2007)13[76:POOHS]2.0.CO;2)
- San Diego Natural History Museum. *Making a Plant Collection*. San Diego Natural History Museum. <https://www.sdnhm.org/science/botany/resources/general-information/how-to-make-a-plant-collection/>
- San Diego Natural History Museum. (2016, April 14). *How to Prepare Cacti Herbarium Sheets*. [Video.] Youtube. <https://www.youtube.com/watch?v=C9ntRNJYmyU>
- Smith, C.E. (1971). *Preparing Herbarium Specimens of Vascular Plants*. Ethnobotanical Leaflets. <https://ethnoleaflets.com/prepare.htm>
- The Linnean Society of London. (2020). *Linnaeus and Race*. The Linnean Society of London. <https://www.linnean.org/learning/who-was-linnaeus/linnaeus-and-race>
- University of Connecticut. (2020). *Making a Plant Collection*. Biodiversity Research Collections. <https://biodiversity.uconn.edu/herbarium-making-a-plant-collection/>
- University of Melbourne Herbarium (MELU) (2018). *Make Your Own Herbarium Specimens*. University of Melbourne Herbarium https://biosciences.unimelb.edu.au/_data/assets/pdf_file/0010/2237788/MELU_MakeYourOwnHerb_Specimen_Dec18.pdf
- University of New Mexico Herbarium. *Mounting Specimens at UNM Herbarium*.

8.1 Mushroom Collection Protocol

Cripps, C. L., Evenson, V. S., & Kuo, M. (2016). *The Essential Guide to Rocky Mountain Mushrooms by habitat*. University of Illinois Press.

Gillman, L., & Salzman, J. (2011). *How to Identify Mushrooms and Where to Find Them*. Disqus <https://urbanmushrooms.com/index.php?id=69>

Kenny, J. (2023, April 21). *How to create a home fungi herbarium*. Mushroom Appreciation. <https://www.mushroom-appreciation.com/create-a-home-fungi-herbarium.html>

9.0 Common Trees of NM

Cain, R. and Parker, D. (1997). *Conifer Pests in New Mexico*. United States Department of Agriculture. Forest Service. Southwestern Region. <http://smrna.org/pages/documents/filesOutdoors/Conifer%20Pests%20in%20New%20Mexico.pdf>

Carter, J.L. (1997). *Trees and Shrubs of New Mexico*. Mimbres. *Desert Plants*. Desert USA. <https://www.desertusa.com/flora.html>

USDA. (2023). *Fire Effects Information System (FEIS)*. USDA. <https://www.feis-crs.org/feis/>

Home. Santa Fe Botanical Gardens. <https://santafebotanicalgarden.org/>

Home. Trees for me. <https://www.treesforme.com/>

Clemson Cooperative Extension. (2021). *Juniper Diseases & Insect Pests*. Home & Garden Information Center. <https://hgic.clemson.edu/factsheet/juniper-diseases-insect-pests/>

Oregon Master Gardener Association, J. Frank Schmit Family Charitable Foundation. (2024). *Landscape Plants*. Oregon State University. <https://landscapeplants.oregonstate.edu/>

List of North American Trees. Trees of North America. <https://treesofnorthamerica.net/>

USDA. (2024). *PLANTS Database*. U.S. Department of Agriculture. Natural Resource Conservation Service. <https://plants.usda.gov/>

SEINet Portal Network Home. SEINet Arizona-New Mexico Chapter. <https://swbiodiversity.org/seinet/>

USU. *USU Research and Scholarship*. Utah State University University Libraries. <https://digitalcommons.usu.edu/>

10.0 Common Shrubs of NM

Arnberger, L.P., and Janish, J.R. (1982). *Flowers of the Southwest Mountains*. Southwest Parks and Monuments Association.

Carter, J.L. (1997). *Trees and Shrubs of New Mexico*. Mimbres.

USDA. *PLANTS Database*. U.S. Department of Agriculture. Natural Resource Conservation Service. <https://plants.usda.gov/>

SEINet Portal Network Home. SEINet Arizona-New Mexico Chapter. <https://swbiodiversity.org/seinet/>

11.0 Poisonous Plants of NM

SEINet Portal Network Home. SEINet Arizona-New Mexico Chapter. <https://swbiodiversity.org/seinet/>

North Carolina State Extension Gardener Plant Toolbox. *Urtica dioica*. NC State Extension. <https://plants.ces.ncsu.edu/plants/urtica-dioica/>

Innes, Robin J. 2012. *Toxicodendron radicans*, *T. rydbergii*. In: *Fire Effects Information System*, [Online]. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (Producer). Available: <http://www.fs.usda.gov/database/feis/plants/shrub/toxspp/all.html> [2024, April 21].

- USDA. Plant of the Week: Western Poison-ivy (Toxicodendron rydbergii) https://www.fs.usda.gov/wildflowers/plant-of-the-week/toxicodendron_rydbergii.shtml
- USDA. (2018). Poisonous Plant Research. Poison Hemlock (Conium maculatum) <https://www.ars.usda.gov/pacific-west-area/logan-ut/poisonous-plant-research/docs/poison-hemlock-conium-maculatum/>
- Konca C, Kahramaner Z, Bosnak M, Kocamaz H. Hemlock (Conium Maculatum) *Poisoning In A Child*. Turk J Emerg Med. 2016 Feb 26;14(1):34-6. doi: 10.5505/1304.7361.2013.23500. PMID: 27331163; PMCID: PMC4909876. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4909876/>

13.1 Declination

- NOAA. *Magnetic Field Calculators*. National Oceanic and Atmospheric Administration. <https://www.ngdc.noaa.gov/geomag/calculators/magcalc.shtml>
- USGS. Magnetic Declination Varies Considerably Across The United States: Isogonic Lines Show The Pattern of Magnetic Declination. Education Resources. <https://www.usgs.gov/educational-resources/magnetic-declination-varies-considerably-across-united-states>
- USGS. *What is declination?* United States Geological Survey. <https://www.usgs.gov/faqs/what-declination>
- USDA Forest Service. (2000). FSH 2409.12 - TIMBER CRUISING HANDBOOK. https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fsbdev2_029371.pdf

19.31 Rules for Measuring DBH

- USDA Forest Service. (2000). FSH 2409.12 - TIMBER CRUISING HANDBOOK. https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fsbdev2_029371.pdf

19.32 Rules for When and How to Measure at DRC

- Bonfantine, K., Zebrowski J., and Egan, A. (2011). *Guidelines and protocols for monitoring riparian forest restoration projects*. New Mexico Forest and Watershed Restoration Institute. https://nrmfwri.org/wp-content/uploads/2020/07/Riparian_forest_monitoring_guidelines-1.pdf
- Chojnacky, D.C, and Rogers, P. (1999). *Converting Tree Diameter Measured at Root Collar to Diameter at Breast Height*. U.S. Department of Agriculture. Forest Service. Rocky Mountain Research Station. https://www.usu.edu/beetle/documents2/1999Chojnacky%20Rogers_Converting%20Tree%20Diam.pdf

19.4 Damage Codes and Status

- Lutes, Duncan C.; Keane, Robert E.; Caratti, John F.; Key, Carl H.; Benson, Nathan C.; Sutherland, Steve; Gangi, Larry J. 2006. *FIREMON: Fire effects monitoring and inventory system*. Gen. Tech. Rep. RMRS-GTR-164-CD. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 1 CD. https://www.fs.usda.gov/rm/pubs_series/rmrs/gtr/rmrs_gtr164.pdf
- Environmental Horticulture Department, University of Florida, Institute of Food and Agricultural Science. (2013). *Spanish Moss, Ball Moss, and Lichens – Harmless Epiphytes*. Retrieved from <file:///C:/Users/Monitoring/Downloads/cmccgillcuddy,+ep485.pdf>
- Sinclair, W.A. and Lyon, H.H. (2005). *Diseases of Trees and Shrubs*. Cornell University Press.
- U.S. Department of Interior, National Park Service. (2003). *Fire Monitoring Handbook*. Retrieved from <https://www.nps.gov/orgs/1965/upload/fire-effects-monitoring-handbook.pdf>
- U.S. Department of Agriculture, Forest Service, Natural Resource Manager. (2015). *Appendix K: Damage Categories, Agents, Severity Ratings, and Trees Parts*. In FSveg Common Stand Exam User Guide Region 3 Appendices. Retrieved from https://www.fs.usda.gov/nrm/documents/fsveg/cse_user_guides/userguide_fsveg_r3_apdx.docx

22.0 References

- U.S. Department of Agriculture, Forest Service, Rocky Mountain Region, Forest Health Protection. (2010). *Field Guide to Diseases & Insects of the Rocky Mountain Region*. Gen. Tech. Rep. RMRS-GTR-241 Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station.
- U.S. Department of Agriculture, Forest Service. *What are Mycotrophic Wildflowers?* Retrieved from <https://www.fs.usda.gov/wildflowers/beauty/mycotrophic/whatarethey.shtml>

20.0 Fuel Transects for Restoration Monitoring

- Brown, J. K. (1974). *Handbook for inventorying downed woody material*. U.S. Department of Agriculture. Forest Service. Gen. Tech. Rep. INT-16. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station. 24 p. <https://www.fs.usda.gov/research/treesearch/28647>
- Brown, J.K., R.D. Oberheu, and C.M. Johnston. (1982). *Handbook for Inventorying Surface Fuels and Biomass in the Interior West*. U.S. Department of Agriculture. Forest Service (General Technical Report INT-129.) <https://www.fs.usda.gov/research/treesearch/29401>
- USFS. *Down Woody Materials Indicator*. (2004). U.S. Department of Agriculture. Forest Service. Northern Research Station. https://www.nrs.fs.usda.gov/fia/topics/dwm/documents/DWM_Training_Plan_04.doc
- Fuel Load Sampling Methods*. FIREMON. [https://www.frames.gov/firemon/sampling-methods#:~:text=The%20Fuel%20Load%20methods%20\(FL,transect%20method%20\(Brown%201974\).](https://www.frames.gov/firemon/sampling-methods#:~:text=The%20Fuel%20Load%20methods%20(FL,transect%20method%20(Brown%201974).)

21.1 Data Quality Assurance in the Field

- Pollard, James E.; Westfall, James A.; Patterson, Paul L.; Gartner, David L.; Hansen, Mark; Kuegler, Olaf. 2006. *Forest Inventory and Analysis National Data Quality Assessment Report for 2000 to 2003*. Gen. Tech. Rep. RMRS-GTR-181. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 43 p.

21.3 Data Analysis Calculations

- Brown, J.K., R.D. Oberheu, and C.M. Johnston. (1982). *Handbook for Inventorying Surface Fuels and Biomass in the Interior West*. U.S. Department of Agriculture. Forest Service (General Technical Report INT-129.) <https://www.fs.usda.gov/research/treesearch/29401>

21.4 Reporting and Management Implications

- Forest Mensuration*, 5th Edition, John A. Kershaw Jr., Mark J. Ducey, Thomas W. Beers, Bertram Husch 2017

SUPPLEMENTAL INFORMATION

A Basic CSE Plot Workflow with a 3-person crew

Task	Person 1	Person 2	Person 3
Navigate w/ GPS, update point & record coordinates/elevation with Geode/ QuickCapture	1		
Install rebar at plot center (PC)		1	
Plot slope (take & record)	2		
Aspect (take & record)	3		
Regeneration (small plot seedlings/saplings)	5		
Aerial/ground cover (small plot)	6		
Take canopy with densiometer at all 4 inner flags		4	
Record canopy from Person 2	7		
Take PC photo of whiteboard			1
Layout plot to E & S		2	
Layout plot to N/B0, W/B270, B135 (if applicable)			2
Take photos from 75' facing PC on Brown's transects			4
Take slope on Brown's transect			3
Hold whiteboard for Brown's photos	8		
ID tree species, condition, & take DBH			6
Flag witness tree		3	
Record witness tree	4		
Measure tree Ht & LiCrBHt		5	
Record trees from Person 2 and Person 3	10		
Count Brown's transects, cylinders, and litter & duff			5
Record Brown's counts, cylinders, slope & fuelbed	9		
Take NESW photos from PC & pick up inner flags			7
Hold whiteboard for NESW photos at 37.24' & pick up outer flags		6	
Write down the photo order and photo numbers, the group's comments on plot, & double-check datasheets are completely filled out	11		
Double-check all photos with camera playback			8
Mark off plot on master map & confirm next destination		7	

Basic CSE Plot Workflow – Tasks by Person

Person 1

1. Navigate w/ Garmin GPS, update point & record coordinates/elevation with Geode and QuickCapture
2. Plot slope (take & record)
3. Aspect (take & record)
4. Record witness tree
5. Regeneration (small plot seedlings/saplings)
6. Aerial/ground cover (small plot)
7. Record canopy from Person 2
8. Hold whiteboard at PC for Brown's photos
9. Record Brown's counts, cylinders, slope, & fuelbed
10. Record Trees from Person 2 and Person 3
11. Write down the photo order and photo numbers, the group's comments on plot, & double-check datasheets are completely filled out

Person 2

1. Install rebar at plot center
2. Layout plot to E & S
3. Flag witness tree
4. Take canopy with the densiometer at all four inner flags
**** Help Person 1 with the small plot tally if needed ***
5. Measure tree Ht & LiCrBHt (clinometer or hypsometer/rangefinder)
6. Hold whiteboard for NESW photos at 37.24' & pick up outer flags
7. Mark off plot on master map & confirm next destination

Person 3

1. Take PC photo of whiteboard
2. Layout plot to N/B0, W/B270, B135
3. Take slope on Brown's transect
4. Take photos from 75' facing PC on Brown's transects
5. Count Brown's transects, cylinders, and litter & duff
***If Person 1 is busy, record your Brown's transect in your own field book or whiteboard and give it to them when they are free ***
6. ID tree species, condition & take DBH
7. Take NESW photos from PC & pick up inner flags
8. Double-check all photos with camera playback

SUPPLEMENTAL INFORMATION

B Species Code Cheat Sheet

Common Upland Tree Codes

Code	Scientific Name	Common Name
ABCO	<i>Abies concolor</i>	white fir
ABLAA	<i>Abies lasiocarpa</i> var. <i>arizonica</i>	corkbark fir
JUCO6	<i>Juniperus communis</i>	common juniper
JUDE2	<i>Juniperus deppeana</i>	alligator juniper
JUMO	<i>Juniper monosperma</i>	one-seed juniper
JUSC2	<i>Juniperus scopulorum</i>	Rocky Mountain juniper
PIAR	<i>Pinus aristata</i>	bristlecone pine
PIED	<i>Pinus edulis</i>	two-needle piñon <i>piñon pine*</i>
PIEN	<i>Picea engelmannii</i>	Engelmann spruce
PIFL2	<i>Pinus flexilis</i>	limber pine
PIPO	<i>Pinus ponderosa</i>	ponderosa pine
PIPU	<i>Picea pungens</i>	blue spruce
POTR5	<i>Populus tremuloides</i>	quaking aspen
PSME	<i>Pseudotsuga menziesii</i>	Douglas-fir
QUGA	<i>Quercus gambelii</i>	Gambel oak
QUGR3	<i>Quercus grisea</i>	gray oak
QUPA4	<i>Quercus pauciloba</i>	wavyleaf oak
QUTU2	<i>Quercus turbinella</i>	Sonoran scrub oak <i>desert scrub oak*</i>

Common Riparian Codes

Code	Scientific Name	Common Name
AIAL	<i>Ailanthus altissima</i>	tree of heaven
ACGL	<i>Acer glabrum</i>	Rocky Mountain maple
ACNE2	<i>Acer negundo</i>	boxelder
BASA4	<i>Baccharis salicifolia</i>	seepwillow <i>mule-fat*</i>

Code	Scientific Name	Common Name
COSE16	<i>Cornus sericea</i>	redosier dogwood
ELAN	<i>Elaeagnus angustifolia</i>	Russian olive
FOPU2	<i>Forestiera pubescens</i>	stretchberry New Mexico olive*
PODEW	<i>Populus deltoides ssp. wislizeni</i>	Rio Grande cottonwood
PRVI	<i>Prunus virginiana</i>	chokecherry
SAEX	<i>Salix exigua</i>	narrowleaf willow coyote willow*
TAMAR2	<i>Tamarix sp</i>	tamarisk salt cedar*, species unknown
ULPU	<i>Ulmus pumila</i>	Siberian elm

Common Cacti Codes

Code	Scientific Name	Common Name
CYIM2	<i>Cylindropuntia imbricata</i>	tree cholla
CYLIN2	<i>Cylindropuntia sp.</i>	cholla, species unknown
OPEN3	<i>Opuntia engelmannii</i>	cactus apple desert prickly pear*
OPPH	<i>Opuntia phaeacantha</i>	tulip prickly pear
OPUNT	<i>Opuntia sp.</i>	prickly pear, species unknown

Common Upland Shrub Codes

Code	Scientific Name	Common Name
AMCA6	<i>Amorpha canescens</i>	lead-plant
AMFR	<i>Amorpha fruitcosa</i>	false indigo bush
ARTR2	<i>Artemisia tridentata</i>	big sagebrush
ARPU5	<i>Arctostaphylos pungens</i>	point-leaf manzanita
ARUV	<i>Arctostaphylos uva-ursi</i>	kinnickinnick
ATCA2	<i>Atriplex canescens</i>	fourwing saltbush
CEFE	<i>Ceanothus fendleri</i>	Fendler's ceanothus
CEMO2	<i>Cercocarpus montanus</i>	alderleaf mountain mahogany

Code	Scientific Name	Common Name
DAFR6	<i>Dasiphora fruticosa</i>	shrubby cinquefoil
ERNA10	<i>Ericameria nauseosa</i>	rubber rabbitbrush
FAPA	<i>Fallugia paradoxa</i>	Apache plume
FOPU2	<i>Forestiera pubescens</i>	stretchberry <i>desert olive*</i>
FRVE2	<i>Fraxinus velutina</i>	velvet ash
GUSA2	<i>Gutierrezia sarothrae</i>	broom snakeweed
KRLA2	<i>Krascheninnikovia lanata</i>	winterfat
MARE11	<i>Mahonia repens</i>	creeping barberry
NOGR5	<i>Nolina greenei</i>	woodland beargrass <i>Greene's beargrass*</i>
PAMY	<i>Paxistima myrsinites</i>	Oregon boxleaf <i>mountain-lover *</i>
RHTR	<i>Rhus trilobata</i>	skunkbush sumac <i>three-leaved sumac *</i>
RIBES	<i>Ribes sp.</i>	currant, species unknown
RICE	<i>Ribes cereum</i>	wax currant
RIIN2	<i>Ribes inerme</i>	whitestem gooseberry
RONE	<i>Robinia neomexicana</i>	New Mexico locust
ROWO	<i>Rosa woodsii</i>	Woods' rose
RUID	<i>Rubus idaeus</i>	American red raspberry
SHCA	<i>Shepherdia canadensis</i>	russet buffaloberry
SYAL	<i>Symphoricarpos albus</i>	white snowberry
SYMPH	<i>Symphoricarpos sp.</i>	snowberry, species unknown
SYRO	<i>Symphoricarpos rotundifolius</i>	roundleaf snowberry
VAMY2	<i>Vaccinium myrtillus</i>	whortleberry
YUBA	<i>Yucca baccata</i>	banana yucca
YUCCA	<i>Yucca sp.</i>	yucca, species unknown

**Italic common name* represents an alternative common name that differs from the common name found in the USDA plant database.

SUPPLEMENTAL INFORMATION

C USFS Damage Codes Reference Chart

USFS Damage Category	NPS Damage Code	Damage Description	Severity	Notes
10000	INSE	General Insects	<p>101 - Minor: bottlebrush or shortened leaders, 0-2 forks on stem, OR <20% of branches affected, OR <50% of bole with visible larval galleries</p> <p>OR</p> <p>102 - Severe: 3 or more forks on bole, OR 20% or more branches affected, OR terminal leader dead, OR 50% or more of bole with visible larval galleries</p>	Beetles, moths, sawflies, ants, wasps.
11000	---	Bark Beetles	<p>900: 0 – 9% affected</p> <p>901: 10 – 19% affected</p> <p>902: 20 – 29% affected</p> <p>903: 30 – 39% affected</p> <p>904: 40 – 49% affected</p> <p>905: 50 – 59% affected</p> <p>906: 60 – 69% affected</p> <p>907: 70 – 79% affected</p> <p>908: 80 – 89% affected</p> <p>909: 90 – 100% affected</p>	The presence of small holes, usually exuding frass and galleries (tunnels beneath bark).
17000	GALL	Gallmarker Insects	<p>171 - Minor</p> <p>OR</p> <p>172 - Severe</p>	Abnormal growths on stems, roots, or leaves. Formed by pathogen/ parasitic infection.
19000	---	General Disease	<p>191 - Minor</p> <p>OR</p> <p>192 - Severe</p>	Blister rust, etc.

USFS Damage Category	NPS Damage Code	Damage Description	Severity	Notes
21000	ROTT	Root/Butt Disease	900: 0 – 9% affected 901: 10 – 19% affected 902: 20 – 29% affected 903: 30 – 39% affected 904: 40 – 49% affected 905: 50 – 59% affected 906: 60 – 69% affected 907: 70 – 79% affected 908: 80 – 89% affected 909: 90 – 100% affected	The presence of fungi other than shelf-like fruiting bodies/ conks. Indicate specific fruiting body or its general morphology in the comments.
22000	CONK	Stem Decay/ Canker	220: 0-4% rotten 221: 5-15% rotten 222: 16-25% rotten 223: 26-35% rotten 224: 36-45% rotten 225: 46-55% rotten 226: 56-65% rotten 227: 66-75% rotten 228: 76-85% rotten 229: 86-100% rotten	The presence of shelf-like fruiting bodies/ conks. If not shelf-like fungus, use ROTT/2100. Specify presence of conk in the comments.
23000	--- OR EPIC/ LICH/	Parasitic/ Epiphytic Plants	900: 0 – 9% affected 901: 10 – 19% affected 902: 20 – 29% affected 903: 30 – 39% affected 904: 40 – 49% affected 905: 50 – 59% affected 906: 60 – 69% affected 907: 70 – 79% affected 908: 80 – 89% affected 909: 90 – 100% affected	Epiphytic plants: lichen Parasitic plants: dodder (<i>Cuscuta spp.</i>), pinedrop (<i>Pterospora andromedea</i>), bearcorn (<i>Conopholis americana</i>), pinesap (<i>Monotropa hypopitys</i>), etc. Make a note in the comments whether plant is an epiphyte or parasite and record the specific species if able to identify.

USFS Damage Category	NPS Damage Code	Damage Description	Severity	Notes
23001	MISL	Mistletoe	900: 0 – 9% affected 901: 10 – 19% affected 902: 20 – 29% affected 903: 30 – 39% affected 904: 40 – 49% affected 905: 50 – 59% affected 906: 60 – 69% affected 907: 70 – 79% affected 908: 80 – 89% affected 909: 90 – 100% affected	Parasitic plant that often forms a dense cluster of shoots. Can sprout from bole or branches. Affects PIPO, PIFL, PIED, PSME, PIEN, PIPU, JUxx.
25000	--- OR BROM	Foliage Diseases	251 - Minor: <20% of foliage affected or <20% of crown in brooms OR 252 - Severe: >20% of foliage affected or >20% of crown in brooms	Needle cast, needle blight, witches' broom. Note the specific damage in the comments.
25001	BLIG	Blight	251 - Minor: <20% of foliage affected or <20% of crown in brooms OR 252 - Severe: >20% of foliage affected or >20% of crown in brooms	Discoloration of needles, stunted growth. Needles stay attached to the tree in comparison to needle cast where they are shed.
27000	---	Broom Rusts	271 - Minor: <20% of crown in brooms OR 272 - Severe: >20% of crown in brooms	Dense cluster of growth. More yellow than brooms caused by mistletoe and lacks mistletoe shoots.
30000	FIRE	Fire	Maximum scorch height (foliage) & char height (bark)	No % or severity needed, assessed by recording the maximum height of scorch and char.
40000	MAMM	Animal Damage, Source Unknown	401 - Minor OR 402 - Severe	Bear claw marks, porcupine or beaver chewings, and deer/elk rubbings. Make a note in the comments about specific damage.

USFS Damage Category	NPS Damage Code	Damage Description	Severity	Notes
41010	BIRD	Woodpecker	411 - Minor: <20% of crown affected, bole damage is <50% circumference OR 412 - Severe: >20% of crown affected, bole damage is >50% circumference, upper 1/3 of crown is killed	Holes are larger, more chiseled than beetle holes. 41010 code indicates woodpecker, NPS letter code not as specific.
50000	-- OR OZON/ FRST	Abiotic Damage	501 - Minor: <20% of crown affected, bole damage is <50% of circumference OR 502 - Severe: >20% of crown affected, bole damage is >50% of circumference, upper 1/3 of crown is killed	Air pollutants, chemical damage, drought, frost. Note the specific damage in the comments.
50008	LIGT	Lightning Scar	501 - Minor: <20% of crown affected, bole damage is <50% circumference OR 502 - Severe: >20% of crown affected, bole damage is >50% circumference, upper 1/3 of crown is killed	Narrow vertical scar/wound running down the length of the bole.
70000	UMAN	Human Activities	701 - Minor OR 702 - Severe	Markings, girdling, cuttings, etc. Note the specific damage in the comments.
90000	---	Unknown	900: 0 – 9% affected 901: 10 – 19% affected 902: 20 – 29% affected 903: 30 – 39% affected 904: 40 – 49% affected 905: 50 – 59% affected 906: 60 – 69% affected 907: 70 – 79% affected 908: 80 – 89% affected 909: 90 – 100% affected	Used when damage cannot be identified.

USFS Damage Category	NPS Damage Code	Damage Description	Severity	Notes
99001	BROK	Broken Top	% of original height missing: 900: 0 – 9% affected 901: 10 – 19% affected 902: 20 – 29% affected 903: 30 – 39% affected 904: 40 – 49% affected 905: 50 – 59% affected 906: 60 – 69% affected 907: 70 – 79% affected 908: 80 – 89% affected 909: 90 – 100% affected	Live, sick, and dead trees can all have broken tops.
99002	DTOP	Dead Top	% of total tree height that is dead: 900: 0 – 9% affected 901: 10 – 19% affected 902: 20 – 29% affected 903: 30 – 39% affected 904: 40 – 49% affected 905: 50 – 59% affected 906: 60 – 69% affected 907: 70 – 79% affected 908: 80 – 89% affected 909: 90 – 100% affected	Only live and sick trees can have a dead top.
99004	FORK/ TWIN	Forked Top	% of total tree height above fork 900: 0 – 9% affected 901: 10 – 19% affected 902: 20 – 29% affected 903: 30 – 39% affected 904: 40 – 49% affected 905: 50 – 59% affected 906: 60 – 69% affected 907: 70 – 79% affected 908: 80 – 89% affected 909: 90 – 100% affected	Uncharacteristic, forked top (not applicable for POTR5, <i>Quercus spp.</i> , etc.). NPS letter codes use FORK for forking above DBH and TWIN is used for forking below DBH. Indicate whether fork is V-shaped or U-shaped in the comments in addition to recording the height of where the bole forks.

USFS Damage Category	NPS Damage Code	Damage Description	Severity	Notes
99006	CROK	Crook or Sweep	% of total tree height, which contains the crook or sweep 900: 0 – 9% affected 901: 10 – 19% affected 902: 20 – 29% affected 903: 30 – 39% affected 904: 40 – 49% affected 905: 50 – 59% affected 906: 60 – 69% affected 907: 70 – 79% affected 908: 80 – 89% affected 909: 90 – 100% affected	Use when crooked bole or sweep is uncharacteristic for tree species.
99016	SPAR	Foliage Loss	1 = Minor OR 2 = Severe	Unusually sparse foliage.
99026	WOND	Open Wound	% of bole affected: 900: 0 – 9% affected 901: 10 – 19% affected 902: 20 – 29% affected 903: 30 – 39% affected 904: 40 – 49% affected 905: 50 – 59% affected 906: 60 – 69% affected 907: 70 – 79% affected 908: 80 – 89% affected 909: 90 – 100% affected	Opening or cavity on bole with the outer bark missing.
99036	FIRE	Fire Scar	% of bole covered by fire scar	Scar that forms at the base of the tree, usually triangular in shape.
99037	LEAN	Leaning tree	% lean from vertical: 901: 10 – 19% affected 902: 20 – 29% affected 903: 30 – 39% affected 904: 40 – 49% affected 905: 50 – 59% affected 906: 60 – 69% affected 907: 70 – 79% affected 908: 80 – 89% affected 909: 90 – 100% affected	Should be greater than 15%, use 900 severity rating. In the comments, specify the exact %. Snags (dead trees) with a lean greater than 45 deg or 50% lean severity are not recorded as trees. They instead are recorded as CWD in the fuel measurements.

USFS Damage Category	NPS Damage Code	Damage Description	Severity	Notes
99000	--- OR ABGR/ BURL/ EPIC/ HOLW/ ROOT/ SRPT	Physical Effects	900: 0 – 9% affected 901: 10 – 19% affected 902: 20 – 29% affected 903: 30 – 39% affected 904: 40 – 49% affected 905: 50 – 59% affected 906: 60 – 69% affected 907: 70 – 79% affected 908: 80 – 89% affected 909: 90 – 100% affected	Large, exposed roots, hollowed out bole, abnormal growth pattern, burl, epicormic sprouts from bole/limbs, sprouts at base, etc. Make a note in the comments of the specific damage.
---	X	Not assessed	-1	

SUPPLEMENTAL INFORMATION

D Completed Example Datasheets

Plot Description

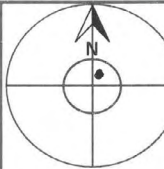
Observer: LM, AB
 Recorder: KS
 Latitude (dd.ddddd): 35.5453933°
 Longitude (ddd.ddddd): -105.1520001°
 Elevation (ft): 8,438ft

Administrative Unit: Santa Fe National Forest
 Project Unit: Maestas Northridge
 Macroplot: M-4
 Date (MM/DD/YYYY): 07/06/2023
 Time: 2:14 P.M.

Photo
 Azimuths: (1) of whiteboard at PC. (1) from 75 feet N looking south to PC (4) from PC in all four cardinal directions; (1) from each Brown's transect looking toward PC.
 PC(100-0985), N(0985), E(0986),
 ORDER TAKEN & #: S(0987), W(0988), BR200(0989), C(0990)

Hill Slope (% where steepest): 10 %
 Aspect (circle one): N E (S) W
 Aspect azimuth (degrees): 195 °
 Mag Declination: 8 °

Comments: Tree #4 fell since last visit
Lots of mulein on plot
Ravine to the south
open w/ mainly ponderosa pine and aspen
Large boulders at edge of plot to the west



Describe Witness Tree(s):
 @ 25° azimuth
5' from PC
Tree #5, 17.5" DBH
55.1' HT, 23.1' Live crown HT
 Draw location of tree on plot
 Color of Flagging/Marker Used: double orange flagging

Aerial cover (%) (1/100th acre plot)			
Tree regen.	Shrubs	Graminoids	Forbs
<u>2%</u>	<u>7%</u>	<u>10%</u>	<u>12%</u>

Macroplot Sizes		
Size (Acres)	1/100	1/10
Radius (Feet, Decimal Feet)	11.78	37.24
Radius (Feet, Inches)	11' 9"	37' 3"

Canopy (%)

N <u>7</u>	S <u>10</u>
E <u>5</u>	W <u>2</u>

Squares →

Ground cover (%) (1/100th acre plot) (total 100 %)						
Plant basal (including cacti)	Bole (woodies)	Litter	Bare soil	Rock (>2.5in)	Gravel (<2.5 in)	Total (%)
<u>15%</u>	<u>9%</u>	<u>30%</u>	<u>20%</u>	<u>15%</u>	<u>1%</u>	<u>100%</u>

Species	Condition (Live, Dead, Sick)	Small Plot—Tree Regen, Shrubs & Cacti					Small Plot—Tree Regen, Shrubs & Cacti		
		Height classes—Seedlings (<4.5', <1" dbh/drc)					Species	Saplings ≥4.5', <1"	
		> 0 - 0.5'	> 0.5' - 1.5'	> 1.5' - 2.5'	> 2.5' - 3.5'	> 3.5' - 4.5'			
ARUV	L	(2)		(6)		(1)	POTRS	L	(2)
ROWO	L	(3)	(2)	(4)	(2)				
ROWO	D	(5)	(1)						
POTRS	L	(3)			(4)	(2)			
PIPO	L		(1)						

Observer/Recorder: AR/NL Project/Site/Plot: SFNF Mesquits Date: 7/6/23 Plot Number: M-4 Page 1 of 1

1/10th acre plot (37' 3" radius)

Tree Tag #	Species	Tree cond. (L, D, S)	DBH/DRC (add down arrow if DRC was taken)	# stems	Total Tree Ht	LICRHT	Damage 1	Severity 1	Damage 2	Severity 2	Char Ht	Scorch Ht	Comments (witness tree, etc.)
1	PIPO	L	3.8 inches	1	16.9 ft	10.1'							
2	PIPO	D	9.2 in.	1	32.2'	—	99001	901					
3	POTRS	L	5.0"	1	31.1 ft	22.6'	30000	—			0.5'	2.4'	
5	PIPO	L	17.5"	1	55.1'	23.1'							Witness tree
6	PSME	L	10.2 in.	1	45.9'	25.5'	23001	902					
7	POTRS	L	6.4"	1	33.4'	18.6'							
8	PIPO	L	13.1"	1	48.9'	17.9'	30000	—			6.5'		
9	PIPO	L	12.7"	1	49.8'	15.3 ft							
10	PIFL2	D	7.6"	1	28.6'	—							
11.1	PIPO	L	4.9"	2	30.2'	11.0 ft	99004	909					V fork at 3'
11.2	PIPO	L	5.7"	2	33.7'	10.5'	99004	909					V fork at 3'
12	PIFL2	S	9.0"	1	30.0'	22.3'	11000	908	23001	909	10'	22.3'	Damage 3: 30000
13	POTRS	L	1.2"	1	9.1 feet	6.4'							Reached cutoff in past 5 years, 15° azimuth between #2 + #3

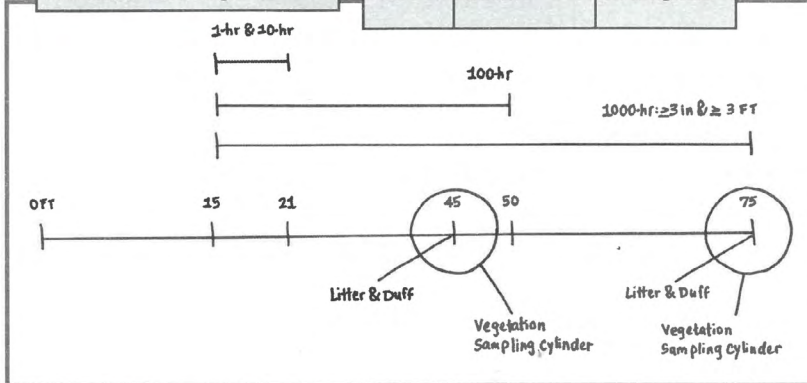
Surface Fuels

Sheet 1 of 2: Fine Woody Debris—Coarse Woody Debris

1-hour Transect Length - 6'
10-hour Transect Length - 6'
100-hour Transect Length - 35'
1000-hour Transect Length - 60'

	Class	Diameter (in)
FWD	1-hr	0 to 0.25
	10-hr	0.25 to 0.9
	100-hr	1.0 to 2.99
CWD	1000-hr +	3.0 and greater

Observer	LM
Recorder	LM
Number of Transects	1



Admin Unit:	Santa Fe National Forest
Project Unit:	Maestas Northridge
Macroplot:	M-4
Date (MM/DD/YYYY):	07/06/2023
Time:	2:45 P.M.

Fine Woody Debris (1, 10, 100 hr fuels)	Transect	Azimuth	Slope	1 - Hr Count	10 - Hr Count	100 - Hr Count	Comment
	1	* Random for CFRP or (0°) 20°	4	(3)	(2)	—	
	2	135°					
	3	270°					

Coarse Woody Debris (1000 hr fuels)	Transect	Log No.	Log Diameter	Decay Class	Comment (e.g. spp)
	1	1	7.2"	2	Tree tag #4, PIP0
	1	2	10.0"	5	

Precisions: Diameter: ±0.5 in ; decay class ±1 class ; Slope ±5 percent

Decay Class Description

- All bark is intact. All but the smallest twigs are present. Old needles probably still present. Hard when kicked
- Some bark is missing, as are many of the smaller branches. No old needles still on branches. Hard when kicked
- Most of the bark is missing and most of the branches less than 1 in. in diameter also missing. Still hard when kicked
- Looks like a class 3 log but the sapwood is rotten. Sounds hollow when kicked and you can probably remove wood from the outside with your boot. Pronounced sagging if suspended for even moderate distances
- Entire log is in contact with the ground. Easy to kick apart but most of the piece is above the general level of the adjacent ground. If the central axis of the piece lies in or below the duff layer then it should not be included in the CWD sampling as these pieces act more like duff than wood when burned.



Surface Fuels

Sheet 2 of 2: Duff, Litter, and Vegetation

Observer	<u>LM</u>
Recorder	<u>LM</u>
Number of Transects	<u>1</u>
Transect Length: 75'	

Administrative Unit:	<u>Santa Fe National Forest</u>
Project Unit:	<u>Maestas Northridge</u>
Macroplot:	<u>M-4</u>
Date (DD/MM/YYYY):	<u>07/06/2023</u>
Time:	<u>2:50 P.M.</u>

Transect	Sample Location	Litter Depth	Duff Depth	Veg Item	% Veg Cover	Veg Hgt (d.d')	Surface Fuels-Vegetation Item Code and Description
1	45'	1.5"	0.5"	HD	0.5	0.3'	HD dead non-woody vegetation
				HL	3	1'	HL Live non-woody vegetation
				SD	0	—	SD Dead woody vegetation
1	75'	1"	0"	SL	3	1.5'	SL Live woody vegetation
				HD	3	0.5'	
				HL	10	1.2'	
2	45'			SD	0	—	
				SL	0	—	
				HD			
2	75'			HL			
				SD			
				SL			
3	45'			HD			
				HL			
				SD			
3	75'			SL			
				HD			
				HL			

% Veg cover	
Code	Cover
0	No cover
0.5	>0-1 % cover
3	>1-5 % cover
10	>5-15 % cover
20	>15-25 % cover
30	>25-35 % cover
40	>35-45 % cover
50	>45-55 % cover
60	>55-65 % cover
70	>65-75 % cover
80	>75-85 % cover
90	>85-95 % cover

Comments:



SUPPLEMENTAL INFORMATION

E Completed Herbarium Voucher Collection Datasheet

NMFWRI Herbarium Voucher Collection

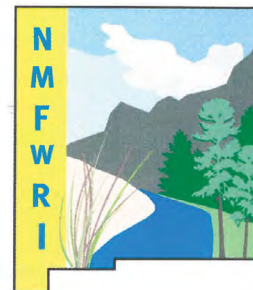
Collection No.: Soil Value Added-2022-009

Associated Plot ID:

Date: 7-19-2022

Collected by: Sarah Smith

Identified by: Sarah Smith



Location (site, country, state): Cibola National Forest, Tijeras, NM - Sandia District

Latitude (dd.dxxxxx): 34.968163

Longitude (ddd.dxxxxx): -106.358029

Elevation (ft): 7,245ft

Scientific Name: *Teucrium laciniatum*

USDA PLANTS Symbol: TELA

Common Name(s): lacy germander

Family: *Lamiaceae*

Lifeform (forb, shrub, graminoid, tree, mushroom, bryophyte): forb

Species Description (height, flower color/scent, stickiness, texture, gill type, cap shape, etc.):

Long root, white irregular flowers. Linear leaves
feathery appearance, opposite leaves.

Habit (annual, biennial, perennial):

perennial

Habitat (ex. P-J, Ponderosa Pine, associated plants in the area, note any disturbance):

Ponderosa Pine, JUSC, GUSA, bottom of canyon next to road

Extent of Species Population: 12 approx. # of individuals in 1/10th acre approx. area

Slope: 3

Aspect: North

Soil Info (texture, parent material, other): Sandy soil texture

SUPPLEMENTAL INFORMATION

F Optional Measures For Fuel Loading

These variables are not usually measured, but could be collected in special cases. Only use these measures if specifically stated.

Sampling Residue Piles

The line transect method is not practical when sampling CWD within piles and windrows. Piles and windrows are located and sampled on the plot, whether or not they intersect a transect.

Piles and windrows created directly by human activity, and log piles at the bottom of steep-sided ravines in which individual pieces are impossible to tally separately, are more efficiently sampled by using the following instructions. However, loose CWD in piles created by wind throw, landslides, fires, and other natural causes should be tallied using line transects unless it is physically impossible to measure the pieces in the natural pile.

For a pile to be tallied, the following criteria must be met:

- The pile's center must be within 24.0 horizontal feet of plot center, and
- It contains pieces of CWD ≥ 3 inches diameter that would be impossible to tally separately.

Use the PILE DENSITY variable to estimate the percent of the pile that contains woody material ≥ 3 inches. The pile is assigned to the condition class in which the pile center lies.

Apply the following steps to determine the center of a pile or windrow:

1. Determine the longest axis of a pile.
2. Determine the midpoint of this axis.
3. Project a line through this midpoint that is perpendicular to the axis determined in step 1.
4. Determine the midpoint of the segment of this projected line that crosses the pile.
5. This is the center of the pile.

Piles that cross the 24.0-foot fixed-radius subplot boundary: If the center of a pile is within 24.0 horizontal feet of plot center, tally the pile, recording the dimensions of the entire pile even if part of the pile is beyond 24.0 feet. If the center of a pile is more than 24.0 horizontal feet of subplot center, do not tally the pile or any portion of the pile.

Diameter at the Small End of the Log

Record the code indicating 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.

Diameter at Large End of the Log

Measured for wildlife concerns. Record the diameter of the large end of the log to the nearest 0.1 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. If a piece is broken but the sections are touching, consider that one log. If the broken sections are not touching, then consider them two logs and record the diameter of the large end of the piece that is passing through the sampling plane.

Log Length

Important for wildlife concerns and useful for rough determination of piece density. CWD TOTAL LENGTH is the length of the piece that lies between the piece's recorded DIAMETER AT THE SMALL END and DIAMETER AT THE LARGE END. For curved logs, measure along the curve. The minimum log length is 3.0 feet before it is a valid tally log. Record length of CWD to the nearest 0.1 feet. If a piece is broken but the two parts are still touching, then record the length end-to-end (A) or sum the lengths for broken pieces not lying in a straight line (B). If piece is broken and the two parts are not touching, then only measure the length of the piece that intercepts the sampling plane (C).

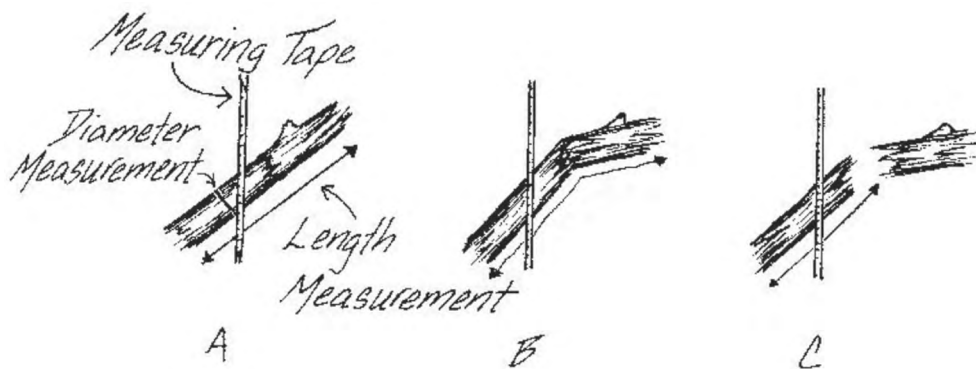


Figure 13. Log length and diameter measurement for optional CWD data. In each case the diameter measurement is made at the same point. In A and B the broken pieces are touching so length includes both pieces. In C, only the piece crossed by the measuring tape is measured for length. Image by FIREMON

Distance from Beginning of Transect to Log

This measurement makes relocation of specific logs easier. Frequently, logs that were included in pre-fire sampling roll away from the sampling plane during a fire while other logs, not originally sampled, roll into the plane. Recording the distance from the start of the line, in addition to permanently marking the logs with tags, will make post-fire sampling easier. Record the distance from the start of the measuring tape to the point where the diameter was measured.

Proportion of Log That is Hollow

This characteristic is important for wildlife concerns but also allows more accurate estimates of carbon. Estimate the percent diameter and percent length that has been lost to decay.

A piece is considered hollow if a cavity extends at least two feet along the central longitudinal axis of the piece, and the diameter of the entrance to the cavity is at least one-quarter 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.

Class	Lost to decay
0	No Loss
0.5	>0-1 percent lost
3	>1-5 percent lost
10	>5-15 percent lost
20	>15-25 percent lost
30	>25-35 percent lost
40	>35-45 percent lost
50	>45-55 percent lost
60	>55-65 percent lost
70	>65-75 percent lost
80	>75-85 percent lost
90	>85-95 percent lost
98	>95-100 percent lost

Table 5. Use these classes for recording the percent of diameter and length lost to rot in CWD

References

- Brown, J.K., R.D. Oberheu, and C.M. Johnston. (1982). *Handbook for Inventorying Surface Fuels and Biomass in the Interior West*. U.S. Department of Agriculture. Forest Service (General Technical Report INT-129.) <https://www.fs.usda.gov/research/treesearch/29401>
- Down Woody Materials Indicator*. (2004). U.S. Department of Agriculture. Forest Service. Northern Research Station. https://www.nrs.fs.usda.gov/fia/topics/dwm/documents/DWM_Training_Plan_04.doc
- Fuel Load Sampling Methods*. FIREMON. [https://www.frames.gov/firemon/sampling-methods#:~:text=The%20Fuel%20Load%20methods%20\(FL,transect%20method%20\(Brown%201974\).](https://www.frames.gov/firemon/sampling-methods#:~:text=The%20Fuel%20Load%20methods%20(FL,transect%20method%20(Brown%201974).)

Forms

Blank Forms for Field Work

The following pages have blank forms to be used for field work. Reference the preceding pages to view samples of filled out forms.

Equipment Checklist

FIELD SUPPLIES – PER CREW

- SPOT device for check-ins (1 per crew or sat phone)
- Sat phone for emergencies (1 per crew or SPOT)
- Folder with emergency action plans (EAPs) and group medical history/confidential info
- Hypsometer (Rangefinder), packed carefully with extra battery & charger (1 per crew)
- Spherical densiometer with flagging tied around it (1 per crew)
- Handheld walkie-talkie radio with extra batteries and/or charger (1 per crew)
- Camera with space on memory card, spare charged batteries, spare memory card, & charger (1 per crew)
- Inverter (for car charging; 1 per crew)
- External GNSS receiver and tablet unit with points loaded & charger (1 per crew)
- Mini-Tripod for Geode (1 per crew)
- Samsung tablet for use with Geode with points loaded & charger (1 per crew)
- Tablet or Toughbook laptop with data entry software set up and charger/battery pack (if using; 1 per crew)
- Fiberglass 100 ft or longer tape (2 per crew)
- Pin flags (10+ per crew)
- Flag bags for carrying pin flags and/or rebar (1 per crew)
- Whiteboard, whiteboard markers, & whiteboard wipes (1 set per crew)
- Chaining Pins (2 per crew)
- Rebar cut to length & caps to match (number of plots needed + 5)
- Clipboard (1 regular and 1 waterproof per crew)
- Paperwork: emergency contacts, driving directions, driving maps, field maps, authority contacts, datasheets and EXTRA datasheets (including some on waterproof paper), plot photos, and data from previous trip
- Tree calipers (if using; 1 per crew)
- Fuels gage (min 1 per crew)
- Plant ID guides (e.g. Trees and Shrubs by Jack Carter)
- Training manual, tree codes, and protocol cheat sheets (min 1 per crew)
- Calculator (1 per crew)
- Field plant press (1 per group) and blank voucher collection sheets
- Metal detector & spare batteries (if using, 1 per group)
- Scribes (if using, 1 per crew)

- Kestrel and fire weather kit (1 per group)
- Tree tagging machine + tagging kit (extra metal tape reels, nails, hammer, pocket knife, etc) (1 per crew)

FIELD SUPPLIES – PER PERSON

- Field packs (1 per person)
- Compass (1 per person)
- Clinometer & case (1 per person)
- Garmin GPS with extra AA batteries and points loaded (1 per person)
- Diameter tape (logger's tape) (1 per person)
- Arctic Vinyl orange glo heavy duty flagging (1 roll per person)
- Pencil, pen, & Sharpie (min. 1 each per person)
- First aid kit (1 per person)
- Angle gauge (if using; 1 per person – do not share)
- Field vests (optional; 1 per person)
- Rattlesnake chaps (optional)
- Hardhats (if working in windy or burned areas) (1 per person)
- Field notebook (1 per person)
- Hand lens (1 per person)
- Safety sunglasses (1 per person)
- Sun hat (1 per person)
- Leather gloves (1 per person)
- Bandanas (min 1 per person)
- Lunch & snacks (mandatory per person)
- Raincoat & rain pants (1 set per person)
- Small flashlight or headlamp with extra batteries (1 per person)
- Durable watch with alarm setting – NOT cell phone (1 per person)
- Sturdy hiking or wildland fire boots – no tennis shoes or sandals when doing fieldwork (1 per person)
- More water & Gatorade than you think you will drink (recommended 10 L/day/person)
- Toiletries – toilet paper/trowel/hand sanitizer, sunscreen, etc. (1 kit per person)
- Tree codes & protocol cheatsheets
- Pack cover or contractor trash bag

Plot Description

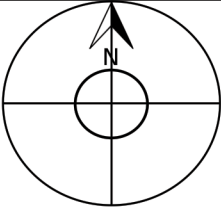
Observer: _____
 Recorder: _____
 Latitude (dd.dddd): _____
 Longitude (ddd.ddddd): _____
 Elevation (ft): _____

Administrative Unit: _____
 Project Unit: _____
 Macroplot: _____
 Date (MM/DD/YYYY): _____
 Time: _____

Photo
 Azimuths: (1) of whiteboard at PC. (1) from 75 feet N looking south to PC (4) from PC in all four cardinal directions; (1) from each Brown's transect looking toward PC.
 ORDER TAKEN & #: _____

Hill Slope (% where steepest): _____ %
 Aspect (circle one): **N E S W**
 Aspect azimuth (degrees): _____ °
 Mag Declination: _____ °

Comments:

 Describe Witness Tree(s):
 Draw location of tree on plot
 Color of Flagging/Marker Used: _____

Aerial cover (%) (1/100th acre plot)			
Tree regen.	Shrubs	Graminoids	Forbs

Macroplot Sizes		
Size (Acres)	1/100	1/10
Radius (Feet, Decimal Feet)	11.78	37.24
Radius (Feet, Inches)	11' 9"	37' 3"

Canopy (%)	
N	S
E	W

Ground cover (%) (1/100th acre plot) (total 100 %)						
Plant basal (including cacti)	Bole (woodies)	Litter	Bare soil	Rock (≥2.5in)	Gravel (< 2.5 in)	Total (%)

Species	Condition (Live, Dead, Sick)	Small Plot—Tree Regen, Shrubs & Cacti					Small Plot—Tree Regen, Shrubs & Cacti		
		Height classes—Seedlings (<4.5', <1" dbh/drc)					Species	Condition (Live, Dead, Sick)	Saplings ≥4.5', < 1"
		> 0 - 0.5'	> 0.5'—1.5'	> 1.5' - 2.5'	>2.5' - 3.5'	>3.5' - 4.5'			



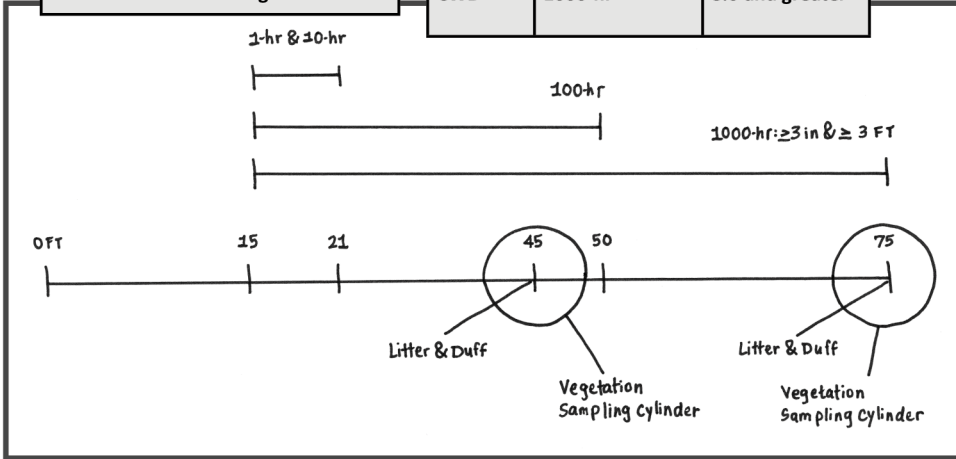
Surface Fuels

Sheet 1 of 2: Fine Woody Debris—Coarse Woody Debris

1-hour Transect Length - 6'
10-hour Transect Length - 6'
100-hour Transect Length - 35'
1000-hour Transect Length - 60'

Class		Diameter (in)
FWD	1-hr	0 to 0.25
	10-hr	0.25 to 0.9
	100-hr	1.0 to 2.99
CWD	1000-hr +	3.0 and greater

Observer	_____
Recorder	_____
Number of Transects	_____



Admin Unit:	_____
Project Unit:	_____
Macroplot:	_____
Date (MM/DD/YYYY):	_____
Time:	_____

Fine Woody Debris (1, 10, 100 hr fuels)	Transect	Azimuth	Slope	1 - Hr Count	10 - Hr Count	100 - Hr Count	Comment
	1	* Random for CFRP or (0°)					
	2	135°					
	3	270°					

Coarse Woody Debris (1000 hr fuels)	Transect	Log No.	Log Diameter	Decay Class	Comment (e.g. spp)	

Precisions: Diameter: ±0.5 in ; decay class ±1 class ; Slope ±5 percent

Decay Class Description

- 1 All bark is intact. All but the smallest twigs are present. Old needles probably still present. Hard when kicked
- 2 Some bark is missing, as are many of the smaller branches. No old needles still on branches. Hard when kicked
- 3 Most of the bark is missing and most of the branches less than 1 in. in diameter also missing. Still hard when kicked
4. Looks like a class 3 log but the sapwood is rotten. Sounds hollow when kicked and you can probably remove wood from the outside with your boot. Pronounced sagging if suspended for even moderate distances
- 5 Entire log is in contact with the ground. Easy to kick apart but most of the piece is above the general level of the adjacent ground. If the central axis of the piece lies in or below the duff layer then it should not be included in the CWD sampling as these pieces act more like duff than wood when burned.



Surface Fuels

Sheet 2 of 2: Duff, Litter, and Vegetation

Observer	_____
Recorder	_____
Number of Transects	_____
Transect Length: 75'	

Administrative Unit:	_____
Project Unit:	_____
Macroplot:	_____
Date (DD/MM/YYYY):	_____
Time:	_____

Transect	Sample Location	Litter Depth	Duff Depth	Veg Item	% Veg Cover	Veg Hgt (d.d')	Surface Fuels-Vegetation Item Code and Description
1	45'			HD			HD dead non-woody vegetation
				HL			HL Live non-woody vegetation
				SD			SD Dead woody vegetation
				SL			SL Live woody vegetation
1	75'			HD			% Veg cover Code Cover 0 No cover 0.5 >0-1 % cover 3 >1-5 % cover 10 >5-15 % cover 20 >15-25 % cover 30 >25-35 % cover 40 >35-45 % cover 50 >45-55 % cover 60 >55-65 % cover 70 >65-75 % cover 80 >75-85 % cover 90 >85-95 % cover
				HL			
				SD			
				SL			
2	45'			HD			
				HL			
				SD			
				SL			
2	75'			HD			
				HL			
				SD			
				SL			
3	45'			HD			
				HL			
				SD			
				SL			
3	75'			HD			
				HL			
				SD			
				SL			

Comments:



Data Quality Assurance Checklist

Ensuring quality data collection requires taking steps to check data during collection and before leaving the plot. This practice applies to both paper datasheets and electronic data entry. Have two crew members look over the data to ensure completion and accuracy before removing flags and leaving the plot. Some best practices for on-plot quality assurance are listed below:

1) Is data being collected consistently?

- Ensure all technicians are following all established protocols (i.e., DBH is taken from the correct height; any trees located near the edge of a plot are carefully measured with a tape; fuels transects are laid out to match photos of previous transects).
- Training on practice plots and conducting an error analysis before collecting project data can highlight any areas of inconsistency where crew members need further practice.

2) Are all protocols completed?

- If using paper datasheets, ensure every box is filled in. If no trees/seedlings/fuels were present, a line through the box or comment should indicate that this protocol was completed. Do not leave anything blank!
- If using computer/tablet data entry, ensure every protocol tab is filled out completely.
- Confirm all photos are present on the camera.
- Confirm GPS location is recorded on GPS unit and in datasheets/data entry forms.

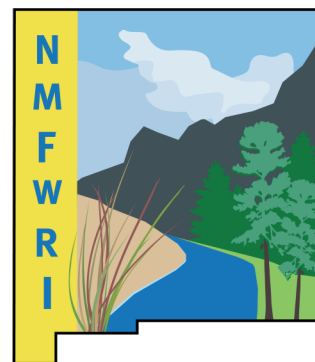
3) Within protocols, are all required data present?

- Are the plot center coordinates and elevation recorded?
- Does the witness tree have distance and azimuth recorded?
- Do all trees have a height, DBH, and status recorded? Do all live trees have a crown base height?
- Are all tree damages recorded (char/scorch, diseases, abnormal growth) with appropriate severities?
- Do all 1000-hr fuels have a diameter listed?
- Are all surface vegetation coverage values recorded? Does each have a height? Has the slope of the fuel transect been recorded? Ensure there was no height entered if the aerial cover for that category was zero.
- On paper datasheets, are final tallies counted and circled?
- Is all plot description info filled in? Does anyone else on the crew have anything to add to the comments sections?

4) Scan through data. Do data values make sense?

- Do any live crown base heights exceed tree heights?
- Do ground cover percentages add up to 100?
- Do trees with small diameters have excessive heights listed? Do trees with large diameters, and no damages, have abnormally short heights?
- Are the appropriate units used and labeled for surface fuel vegetation heights, litter, duff depths, and other measurements?
- Is all written data legible?

NMFWRI Herbarium Voucher Collection



Collection No.:

Associated Plot ID:

Date:

Collected by:

Location (site, country, state):

Latitude (dd.dddddd):

Longitude (ddd.dddddd):

Scientific Name:

USDA PLANTS Symbol:

Common Name(s):

Family:

Lifeform (forb, shrub, graminoid, tree, mushroom, bryophyte):

Species Description (height, flower color/scent, stickiness, texture, gill type, cap shape, etc.):

Habit (annual, biennial, perennial):

Habitat (ex. P-J, Ponderosa Pine, associated plants in the area, note any disturbance):

Extent of Species Population: _____ approx. # of individuals in _____ approx. area

Slope:

Aspect:

Soil Info (texture, parent material, other):



Photo by Kathryn Mahan



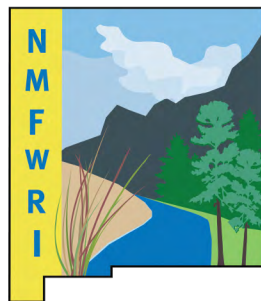
Photo by Carolina May



Photo by NMFWRI Field Crew



Photo by NMFWRI Field Crew



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