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Environmental Protection and Compliance Division

Environmental Stewardship Group

Technical Procedure

Monitoring and Documentation of Forest Management Activities for Los Alamos National Laboratory

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EPC-TP-01-2022, R0	TBD	• New document

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1.0 INTRODUCTION

Forest management treatments at Los Alamos National Laboratory (LANL) are administered by the Emergency Management Division (EMD-DO) Wildland Fire Program within the Wildland Fire and Forest Management Program (WFFM Program or the Program). Open space forest inventory monitoring is conducted by Forest Health Program staff and students within the Environmental Stewardship Group (EPC-ES). The goals of the integrated Wildland Fire and Forest Management Program are to reduce impacts to Laboratory operations from climate-driven events by implementing forest management and healthy forest initiatives such as forest thinning and erosion control. The *LANL Wildland Fire Mitigation and Forest Health Plan* (EMD-PLAN-200, LA-UR-19-25122; LANL 2019) presents treatment standards for LANL property to meet the following goals:

- Restore and maintain landscapes: LANL landscapes are resilient to disturbances.
- Develop a fire-adapted community: LANL workforce, neighbors, and infrastructure can withstand a wildland fire without loss of life and property.
- Ensure wildland fire mitigation implementation: All wildland fire mitigation working group organizations participate in making and implementing safe, effective, efficient risk-based wildland fire management decisions.

1.1 Objectives

The purpose of this monitoring plan is to establish a sampling design and data-collection procedure for measuring vegetative communities treated with wildland fire mitigations.

1.1.1 EMD-PLAN-200 Objectives Monitored by This Plan

- Implement treatments to manage vegetative communities for resilience, including fire-related disturbances
- Protect habitat for federally listed threatened or endangered species
- Minimize soil erosion and off-site sediment transport
- Assess effectiveness of fuel treatments

1.1.2 Forest Health Objectives Monitored by This Plan

- Increase forest resilience to drought and fire (i.e., achieve more water available to individual trees/shrubs by establishing lower tree density, increased water infiltration, and slower water runoff)
- Establish a mosaic forest structure in both space and time (i.e., treatments will be implemented over several years, with spatial gaps between heavily treated areas)
- Increase adequate forest gaps and openings to increase available light to and diversity of understory herbaceous vegetation
- Avoid and arrest the spread of invasive plant species, including Siberian elm, teasel, and thistles
- Preserve the oldest ponderosa pine individuals for their genetic and habitat importance

- Limit the spread of damaging insects
- Improve riparian ecosystem function (e.g., cover of native riparian vegetation and reduced channel downcutting/access of water to floodplain)
- Preserve seed sources by collecting cones from any large individuals that are removed (to be used in regional restoration efforts in severely burned areas)

1.1.3 Monitoring Plan Objectives

- Inventory forest metrics
- Use all available information (data collected on vegetation and fuel plots and scientific literature) to determine if fire and resource management objectives are being met as outlined in project scope documents and in the EMD-PLAN-200 (LANL 2019) treatment standards
- Document, analyze, and communicate short- and long-term treatment effects on vegetation communities
- Use thinning treatment monitoring data to evaluate alternative management options for desired future vegetative conditions

Table 1 provides a summary of objectives and associated monitoring objectives.

Table 1. Summary of Forest Health Objectives and Associated Monitoring Objectives

Forest Health Objectives	Monitoring Metric
Vegetative community resilience	Stand density, line-point intercept (LPI), erosion metrics
T&E habitat	1000-hr fuel loading, snag density, canopy cover
Soil erosion	Soil erosion assessment, photos
Fuel treatment effectiveness	Tree density, fuel loading
Forest structure	Stand density and species composition, tree size distribution
Gaps/openings	Stand density, drones, LPI, photos
Invasives spread	LPI, invasives early detection
Forest insects	Stand inventory and health metrics
Riparian function	Erosion monitoring, photos, stream gauge data, LPI, riparian mapping
Seed source	Tree life stage

1.2 Purpose and Need for Monitoring Plan

Treatment monitoring is necessary to assess fuel reduction and other treatment effectiveness at improving forest resiliency and protecting threatened and endangered species habitat (EMD-PLAN-200, LANL 2019). The *2008 Site-Wide Environmental Impact Statement* (SWEIS) analysis assumes that wildfire management practices are in place to protect LANL facilities through tree thinning, monitoring regrowth, and prescribing fire (DOE 2008). Through integration of the WFFM Program implementation and monitoring programs, wildfire risk reduction is formally documented, as required by EMD-PLAN-200, through Annual Operating Plans (EMD-PLAN-201, R2, LA-CP-22-20056; LANL 2022), and the February 2021 Audit Report, *The Department of Energy's Wildland Fire Prevention Efforts at the Los Alamos National Laboratory*, by the U.S. Department of Energy Office of Inspector General and Office of Audit Services (DOE-OIG-21-13; DOE 2021), which emphasized the need for formality and documentation.

> . . . Mitigation measures such as tree thinning identified in the 2014 LANL Forest Management Plan (Forest Plan) and 2016 LANL Five-Year Wildland Fire Management Plan (Wildland Fire Plan), which are necessary to reduce the risk of crown fires, were not always performed, increasing the potential for a devastating wildland fire to spread. . . . Further, we could not obtain evidence demonstrating that annual planning and preparedness activities were completed as required. Without documenting planning and preparedness activities, there was no assurance that all prevention and mitigation options were considered and that the site was fully prepared for wildland fire events. . . . In addition, the issues we identified also occurred due to a lack of formality in the implementation of the Wildland Fire Plan. . . .

This monitoring plan describes the WFFM Program data collection variables, sampling design, data collection protocols, data management, and analysis procedures to best fulfill the requirements laid out by the SWEIS and PLAN-EMD-200 (DOE 2008, LANL 2019). Pre- and post-treatment monitoring (i.e., evaluation monitoring) will be conducted at all Open Space treatment project areas. Formalized treatment monitoring provides documentation of all treatments conducted on LANL property by the WFFM Program. All monitoring will be documented with quantitative data collection (outlined below) and with visuals, such as photos and geographic information system mapping. Information will be collected on trees per acre, basal area, tree size, crown base height, understory vegetation, fuel loading, soil cover, and erosion risk. Ground-truthed data are necessary to validate fire risk assessment, identify silvicultural treatment prescriptions, and for forest health and resilience treatment planning. The documentation of all monitoring data and treatments formalizes the necessary requirements to fulfill the wildfire management best practices in the SWEIS and EMD-PLAN-200 (DOE 2008, LANL 2019).

Forest Health Program staff consulted and collaborated with nearby land management partners to establish a monitoring program; thus, portions of this report are adapted from the "Valles Caldera National Preserve Fire Ecology Program, Fire Ecology Monitoring Plan, Updated 2021" and "The Interagency Fuel Monitoring Protocol Manual" by Tall Timbers and the U.S. Fish and Wildlife Service (Trader 2021, Tall Timbers 2020).

Adaptive Management

The WFFM Program Wildland Fire and Forest Management Team is committed to following the adaptive management process, of which monitoring is an essential component. Adaptive management is the process of continually adjusting management strategies in response to new information, knowledge, or technologies. It is “A process for implementing management decisions that requires monitoring of management actions and adjustment of decisions based on past and present knowledge. Adaptive management applies scientific principles and methods to improve management decisions incrementally as experience is gained and in response to new scientific findings and societal changes” (Trader 2021).

The WFFM Program uses an adaptive management approach to implement deliberate and measurable mitigation treatments. The adaptive management cycle begins with developing a plan that articulates the project’s goals, objectives, and strategies. The plan is then implemented, and the actions and responses are monitored. Monitoring those mitigation treatments informs whether the conditions produced are favorable, sustainable, and maintain or improve the ecosystem, which then helps to inform further realistic objectives for desired vegetative conditions. Adaptive management requires evaluating if fire and resource management objectives are met and to determine if additional treatments are needed. If unexpected trends are identified, the WFFM Program can re-evaluate and/or revise objectives. When this information is used to re-evaluate the forest management program and to revise goals or objectives, the adaptive management process comes full circle.

2.0 PRECAUTIONS AND PREREQUISITE ACTIONS

2.1 Precautions

The work described in this procedure is fieldwork and has a Moderate Hazard rating. Hazards of the work described in this procedure are controlled through the site-specific integrated work documents (IWDs). An approved IWD must be used in conjunction with this procedure, and all associated training must be up to date.

Before beginning the work described in this procedure, field staff must review safety needs and requirements, identify hazards, and develop hazard mitigation measures. For safety reasons, at least two people are required to work together in the field.

2.2 Planning and Coordination

While scheduling fieldwork, contact the appropriate facility operations director to be added to the Plan of the Day for the designated area. Before starting fieldwork, personnel shall conduct a pre-job tailgate meeting to go over activities, safety hazards, security concerns, and environmental controls associated with the work. The pre-job tailgate should remind personnel that they have the authority to stop/pause work when an activity poses a safety, security, or environmental compliance concern. If fieldwork is being performed at multiple locations within the same trip, additional tailgate briefings should be held at each location that has different activities, hazards, security concerns, or environmental controls associated with the work.

2.3 Equipment and Tools

Table 2 lists materials that are to be brought to the field for data sampling. The quantities needed depend on the number of people sampling a plot. It is advisable to have extra tools on hand in case equipment is lost or broken in the field.

Table 2. Field Work Monitoring Equipment

General Field Equipment	General Personal Gear	Field Electronics
• Ten-factor wedge (glass) prism • Chaining pins • Compass • Data sheets, paper, and pens • Diameter tape (D-tape) • Densiometer • Fuel sampling rod • Flagging tape • Go/no-go gauge • Suunto clinometer • Transect tape (T-tape)	• Backpack, optional • Personal protective equipment, such as – Hi-vis mesh vest – Appropriate footwear – Safety glasses or sunglasses – Hat, optional – Work gloves, optional – Sunscreen and/or insect repellant – First-aid kit – Hard hat, when appropriate	• Anemometer • Bad Elf GPS* unit • iPad • LANL radio • LANL phone • Laser hypsometer • Battery pack and charging cables • LiDAR unit**

*GPS = geospatial positioning system.
**If the light detection and ranging (LiDAR) unit is to be brought into the field, additional equipment may be necessary.

3.0 MONITORING LEVELS AND FREQUENCY

The WFFM Program conducts different mitigation treatments across Lab property. Table 3 lists the different ways in which these treatments are monitored.

Table 3. Monitoring Intensities

Mitigation Treatments	Primary Monitoring	Supplemental Monitoring
Open Space	• Pre- and post-treatment monitoring • Photo monitoring	• Fuel transects • Line-point intercept • Visual indicators of erosion
Fire Roads	• Wildland Fire Road Inspection Form (EMD-FORM-370; LANL 2020a) • Photo monitoring	• Visual indicators of erosion
Wildland Fire Roadside	• Wildland Fire Roadside Mitigation Inspection Form (EMD-FORM-371; LANL 2020b) • Photo monitoring	• Visual indicators of erosion

Mitigation Treatments	Primary Monitoring	Supplemental Monitoring
Defensible Space	• Wildland Fire Defensible Space Inspection Form (EMD-FORM-372; LANL 2020c) • Photo monitoring	N/A
Firebreaks	• Wildland Fire Break Inspection Form (EMD-FORM-373; LANL 2020d) • Photo monitoring	• Visual indicators of erosion
Utility Infrastructure	• Wildland Fire Mitigation Treatment – Utility Infrastructure Inspection Form (EMD-FORM-374; LANL 2020e) • Photo monitoring	• Visual indicators of erosion • Line-point intercept
Firing Site	• Monthly inspections by Fire Management Officer (WFO-OP-276; LANL 2021a) • Photo monitoring	N/A

Primary monitoring for five of the seven mitigation treatments follows inspection forms EMD-FORM-370 through EMD-FORM-374 (LANL 2020a through LANL 2020e). This plan focuses on Open Space treatments that require full evaluation monitoring to provide information on fuel reduction and vegetative structure changes as a result of management actions. These data allow fire and resource managers to make a quantitative evaluation of whether management objectives are being met.

Monitoring is conducted pre-treatment, immediately post-treatment, 1-year post-treatment, and 2 years post-treatment for short-term monitoring. Monitoring continues at 5 years post-treatment, 10 years post-treatment (and every 10 years following) for long-term monitoring. Long-term monitoring can reveal significant trends to help guide fire management planning and decision making.

4.0 OPEN SPACE TREATMENT MONITORING

A list of monitoring metrics associated with Forest Health Objectives are covered in Table 1 with data collection variables outlined below in Section 4.4.

4.1 Plot Identification Codes

Project areas are named by technical area (TA) or physical feature (e.g., a watershed or canyon). Project areas are stratified by vegetative community into relatively homogenous units, and sampling plot locations are randomly located within units. Plot data files follow a standard nomenclature. Open Space Treatment plots are identified with two unique identification codes, Forest Health Plot Code and LiDAR Plot Code, as shown in Table 4.

Table 4. Plot Identification Codes

Forest Health Plot Code example: TA08_5_01_2022 (TA##_UnitX_##_YYYY)	
TA08	Technical area of the plot or physical feature (e.g., a watershed or canyon)
5	Monitoring unit number designated by Forest Health personnel, generally based on stand delineation from aerial imagery
01	Plot number; plots are numbered consecutively within each unit
2022	Year
LiDAR Plot Code example: LANLP_20220819_0002 (XXXXX_YYYYMMDD_####)	
LANLP	Five-letter label that describes the location within LANL property boundaries
20220819	Year (YYYY), month (MM), and date (DD)
0002	Plot number; plots are numbered consecutively within each unit

4.2 Sampling Design

Plots are randomly located using a geographic information system (GIS) within a unit for an average of one plot established for every 3 acres of a monitoring unit. Using Avenza Maps (Avenza 2023) for LANL mobile devices, plot centers are located in the field, and latitude/longitude decimal degree coordinates are determined with a GPS unit (Wireless Component Plan, SD-016-CP-138/L2; LANL 2021b). All GIS data are stored in the Forest Health GIS Application maintained and operated by the GIS team at LANL.

There is one primary sampling plot design (Figure 1). Data are collected before the treatment is implemented. The first visit to a plot is recorded as pre-treatment. The sampling plot design is a 20-m transect cross (Figure 1) with two perpendicular 20-m transects that intersect at plot center and arms stretched in the cardinal directions.

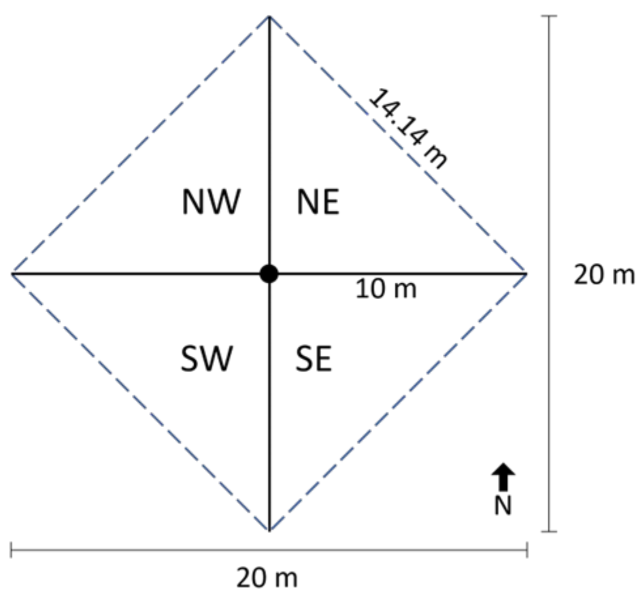

Figure 1. Sampling plot design includes two 20-m transects that intersect perpendicularly at plot center (circle) in the shape of a cross. Overstory trees are sampled by quadrant clockwise (NE, SE, SW, NW). Line-point intercept sampling occurs at every meter along the transect, for a total of 40 recorded points. Coarse, woody debris is subsampled along each arm of the cross. The blue dashed lines that form a diamond outline the boundary for the midstory tree sampling.

4.3 Data Sheets

There is a data sheet for tree sampling and a data sheet for fuel sampling (Appendix 1). The fuel sampling data sheet includes the plot information, line-point intercept, coarse woody debris, and fuelbed depth. Shrub and midstory tree data are collected on separate forms. The tree sampling and densiometer data are typically collected on a LANL iPad in Excel, however, may be collected on paper data sheets.

Units are inconsistent throughout this document. English units are the standard for forest measurements, but the sampling design was created using metric units to align with the scientific community. Therefore, most data collected in the field are written in English units whereas the transect lines are described in metric units.

4.4 Data Collection Variables and Calculations

This section contains a general description of data collected at each plot and the common calculations for each variable. The sampling design and methodology were being created and refined while collecting data, so the monitoring data collected in 2022 might not contain all variables presented in the following subsections.

4.4.1 Photographs

Nine photographs are taken at each plot using a LANL-owned digital camera or phone. Photos are taken from plot center facing each cardinal direction (N, E, S, W), intercardinal direction (NE, SE, SW, NW), and one additional photo of the plot center from 10 meters south. The same photos are taken at each subsequent visit to each plot. The photos can be used as a visual comparison of vegetation and fuel changes over time at the same point. Additional photo-monitoring procedures are described in the following subsections.

4.4.2 Overstory Tree Inventory

Using a 10-factor wedge prism, tree data are collected from the center of each plot. The prism should be held directly over the plot center and targeted at the diameter at breast height (DBH; 4.5 ft high) of any tree in the general plot area. Starting in the NE quadrant and working clockwise with a wedge prism (Figure 2), categorize each tree as either “in” or “out” (“borderline” trees are considered in following Tall Timbers 2020), and record all tree data for in trees on the data sheet. With a 10-factor prism, each in tree accounts for 10 ft^2/acre of basal area.

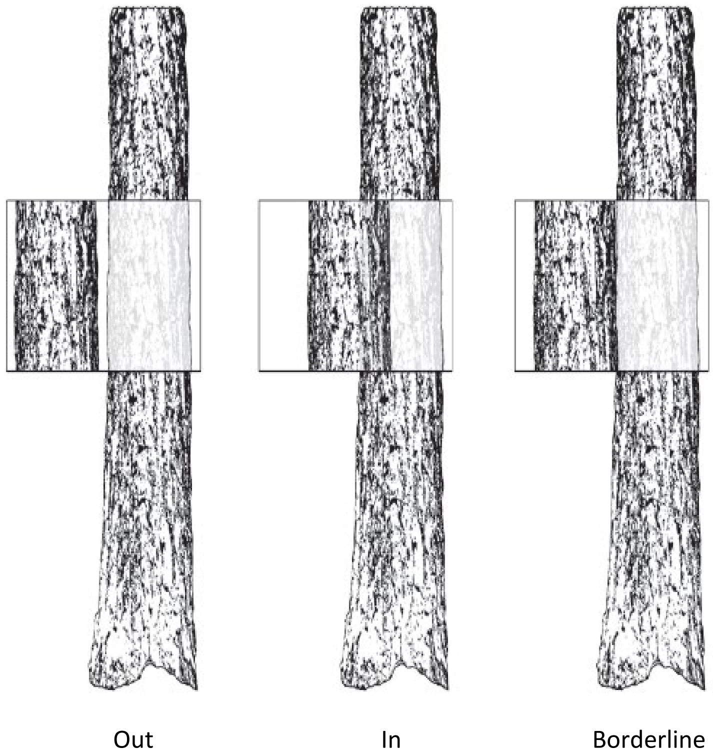

Figure 2. Classification of "out," "in," and "borderline" trees using a wedge 10-factor prism is based on whether the refraction of the stem in the prism intersects the actual stem. Data are collected for all in and borderline trees.

Summary of information collected for overstory trees: genus and species, DBH, height, crown base height, crown ratio, damages (Table 5) status (live or dead), life stage (specifically for ponderosa pine; Table 6); snag decay class (if dead; Figure 3 and Table 7), crown class (open grown, dominant, co-dominant, intermediate, suppressed; Figure 4), and quadrant located within the plot (Figure 1).

Common calculations for overstory trees: density (trees per acre, basal area live/dead) and frequency by plot, species, nativity, DBH, and height class. Average crown base height and crown ratio (live and/or dead) by plot, species, DBH, and height. Tree damage summary.

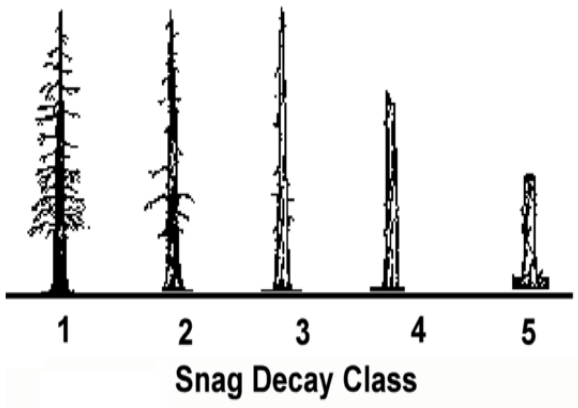

Figure 3. Snag decay classes adapted from Thomas et al. 1979.

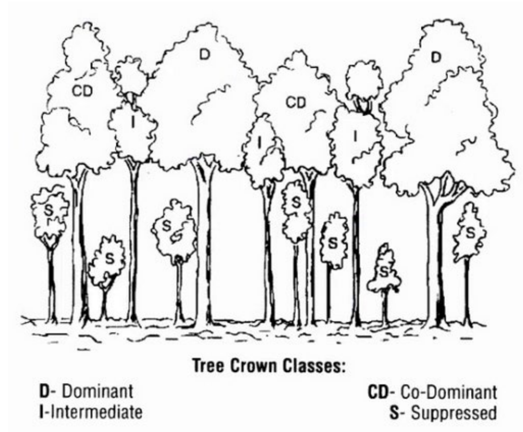

Figure 4. Tree crown classes.

Table 5. Damage Codes

Code	Description	Code	Description	Code	Description
ABGR	Abnormal Growth Pattern	FRST	Frost Crack	ROTT	Rot, Fungus (not CONK)
BIRD	Bird (Woodpecker Holes)	GALL	Galls	SNAG	Snag
BROK	Broken Top	HOLW	Hollowed Out	SNAP	Snapped near base
BROM	Witches Broom	INSE	Insects or their Sign	SPAR	Unusually Sparse Foliage
BURL	Burl	LEAN	Tree is Leaning	SPRT	Sprouting from Base
CONK	Conk, Shelf Fungus	LICH	Lichen	TWIN	Twinned Tree – Below DBH
CROK	Crooked or Twisted Bole	LIGT	Lightning Scar	YELL	Yellowing Foliage
DTOP	Dead Top	MAMM	Mammal-caused	UMAN	Human Caused Damage
EPIC	Sprouting from Bole/ Limbs	MISL	Mistletoe Present	WOND	Wound, Cracks, etc.
FIRE	Fire Scar/Cambial Damage	MOSS	Moss		
FORK	Forked Top	ROOT	Large Roots Exposed		

Table 6. Life Stages of Ponderosa Pine*

Life Stage	Age	Crown Shape	Live Crown Ratio (LCR)	Branches	Trunk Shape	Bark	Likely Injuries
1	Seedling	Pointed top, dense foliage	Large	Many fine, dense near trunk		Greyish brown	
2	Young subcanopy	Pointed top, dense foliage	Large	Many fine, dense near trunk			
3	Young canopy (<150 years)	Pointed top, “teardrop” or “Christmas tree” shape, dense foliage	Large	Many fine, dense foliage near trunk	Tapered	Large, coarse flakes, deep fissures, dark grey or black with dark orange	Very few; possible mistletoe or lightning scars
4	Old growth transitional/ legacy (150–250 years)	Ovoid, flattening on the top, full and rounded	Moderate; perhaps half the trunk, beginning to self-prune	Fine branches in interior of crown dying, longer branches thickening	Beginning to lose taper	Orange or grey flakes with dark edges, shallow fissures, becoming smoother, plated or deeply furloughed bark, yellowish color	Relatively few; possibly/mostly healed
5	Old growth/ legacy (>200 years)	Flattened, “bonsai” shape, sparse and open, may be lopsided	Small; often fire-pruned	Few but large	Columnar	Smooth, small flakes, pale orange or grey	Fire scars, dead tops, broken branches, lightning scars, rot, burls, exposed roots

*Adapted from Huckaby et al. 2003.

Table 7. Snag Decay Classes*

Class	Bark	Heartwood Decay	Sapwood Decay	Limbs	Top Breakage	Bole Form	Time since Death
1	Tight, intact	Minor	None to incipient	Mostly present	May be present	Intact	≤5 years
2	50% loose or missing	None to advanced	None to incipient	Small limbs missing	May be present	Intact	>5 years

Class	Bark	Heartwood Decay	Sapwood Decay	Limbs	Top Breakage	Bole Form	Time since Death
3	75% missing	Incipient to advanced	None to 25%	Few remain	Approx 1⁄3	Mostly intact	>5 years
4	75% missing	Incipient to advanced	+25%	Few remain	Approx 1⁄3 to 1/2	Losing form, soft	>5 years
5	+75% missing	Advanced to crumbly	+50% advanced	Absent	Approx +1/2	Form mostly lost	>5 years

*Adapted from Raphael and Morrison 1987.

4.4.3 Midstory Tree Inventory

The midstory trees consist of pole-sized trees and seedlings. A pole-sized tree is defined as any tree with a DBH ranging from 1.0 to 6 inches; a seedling is any tree that has a DBH less than 1.0 inch. All midstory trees are measured within approximately a 1/20-acre plot created by connecting the ends of each transect, as depicted in Figure 1 . Root collar diameter (RCD) will be measured for clusters of oaks and junipers.

Summary of information collected for pole-sized trees: genus and species, DBH, number of stems or individuals, height, crown base height, crown ratio, damages (Table 5), status (live or dead), and quadrant located within the plot (Figure 1).

Summary of information collected for seedlings: genus and species, DBH (if seedling is 4.5 ft tall), RCD, number of stems or individuals, height class, status (live or dead), and quadrant located within the plot (Figure 1).

Common calculations for midstory trees: density (trees per acre, basal area live/dead) and frequency by plot, species, nativity, DBH, and height class. Average crown base height and crown ratio (live and/or dead) by plot, species, DBH, and height. Tree damage summary.

4.4.4 Shrub Inventory

Shrubs are measured in a belt transect along the N/S transect line. The dimensions of the belt transect are either 20 m × 2 m or 20 m × 5 m, depending on the vegetation community or project area. Shrubs are distinguished from trees by their multiple stems and shorter height and are less than 30 ft tall. The genus and species, number of stems or individuals, and status (live or dead) are recorded.

Summary of information collected for shrubs: genus and species, number of individuals, and status (live or dead).

Common calculations for shrubs: density and frequency by various groupings such as by plot, genus and species, native, non-native, and live vs dead.

4.4.5 Canopy Closure

Canopy closure is a measure of how dense the overstory canopy is. Data are collected using a spherical densiometer from the center of each plot and at the end of each transect arm. At each point, the data are collected while the observer faces in the four cardinal directions. The densiometer has a convex mirror that reflects a large overhead area. A cross-shaped grid is etched over the surface of the mirror, making it possible to estimate the percentage of the overhead area that is covered with forest canopy. To convert canopy closure estimates to canopy cover, see Paletto and Tosi 2009.

Summary of information collected for canopy closure: canopy closure estimates at plot center and the end of each transect arm (in four different directions) for each plot.

Common calculations for fuel transects: average percent of canopy closure per point, by plot, or by area.

4.4.6 Line Point Intercept

Line-point intercept (LPI) is a technique used to quantify soil cover as it changes across an area. Soil cover includes understory plant species, litter, rock, or biological crusts. It uses "points" (or regular interval-sampling locations) along a "line" to rapidly record site ground cover and plant species where the points "intercept" (Figure 5). When used in conjunction with other sampling methods, LPI helps construct a robust understanding of the overall health and wellbeing of a particular site and that site's initial propensity to recover from disturbance.

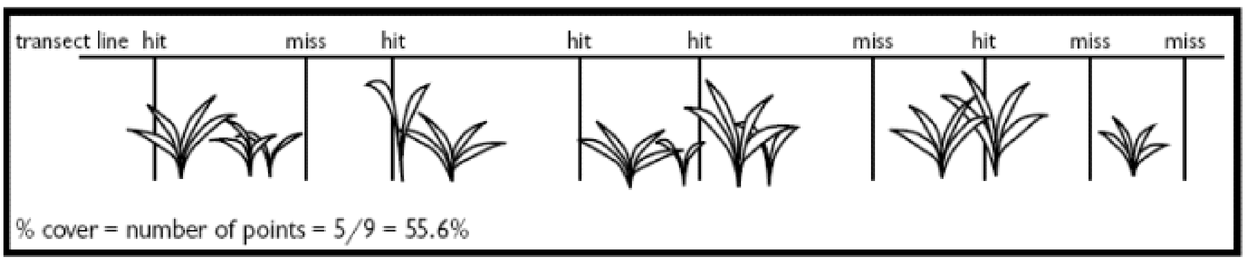

Figure 5. Line-point intercept allows the rapid measurement of soil cover by documenting vegetation and litter along a transect (Elzinga et al. 1998).

Using the dual 20-m crossed transect design, LPI data are collected along both transects, starting at 0.5 m at both the north and west transects. The soil cover intercepted is recorded every 1 m from there (1.5 m, 2.5 m, etc.), ending at 19.5 m. This process gives a total of 20 measured points per transect and 40 total measured points per plot.

To measure at a point, hold the measuring rod approximately 10 cm from the ground and let the rod fall freely toward the ground, using the interval being measured as the target. The rod does not need to be exactly touching the transect line nor aligned with the interval being measured; the measurement is meant to be random.

Once the rod is in place, record what intercepts the measuring rod at each point, starting at the top of the rod and moving down toward the ground. Call out species codes or functional groups of intercepting vegetation to be recorded on the data sheet. Species are not repeated if more than one individual intercepts the rod at the same point. Wind may blow light vegetation, such as grasses, into the measuring rod. This vegetation should not be counted unless it makes contact without outside influence.

Once all live vegetation has been measured, the presence of litter, duff, and soil are recorded. Cover types are counted at a point only if they physically touch the measuring rod when it is lowered to the ground at that point. If the measuring rod drops on a solid object (oak leaf, pinecone, stick, rock, etc.), then don't count any other materials beneath the object. Bare ground or soil should be counted only if it is visible without removing litter or duff.

The following are not recorded: trunks of trees, mosses, or lichens.

Summary of information collected at each point along a 40-m vegetation transect: category of all plants touching the pole at each point, substrate if no litter is encountered, status (live or dead).

Common calculations for vegetation: species richness, percent cover, groundcover percentages, and frequency by various groupings, such as by plot, species, nativity, lifeform (i.e., grass, forb, shrub, tree), and lifecycle (annual/biennial/perennial).

4.4.6.1 LPI Cover Categories

- Live Vegetation
  - Graminoids (grasses, sedges, rushes)
  - Woody (shrubs, saplings)
  - Forbs (non-woody herbaceous plants)
- Ground Cover
  - Bark
  - Pinecone
  - Deciduous litter
  - Woody litter (sticks, twigs, stumps, logs, etc.)
  - Short-needle litter (includes firs, Douglas firs, junipers, etc.)
  - Long-needle litter (includes pines)
  - Fine litter (dead grass, forbs)
  - Bare ground
  - Rock

4.4.6.2 LPI Ground Cover Estimates

Percent ground cover from a sampling plot can be calculated for each of the measured ground cover categories (Figure 6). Taking the total number of intercepts per cover type and dividing it by the total number of LPI points in the plot (40) gives the portion of ground covered by that cover type. Multiplying that result by 100 gives a ground cover percentage of that cover type.

Cover Type	G	W	F	O		BG	R	WL	LN	SN	FL	B	P
Total Points:	9	15	7	0		2	1	6	35	27	3	5	7
Percent Cover (Total/40)×100	22.5	37.5	17.5	0		5	2.5	15	87.5	67.5	7.5	12.5	17.5

Figure 6. Example of line point intercept percent cover estimates. The cover type is listed by category, total points is the number of times that category was counted, and percent cover is calculated by dividing the points by the total possible number of points (40) and multiplying by 100.

4.4.7 Coarse, Woody Debris (Fuels)

The Brown's Line (Brown 1974) is a standard sampling method used to assess dead and down fuels. Downed woody material is dead twigs, branches, stems, and boles of trees and shrubs that have fallen and lie on or above the ground. Parameters measured include 1-, 10-, 100-, and 1000-hour fuels (also called "time-lag fuels") and litter and duff depths. The term "hour" refers to an estimate of how long (i.e., 1 hour) it takes for the moisture percentage of the particular fuel to reach within 66 percent of equilibrium with the local environmental conditions. All time-lag fuels are defined by diameters: 1-hour fuels are 0–0.25 inches in diameter; 10-hour fuels are 0.25–1.0 inches in diameter; 100-hour fuels are 1.0–3.0 inches in diameter; and 1000-hour fuels are 3.0+ inches in diameter.

The same four transect arms are measured for LPI and Brown's line. Forest Health staff record 1-, 10-, 100-, and 1000-hr fuels, including pinecones, for the entire length of the transects using the planar intercept method for down and dead woody fuels. Record the number of intercepts of woody fuels along the transect by size class. If the sampling plane intersects a curved piece more than once, tally each intersection.

The diameter (e.g., 3.7 inches) of each 1000-hr fuel is recorded perpendicular to the central axis of the piece at the point where it intersects the sampling plane. The species is noted, if known. The decay class is recorded (Table 8 and Figure 7). For rotten logs that have fallen apart, try to estimate its original diameter. Tally uprooted stumps and roots not encased in dirt. Do not tally undisturbed stumps.

Table 8. Log Decay Classes*

Class	Bark	Twigs	Texture	Shape	Wood Color
1	Intact	Present	Intact, hard when kicked	Round	Original
2	Intact	Absent	Intact, hard when kicked	Round	Original
3	Trace	Absent	Hard large pieces	Round	Original to faded
4	Absent	Absent	Soft blocky pieces	Round to oval	Light to faded brown
5	Absent	Absent	Soft, powdery	Oval	Faded light yellow or grey

*Adapted from British Columbia Ministry of Forests and Range 2008.

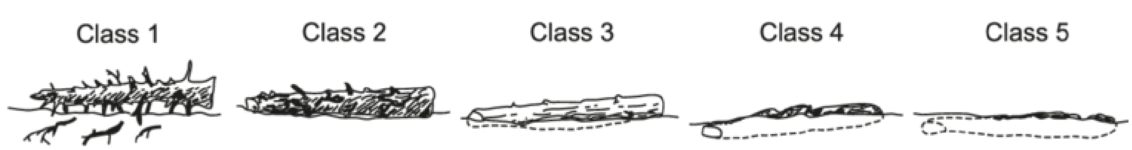

Figure 7. Log decay classes adapted from British Columbia Ministry of Forests and Range 2008.

If consistently distributed, masticated material is abundant on the plot, subsample the 1-hr and 10-hr fuels between 4.5–6.5 N, 14.5–16.5 S, 4.5–6.5 W, and 14.5–16.5 E and multiply the total

1-hr and 10-hr fuels by 5. Count all 100-hr, 1000-hr fuels, and pinecones along the entirety of the transect arms.

Summary of information collected on fuel transects: number of 1-, 10-, 100-, and 1000-hour fuels, diameter of log at tape, species, and decay class.

Common calculations for fuel transects: average fuel load (tons/acre) of 1-, 10-, 100-, and 1000-hour fuels (solid vs. rotten or combined), and total fuel load.

4.4.8 Fuelbed Depths

Mark the fuels at each point before disturbing the area by measuring fuelbed, litter, and duff depths. Fuelbed is the height from the top of the litter layer to the tallest live plant material with a maximum height of 4.5 ft (breast height). Litter is the surface layer of the forest floor that is not in an advanced stage of decomposition, while duff is the layer beneath litter consisting of partially decomposed organic material.

Fuelbed, litter, and duff depths are taken at regular intervals along each transect tape, for a total of 12 measurements. On the north-south and east-west lines, depths are taken at 2.25, 4.5, 6.75, 12.25, 14.5, and 16.75 meters. If no fuelbed is present, record as "0." If trace amounts exist, record as 0.1 and at 1-cm intervals afterward. Fuelbed depth is sampled within a plane 12 inches on each side of the measurement point perpendicular to the tape, with a maximum fuelbed depth of 1.4 m in height. Litter and duff measurements are taken at the sample point. Duff depth is taken down to mineral soil without compressing the duff.

Summary of information collected for fuelbed depths: litter and duff depth at 12 points along the transects.

Common calculations for fuels: average fuel load (tons/acre) of litter and duff, and total fuel load; litter and duff depths.

4.5 Step-by-Step Sampling Procedure for Data Collection

To collect data efficiently and accurately in the field, especially when using a LiDAR unit, an optimum order of sampling operations has been established. Following these operations in order will ensure that sampled data are not trampled by technicians or equipment.

1. Fill out the plot information at the top of the data sheet (plot name, date, observers, etc.).
2. Place a plot marker at plot center and use the Bad Elf GPS unit (LANL 2021b) to determine lat./long. decimal degree coordinates.
3. Stretch a transect tape 12 m north of plot center, place the Fuel Series/LiDAR target placard and 6-ft pole into the ground, and reel in the transect tape.

4. Place the LiDAR scanner on the tripod at maximum height, and situate the tripod so that the laser is directly over the plot center.

5. Turn on the laser, and press the green button on the laser (see scanning below). Once scanning is complete, remove and pack up the laser. Write the time that the scan was started on the data sheet.

6. Create a 40-m fuel transect cross (Figure 1) with two perpendicular 20-m transects that intersect at plot center and arms stretched in the cardinal directions. Do not trample the fuels while laying the transects. Take photos of plot center and from plot center in each cardinal and intercardinal direction.

7. Do a prism pass by holding the prism directly over the plot center, targeted at the DBH (about 4.5 ft high) of any tree in the general plot area. Starting in the NE quadrant and working clockwise, categorize each tree as either “in” or “out” (borderline trees are considered “in” following Tall Timbers 2020; Figure 2), and record all tree data on the data sheet.

8. Record densiometer readings at plot center and at the end of each transect arm.

9. Start line point intercept sampling (Figure 5) at 0.5 m on the N→S Transect and then 0.5 m on the W→E transect to follow the labels on the data sheets. Sample every meter (1.5, 2.5, 3.5, etc.). There should be a total of 40 points sampled.

10. Collect fuelbed depth measurements at 2.25, 4.5, 6.75, 12.25, 14.5, and 16.75 meters for the north/south arms and 2.25, 4.5, 6.75, 12.25, 14.5, and 16.75 meters on the east/west arms.

11. In addition to point intercept sampling, tally any coarse woody debris that crosses the transect. If masticated material is abundant at the plot, subsample the 1-hr and 10-hr fuels between 4.5–6.5 N, 14.5–16.5 S, 4.5–6.5 W, and 14.5–16.5 E and multiply the total 1-hr and 10-hr fuels by 5. Count all 100-hr fuels, 1000-hr fuels, and pinecones along the entirety of the transect arms.

5.0 DATA MANAGEMENT, STORAGE, CALCULATIONS, AND REPORTING

5.1 Data Management and Quality Control

An essential element of a successful monitoring program is implementing and maintaining a system for quality control and management of data. All employees in all positions in the Forest Health Program are responsible for following data collection protocols and for accurately entering data. The fieldwork lead is responsible for properly training employees in field operations and ensuring that employees have read and understand the Monitoring Plan. Data sheets are checked for error before leaving the field and again after entering data.

5.2 Data Storage

All data sheets are organized into treatment-specific binders and folders and stored in the Forest Health office. Copies of the data sheets are stored virtually within the Wildland shared folder in the ENV folder of the dcstorage server. Data are entered and stored in Microsoft Excel, which is used for basic data calculation summaries; R is used for more advanced analysis (R Core Team 2022).

5.3 Data Calculations and Analysis

The role of the Forest Health Program is to gather, analyze, and present summary report information. The results of monitoring data are used to

- develop fire and resource management objectives,
- evaluate if fire and resource management objectives are being met,
- measure the effectiveness of fire and thinning prescriptions, and
- determine if additional research/treatment is needed.

The steps involved in data calculation/analyses and the evaluation of the treatments include the following:

- Examining and quality-checking the raw data
- Documenting the analysis process
- Summarizing and analyzing the data using Microsoft Excel or R
- Evaluating whether fire and resource management objectives are being met
- Measuring the effectiveness of fire and thinning prescriptions
- Determining if additional research/treatment is needed

5.4 Communication of Results

Results are communicated through data summary reports, posters, presentations, meetings, and discussions. Additionally, fire and resource managers can request calculations and information at any time to help guide the WFFM Program. Reports consist of data summaries by plot and unit. Reporting and discussion of the monitoring will be available as an LA-CP or LA-UR monitoring data summary report.

6.0 PHOTO-MONITORING PROCEDURE

For all photos taken, practices are in place to help ensure high quality, reproducible photos (see Figure 8 and Figure 9 for reference). These photos document project activities and track vegetation and soils changes at each plot and the photo-monitoring procedure helps to create reproducible photos which allow visual comparisons of pre- and post-treatment.

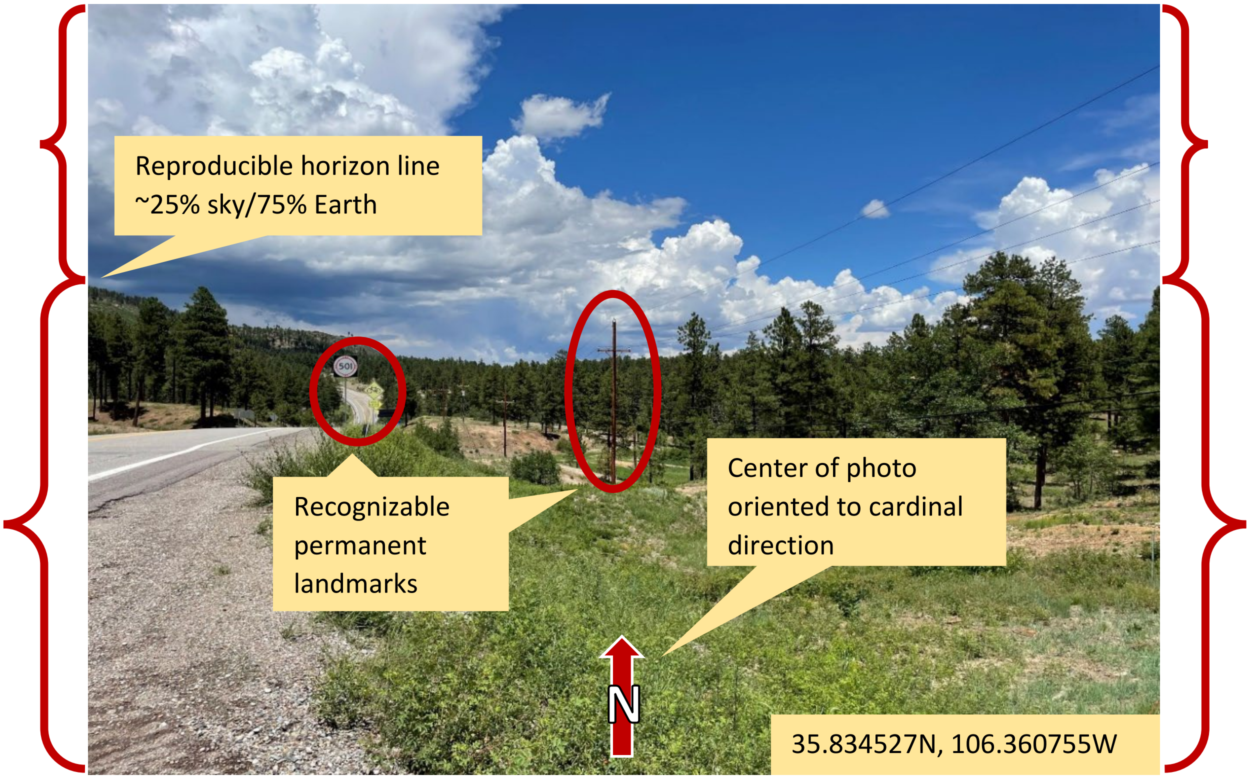

Figure 8. An example of a reproducible photo and best practices.

Figure 9. A monitoring plot photo using the Solocator App.

1. Georeference photos using any one of the following methods:

   - Solocator App (Figure 9)
   - GPS Unit (Bad Elf, Garmin, Trimble, etc.)
   - Avenza Maps App on a downloaded portable document format (PDF) map

   Do not save photos to iCloud using these apps. Ensure that any backup to iCloud is turned off in the settings of each app.

2. Align photos to cardinal directions (North, South, East, West) or include recognizable permanent landmarks as a reference: large rocks, cliff faces, road signs, power poles, etc.

3. Use the horizon as reference. The 25/75 method (25% sky/75% Earth) is a target. The 25/75 method is not always appropriate, especially in steep areas or in areas dense with trees.

6.1 Open Space Monitoring Plots

1. While both 20-m transects are still in place, stand at the center of the monitoring plot (Figure 1).

2. From the plot center, capture a photograph oriented to each cardinal and intercardinal direction (North, Northeast, East, Southeast, South, Southwest, West, and Northwest) for a total of eight photographs.

   - Each photograph must be in landscape mode. (Turn off Rotation Lock to ensure that the cardinal direction reader is in landscape mode as well.)
   - Ensure that GPS coordinates are loading. (Make sure location is turned on in the photo app to get GPS coordinates.)

3. Capture one photograph of the center of the monitoring plot. This photo should be taken from the 10-m South on the North-South transect and be oriented North.

4. Label each photo with the watermark edit feature on Solocator, using the following convention:

   Unit_Plot Number_Cardinal Direction_Pre or Post.
   The date should automatically appear on the bottom righthand side of the photo when using Solocator. Example: 5b_02_N_Pre

5. Save photos to dcstorage ENV > Wildland.

6. Once all photos from the Master Fieldwork Photos in the appropriate month are labeled by Unit_Plot Number_Cardinal Direction_Pre or Post_No GPS or GPS_Location_Date, save to the drive by their project name. Example: dcstorage ENV > Wildland

6.2 Photo-Monitoring Plots

1. Take photos using outlined best practices (Figure 8).
2. Label each photo using the following convention:

   Plot Name. Example: BackGate03

3. Save photos to dcstorage ENV > Wildland.

6.3 Additional Repeatable Photos

1. Take photos using outlined best practices (Figure 8).
2. Label each photo using one of the following conventions:
   - Brief Description with location. Example: DownedTree_LA Canyon
   - If associated with a forest inventory plot. Example: 5b_02_DownedTree

6.4 Derivative Classifier Review

Every photo taken on LANL property needs to be reviewed by a derivative classifier (DC). Photo review needs to be done in addition to respective project organization. Always contact DC reviewers in EPC-ES for review before reaching out to other DC reviewers.

Use one of the following methods to submit your photos for DC review.

- Upload photos from your LANL phone or camera, and move the photos to a specifically named folder in dcstorage ENV > Wildland.
  - DC Reviewer will change the folder name to include “DC Reviewed” once reviewed.
  - DC Reviewer will review photos in these folders when contacted about the photos.
- Email photos to be DC reviewed.
- Use RASSTI to create a submission https://int.lanl.gov/library/rassti-and-rosy/index.shtml

6.5 Remote Sensing

Remote sensing technologies, such as aerial imagery and LiDAR scans, allow for remote observation and measurement of forest characteristics. Using remote sensing technologies results in a visual representation of pre- and post-treatment conditions, which allows for a scale of measurement not realistic in field observations.

6.5.1 Unmanned Aerial Vehicle Imagery

Aerial imagery of treatment areas can be requested through the Infrastructure Programs Office Unmanned Aerial Vehicle (UAV) team. The following information is required for a UAV request:

- Map with area of interest labeled

- Specific imagery requirements

6.5.2 Aerial LiDAR (Light Detection and Ranging)

Aerial LiDAR can be used to accurately assess treatment characteristics without direct interaction and field visits. For forest monitoring purposes, aerial LiDAR can measure trees per unit area and tree height, closely estimate tree crown characteristics, and provide information on canopy gaps, closure, and percent coverage.

- Access to LANL aerial LiDAR imagery is currently provided through the GIS team. Contact maps@lanl.gov for requests.
- By-request LiDAR imagery is potentially available through the Drone Flight Request program.

7.0 RECORDS

7.1 Data

Copies of the data sheets are stored virtually on a shared drive. Paper copies are stored in the Forest Health office.

7.2 Reports

Monitoring data summary reports will have an LA-UR or LA-CP and be stored on a shared drive.

7.3 Photos

Save all photos to dcstorage ENV > Wildland.

- Open Space Monitoring Plot Photos
  - Label each photo with the watermark edit feature on Solocator using the following convention: Unit_Plot Number_Cardinal Direction_Pre or Post
- Photo-Monitoring Plots
  - Label each photo using the following convention: Plot Name
- Additional Repeatable Photos
  - Label each photo using the following convention: Brief Description with location

8.0 ACRONYMS

Acronym	Definition
DBH	diameter at breast height
DC	derivative classifier
DOE	(U.S.) Department of Energy
EMD	Emergency Management Division
EPC-ES	Environmental Protection and Compliance-Environmental Stewardship
GIS	geographic information system

Acronym	Definition
GPS	geospatial positioning system
IWD	integrated work document
LANL or Laboratory	Los Alamos National Laboratory
LiDAR	light detection and ranging
LPI	line-point intercept
RCD	root collar diameter
SWEIS	Site-Wide Environmental Impact Statement
TA	technical area
UAV	unmanned aerial vehicle
WFFM	Wildland Fire and Forest Management Program

9.0 REFERENCES

Avenza 2023. “Avenza Maps Pro,” Avenza Systems Inc, Toronto, ON. https://www.avenza.com/avenza-maps/ (2023).

British Columbia Ministry of Forests and Range. “Vegetation Resources Inventory Ground Sampling Procedures,” Version 4.8, Victoria, BC (2008).

Brown 1974. J. K. Brown. “Handbook for Inventorying Downed Woody Material,” Gen. Tech. Rep. INT-16. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest & Range Experiment Station (1974), 32 pp.

DOE 2008. U.S. Department of Energy. “Site-Wide Environmental Impact Statement for Continued Operation of the Los Alamos National Laboratory, New Mexico,” DOE Publication No. DOE/EIS-0380, Washington, D.C. (2008).

DOE 2021. U.S. Department of Energy. “The Department of Energy’s Wildland Fire Prevention Efforts at the Los Alamos National Laboratory Audit Report,” DOE Publication No. DOE-OIG-21-13, Washington, D.C. (February 2021).

Elzinga 1998. Elzinga, C. L., D. W. Salzer, and J. W. Willoughby. “Measuring & Monitoring Plant Populations,” U.S. Bureau of Land Management Papers (July 1998).

Huckaby 2003. Huckaby, L. S., M. R. Kaufmann, P. J. Fornwalt, J. M. Stoker, and C. Dennis. “Field guide to old ponderosa pines in the Colorado Front Range,” Gen. Tech. Rep. RMRS-GTR-109. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station (2003), 43 pp.

LANL 2019. Los Alamos National Laboratory. “LANL Wildland Fire Mitigation and Forest Health Plan,” EMD-PLAN-200, Revision 0, LA-UR-19-25122, Los Alamos, NM (2019).

LANL 2020a. Los Alamos National Laboratory. Wildland Fire Road Inspection Form, EMD-FORM-370, Revision 0, Los Alamos, NM (2020).

LANL 2020b. Los Alamos National Laboratory. Wildland Fire Roadside Mitigation Inspection Form, EMD-FORM-371, Revision 0, Los Alamos, NM (2020).

LANL 2020c. Los Alamos National Laboratory. Wildland Fire Defensible Space Inspection Form, EMD-FORM-372, Revision 0, Los Alamos, NM (2020).

LANL 2020d. Los Alamos National Laboratory. Wildland Fire Break Inspection Form, EMD-FORM-373, Revision 0, Los Alamos, NM (2020).

LANL 2020e. Los Alamos National Laboratory. Wildland Fire Mitigation Treatment – Utility Infrastructure Inspection Form, EMD-FORM-374, Revision 0, Los Alamos, NM (2020).

LANL 2021a. Los Alamos National Laboratory. "Vegetation and Fuels Prescription Control Requirements for Sited High Explosives Facilities," WFO-OP-276, RC, Los Alamos, NM (2021).

LANL 2021b. Los Alamos National Laboratory. "Bad Elf GNSS GPS Mapping-Grade Unit Wireless Component Plan," SD-016-CP-138/L2, Los Alamos, NM (2021).

LANL 2022. Los Alamos National Laboratory. "Los Alamos National Laboratory Wildland Fire and Forest Health Annual Operating Plan for Fiscal Year 2022," EMD-PLAN-201, Revision 2, LA-CP-22-20056, Los Alamos, NM (2022).

Paletto and Tosi 2009. Paletto, A. and V. Tosi. "Forest canopy cover and canopy closure: comparison of assessment techniques," *Eur J Forest Res* **128**: 265–272 (2009).

R Core Team 2022. "R: A language and environment for statistical computing," R Foundation for Statistical Computing, Vienna, Austria. https://www.R-project.org/.

Raphael and Morrison 1987. Raphael, R. G., and M. L. Morrison. "Decay and dynamics of snags in the Sierra Nevada, California. *Forest Sci.* **33**:3 (September 1987), pp. 774–783.

Tall Timbers 2020. "The Interagency Fuel Monitoring Protocol Manual," Tall Timbers and the U.S. Fish and Wildlife Service (2020).

Thomas et al. 1979. Thomas, J. W., R. G. Anderson, C. Maser, and E. L. Bull. "Snags," pp. 60–77 in J. W. Thomas, ed., *Wildlife Habitats in Managed Forests*, U.S. Department of Agriculture, Forest Service, Agriculture Handbook No. 553. Washington, D.C., U.S.A. (1979).

Trader 2021. Trader, L. DRAFT "Valles Caldera National Preserve Fire Ecology Program, Fire Ecology Monitoring Plan" (2021).

10.0 APPENDIX

- Appendix 1: Data Sheets

APPENDIX – DATA SHEETS
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Tier 2 Fuel Sampling Data Sheet – *Revised 11/18/2022*

Unit & Plot: ________ Date: ________ Scan Time: ________

Initials: ________ GPS: ________ LiDAR Code: ________

Did you subsample for 1 and 10 hr?
☐ Yes ☐ No
How much was subsampled per direction? (ex. 2m)
____

South to North

Slope: ________

1000-hr Tree Species	Diameter (in)	Rot Level

Course Woody Debris				
1-hr: <.25in	**10-hr**: .25-1in	**100-hr**: 1-3in	**1000-hr**: >3in	**Pine cone**
Total:	Total:	Total:	Total:	Total:

Transect Midpoint	North 2.25	North 4.5m	North 6.75	South 12.25	South 14.5m	South 16.75
FUELBED DEPTH (in)						
LITTER DEPTH (Ol) (in)						
DUFF DEPTH (Oe-Oa) (in)						

Transect Midpoint	West 2.25	West 4.5m	West 6.75	East 12.25	East 14.5m	East 16.75
FUELBED DEPTH (in)						
LITTER DEPTH (Ol) (in)						
DUFF DEPTH (Oe-Oa) (in)						

Guidelines:

Litter
Any dead grass is counted as litter, even if still rooted
In pt line intercept, only write bare ground and fine litter if there is no mulch above it.
Coarse Woody Debris
Top killed shrubs count in woody debris
Midpoints
For FUELBED DEPTH find the average height of tallest live vegetation within a foot on either side of transect tape, perpendicular to 4.5m or 14.5m point; up to height of 140 cm.
For LITTER DEPTH, only record highest continuous litter touching fuelstick at that 4.5m or 14.5m point; count loose litter (suchas a pine needle) suspended by other vegetation.
For 1 and 10 hr Fuel
Only sample from 4.5-5.5m, and 14.5-15.5m, then average across the entire plot.

APPENDIX – DATA SHEETS (CONT.)

Page 2 of 2

Line-Point Intercept Datasheet

Plot ID:

Date:

Initials:

LANL - EPC-ES Forest Health Program

Vegetation	N0.5	N1.5	N2.5	N3.5	N4.5	N5.5	N6.5	N7.5	N8.5	N9.5	S10.5	S11.5	S12.5	S13.5	S14.5	S15.5	S16.5	S17.5	S18.5	S19.5	Total:	Vegetation
Graminoid																						Graminoid
Woody																						Woody
Forb																						Forb
Other																						Other
Ground Cover																					Total:	Ground Cover
Bare Ground																						Bare Ground
Rock																						Rock
Woody Litter																						Woody Litter
L Needle Litter																						L Needle Litter
S Needle Litter																						S Needle Litter
Decid. Litter																						Decid. Litter
Fine Litter																						Fine Litter
Bark																						Bark
Pinecone																						Pinecone

Vegetation	W0.5	W1.5	W2.5	W3.5	W4.5	W5.5	W6.5	W7.5	W8.5	W9.5	E10.5	E11.5	E12.5	E13.5	E14.5	E15.5	E16.5	E17.5	E18.5	E19.5	Total:	Vegetation
Graminoid																						Graminoid
Woody																						Woody
Forb																						Forb
Other																						Other
Ground Cover																					Total:	Ground Cover
Bare Ground																						Bare Ground
Rock																						Rock
Woody Litter																						Woody Litter
L Needle Litter																						L Needle Litter
S Needle Litter																						S Needle Litter
Decid. Litter																						Decid. Litter
Fine Litter																						Fine Litter
Bark																						Bark
Pinecone																						Pinecone

Cover Type	G	W	F	O		BG	R	WL	LN	SN	FL	B	P
Total Points:													
Percent Cover (Total/40)X100													

Notes: