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Pepperwood Fire Impacts on Forest Ecology: Rapid Field Methods Description

Post-Fire Forest Vegetation Assessments following the October 2017 Northern CA Fires

Contact: Michelle Halbur (mhalbur@pepperwoodpreserve.org)
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INTRODUCTION AND BACKGROUND *Piloting Methods to Assess Fire-Vegetation Interactions*
Pepperwood is serving as a field-station and regional facilitator for in-depth multidisciplinary assessments of the impact of the October 2017 fires on Northern Californian ecosystems (please see the companion *Post-Fire Assessments Overview* summary for reference). The goal of this document is to summarize proposed methods for assessing the ecological impacts of the burn on local forests that we are piloting at Pepperwood in order to compare locations where forest fuels treatments were conducted with "no treatment" locations.

These methods are drawn from a literature review and consultations with numerous local, university, and agency science affiliates (see *Acknowledgments* and *References Reviewed*). Since there has been little post-fire research in inner Coast Range ecosystems, these methods are being customized to conditions found in our local forests and being field-tested at Pepperwood to refine time and cost estimates for potential regional applications with partners. We are presently coordinating with science affiliates to help define how to nest measurements of burn indicators described below within long-term term plots designed to capture vegetation re-establishment and recovery (long-term demographic plots and vegetation classification relevés) and remote sensing of forest resources.

PEPPERWOOD PILOT *Focusing on the Effects of Douglas-fir Thinning at Pepperwood*
At Pepperwood we have designed a pilot study that aims to assess the influence of Douglas-fir thinning relative to the October 2017 Tubbs Fire behavior via observed effects of the burn on forest ecology. 90% of our 3200-acre property burned, including nearly a thousand acres of forest comprised of Douglas-fir, mixed hardwood, and oak woodlands. Multiple research projects in forested areas were established prior to the Tubbs Fire at Pepperwood (including 50 long-term forest plots monitored by the Ackerly Lab, Department of Integrative Biology, UC Berkeley). A majority of these research plots were reoccupied immediately following the Tubbs Fire and have pre- and post-fire data sets, however the Ackerly Lab plot locations are not conducive to specifically address fuels treatment questions, which initiated the development of this pilot project. These methods may be suitable for assessing a range of vegetation

treatments on fire impacts in addition to Douglas-fir thinning, including prescribed fire and selective harvest.

The proposed methodology balances the need for a landscape-level assessment with the geographic constraints of locating treated/managed forested areas and neighboring untreated areas for comparison, plus time constraints on the pilot given available staffing and the sampling window. The National Park Service recommends capturing primary fire effects as soon after the fire as possible with most metrics collected at most two months post-fire (USDI National Park Service 2003). To ensure we can accurately assess primary fire effects, it is critical that we sample as soon as possible in an efficient manner. Pepperwood is piloting these methods in mid-January 2018, and in parallel scoping opportunities for regional applications with science and land management partners.

METHODS DEVELOPMENT *Rapid Evaluation of Primary Fire Effects on Forest Ecology*
Upon review of fire effects monitoring protocols (e.g. Alaska Interagency Fire Effects Task Group 2007, USDI National Park Service 2003, etc.) and fuels treatment and post-fire assessment reports (e.g. Fites et al. 2007, Fites-Kaufman et al. 2013, etc.) we have determined that a plot-less point-based rapid assessment would facilitate comprehensive coverage across treated and neighboring untreated areas, while efficiently providing enough data to address our questions. Specifically, we will be utilizing the plot-less Point-Centered Quarter (PCQ) method (Cottam et al. 1953) to monitor individual trees and assess forest recovery and regeneration over a 10-year period. The PCQ plot-less distance method is an efficient and unbiased method to calculate (1) relative density, (2) relative frequency, and (3) relative basal area for individual tree species. It is important to note that the PCQ method does not fully document community composition and can underestimate species diversity. If assessing community-level responses to fire is an objective, the goal would be to nest these burn assessment sites within long-term or relevé plots to collect the additional data needed to characterize changes in community structure and composition over time.

By collecting primary (immediately following fire) and secondary fire effects metrics for individual trees, combined with rapid assessment burn severity and vegetation cover data, we can investigate (1) if there were differences in fire severity between treated and untreated areas and (2) how fire behavior influences forest recovery and regeneration in our coastal forests. Furthermore, these ecological data can be used to elucidate the spectrum of fire behavior and effects captured by the Watershed Emergency Response Team (WERT) soil burn severity map categories of "Unburned/Very Low", "Low", "Moderate", and "High", hopefully making these mapped categories relevant to land managers.

These methods can be scaled up and/or nested within a monitoring program to investigate fuels management and forest recovery and regeneration questions at a regional scale. For example, these methods could be incorporated into a program that reoccupies pre-fire sampling locations to look at how fire effects shape community- or species-level change (e.g. CNPS rapid assessment plots associated with the Sonoma Veg Map program) or inversely how vegetation affects fire behavior (e.g. comparing areas with and without fuels management across the region).

PILOT OBJECTIVES

- Advance standardization of rapid field methods for characterizing post-fire vegetation composition and relative degree of ecological fire impact based on published methods and expert input
- Evaluate any measurable effects of pre-fire Douglas-fir removal treatments on wildfire impacts on forest ecology at Pepperwood in field pilot

REGIONAL OUTCOMES SUPPORTED

- Assess the impact of mechanical fuel removal pre-treatments (Douglas-fir thinning) on wildfire impacts at Pepperwood, and evaluate level of effort needed to expand this assessment throughout the 2017 Northern California burn zone
- Assess the variability of fire impacts on forest ecology within the statewide Watershed Emergency Response Team (WERT) "burn severity" map categories (at Pepperwood, especially within the "'low" category)
- Inform recommendations for regional post-fire monitoring methods to assess forest recovery in burn severity and treatment areas over time with regional partners
- Inform management recommendations for fuels treatments moving forward, with regional partners

MANAGEMENT CONTEXT

Pepperwood's forest management includes preserve-wide activities such as invasive species management, Douglas-fir removal, fuels management, and road and trail maintenance. For more information on our forest resources and management strategies, please see our *Adaptive Management Plan* for the preserve (Gillogly et al 2016). The protocols described below were developed to evaluate fire impacts in locations where Douglas-fir thinning was implemented to advance our objective "to manage fuel loads associated with mixed hardwood forests" in comparison to sites where no thinning had been conducted. Features of Douglas- fir fuel treatments at Pepperwood to be evaluated include the following.

- Mechanical removal of Douglas-fir trees with a diameter at breast height (DBH, D_{130}) of up to 10 inches (25.4 cm) using chainsaws (primarily), loppers, and other hand tools.

- Slash from mechanical removal placed on forest floor, limbed, with trunks cut to 4–6 foot-long sections.

- 2015–17 treatment sites included removing limbs along the trunks of larger trees that were left standing (ladder fuels removal).

- Some locations were subject to follow-up hand removal (hand pulling, loppers) of Douglas-fir seedlings and saplings.

Post-Fire Forest Vegetation Assessments: Pepperwood Pilot January 2018

FIELD SAMPLING PROTOCOLS

Goals

Pepperwood's forest management strategies include preserve-wide activities such as invasive species management, Douglas-fir removal, fuels management, and road and trail maintenance. For more information on our forest resources and management strategies, please see our *Adaptive Management Plan* for the preserve (Gillogly et al 2016). The protocols described below were developed to evaluate fire impacts in locations where Douglas-fir thinning was implemented to advance our objective "to manage fuel loads associated with mixed hardwood forests" in comparison to sites where no thinning had been conducted.

Sampling Point Stratification

Fifty sampling points were stratified across mapped landscape, vegetation, and burn variables listed below. Specific locations were selected remotely using Geographic Information Systems (GIS) relative to the State of California's Watershed Emergency Response Team (WERT) soil burn severity map (developed to assess burn-related impacts on infrastructure, rather than natural resources), Douglas-fir treatment areas, and the Sonoma Vegetation Map vegetation classification layers. Points were preferably placed near treatment edges, and paired with "untreated" sites in the same vicinity, located approximately 100 m apart and with untreated sites a distance of at least 50 m away from the treatment edge, if possible.

Key variables used for site selection include the following.

- Time since Douglas-fir removal (2006–2017)
- Vegetation community (Sonoma Veg Map Alliances)
    - Black oak (*Quercus kellogii*)
    - Blue oak (*Quercus douglasii*) - only one patch within treatment area
    - Coast live oak (*Quercus agrifolia*)
    - Oregon oak (*Quercus garryana*)

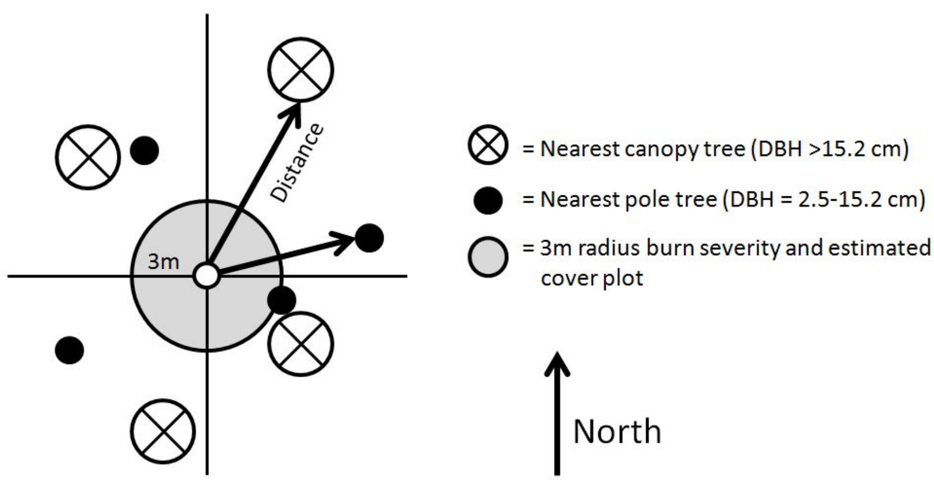
- Douglas-fir (*Pseudotsuga menziesii*)

- WERT soil burn severity map (no High severity category was mapped at Pepperwood)
  - Very Low
  - Low
  - Moderate
- Treatment type
  - Untreated (U) - This category may include areas with or without Douglas-fir encroachment before the fire came through. There is no slash from management activities on the forest floor.
  - Treated (T) - This category has been treated mechanically for Douglas-fir and has slash on the forest floor.

We did not stratify by the date/time when the fire moved through the area, but this variable could be added once available to capture important influences on fire behavior, such as the weather at the time of fire, and should be considered for regional projects. The vegetation communities sampled were selected because of their presence and abundance within and adjacent to Douglas-fir treatment areas. They also happen to be the communities we are managing for Douglas-fir encroachment.

Sampling Point Field Setup

Sampling design is based on the plot-less Point-Centered Quarter method (Cottam et al. 1953). We will establish rebar with a protective tennis ball at the center-point and the sampled area will be based on the distances to the nearest canopy and pole trees in each quadrant. See the figure below for details.



Sampling Metrics - Methods described in detail below

Attribute	When Sampled	Comments
Center-point GPS coordinates	Plot setup	UTME/UTMN
Photopoints	Every visit	Taken facing four cardinal directions (N, E, S, W); Additional photos to capture the general sense of fire severity in that area
Vegetation community	Plot setup	Pulled from Sonoma Veg Map
Slope, aspect, topoindex, climatic water deficit	Plot setup	Pulled from GIS, slope also measured in field with clinometer
Qualitative description of plot	Plot setup and every visit thereafter; Post 1 (Aug-Sept 2018), 2, 5, 10 years	Noticeable land features, rare or invasive plants of interest, general burn conditions, recent disturbances, etc. Does the area have evidence it was encroached by small Douglas-fir trees before the burn?
Tree species and relative density	Plot setup and every visit thereafter; Post 1 (Aug-Sept 2018), 2, 5, 10 years	Point-Centered Quarter method (Cottam et al. 1953)
Tree mortality	Plot setup and every visit thereafter; Post 1 (Aug-Sept 2018), 2, 5, 10 years	National Park Service Live Codes (USDI National Park Service 2003)
Tree health	Plot setup and every visit thereafter; Post 1 (Aug-Sept 2018), 2, 5, 10 years	Qualitative assessment of tree health - wounds, diseases, overall health and condition
Tree growth and productivity; relative basal area	Post 1 (Aug-Sept 2018), 2, 5, 10 years	Measured for 8 tagged trees per center-point: diameter at breast height (DBH, 1.3 m), live canopy cover, height to live canopy base, percent dead canopy; It is not recommended to measure DBH immediately after a fire (USDI National Park Service 2003) - instead wait until the next Fall season or 1-year post-fire
Canopy cover	Post 1 (Aug-Sept 2018), 2, 5, 10 years	Canopy cover at center-point measured with convex densiometer

Understory vegetation	Plot setup and every visit thereafter; Post 1 (Aug-Sept 2018), 2, 5, 10 years	In 3-meter radius plots based around the center-point: estimate relative cover of tree seedlings (no DBH) and juveniles (DBH < 2.5 cm), shrubs, forbs, grasses, litter/duff, rock, and bare soil
Burn severity index	Immediately post-fire	National Park Service's substrate and vegetation burn severity assessment (USDI National Park Service 2003)
Percent canopy leaf scorch	Immediately post-fire	Measured for 8 tagged trees per center-point; disregarding deciduous and in some cases Douglas-fir trees since our current sampling window is beyond the recommended 2 months and they have lost all deciduous leaves and scorched needles
Tree trunk char height	Immediately post-fire	Trunk char can be due to bark or moss burn; represents how high in the canopy was the fire/heat
Cambium burn height and circumference percentage	Immediately post-fire	Document severe, visibly apparent, burning of the cambium layer that may compromise tree canopy and affect mortality

Sampling Method Details-by Task or Metric

Center-point field establishment

Sampling points were assigned remotely using GIS and stratified as described above. When establishing a sampling point in the field it may be necessary to move the exact location to account for landscape features not visible via aerial imagery such as drainages, landslides, unsafe conditions, or other disturbances.

We recommend establishing a point within 10 meters of the original coordinates to maintain the desired distances between sampling points and stay within the right parameters. Please document actual field-based GPS coordinates for the established sampling location in UTMs.

Center-points will be permanently marked with a 3 foot long 1/2" diameter rebar post, covered by a protective tennis ball. Center-points will be labeled with a metal writeable tag with the unique point ID in the following format:

"VegTypeNumberTreatment"

e.g. "QUGA1T" for *Quercus garryana*, point 1, T=treated

T = treated location (Douglas-fir removal); U = untreated location

Photopoints

Photopoints will be taken at all visits to document change over time. When taking photographs, please make sure the camera is zoomed all the way out, the flash is off, and use a whiteboard to document the date, your location (Point ID) and the compass direction you are facing. Have a second person hold the whiteboard to the bottom right of each picture window, near the photographer, so that the whiteboard is legible but does not cover too much of the image (see below for example).

Photopoint example with rebar at bottom center and whiteboard at bottom right.

Photographs will be taken facing North (0°), East (90°), South (180°), and West (270°). Additional photographs should be taken facing additional directions to capture the general burn severity in the area. Be sure to document the azimuth (compass direction) for ALL photographs so they can be reoccupied.

Take the photograph from about 3 meters away from the rebar so that it is visible in the image at the bottom center. This will ensure the rebar is a reference point over the long-term.
Try to capture as much of the forest floor and subcanopy/canopy as possible, always situating the rebar at the bottom center of the photograph.

To ensure all photopoints are lined up similarly between visits please take printouts of previously collected pictures with you in the field. This can also help you relocate your exact sampling point location if the rebar goes missing over time.

Tree species and relative density

For each sampling point, a total of eight trees will be tagged and monitored. In each quadrant (NW, NE, SE, SW) tag the nearest cover tree (DBH >15.2 cm) and nearest pole tree (DBH = 2.5-15.2 cm). We are not targeting live versus dead trees. We are tagging any standing or downed tree that we can measure or estimate a DBH for regardless of mortality. We are also not tagging species that never become forest canopy trees, but may have a DBH of a pole tree. These species include, but are not limited to, toyon, manzanita, coyotebrush, etc.

If a tree lands on a quadrant line (e.g. East at 90°) then put the tree into the quadrant that has most of the tree rooted in it. If the trunk is rooted equally across the quadrant line put the tree into the quadrant starting with that azimuth (e.g. the SE quadrant if split at the 90° line). Please note that some tree species will have multiple trunks or branches that split below 1.3 m (e.g. bay trees that have stumpsprouted after a fire). If the <u>cumulative</u> DBH is >15.2 cm then it is NOT considered a pole tree.

Tree tags should be placed at 1.3 m height along the length of the tree trunk. If the tree is leaning the tag location should not be 1.3 m from the ground, but instead 1.3 m from the base. Tags are placed on the uphill side of the tree. DBH measurements are always taken directly above the tag and perpendicular to the trunk. Therefore, if you need to measure DBH a little above or below 1.3 m because of knots, branches, or other growth anomalies, please make sure the tag is at the DBH measurement location and write a note for how far up the trunk you sampled.

If a tree is branched below 1.3 m, then tag each branch with a DBH ≥2.5 cm with a number (1, 2, 3, etc.) at 1.3 m height. All branches are documented as "TreeNumber.1", ###.2, etc. Similarly, if the tree has multiple trunks, each trunk receives a number. Please mark the largest or main canopy trunk as the tree number and all smaller trunks as ###.1, etc. All trunks and branches will have DBHs summed for biomass calculations.

If a tree has a small DBH, but is ≥2.5 cm, it may be necessary to loosely hang the tag on the tree versus nail it in. Tags will be hung on the branch at or below 1.3 m to guide DBH re-measurements on future visits. Once the tree DBH is large enough to handle a nail it is preferred to switch to the more permanent nail. If the small tree is dead or has been top killed (still alive at base/resprouting), you may tighten the wire at the DBH height 1.3 m because the trunk will not expand between sampling events.

For each tree document the distance from center-point and the tree azimuth (with zero declination; future modifications to magnetic zero can be made if necessary). Measure the distance from the center-point to the tree. Measure the distance and azimuth to the nearest part of the trunk from the center-point. If the tree is leaning greatly, measure to the tree base. If the tree has multiple trunks or branches document the distance and azimuth to the nearest trunk.

Ideally, no quadrant should yield zero trees. We will be tagging trees within 50 m of the center-point. **However, it is important that trees tagged and monitored do not end up in a different soil burn severity index or a different vegetation class than the sampling point is targeting so you may have to adjust the 50 m distance threshold accordingly.**

If there are no pole trees within 50 m that fall into the appropriate categories (soil burn severity, vegetation community, fuel treatment) surrounding the center-point, then the pole tree for that quadrant will be null. We will not be able to calculate the point-centered quarter statistics for pole trees at that sampling point, but we can document pole tree recovery, biomass, etc.

It is critical that there are canopy trees in every quadrant. Center-point adjustment may be necessary if there are quadrants with no canopy trees within 50 m.

If new pole trees establish over time with a DBH ≥2.5 cm it may be necessary to tag additional trees and reassess forest density.

If you see stump sprouts coming out of the ground, but the above-ground tree is completely consumed, do not measure that "tree". We do not know if that was a seedling, juvenile or larger tree.

Tree mortality

During every visit document the status of each tagged tree using the National Park Service Live Code (USDI National Park Service 2003), as follows.

L = Live (resprouting in the canopy only gets a "Live" code)
D = Dead (Hardwoods should default to the "Live" code until a year following the fire even if they have no leaves or were severely burned. This could be top kill, but the tree may still be alive and will eventually resprout.)
R = Resprouting (refers to **basal** resprouting only; count resprouts if present)
C = Consumed/down (can be caused by fire, but we are not tagging these trees initially)
B = Broken below DBH (after originally tagged; tree DBH can no longer be measured)
S = Cut stump (after originally tagged; tree DBH can no longer be measured)

Tree growth and productivity

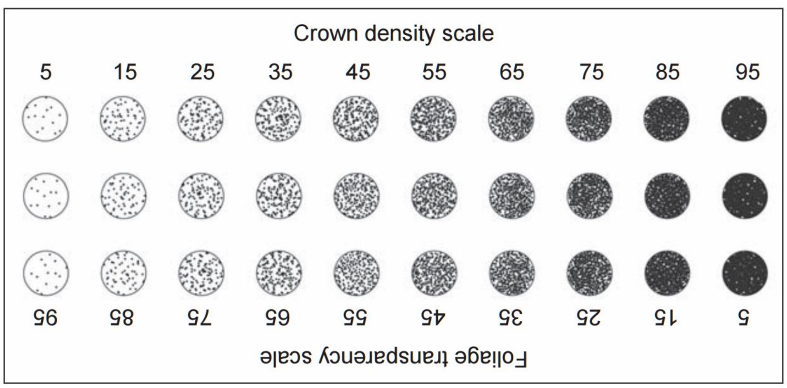
In late summer or early fall of each sampling year (Aug–Sept), before deciduous trees start losing their leaves, we will measure for each tagged tree: (1) Diameter at breast height (DBH), (2) live canopy cover (ocular estimate), and (3) height to live canopy base.

Diameter at breast height (DBH, 1.3 m)

DBH will be measured at 1.3 m along the trunk to the nearest tenth of a centimeter using DBH tapes that are calibrated for measuring along the tree circumference. Measurements should always be taken directly above the tree tag and perpendicular to the trunk axis. It is NOT recommended to measure DBH immediately after a fire (USDI National Park Service 2003) - instead we will wait until the next late summer or early fall 2018 season (or 1-year post-fire).

Live canopy cover

Live canopy cover estimates will be made visually using the guide below.



Height to live canopy

Measuring height to live canopy involves using a clinometer, first measuring the angle at the lowest point along the trunk where the canopy begins (continuous to top of crown or with gaps ≤5', see diagram below). It does not include measuring the height where oak trunk sprouts, sprigs or small branches occur in the understory/subcanopy.

Figure 23-1 from USFS FMH Manual 2002

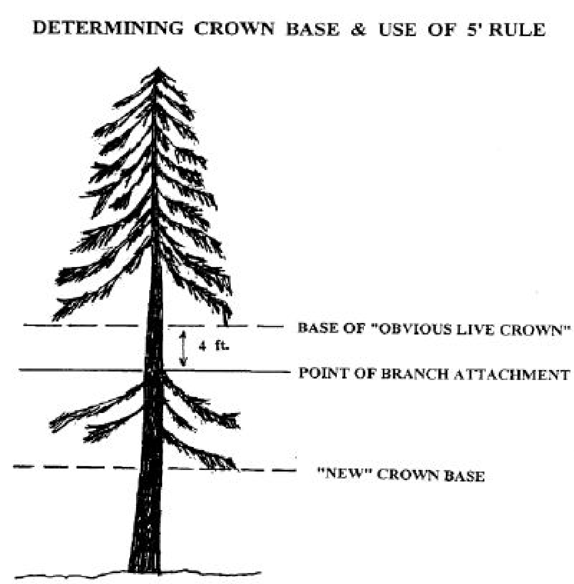
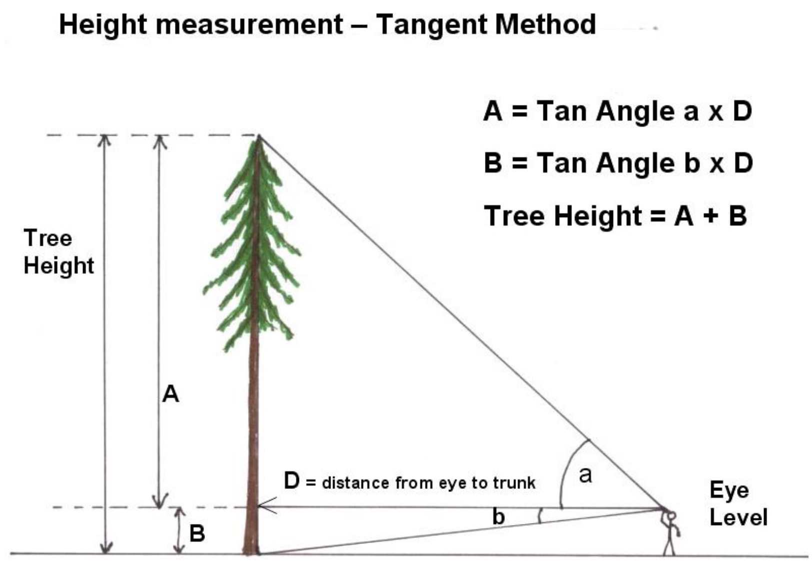


Figure 23-1. Determining the base of the live crown.

Height to live crown measurements are taken from slightly uphill of the tree trunk. Document the distance from the tree at eye height. Using a clinometer measure the angle up to the live canopy base (not the top of the tree as shown below) and the angle down to the base of the tree trunk where it comes out of the ground. See the diagram below for details on the tangent method for measuring and calculating height.



Canopy cover

The canopy cover (overstory density) of the community at the sampling center-point will be measured with a convex spherical densiometer.

General instructions for densiometer use:

"Hold instrument level, 12-18" in front of body and at elbow height, so that operator's head is just outside of grid area. Assume four equi-spaced dots in each square of the grid and systematically count dots equivalent to quarter-square canopy openings. Multiply the total count by 1.04 to obtain percent overhead area **not occupied** by canopy. The difference between this and 100 is an estimation of overstory density in percent. (Assuming each dot to represent one percent is often accurate enough.) Make four reading per location - facing North, East, South and West - record and average."

Percent dead

The percentage of dead canopy will be estimated for each tree. This will capture topkilled trees (100% dead aboveground, but resprouting) or trees heavily damaged by the fire that may have a dense percent cover where there is live canopy still present in small amounts.

Understory vegetation

A rapid assessment of the understory vegetation will be conducted in a 3-meter radius plot surrounding the center-point (see sampling point diagram above). Ocular estimates of relative cover will be made for the functional groups: tree juveniles (DBH < 2.5 cm), tree seedlings (no DBH), shrubs, forbs, grasses, surface fuels (twigs/branches/fallen trunks), litter/duff, rock (>1" diameter), and bare soil.

Do not include dead seedlings or juveniles in the percent cover estimates. We are documenting forest regeneration and succession with this estimate.

Since newly deposited litter after the fire is already accumulating on the forest floor, we will estimate total relative percent cover of litter/duff and then document the approximate proportion of litter cover that is newly fallen. This is the same for surface fuels.
It is HIGHLY recommended to sample the understory vegetation before trampling through the area. This will reduce trampling and impacts to the 3 m plot that could expose bare soil, etc.

Burn severity index

The level of burn severity at each sampling point will be documented using the National Park Service's burn severity index (USDI National Park Service 2003, page 110). It is recommended that this metric be collected as soon as possible up to 2 months post-fire. Burn severity will be categorized according to the forest community coding matrix below for the (1) substrate (within the 3 m radius plot, see sampling point diagram above) and (2) surrounding vegetation (in the general vicinity).

Index	Substrate (S)	Vegetation (V)
Unburned (5)	not burned	not burned
Scorched (4)	litter partially blackened; duff nearly unchanged; wood/leaf structures unchanged	foliage scorched and attached to supporting twigs
Lightly burned (3)	litter charred to partially consumed; upper duff layer may be charred but the duff layer is not altered over the entire depth; surface appears black; woody debris is partially burned; logs are scorched or blackened but not charred; rotten wood is scorched to partially burned	foliage and smaller twigs partially to completely consumed; branches mostly intact
Moderately burned (2)	litter mostly to entirely consumed, leaving coarse, light colored ash; duff deeply charred, but underlying mineral soil is not visibly altered; woody debris is mostly consumed; logs are deeply charred, burned-out stump holes are common	foliage, twigs, and small stems consumed; some branches still present

Heavily burned (1)	litter and duff completely consumed, leaving fine white ash; mineral soil visibly altered, often reddish; sound logs are deeply charred, and rotten logs are completely consumed; This code generally applies to less than 10% of natural or slash burned areas.	all plant parts consumed, leaving some or not major stems or trunks; any left are deeply charred

Percent canopy leaf scorch

Percent leaf scorch is an indicator of how hot the fire burned in or below the canopy. It is important to note that leaf scorch is not due to direct burning. The leaves in this case are tan/brown in color. Leaves that are dark brown/black may have been directly exposed to flames, but we are lumping them into the "scorch" category.

The percentage of leaves scorched in the tree canopy will be estimated for tagged trees. It is recommended that leaf scorch be estimated as soon as possible up to 2 months post-fire. Since we are currently beyond that window and deciduous trees and Douglas-firs with needle scorch have dropped all or most of their leaves, it is not accurate or in some cases not possible to estimate this percentage. Therefore, we will only estimate percent leaf scorch for evergreen hardwood species or for trees that we feel confident estimating.

If the leaves were obviously consumed by the fire (no longer present) it is important to note this. If a portion of the canopy was consumed, but some scorched leaves are remaining, please document it as 100% leaf scorch and note the approximate canopy percentage that was consumed.

Tree trunk char height

Tree trunk char is an indicator of how high the fire moved up into the canopy. Char can be due to actual bark burn or moss/lichen burn. Since evidence of char can be washed away by rain or fade over time it is recommended that this metric be collected as soon as possible up to 2-months post-fire. However, in some cases, char can be detectable long after a fire came through. This might be a primary fire effect metric that can be measured or estimated up to 1-year post-fire for a regional project.

Measure the height of tree trunk char using the same clinometer tangent method described and diagramed above. If there is a break in the char along the trunk, it is important to measure the highest char point along the tree trunk.

Do not measure char height along the length of a downed tree trunk. It is not possible to tell if the char is from when the tree was standing or after it fell on the forest floor.

Cambium burn height and circumference

Severe heat or direct burning of the tree trunk results in killing the cambium layer, leading to canopy reduction or tree mortality. We will not be measuring cambium burn by exposing the cambium layer. Instead, we are only documenting severe, visibly apparent, burning of the cambium layer. Cambium burn can look like new fire scars, wounds, or even pocks where the bark burn was intense enough the cambium becomes visible in sections and the underlying exposed heartwood is dark brown or burnt gray.

Determining whether or not a tree has evident cambium burn can be difficult. It is important to come up with a standard among samplers as much as possible. If there is any question about whether or not the wound is new, it may be best to measure the wound, but put a detailed note explaining any doubt you may have.

For example, often times old fire scars become more severely burned in the most recent fire. Old fire scars will have bark growth curled over the edges. If it is not clearly evident that new areas of cambium burned increasing the circumference or height of the old wound, then do not document the wound. It could be that the old fire wound exposed heartwood and that the inner part of the tree burned back during the recent fire. Or, if you DO see newly exposed cambium above or adjacent to an old wound, only measure the NEW amount of cambium burn, disregarding the old wound area.

Cambium burn height is measured from the base of the tree to the uppermost point in meters. Cambium burn circumference is estimated as the percent of the circumference burned. If there are multiple cambium burn wounds on one tree, add up all the widest points to come to one cumulative percentage.

Field Supplies List

- Rebar (1/2" diameter, 3' sections)
- Protective tennis ball with slit cut
- Tree tags - pre-numbered
- Tree tags - blank
- Steel hand stamp die kit
    - For additional branches/trunks (###.1 for first branch below DBH, ###.2 for second, etc.)
- Writeable metal tree tag - for center-point ID

- Hammer
- Nails
- Wire cutters
- 14-gauge wire - for hanging tree tags on smaller DBH trees
- Camera with extra charged battery
- GPS unit with extra charged batteries
- 100 m transect tape
- DBH tape
- Pin flags - for 4 cardinal directions, for 3 m radius cover plot
- Compass - no declination adjustment
- Clinometer
- Densiometer
- Pencils
- Maps
- Data sheets
- CNPS vegetation percent cover reference sheet - preferably with circular plots
- Crown density scale reference sheet
- Whiteboard for photopoints - Date, Point ID, Compass Direction
- Large dry erase pen
- Binoculars (recommended for hard to see trunk char marks - especially in winter days)

Recommended Sampling Workflow

ǒ Find your point location and pound in the rebar. Cover with tennis ball. Document UTMs of actual field location.

ǒ Measure 3 m from the center-point and place a pinflag at every cardinal direction - N, E, S, W.

ǒ Starting facing North from the Southern flag, stand at each 3 m flag and take a photopoint with the whiteboard in the bottom right corner and the rebar in the bottom center of the picture window.

ǒ Take photos rotation clockwise through all four cardinal directions.

ǒ Document burn severity indices and plot percent cover estimates in the 3 m radius plot before trampling the soils and vegetation around the center-point.

ǒ Starting in the NE quadrant, tag the nearest canopy and pole trees. Document their distances, azimuths, live codes, resprouts, cambium burn information, and trunk char heights before moving onto the next tree or quadrant.

- Rotate clockwise to the SE quadrant and repeat sampling trees through all four quadrants.
- Clean up all supplies before leaving.

DATA ANALYSIS & MANAGEMENT

Section Pending - Scan field datasheets, backups, include R script references and other calculations used

ACKNOWLEDGMENTS

Sasha Berleman, David Ackerly, Mark Tukman, OTHERS

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APPENDIX 1 – Example field data sheets

Date: Point ID:
Sampler(s):

Pepperwood Fuels Treatment Efficacy Assessment
Initial Sampling Point Setup and Primary Burn Effects

Centerpoint UTME:
Centerpoint UTMN:
Measured slope:

Photopoint checklist:
- ☐ North (0)
- ☐ East (90)
- ☐ South (180)
- ☐ West (270)

Additional Photos:
Azimuth:
Azimuth:
Azimuth:
Azimuth:

Evidence of D-fir encroachment? YES NO
Site Conditions:

Tag #	Quadrant	Species	Distance (m)	Azimuth	Live Code	# Basal Sprouts	% Leaf Scorch	Old Fire Scars?	Other wounds, diseases, overall health
	NE - Canopy								
	NE - Pole								
	SE - Canopy								
	SE - Pole								
	SW - Canopy								
	SW - Pole								
	NW - Canopy								
	NW - Pole								

Tag #	Cambium Burn Ht. (m)	Cambium Burn % Circ.	Char Dist. (m)	Char Angle Up	Char Angle Down	Comments

Burn Severity Index (see back) (Substrate in 3-m plot)	
Substrate	
Vegetation	
3-m Plot % Cover	
Bare soil	
Rock (>1")	
Litter/Duff	Total: Prop. New:
Fuels	Total: Prop. New:
Grasses	
Forbs	
Shrubs	
s	
Juveniles	

Tree Seedlings: no DBH
Tree Juveniles: DBH < 2.5cm
Pole Tree: DBH = 2.5-15.2cm
Canopy tree: DBH > 15.2cm

Live Codes: L=Live D=Dead R=Resprouting C=Consumed/Down B=Broken below DBH S=Cut Stu

Date Entered:________ Initials:________
Date QC'd:________ Initials:________

Date: Point ID:
Sampler(s):

Pepperwood Fuels Treatment Efficacy Assessment
Initial Sampling Point Setup and Primary Burn Effects

ADDITIONAL BRANCHES

Tag #	Live Code	Comments

NPS Burn Severity Index Categories - Forests

Index	Substrate (S)
Unburned (5)	not burned
Scorched (4)	litter partially blackened; duff nearly unchanged; wood/leaf structures unchanged
Lightly Burned (3)	litter charred to partially consumed; upper duff layer may be charred but the duff layer is not altered over the entire depth; surface appears black; woody debris is partially burned; logs are scorched or blackened but not charred; rotten wood is scorched to partially burned
Moderately Burned (2)	litter mostly to entirely consumed, leaving coarse, light colored ash; duff deeply charred, but underlying mineral soil is not visibly altered; woody debris is motly consumed; logs are deeply charred, burned-out stump holes are common
Heavily Burned (1)	litter and duff completely consumed, leaving fine white ash; mineral soil visibly altered, often reddish; sound logs are deeply charred, and rotten logs are completely consumed. This code generally applies to less than 10% of natural or slash burned

Index	Vegetation (V)
Unburned (5)	not burned
Scorched (4)	foliage scorched and attached to supporting twigs
Lightly Burned (3)	foliage and smaller twigs partially to completely consumed; branches mostly intact
Moderately Burned (2)	foliage, twigs, and small stems consumed; some branches still present
Heavily Burned (1)	all plant parts consumed, leaving some or no major stems or trunks; any left are deeply charred

Date:
Name(s):

UPPER HALF OF TREE

Fuels Treatment Efficacy Assessment
2 Years Post-fire Monitoring

Tree Seedlings: no DBH
Tree Juveniles: DBH < 2.5cm
Pole Tree: DBH = 2.5-15.2cm
Canopy tree: DBH > 15.2cm

3-m Plot % Cover

Bare soil		Grasses	
Rock (>1")		Forbs	
Litter/Duff		Shrubs	
Fuels		Seedlings	
		Juveniles	

Canopy **GAPS** at T-post facing N: E: S: W:

Comments:

Live Codes: L=Live D=Dead R=Resprouting C=Consumed/Down B=Broken below DBH S=Cut Stump

PointID	No.	Quad	Tree Class	Species	ID	Distance	Azimuth	Code	New Code	Standing?	DBH (cm)	% Dead	Canopy Cover	Live Distance (m)	Live Angle Down	Live Angle Up	Insects? (No, Few, Lots)
PSME1T	296	NE	Canopy	NODE	1	7.20	77	R									
PSME1T	295	NE	Pole	UMCA	1	1.95	30	R									
PSME1T	297	SE	Canopy	PSME	1	2.80	170	L									
PSME1T	299	SE	Pole	UMCA	1	3.30	170	R									
PSME1T	401	SW	Canopy	NODE	1	5.00	210	R									
PSME1T	402	SW	Pole	NODE	1	5.55	257	R									
PSME1T	403	NW	Canopy	NODE	1	4.10	273	R									
PSME1T	403.1	NW	Canopy	NODE	1	4.10	273	R									

Date:
Name(s):

BOTTOM HALF OF TREE

Fuels Treatment Efficacy Assessment
2 Years Post-fire Monitoring

Bins for Herbivory and Pathogens: 0 = 0% 1 = <25% 2 = 25-50% 3 = >50%

PointID	No.	Quad	Tree Class	Species	ID	Distance	Azimuth	Code	Sprouts (0, <20, >20)	Sprout Ht Distance	Sprout Ht Angle Down	Sprout Ht Angle Up	Herbivory	Pathogens	Comments
PSME1T	296	NE	Canopy	NODE	1	7.20	77	R							
PSME1T	295	NE	Pole	UMCA	1	1.95	30	R							
PSME1T	297	SE	Canopy	PSME	1	2.80	170	L							
PSME1T	299	SE	Pole	UMCA	1	3.30	170	R							
PSME1T	401	SW	Canopy	NODE	1	5.00	210	R							
PSME1T	402	SW	Pole	NODE	1	5.55	257	R							
PSME1T	403	NW	Canopy	NODE	1	4.10	273	R							
PSME1T	403.1	NW	Canopy	NODE	1	4.10	273	R							