July 11, 2025
Docket # 2026-2028-Base-WMPs

PacifiCorp 2026-2028 Wildfire Mitigation Plan_R0 – Appendix G Attachment List

Appendix	Attachment Number	Standard, Policy, or Document	Section Referenced
G	1	Wildfire Mapping Refresh & Benchmark	Section 5.6
G	2	ANSI A300 Tree Care Standards - Tree Care Industry Association, LLC.	Section 9
G	3	International Society of Arboriculture	Section 9.3
G	4	Marking Guidelines for Fire-Injured Trees in California	Section 9.10

Guidehouse

PACIFICORP

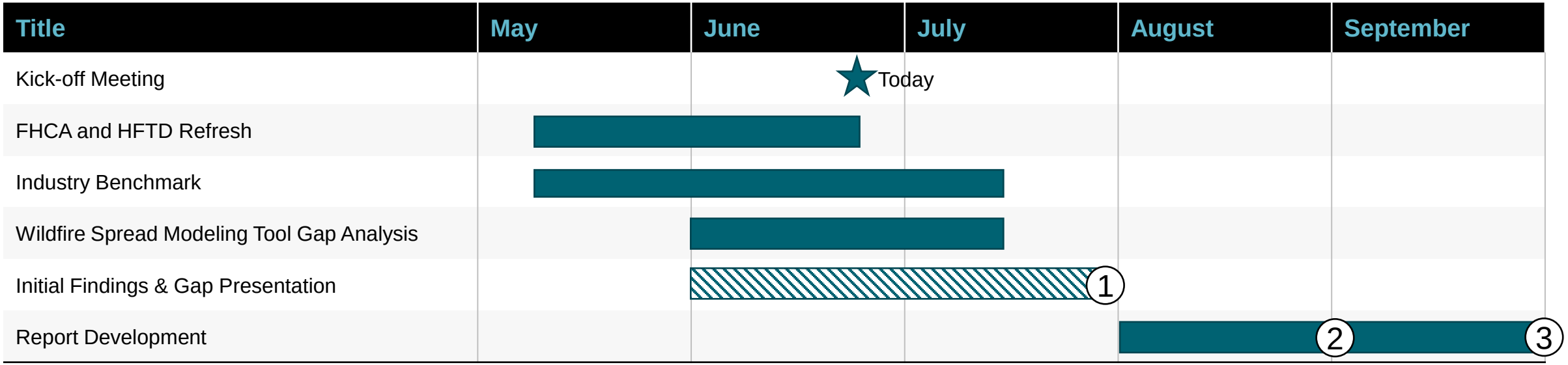
Final

Wildfire Mapping Refresh & Benchmark

Findings, Gaps & Benchmark
June 24, 2024

Table of Contents

Timeline



Contract ends 9/30/24

Tentative Deliverable Titles and Dates

① Draft Findings & Gaps Presentation –*TBD*

② Draft Report – 8/30 (*feedback from PacifiCorp by 9/15*)

③ Final Report – 9/30

Overview and Task Mapping

Today findings are based on a collaborative approach between Tasks 1 and 2 to review and compare best practice risk mapping methodologies

Task	Goal	Current Findings
Task 1: FHCA and HFTD Refresh	Determine if current FHCA maps provide a valid and comprehensive representation of wildfire risk within the PacifiCorp service territory based on wildfire risk mapping best practices, electric utility industry standards, and comparison to wildfire risk maps published by government agencies and other entities.	• Methodologies: PacifiCorp & CPUC • Existing Map Comparisons
Task 2: Industry Benchmark	Ensure PacifiCorp's risk mapping methodology aligns with the other large investor-owned utilities (IOUs) in the states where PacifiCorp operates.	• Summary of Utility Risk Mapping
Task 3: Wildfire Spread Modeling Tool Gap Analysis	To the extent permissible under requirements to protect proprietary vendor products, review wildfire models that serve as inputs to risk scoring and FHCA development.	• Initial documentation underway

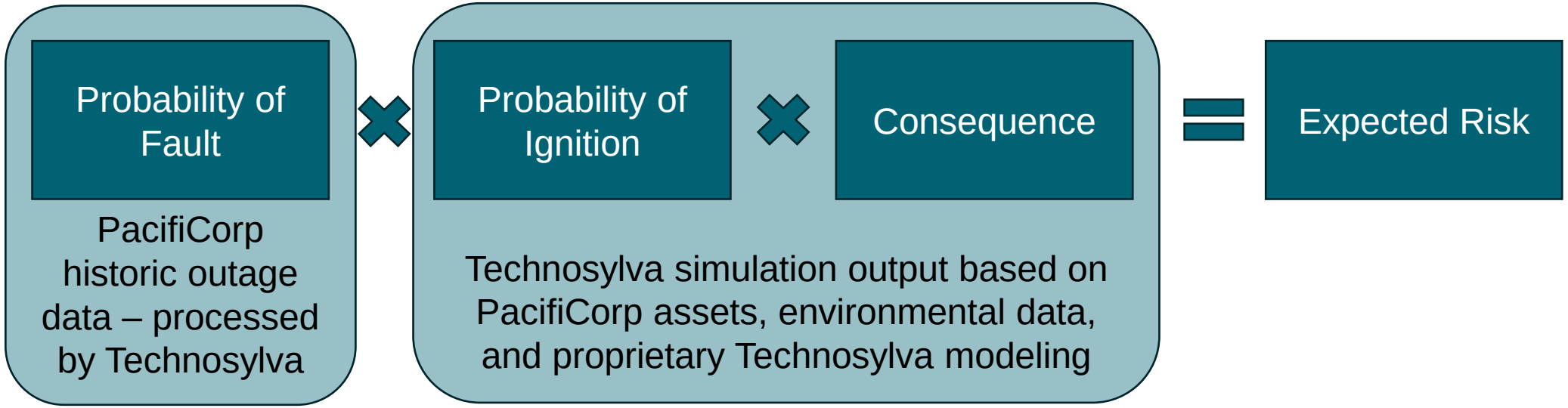
Methodologies: PacifiCorp & CPUC

PacifiCorp Methodology

Technosylva uses PacificCorp data to run personalized simulation models. PacificCorp then uses model outputs to identify risk areas, including FHCAs.

PacifiCorp uses Technosylva's FireSight module to assess wildfire risk in all of their territories.

1. PacifiCorp provides Technosylva with asset locations and historic outage data.
2. Technosylva uses this along with data sets for weather, forestry, census, and other environmental factors to inform their simulation model and output expected wildfire risks for each part of PacifiCorp's lines and assets.
   - Technosylva's risk calculation is comprised of Risk Associated with Ignition Location and Risk Associated with Value Exposure. These risk values chart asset ignition risk and community environmental risk respectively.



PacifiCorp Methodology

Risk is split into levels, with Fire High Consequence Areas being the most at-risk

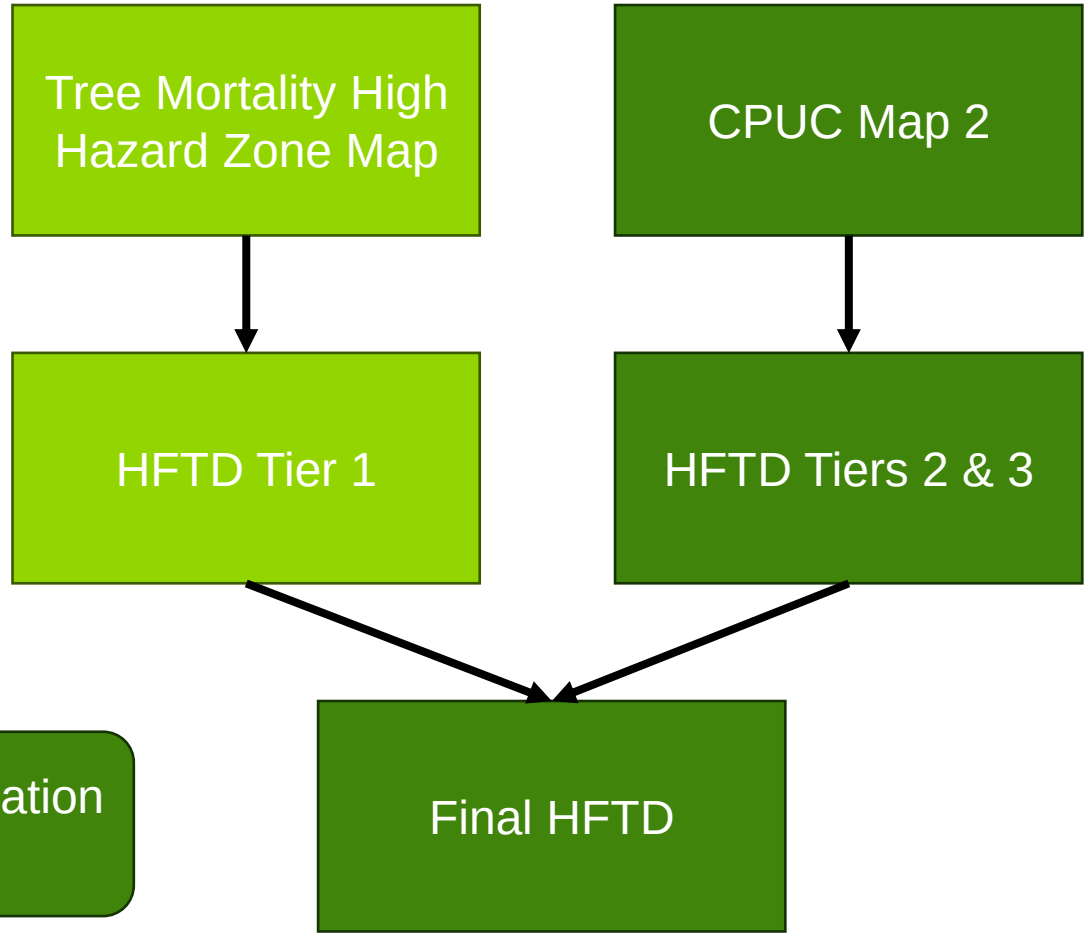
- Division of risk by type of wildfire
  - Wind driven fire risk and terrain driven fire risk are calculated separately with unique risk parameter weightings. Weightings were determined by discussions with PacifiCorp and Technosylva experts.
- Division of risk by level
  - All risk scores are divided by the maximum risk score to normalize from 0 to 1
  - Fire High Consequence Areas (FHCA) are designated in areas with scores over 0.85
  - Additional Areas of Interest (AOI) are designated for locations with scores between 0.45 and 0.84
  - FHCA receives highest priority for wildfire mitigation planning.

Class:	Wind/Terrain Score Range:
AOI2	0.45 – 0.64
AOI1	0.64 – 0.84
FHCA	0.85 – 1.00

Defining California Public Utility Commission (CPUC) Methodology

High fire threat districts (HFTD) are the baseline for California utility Wildfire Mitigation Plans (WMPs).

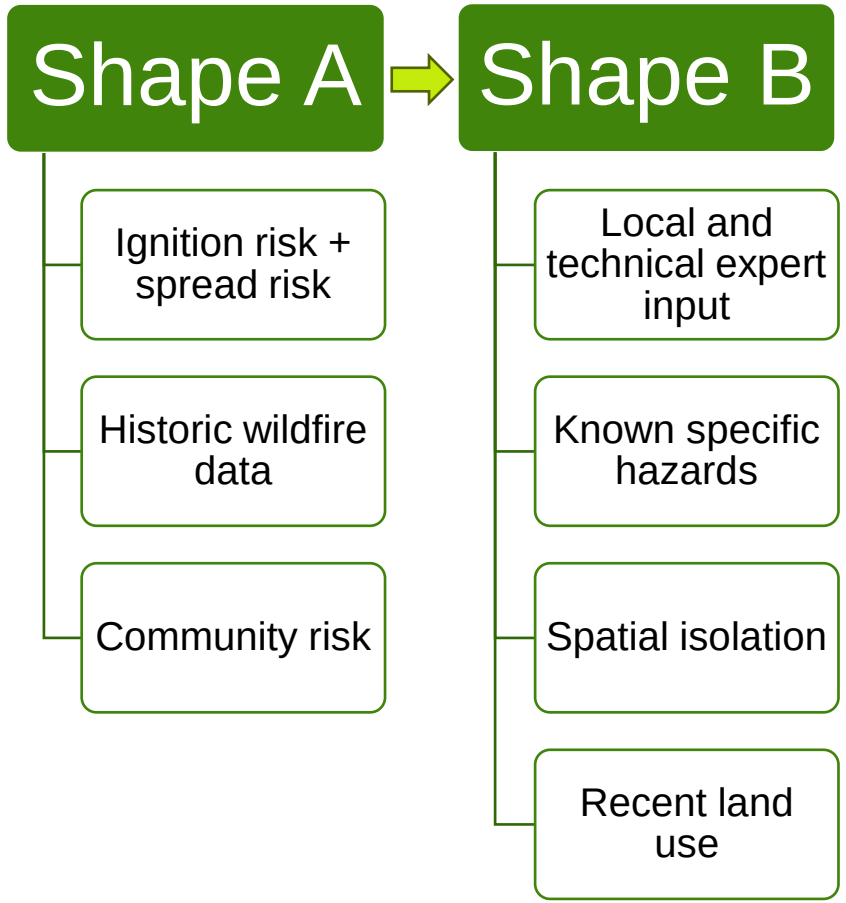
- HFTD methodology as defined by the CPUC is considered the most detailed wildfire risk mapping approach.
- Utility WMPs must use the HFTD map in their risk analysis as well as proposing updates based on their own analysis.
- CPUC Map 2 was developed in 2017 and updated in 2021.
- **The CPUC Map 2 process exemplifies the wildfire risk assessment process.**



Guidehouse review is focused exclusively on Map evaluation process and the subsequent HFTD Tiers 2 and 3.

Risk Mapping Process for HFTDs

Map 2 is a risk map developed by the CPUC, outlining a high-quality process for risk assessment



- Map 2 is developed in two phases, Shape A and Shape B.
- Shape A is a composite of multiple risk maps.
  - These maps are calculated data based on specific risk factors.
- Shape B is a manual review of Shape A by a set of experts to further refine the calculated data.
  - **This is a more granular review than the independent reviews conducted by some California utilities.**
- Utilities are then instructed to apply their own infrastructure maps to the final map.

PacifiCorp's FHCA methodology is very similar to Shape A with the addition of some elements of Shape B.

Gaps and Recommendations

Current use of 1-Mile Grid resolution for program management looses FHCA detail when multiple assets are within a single mile.

PacifiCorp currently uses a 1-Mile Grid system for program management while Technosylva calculates risk on asset segments much smaller than 1-mile resolution

GAP: When Technosylva-based risk is applied onto the 1-Mile Grid significant resolution is lost and lower risk assets may be "swept in" as FHCA due to neighboring areas of higher risk. This increases costs unnecessarily as these now mislabeled low risk assets must be targeted for mitigation

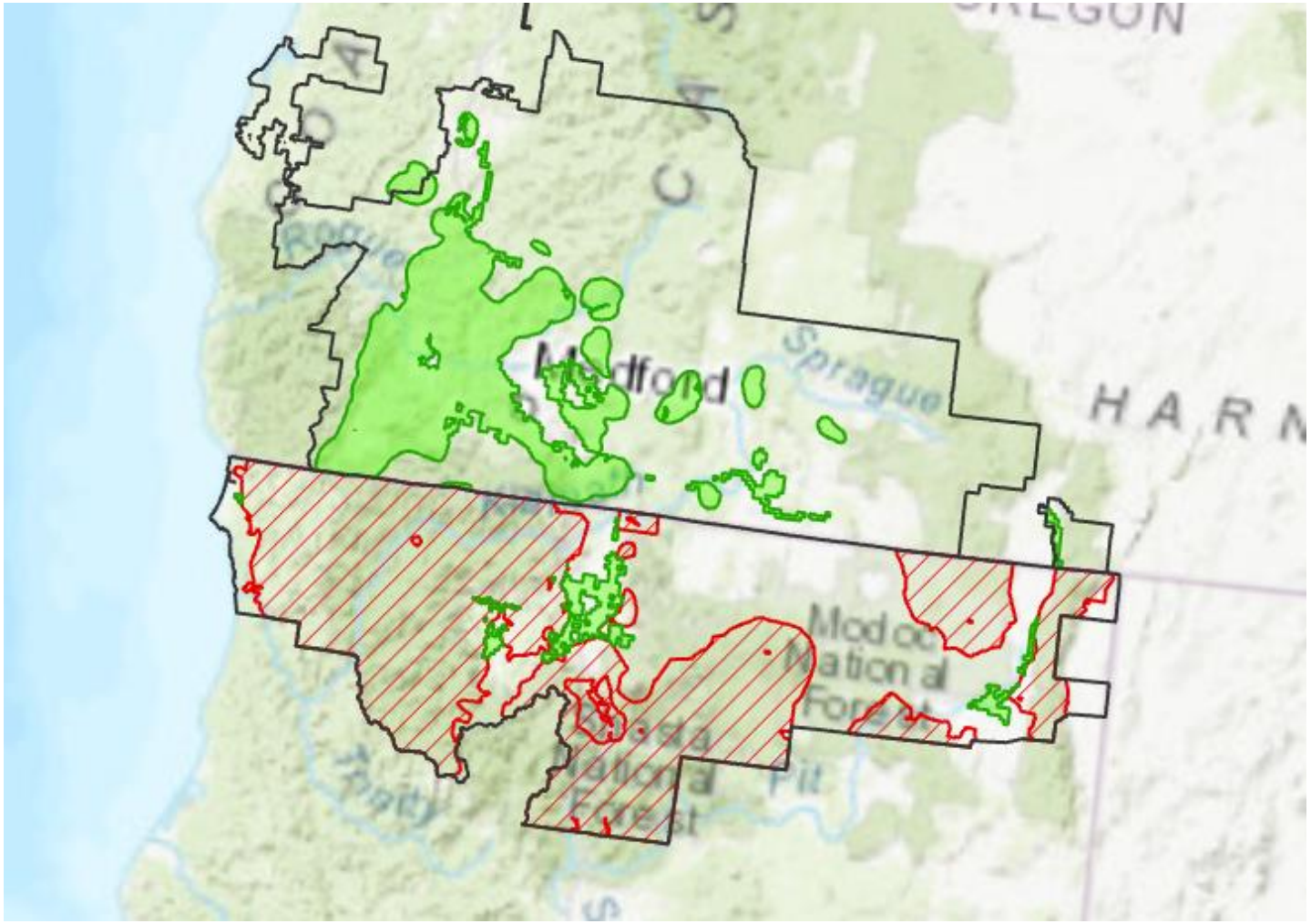
- Since the 1-Mile Grid system is a company-wide and legacy policy any changes may necessitate a wider change-management effort.

RECCOMENDATION: PacifiCorp may consider using a step similar to "shape B" of the CPUC Map 2. This step manually revises the generated FHCA to include/exclude areas where local and technical experts disagree with the calculated risk.

Existing Map Comparisons

Map Comparison: FHCA & HFTD

FHCA area covers all of CPUC's HFTD risk area.



FHCA and HFTD Area Overlap

FHCA Independent Areas

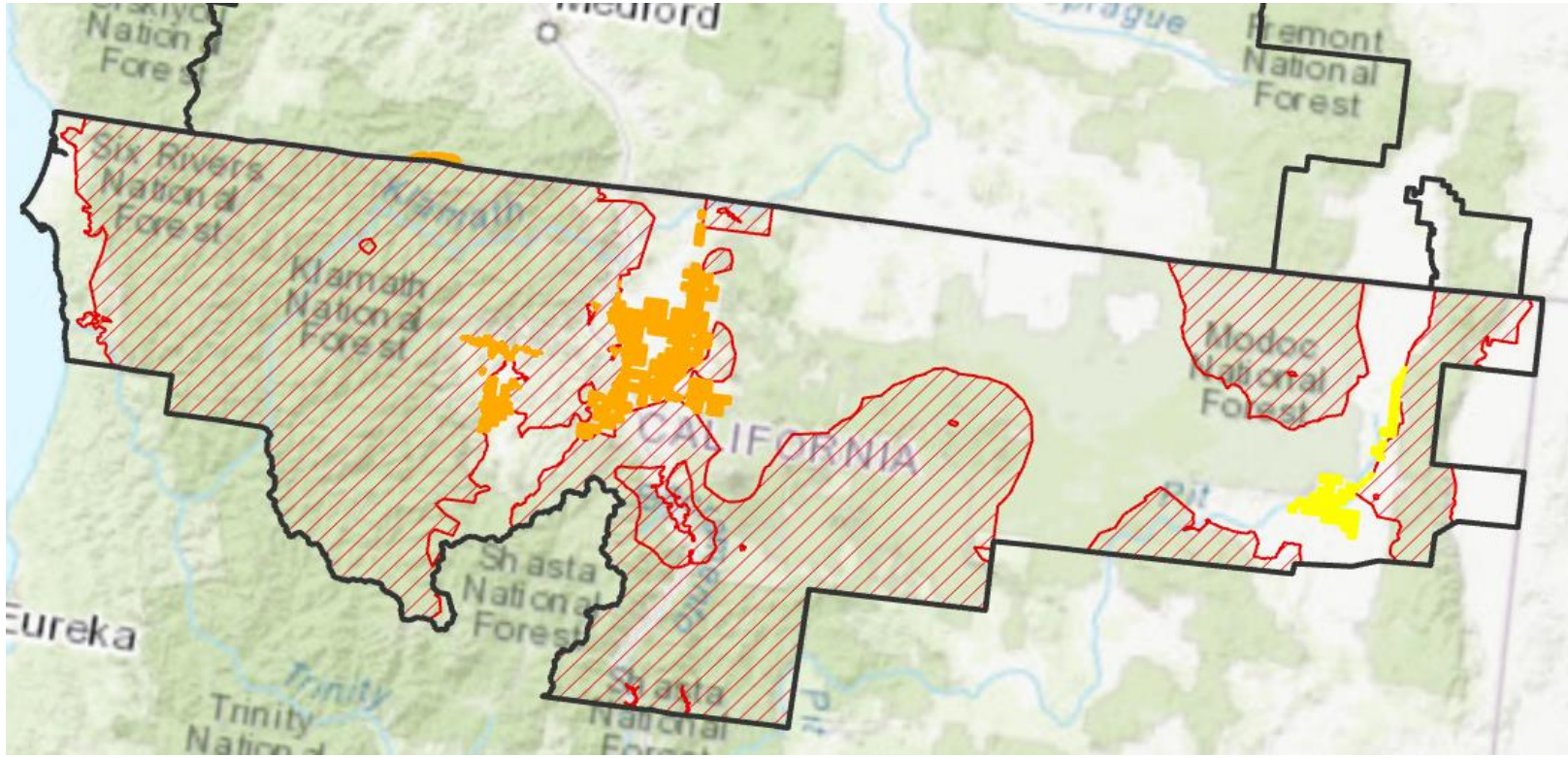
PacifiCorp Service Territory

Key Findings

- FHCA has expanded territory identified beyond HFTD's identified regions.
- Overlapping FHCA has uniform Tier 2 and 3 classification from HFTD, likely a borrowed ID from the HFTD maps.
  - **Independent FHCA has no Tier 2 or 3 classification.**
- These independent regions are all attached to risk area identified by HFTD (connected regions).

FHCA & HFTD – County Level

Independent FHCA areas located primarily in rural counties with relatively more concentrated population centers.



PacifiCorp Service Territory

FHCA and HFTD Area Overlap

Modoc County FHCA Area

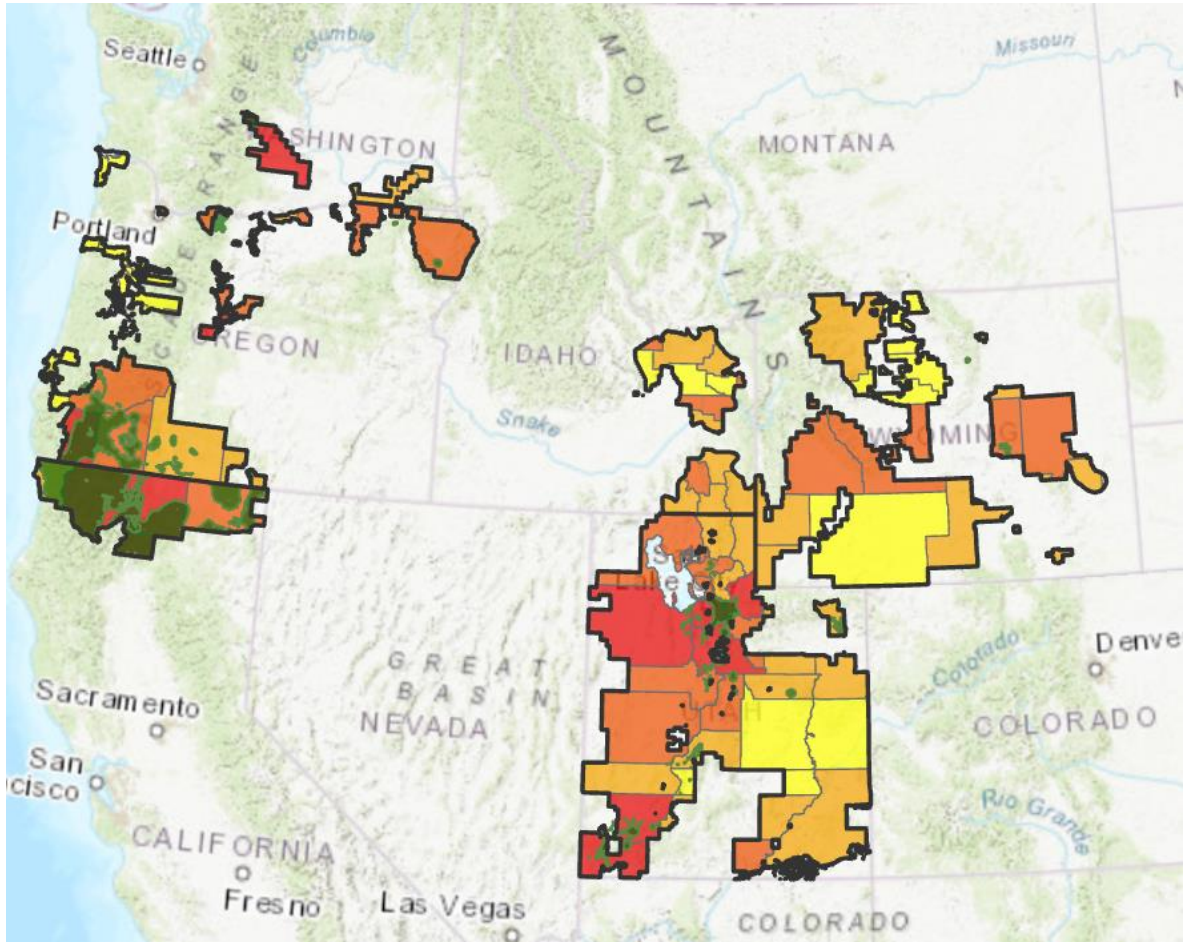
Siskiyou County FHCA Area

Key Findings

Additional FHCA risk area in California is primarily located in Siskiyou County and a minor area in Modoc County. Both areas appear to be associated with relatively more concentrated population centers.

FHCA & National Risk Index

FHCAs are consistent with the Federal Emergency Management Agency's National Risk Index (NRI) wildfire risk classification.



PacifiCorp Service Territory

FHCA

NRI Wildfire Risk Rating

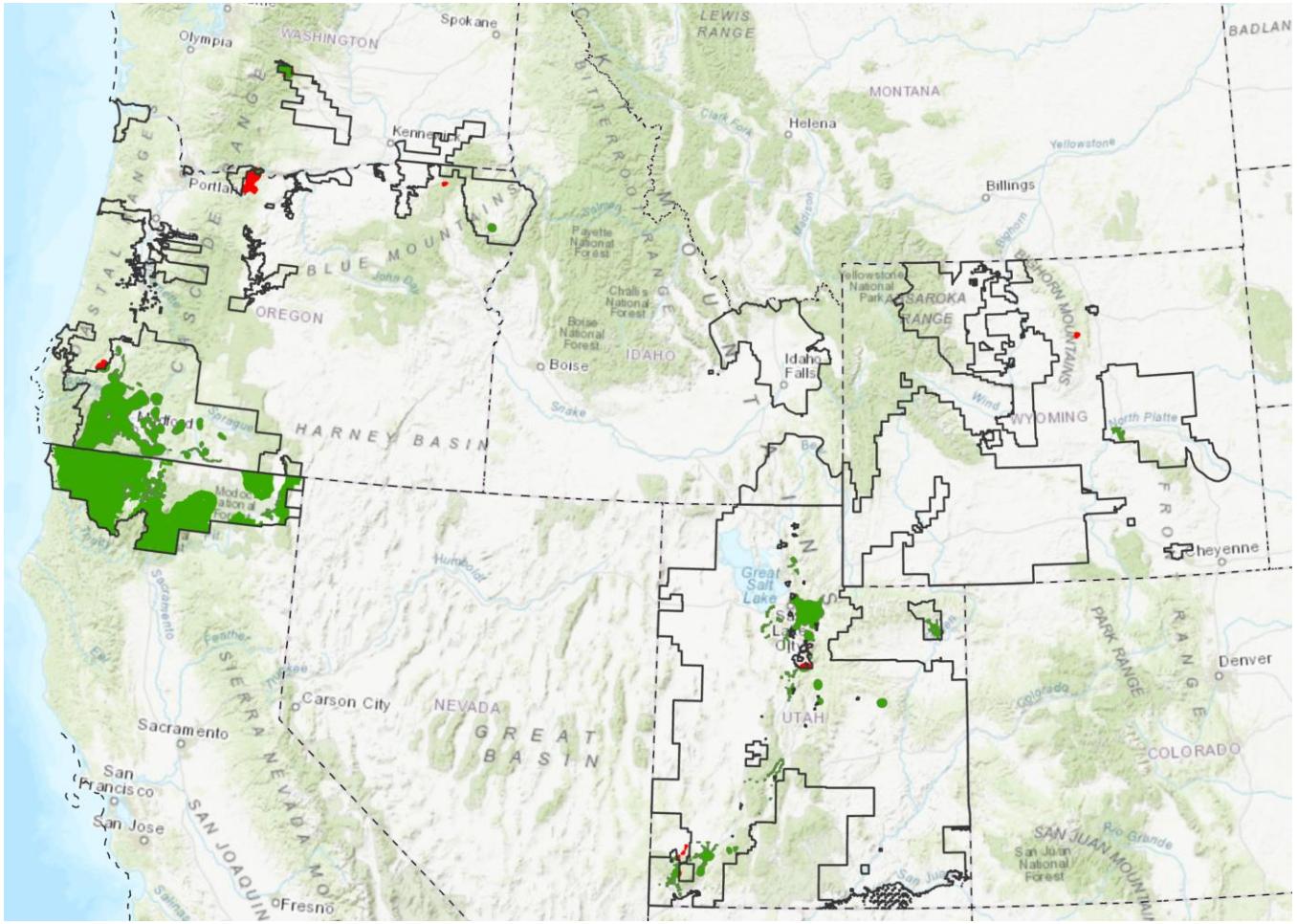
- Relatively High
- Relatively Moderate
- Relatively Low
- Very Low

Key Findings

- NRI ratings are at the county level
- FHCA located primarily in relatively moderate to relatively high wildfire risk zones as identified by the NRI.

Over-mapping FHCA Areas

Some FHCA territory falls outside of PacifiCorp service territory boundaries.



US State Boundaries

PacifiCorp Service Territory

FHCA

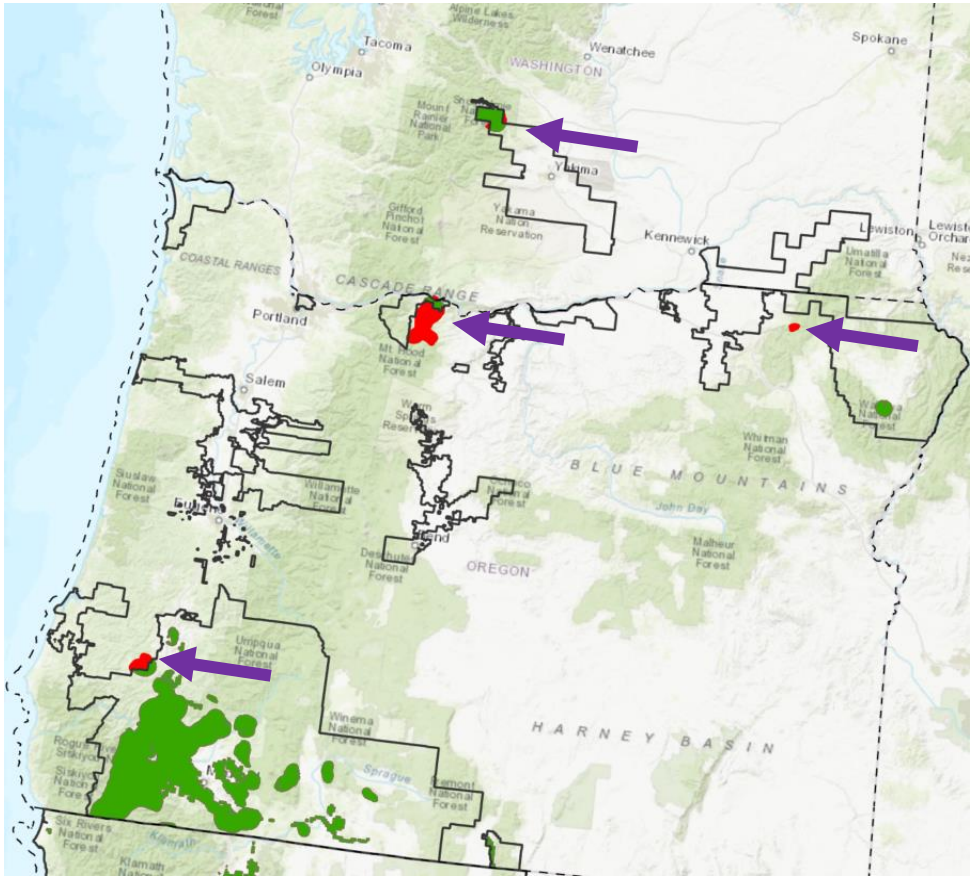
FHCA Outside PacifiCorp Service Territory

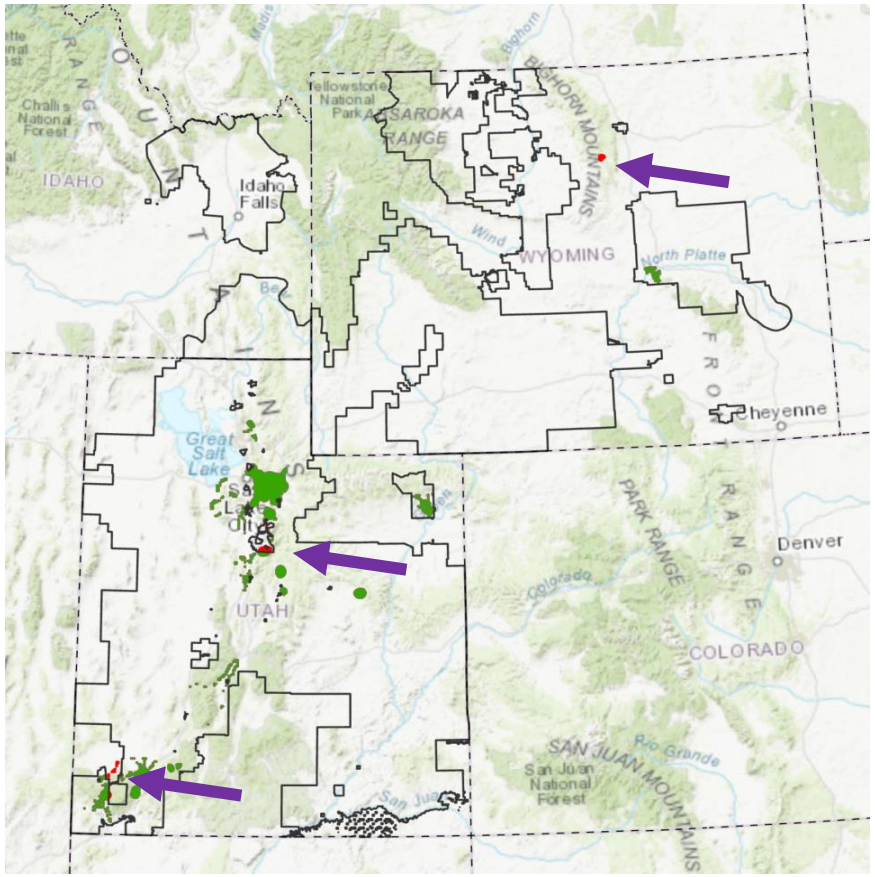
Potential Source

- Mismatch may be due to missing PacifiCorp service territory boundary
- Potential XY coordinate mismatch for these specific boundaries (other areas seem to match up well – ie California territory)

Over-mapping FHCA Areas

Majority of over-mapped areas are in Oregon and Utah, with minor areas in Washington and Wyoming.





Gaps and Recommendations

GAP: Several areas in PacifiCorp's California territory are classified as FHCA but not HFTD.

- Does PacifiCorp apply Tier classifications to FHCAs and should these be extended to FHCAs outside of HFTDs?

RECOMMENDATION: For areas classified as FHCA outside of service territory, PacifiCorp may want to check for:

- Review data input
  - Service territory boundary inclusive of potential additional assets outside of PacifiCorp serviced area
- Potential excess FHCA coverage

Benchmark Summary: Utility Risk Mapping

Puget Sound Energy (PSE)

PSE uses geospatial datasets quantifying ignition probability, spread probability, and Wildland Urban Interface (WUI) with overlaid with PSE's geospatial datasets of overhead electrical assets to determine the areas in which each type of risk exists.

Utility	Map Includes:					Modeling Software Used
	Ignition Probability	Spread Probability	WUI	Housing	Independent Review	
PacifiCorp	X	X	X	X		Technosylva: FireSight
CPUC	**X**	**X**	**X**	**X**	**X**	**Reax**
Puget Sound Energy	X	X	X			

Definitions:

- Ignition probability – Predicting where fires are most likely to start by considering factors like drought conditions, weather patterns, topography, human activities, and broad vegetation characteristics to help identify high-risk areas.
- Spread probability – Predicting where fires are most likely to spread to by considering fuel load, wind, topography, and other factors.
- Wildland Urban Interface (WUI) – The zone of transition between unoccupied land and human development. It is the line, area or zone where structures and other human development meet or intermingle with undeveloped wildland or vegetative fuels.

Idaho Power

Idaho Power has a multi-state service area and creates wildfire risk maps based on GIS visual depictions of their Wildfire Risk Modeling Process.

Utility	Map Includes:					Modeling Software Used
	Ignition Probability	Spread Probability	WUI	Housing	Independent Review	
PacifiCorp	X	X	X	X		Technosylva: FireSight
CPUC	**X**	**X**	**X**	**X**	**X**	**Reax**
Idaho Power	X	X	X	X		Federal LANDFIRE program

Definitions

- Housing – Consideration of potential fire's impact on structures (i.e., homes, businesses, other man-made structures).

San Diego Gas & Electric (SDG&E)

SDG&E was part of the construction of the initial CPUC Map 2 Shape A construction, alongside Reax. SDG&E is an example of a best-in-class risk assessment.

Utility	Map Includes:					Modeling Software Used
	Ignition Probability	Spread Probability	WUI	Housing	Independent Review	
PacifiCorp	X	X	X	X		Technosylva: FireSight
CPUC	**X**	**X**	**X**	**X**	**X**	**Reax**
SDG&E	X	X	X	X	X	Technosylva: Wildfire Analyst

Definitions:

- Independent Review – Third-party review of utility wildfire mitigation plan. This includes stakeholder discussion, data review, and model evaluation. The utility-level independent review differs from CPUC's Shape B analysis in that Shape B procedure included stakeholders and reviewers in order to provide a granular and manual map update

SDG&E also incorporates additional levels of detail including:

- Public Safety Power Shutoff (PSPS) risk and consequence
- Safety consequence at the meter level based on community vulnerability and individual customer category/attributes
- Financial consequence of damage and outages

Utility Risk Mapping Benchmarking: California

Utility	Map Includes:					Modeling Software Used
	Ignition Probability	Spread Probability	WUI	Housing	Independent Analysis	
PacifiCorp	X	X	X	X		Technosylva: FireSight
CPUC	**X**	**X**	**X**	**X**	**X**	**Reax**
SDG&E	X	X	X	X	X	Technosylva: Wildfire Analyst, FireSight
Liberty	X	X	X*	X		Technosylva: FireSight
Bear Valley	X	X	X†	X		Technosylva: Wildfire Analyst, FireSight, DIREXYON
Pacific Gas & Electric	X	X	X	X	X‡	Technosylva: FireSight
Southern California Edison	X	X	X	X	X	Technosylva: FireSight, and Wildfire Analyst

* Liberty has 95% of customers in WUI, so they do not use it as a meaningful metric.
† Bear Valley's service territory is 100% WUI.
‡ Pacific Gas & Electric does an internal qualitative review.

Utility Risk Mapping Benchmarking: Non-CA

Utility	Map Includes:					Modeling Software Used
	Ignition Probability	Spread Probability	WUI	Housing	Independent Review	
PacifiCorp	X	X	X	X		Technosylva: FireSight
CPUC	**X**	**X**	**X**	**X**	**X**	**Reax**
Portland General Electric	X	X	X	X	X	*
Idaho Power	X	X	X	X		Federal LANDFIRE program, *
Puget Sound Energy	X	X	X			*
Avista	X†		X	X		*
Black Hills	ǂ					

* Utilities do not explicitly publish their modeling software sources or methodologies as the standards for WMPs or equivalent documents are less robust outside of California.

† Avista currently uses a burnable landscape probability approach to risk assessment, rather than the ignition + spread approach seen in most other peers evaluated.

ǂ Black Hills does not have a WMP and only references the FEMA wildfire map in regard to monitoring risk in their service area.

Future Steps: Deep dive into most comparable utilities

- The next step is evaluating the appropriateness of PacifiCorp FHCAs.
- Using the most comparable peer utilities we can compare wildfire risk maps and processes to assess appropriateness and gaps
- The currently identified most comparable peer utilities are shown below

Liberty

- Similar customer count and location

Pacific Gas & Electric (PG&E)

- Similar location with best-in-class risk analysis

Idaho Power or Portland General Electric (PGE)

- Strong risk analysis outside of California
- Idaho Power is a multi-state utility

Identified Gaps for Additional Review

These items were identified in a Guidehouse call with PacifiCorp SMEs.

- The probability of fault is calculated by Technosylva from PacifiCorp historic outage data.
  - Historic outage data is unlikely to be 100% accurate.
  - Poor outage data decreases the accuracy of the risk assessment.
  - Suggest PacifiCorp have a conversation with Technosylva to determine how the data is cleaned and verified.
- PacifiCorp is considering separating transmission and distribution risk onto two maps to allow Tx and Dx teams to work separately.
  - Transmission and distribution teams often work separately and calculate budgets separately.
  - Significant work would be required to ensure separation does not disrupt risk level accuracy.

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Thank You

Appendix G – Attachment 2

ANSI A300 Tree Care Standards - Tree Care Industry Association, LLC.[1]

[1] https://treecareindustryassociation.org/business-support/ansi-a300-standards/

Appendix G – Attachment 3

International Society of Arboriculture[1]

[1] https://www.isa-arbor.com/store/product/101/

US Forest Service, Region 5, Forest Health Protection

May 2011 (Report # RO-11-01)

Replaces April 2009 Report # RO-09-01

Marking Guidelines for Fire-Injured Trees in California

Sheri L. Smith and Daniel R. Cluck

If you are using these marking guidelines for your post-fire restoration it is imperative that you contact your local Forest Health Protection (FHP) service area staff for review of your draft NEPA document (before public distribution), responses to comments and for assistance with marking guideline selection and project implementation.

Yellow pine (ponderosa and Jeffrey pine), white fir, sugar pine and incense cedar guidelines are based on: Hood, Sharon M.; Smith, Sheri L.; Cluck, Daniel R. 2010. *Predicting mortality for five California conifers following wildfire*. Forest Ecology and Management. 260: 750-762.

Red fir guidelines are based on: Hood, Sharon M.; Smith, Sheri L.; Cluck, Daniel R. 2007. *Delayed conifer tree mortality following fire in California* In: Powers, Robert F., tech. editor. Restoring fire-adapted ecosystems: proceedings of the 2005 national silviculture workshop. Gen. Tech. Rep. PSW-GTR-203, Albany, CA: Pacific Southwest Research Station, Forest Service, U.S. Department of Agriculture: p. 261-283.

Douglas-fir guidelines are based on: Hood, Sharon M. 2008. *Delayed Tree Mortality following Fire in Western Conifers*. JFSP Final Report 05-2-1-105, US Department of Agriculture, Forest Service, Rocky Mountain Research Station, Missoula, MT. 35 p.

Lodgepole pine guidelines are based on: Ryan, Kevin C.; Reinhardt, Elizabeth D. 1988. *Predicting post-fire mortality of seven western conifers.* Canadian Journal of Forest Research 18: 1291-1297.

The following guidelines use percent crown length killed (and percent crown length scorched for yellow pine) or percent crown volume killed (for Douglas-fir and lodgepole pine) only or in combination with dbh, cambium kill rating and/or the presence or absence of bark beetle activity. The yellow pine, white fir, incense cedar, sugar pine and red fir guidelines are based on five year post-fire data, the Douglas-fir guidelines are based on three year post-fire data and the lodgepole pine guidelines are based on three to eight year post-fire data.

The yellow pine guidelines are separated for percent of crown length scorched and percent crown length killed. The percent crown length scorched guideline is appropriate when evaluating trees in late season fires prior to subsequent bud break (heat killing of foliage may occur with only light injury to buds and twigs and the full extent of crown kill cannot be determined until bud break occurs). The percent crown length killed guideline is appropriate when evaluating trees post-bud break. The percent crown length killed guidelines for sugar pine, incense cedar and red and white fir, or the percent crown volume killed models for Douglas-fir and lodgepole pine are appropriate any time after fire injury (all trees should be evaluated before the beginning of the second post-fire winter, preferably within the first post-fire year).

Evaluation of Crown Injury

Visually estimate the percent crown length killed (PCLK) for **white fir, red fir, incense cedar and sugar pine** to the nearest 5 percent, by standing far enough back from the tree so that the entire crown is visible. Optimum viewing of the crown is against a blue sky away from the sun.

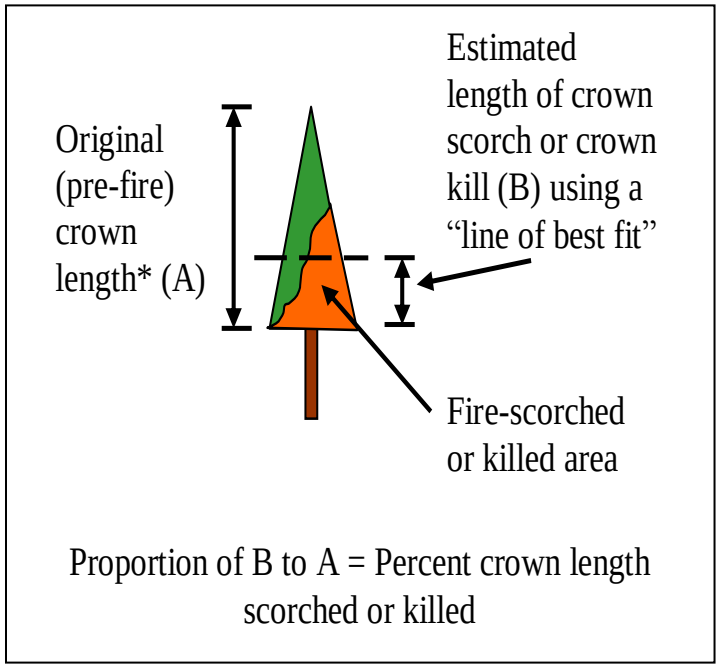


Figure 1. Estimating the percent crown length or scorched killed.

First, determine the original crown base height. Pre-fire crown base height can be estimated by looking at the fine branch structure and needles. Branches lacking fine twigs were likely dead before the fire. Trees often have asymmetrical crown bases so, if necessary, visually "move" some of the lower branches to the other side of the crown to even out the base.

Next, determine the crown kill height by establishing a "line of best fit" (Figure 1). Crown killed areas include any brown needles, as well as any areas that have blackened fine branches. If large gaps occur in the crown (> 4 feet in length), visually "move" lower branches up to fill in these areas. Be sure to evaluate the backside of the tree if its condition cannot be determined from the original vantage point.

Evaluate **yellow pine** *pre-bud break* (estimating percent crown length scorched or PCLS) using this same method and the *pre-bud break* guideline (Table 3). *Crown length is a linear measurement and does not account for crown shape.*

Visually estimate the percent crown length killed (PCLK) for **yellow pine** *post-bud break*, to the nearest 5 percent, by looking for completely dead branches (both scorched and/or blackened). Count an entire scorched branch as part of the live crown if green needles are extending from any of its lateral shoots (Figure 2).

Visually estimate the percent crown volume killed (PCVK) for **Douglas-fir and lodgepole pine**, to the nearest 5 percent, by comparing the volumetric proportion of crown kill (brown needles and blackened fine branches) to the volume occupied by the entire pre-fire crown. *Crown volume estimates consider crown shape.*

Figure 2. Bud survival on scorched branch.

Evaluation of Crown Injury

Figures 3 and 4 illustrate the different portions of fire-injured crowns for yellow pine and white fir and provide examples of the estimated crown length scorched (for pine) and crown length killed (for both pine and fir) as percentages of the original, pre-fire crown length.

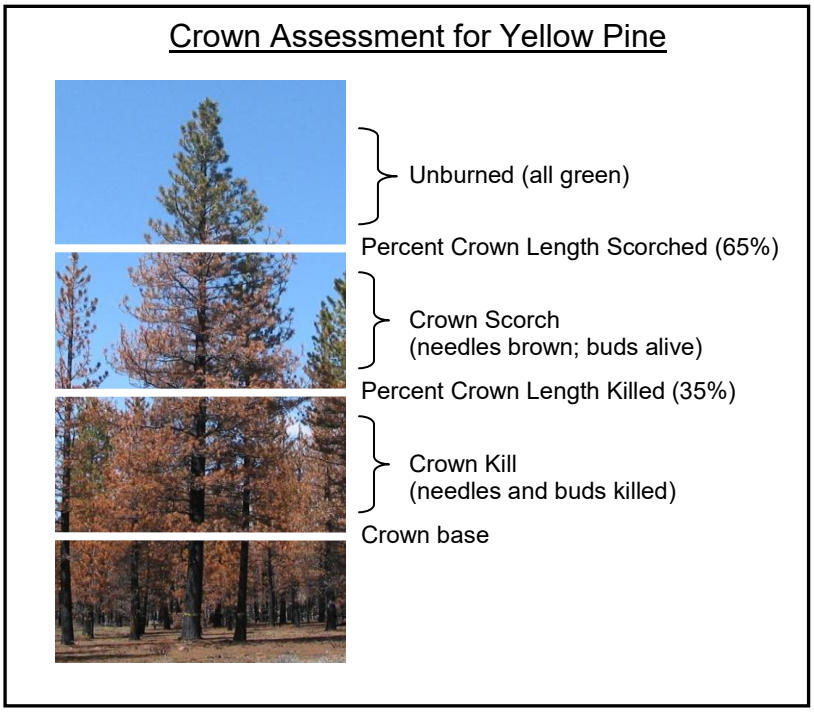


Figure 3. Crown assessment for yellow pine.

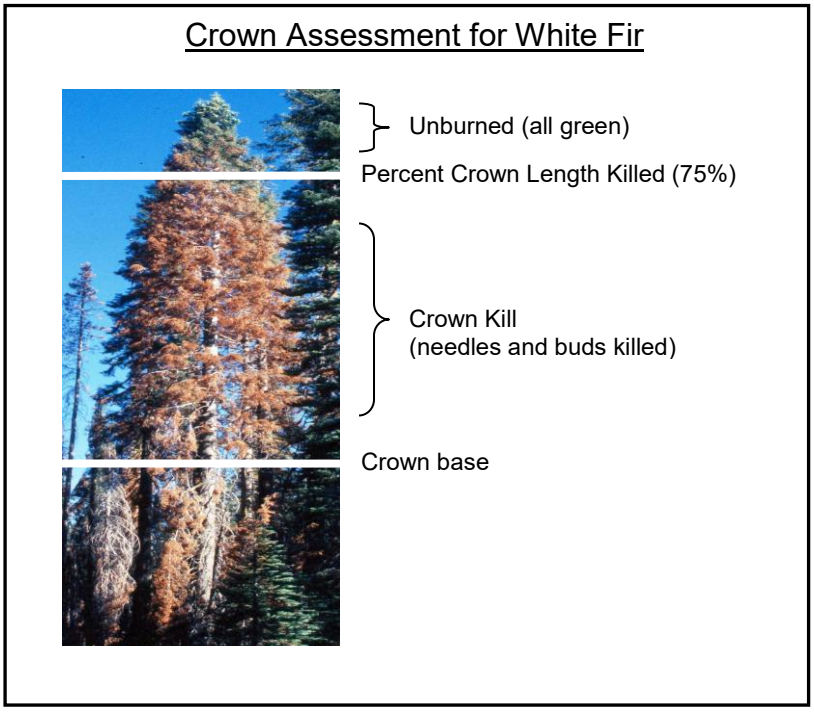
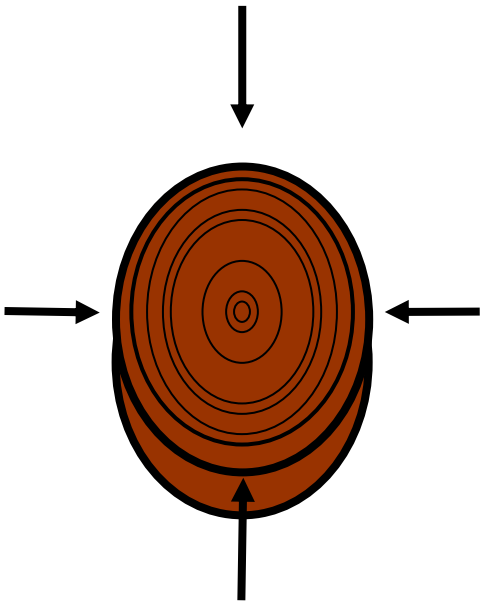


Figure 4. Crown assessment for white fir.

Evaluation of Cambium Injury



Sample cambium in as small an area as possible at 4 equally spaced locations around bole and within 3” of the ground line to minimize tree wounding
(Figure 5)

Each sample is visually inspected in the field for color and condition of the tissue. Dead cambium is darker in color, often resin soaked and hard or gummy in texture. Live cambium is lighter in color, moist and rather pliable. Dead cells in the cambium zone also lose their plasticity which may allow the bark and wood to separate more easily (Ryan 1982). Add up the total number of dead samples (0 to 4) to determine the cambium kill rating (CKR). When both live and dead cambium is encountered in a sample choose the dominant condition of that sample (e.g. if more than half of the sample is dead then count it as dead).

Figure 6. Sampling cambium with a small hatchet.

Evaluation of Cambium Injury

Bark Charring as a substitute for direct cambium sampling

When salvage marking includes cambium sampling, additional time is required to assess each tree. Direct cambium sampling can be reduced by using unburned, light and deep bark char classes as a substitute (Hood et al 2008). **Moderately charred quadrants would still require direct sampling (except for lodgepole pine and Douglas-fir)**. Divide the tree bole into four quadrants and assess the bark within 1 foot of ground line. Use the bark char class that best represents the majority of the area. Please refer to the following bark char descriptions (Ryan 1982) when substituting bark char classes for direct cambium sampling. Determine the CKR (0 to 4) as previously described.

Unburned or light charring – light charring has some blackened areas on the bark but unburned portions remain. These unburned portions are generally found in the bark fissures. *(Assume cambium is alive except for lodgepole pine; must directly sample lightly charred quadrants for lodgepole pine)*

Moderate charring – with moderate charring, all bark is blackened but the bark characteristics remain. *(Must directly sample to determine cambium status except for lodgepole pine and Douglas-fir; assume cambium is dead for moderately charred quadrants on lodgepole pine; assume cambium is alive for moderately charred quadrants on Douglas-fir)*

Deep charring – with deep charring, all the bark is blackened and bark characteristics are no longer discernable. *(Assume cambium is dead)*

Evaluation of Red Turpentine Beetle Activity

Figure 7. Red turpentine beetle pitch tubes.

Determine the simple presence or absence of red turpentine beetle pitch tubes (Figure 7) on yellow and sugar pine. The density or percent coverage of attacks around the bole is not a concern. The importance of this variable depends on the timing of the fire and the subsequent level of red turpentine beetle activity and is only used when significant activity is detected. FHP personnel can assist with this determination. Even though the presence of red turpentine beetle pitch tubes is used as criterion in some of the pine guidelines, it should not be used exclusively to mark trees for removal (see top of page 8).

Determining what variables to use when marking trees

Managers need to determine how much time is available for assessing each tree. The most accurate marking guidelines (requiring the most time) assess crown injury, cambium injury and red turpentine beetle (RTB) activity (for yellow and sugar pine). At a minimum, a crown injury assessment is required for all species. Assessing cambium injury and/or RTB activity (for yellow and sugar pine) requires additional time per tree but does provide a slight increase in accuracy for white fir, sugar pine and yellow pine. In general, if managers choose to only assess crown injury and the fire resulted in cambium kill ratings >2 on most trees, mortality will be under predicted. The opposite is true if the fire resulted in cambium kill ratings of ≤ 2 on most trees, as mortality will then be over predicted (this varies by tree species). Mortality could also be under or over predicted if RTB activity is not assessed (depends of level of post-fire RTB activity). Knowledge of fire behavior, pre-fire fuel conditions and post-fire RTB activity will help to determine the value of assessing for these variables.

Selecting the predicted probability of mortality (Pm) level that will meet land management objectives

The probability of mortality (Pm) levels incorporated into the guidelines are thresholds where all trees meeting or exceeding a selected Pm level are marked for removal. Providing a range of Pm levels afford land managers more options to meet post-fire management objectives. The number of trees removed from a project area will generally vary with different Pm levels; fewer trees will be marked at higher Pm levels (a more conservative mark) and more trees will be marked at lower Pm levels (a less conservative mark) (Figure 8). The exact amount of difference in the mark between Pm levels depends on the population of fire-injured trees within the project area. For example, if the project consists primarily of high severity burn areas the number of trees marked for removal will not significantly change with different Pm levels.

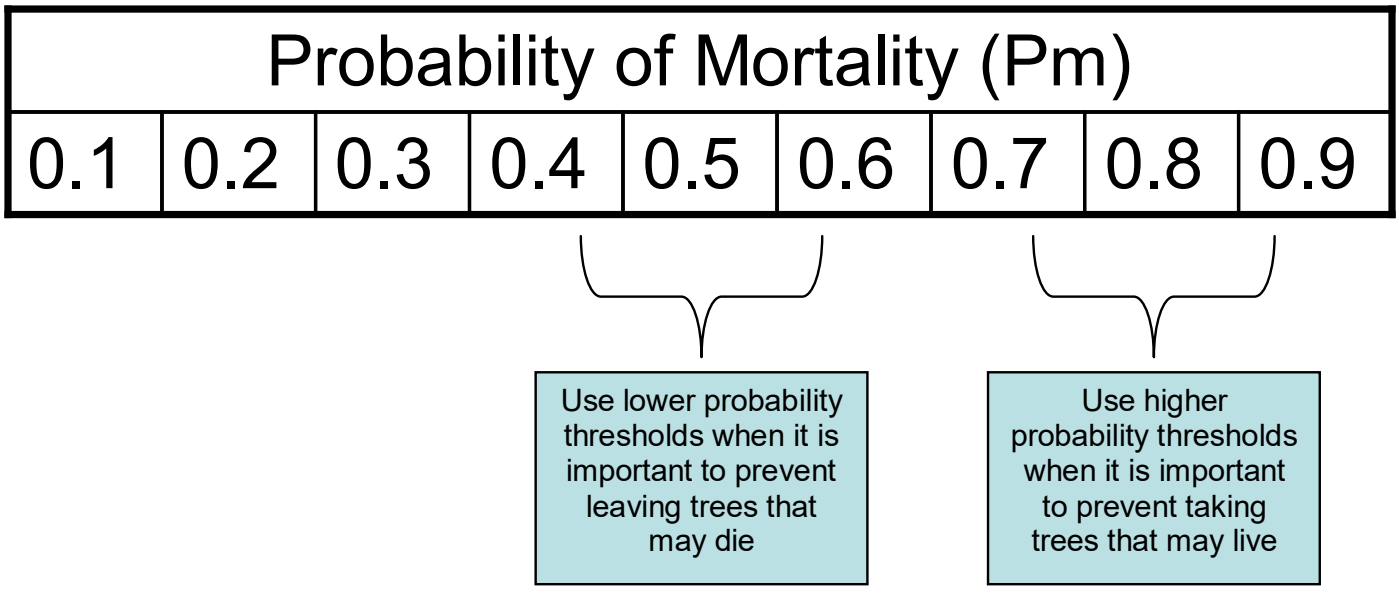


Figure 8. General recommendations based on management objectives for various Pm levels.

The selection of the Pm level should take into consideration the following factors:

- The population of fire-injured trees within the project area [can be based on vegetation burn severity maps showing low, moderate and high severity (Figure 9)]
- Management objectives and desired future conditions
- Number of harvest entries allowed
- Post-salvage fuels objectives
- Snag requirements
- Method of harvest: tractor, helicopter, cable, etc
- Economics and logistics (availability of marking crews and operators, timber values, length of contracts, etc.)
- Reforestation plans: planting and/or natural regeneration
- NEPA process
- Hazard trees
- Environmental conditions (drought, stand density, and beetle activity)

After identifying project-specific objectives, conditions and requirements, land managers should be able to determine which Pm level, or levels (more than one may be selected), will best meet their needs. Consultation with Forest Health Protection staff and other land managers that have implemented projects using these guidelines can greatly assist in making a Pm selection. It is also recommended that land managers document the rationale used to make Pm level selections for future reference.

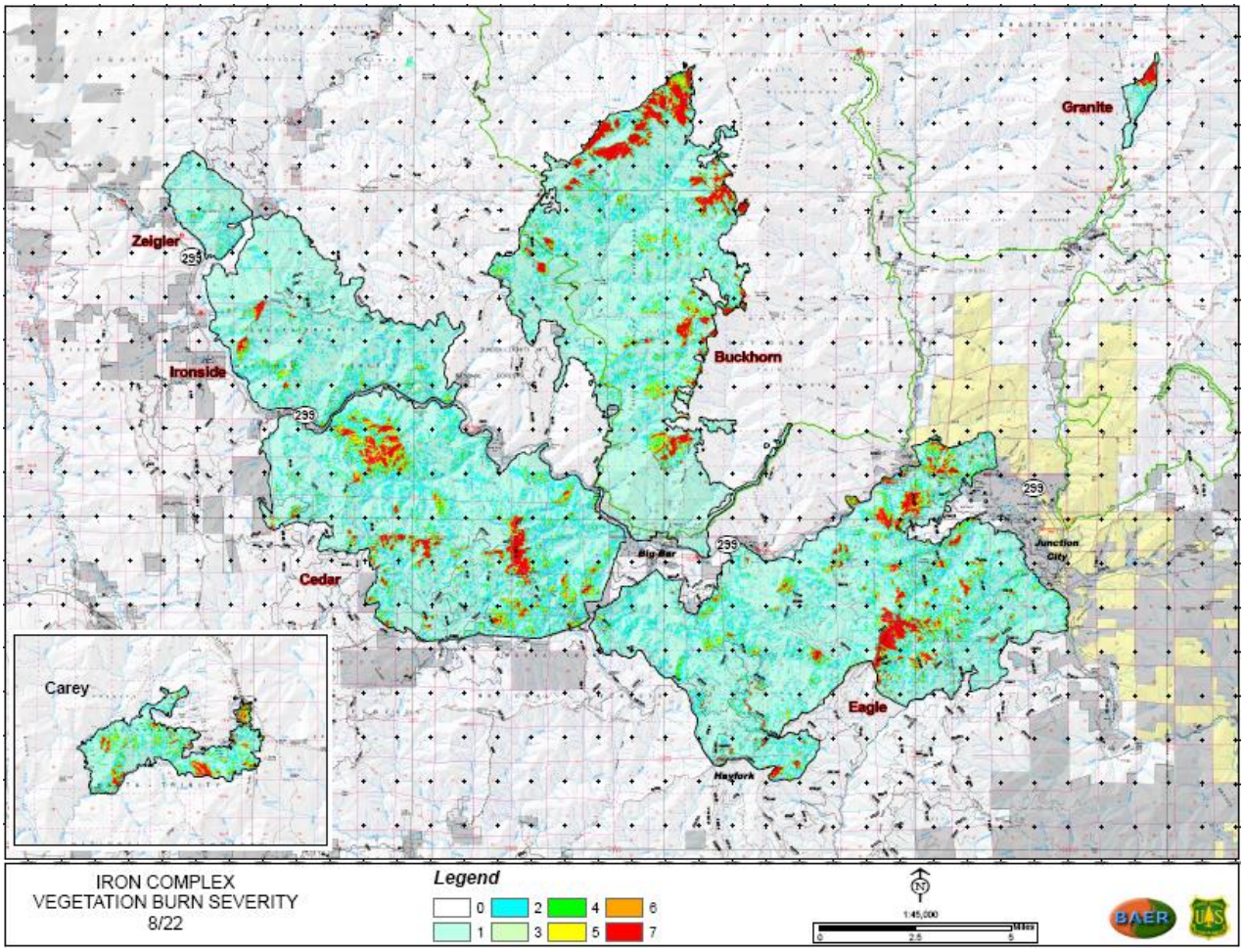


Figure 9. Vegetation Burn Severity Map.

MARKING GUIDELINES FOR FIRE-INJURED TREES

Evidence of significant bark and/or wood boring beetle activity

(Any tree meeting this criteria is predicted to die and no further assessment is required)

Trees should be marked for removal if any combination of the following factors are present over at least 1/3 of the bole circumference: 1) pitch tubes with pink or reddish boring dust associated with them (not clear pitch streamers); 2) pouch fungus conks and/or current woodpecker activity (holes into the sapwood and/or bark flaking, specifically excludes injury caused by sapsucker feeding); 3) boring dust or frass (in bark crevices, webbing along the bole, or that accumulates at the base of the trees). This specifically excludes basal attacks by the red turpentine beetle (large pitch tubes associated with coarse boring dust generally restricted to the lower 2 to 3 feet of the bole or woodpecker activity restricted to this area)* and when the above indicators are only associated with wounds, old fire scars, etc. (Cluck 2008)

*The presence or absence of red turpentine beetle pitch tubes are incorporated into the yellow pine marking guidelines in Tables 2a and 2b.

YELLOW PINE

Table 1 or Tables 2a and 2b are to be used when evaluating trees ***post-bud break***.
Table 3 is used when evaluating trees ***pre-bud break***.

Table 1. YELLOW PINE: percent crown length killed (PCLK) and DBH *(use post-bud break)**

- Use Table 1 when only assessing crown injury.

Probability of mortality (Pm)	**.10**	**.20**	**.30**	**.40**	**.50**	**.60**	**.70**	**.80**	**.90**
DBH	**Percent crown length killed (PCLK)**								
10 - <30”	25	35	40	45	50	55	60	65	70
30 - 40”	--	5	10	15	25	30	40	45	60
>40 - 50”	--	--	--	5	10	15	25	30	45

Table 2a. YELLOW PINE: PCLK, DBH and red turpentine beetle pitch tubes PRESENT*

- Use Tables 2a and 2b when assessing crown injury and red turpentine beetle presence/absence
  Note: Use of this guideline is appropriate when significant red turpentine beetle activity is detected. FHP personnel can assist with this determination.

Probability of mortality (Pm)	**.10**	**.20**	**.30**	**.40**	**.50**	**.60**	**.70**	**.80**	**.90**
DBH	**Percent crown length killed (PCLK)**								
10 - <30”	10	30	35	40	45	50	55	60	65
30 - 40”	--	--	--	--	--	5	10	15	25
>40 - 50”	--	--	--	--	--	--	--	5	10

YELLOW PINE (continued)

Table 2b. YELLOW PINE: PCLK, DBH and red turpentine beetle pitch tubes ABSENT*

Probability of mortality (Pm)	.10	.20	.30	.40	.50	.60	.70	.80	.90
DBH	Percent crown length killed (PCLK)								
10 - <30"	30	35	50	55	60	65	70	75	80
30 - 40"	5	10	20	25	30	40	45	55	65
>40 - 50"	--	--	--	5	10	15	25	35	45

* When the cambium kill rating (CKR) is determined for **yellow pine,** *post-bud break*, use the following percent crown length killed adjustments for Tables 1, 2a and 2b: For yellow pine **10 - <30" dbh**, *add* 5 percentage points when CKR = 0 or 1, *no change* when CKR = 2, and *subtract* 10 percentage points when CKR = 3 or 4. For yellow pine **>30" dbh**, *add* 5 percentage points when CKR = 0 or 1, *no change* when CKR = 2, and *subtract* 5 percentage points when CKR = 3 or 4.

Table 3: YELLOW PINE: percent crown length scorched (PCLS) and DBH *(use pre-bud break)**

- *Note: The red turpentine beetle guideline is not used in the pre-bud break model*

Probability of mortality (Pm)	.10	.20	.30	.40	.50	.60	.70	.80	.90
DBH	Percent crown length scorched (PCLS)								
10 - <30"	50	50	70	75	80	85	90	95	100
30 - 40"	10	25	35	40	45	55	60	70	80
>40 - 50"	--	10	15	20	30	35	40	50	65

* When the cambium kill rating (CKR) is determined for **yellow pine,** *pre-bud break*, use the following percent crown length scorched adjustments for Table 3: For yellow pine **10 - <30" dbh**, *add* 15 percentage points when CKR = 0, *add* 10 percentage points when CKR = 1, *no change* when CKR = 2, *subtract* 10 percentage points when CKR = 3 and *subtract* 15 percentage points when CKR = 4. For yellow pine **>30" dbh**, *add* 5 percentage points when CKR = 0, *no change* when CKR = 1, *subtract* 5 percentage points when CKR = 2, and *subtract* 10 percentage points when CKR = 3 or 4.

INCENSE CEDAR

Table 4: INCENSE CEDAR - percent crown length killed (PCLK)*

Probability of mortality (Pm)	.10	.20	.30	.40	.50	.60	.70	.80	.90
DBH	Percent crown length killed (PCLK)								
10 – 60"	65	70	75	80	85	85	90	90	95

* Cambium sampling is not recommended for incense cedar.

SUGAR PINE

Table 5: SUGAR PINE - percent crown length killed (PCLK)*

- Use Table 1 when only assessing crown injury.

Probability of mortality (Pm)	.10	.20	.30	.40	.50	.60	.70	.80	.90
DBH	Percent crown length killed (PCLK)								
10 – 60”	--	30	40	50	50	55	60	65	70

Table 6a: SUGAR PINE - PCLK and red turpentine beetle pitch tubes PRESENT*

- Use Tables 6a and 6b when assessing crown injury and red turpentine beetle presence/absence
  Note: Use of this guideline is appropriate when significant red turpentine beetle activity is noted. FHP personnel can assist with this determination.

Probability of mortality (Pm)	.10	.20	.30	.40	.50	.60	.70	.80	.90
DBH	Percent crown length killed (PCLK)								
10 – 60”	--	--	--	30	40	45	55	60	65

Table 6b: SUGAR PINE - PCLK and red turpentine beetle pitch tubes ABSENT*

Probability of mortality (Pm)	.10	.20	.30	.40	.50	.60	.70	.80	.90
DBH	Percent crown length killed (PCLK)								
10 – 60”	30	45	55	60	60	65	70	75	80

* When the cambium kill rating (CKR) is determined for **sugar pine**, use the following percent crown kill adjustments for Tables 5, 6a and 6b: *Add* 5 percentage points when CKR = 0 - 3 and *subtract* 20 percentage points when CKR = 4.

WHITE FIR

Table 7. WHITE FIR: percent crown length killed (PCLK) and DBH * º

Probability of mortality (Pm)	.10	.20	.30	.40	.50	.60	.70	.80	.90
DBH	Percent crown length killed (PCLK)								
10 - 35”	50	60	65	70	75	80	80	85	90
>35 - 60”	--	35	45	50	60	65	70	75	80

* When the cambium kill rating (CKR) is determined for **white fir**, use the following percent crown kill adjustments for Table 7: *Subtract* 5 percentage points when CKR = 1 or 2, *subtract* 10 percentage points when CKR = 3 or 4 and *no change* when CKR = 0.

º FHP monitoring of fire-injured **white fir** revealed high levels of decay developing where significant cambium kill occurred at the root collar and on the bole. A portion of these decayed trees failed during the five-year period while still retaining green foliage. Land managers should be aware that even though true firs with high levels of cambium kill have a high probability of survival they may become hazards to people or property (Cluck 2005).

RED FIR

Table 8. RED FIR: percent crown length killed (PCLK) º

Probability of mortality (Pm)	.10	.20	.30	.40	.50	.60	.70	.80	.90
DBH	**Percent crown length killed (PCLK)**								
6 – 40”	--	40	45	65	70	75	80	85	95

º FHP monitoring of fire-injured **red fir** revealed high levels of decay developing where significant cambium kill occurred at the root collar and on the bole. A portion of these decayed trees failed during the five-year period while still retaining green foliage. Land managers should be aware that even though true firs with high levels of cambium kill have a high probability of survival they may become hazards to people or property (Cluck 2005).

DOUGLAS-FIR (Hood 2008)

Table 9. DOUGLAS-FIR: percent crown volume killed (PCVK), and DBH *

- This guideline uses ***percent crown volume killed*** (not percent crown length killed). Visually estimate the volumetric proportion of crown killed compared to the space occupied by the pre-fire crown volume to the nearest five percent (Ryan 1982).

Probability of mortality (Pm)	.10	.20	.30	.40	.50	.60	.70	.80	.90
DBH	**Percent crown length killed (PCLK)**								
4 – 40”	--	10	25	55	65	70	75	80	90

***** When the cambium kill rating (CKR) is determined for **Douglas-fir**, use the following percent crown kill adjustments for Table 9: *Add* 5 percentage points when CKR = 0, *no change* when CKR = 1, *subtract* 5 percentage points when CKR = 2, *subtract* 10 percentage points when CKR = 3, *subtract* 20 percentage points when CKR = 4.

LODGEPOLE PINE (Ryan and Reinhardt 1988)

Table 10. LODGEPOLE PINE: percent crown volume killed (PCVK) and DBH

- This guideline uses ***percent crown volume killed*** (not percent crown length killed). Visually estimate the volumetric proportion of crown killed compared to the space occupied by the pre-fire crown volume to the nearest five percent (Ryan 1982).

Probability of mortality (Pm)	.10	.20	.30	.40	.50	.60	.70	.80	.90
DBH	**Percent crown volume killed (PCVK)**								
≤10”	-	-	-	-	-	5	30	40	55
>10 - 15”	-	-	-	-	20	35	45	55	70
>15 – 20”	-	-	-	25	35	40	50	60	70
All lodgepole pine, regardless of diameter, are predicted to die if all bole quadrants have moderate or deep char as defined by Ryan (1982) (Hood 2006).									

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Appendix A: Project specific guideline example

Marking Guidelines for Fire-injured Trees: Scorch Fire Salvage Project

Guideline Objectives: *These guidelines will provide a means to identify and remove trees that were killed or severely injured as a result of fire and/or insect attack within the Scorch Fire, California Ranger District.*

These guidelines are based on the fire injured tree marking guidelines developed by Region 5 Forest Health Protection (Report #RO-11-01, Smith and Cluck, May 2011). The guideline criteria (#3) for delayed conifer tree mortality are based on the post-bud break model (% crown length killed) for yellow pine, and the white fir and red fir models (% crown length killed). A probability of mortality of 0.7 (Pm=0.7) was selected for this project to meet the management objectives of: 1) removing trees that were killed or that have a high probability of mortality to recover their economic value; and 2) retaining those trees that have a moderate to high probability of survival to provide forest cover as a seed source for natural regeneration and wildlife habitat. **All trees >40" dbh, regardless of condition, will be retained to provide for wildlife except when they pose a hazard to people or property.**

> **Note:** The Smith and Cluck 2011 guidelines also discuss the evaluation of cambium injury (for yellow pine, sugar pine and white fir) for adjusting crown kill marking criteria. The Scorch Fire Salvage Project marking guidelines **DO NOT** include cambium sampling for this purpose due to the additional time required to assess individual trees and the minimal loss of accuracy incurred by dropping this variable.

Mark for removal any tree that meets the following criteria:

1. Any tree with no green needles (does not include those designated for snag retention).

2. For all species, trees should be marked for removal if any combination of boring dust or frass (in bark crevices, webbing along the bole, or that accumulates at the base of the trees), pitch tubes with pink or reddish boring dust associated with them, pouch fungus conks and/or current woodpecker activity (holes into the sapwood and/or bark flaking, specifically excludes injury caused by sapsucker feeding) is present over at least 1/3 of the bole circumference. This specifically excludes basal attacks by the red turpentine beetle on pines (large pitch tubes associated with coarse boring dust generally restricted to the lower 2 to 3 feet of the bole or woodpecker activity restricted to this area) and when the above indicators are only associated with wounds, old fire scars, etc. The presence or absence of red turpentine beetle pitch tubes will be accounted for in criteria #3.

3. Any tree that meets or exceeds the following fire-injured conifer mortality guidelines (Table 1) at the Pm = 0.7 level. This assessment will be made by visually estimating the percent of the original pre-fire crown length that was killed (yellow and sugar pine, white and red fir), the presence or absence of red turpentine beetle pitch tubes (yellow and sugar pine) and tree diameter (yellow pine and white fir).

Table 1: Specific criteria for marking fire-injured trees at the Pm = 0.7 level.

Yellow Pine – Red turpentine beetle absent	
DBH	**Minimum % Crown Length Killed**
10 - <30″	70
30 - 40″	45
Yellow Pine – Red turpentine beetle present	
DBH	**Minimum % Crown Length Killed**
10 - <30″	55
30 - 40″	10
Sugar Pine – Red turpentine beetle absent	
DBH	**Minimum % Crown Length Killed**
10-40″	70
Sugar Pine – Red turpentine beetle present	
DBH	**Minimum % Crown Length Killed**
10-40″	55
White fir	
DBH	**Minimum % Crown Length Killed**
10 - 35″	80
>35 - 40″	70
Red fir	
DBH	**Minimum % Crown Length Killed**
10-40″	80

References for Scorch Fire Salvage Marking Guidelines

Cluck, D.R. 2008. *Salvage Marking Guidelines for the Lassen, Plumas, Modoc and Tahoe National Forests.* US Forest Service, Forest Health Protection, Northeastern California Shared Service Area, Susanville, CA. 4 p.

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