Post-fire tree mortality

Forest Health Fact Sheet

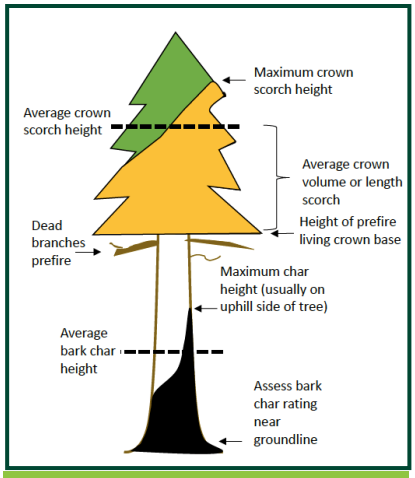
November 2020

Crown scorch in ponderosa pine (C. Buhl)

This guide serves as an overview on how to estimate and predict tree mortality after wildfire. A comprehensive guide with complete species-specific post-fire mortality ranking tables is available in the U.S. Forest Service publication (R6-FHP-RO-2020-02): "**Post-fire Assessment of Tree Status and Marking Guidelines for Conifers in Oregon and Washington**". Many ranking guides exist so it is best to use those from your region that were developed from local research or field-verified models. These guides are meant to help determine which trees should be removed in the salvage or sanitation process. The guides are not *exact* but serve as a starting point to understand which aspects of fire damage have the most influence on tree mortality, as well as how much damage each tree species can withstand. Post-fire mortality marking guides should not be used as substitutes for hazard tree marking guides (see "**Field Guide for Hazard-Tree Identification and Mitigation**"). Lastly, expedient tree removal and processing will reduce the amount of insect and fungi-caused defects in fire-damaged timber.

How does fire kill trees?

Wildfire can directly kill trees by heating or burning the crown, trunk and/or roots, which damages photosynthetic and vascular tissues that support tree growth and defense. The ability for a tree to survive after a fire depends primarily on the magnitude of crown and cambium damage. Various conditions can influence these damage levels (e.g., fire intensity, duration, timing, heat conductivity across soil types, bark thickness, basal duff buildup, etc.).



Crown scorch and bole char (USFS R6 FHP)

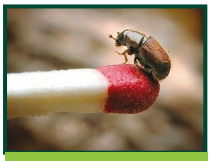
Crown damage occurs when needles are scorched or consumed by fire which disrupts photosynthesis. Buds and cones may also be damaged, which affects needle and seed production in the short term and tree survival and stand regeneration in the long term. Proportion of the live crown with crown scorch is the metric for crown damage.

Cambium damage occurs when the bole of a tree is charred or "cooked" enough to kill tissues. Cambium tissue includes both phloem and xylem, which are vascular tissues that transport water and nutrients throughout the tree. Trees with high levels of cambium damage but low crown scorch may take years to die from fire damage. For example, xylem tissues, which are deeper in the trunk, are unaffected by bole charring and continue to transport water to the crown for photosynthesis. While cambium and phloem tissues are closer to the surface and therefore more exposed to heat and bole char, which disrupts transport of nutrients from the crown to the roots. When the fine roots eventually start to die back, less water can be obtained and the tree starts to die. Proportions of the bole circumference with bole char or dead cambium is the metric for cambium damage.

Insect pests following wildfire

Trees have chemical and mechanical defenses that repel, kill, or allow trees to tolerate insect and microbial pests. Fires can damage these defenses and cause trees to release volatiles that signal their stressed state to attacking pests. Opportunistic insects such as bark beetles and woodborers are usually the first to move into fire-damaged trees and may continue to attack damaged stands for 2-4 years following fire. Susceptibility to insect pests is higher in stands that were already stressed before the fire by drought, storm damage, overstocking, root diseases, etc.

Bark beetles are small but mighty! They are part of a functioning ecosystem and at normal levels they kill off struggling trees. However, when there is an abundance of stressed trees, bark beetle populations can build to levels where they can overwhelm tree defenses. They also vector fungi that clog vascular tissues and hasten tree mortality. Bark beetles do not enter wood but their vectored fungi can stain (but not rot) wood which may result in defect.



Bark beetle (USFS)

Woodborers range from bark beetle size to the length of a finger and can sometimes be heard chomping away at wood. Woodborers are not typically tree killers but they can cause wood defects by creating holes in the wood and some can vector wood-staining fungi. The ability for fire-damaged trees to withstand insect attacks depends on both the severity of fire damage and tree health before the fire.

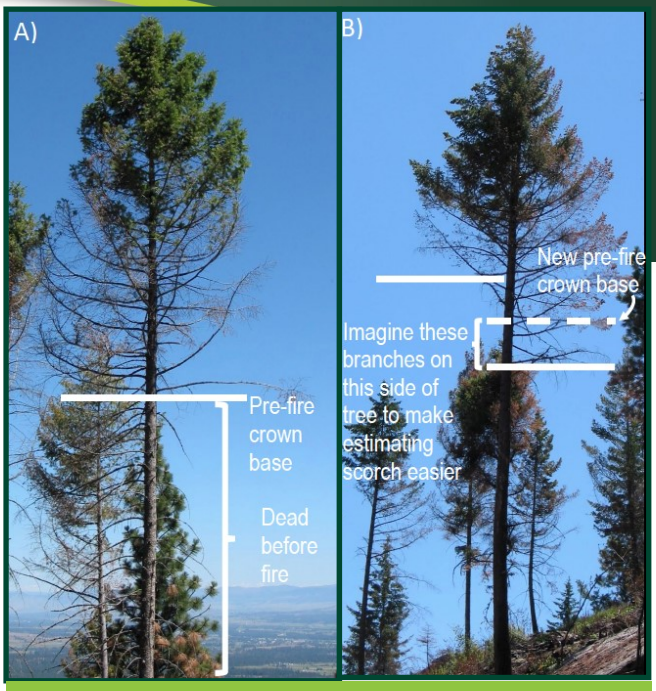
Woodborer (C. Buhl)

Assessing probability of tree mortality

Ranking guides that assess the probability of post-fire tree mortality typically use these metrics:

- Tree species
- Proportion of crown volume or length that was scorched
- Proportion of charring around bole circumference (approximates cambium damage)
- Proportion around bole circumference with evidence of insect attack

Estimating crown scorch:
Determine the proportion of the live crown scorched by fire. The live crown includes branches that were alive and contained green needles before the fire. If the crown is asymmetrical, imagine rearranging branches to fill the space. It may be helpful to first visualize the 50% mark.

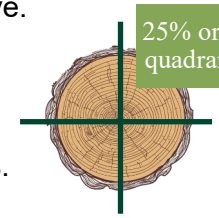


Assessing live crown : A) the white line indicates the bottom of the live crown proportion, B) the dotted line indicates where the bottom of the live crown proportion would be if the branches below it were "moved" up to symmetrically even out the crown base. Both trees have about 50% live crown scorch. (USFS R6 FHP)

It is important to assess trees for removal within the first year after wildfire before crown symptoms change. While the appearance of new growth and epicormic resprouts can look promising, they can also mask the intensity of initial fire damage.

Estimating bole char/cambium damage:
External bole charring can be used as a proxy for cambium damage because sampling the cambium is more difficult and destructive to the tree. Some tree species such as ponderosa pine, incense cedar, Douglas-fir and western larch, or older trees have thicker bark and are more insulated from damage to cambium. For these trees external estimates of bole char are appropriate to determine damage. Intense charring will reduce bark furrows and patterns. For thin-barked tree species such as lodgepole pine, Engelmann spruce and some firs, the more destructive method of sampling cambium may be easier and more informative.

To measure bole char, visually separate the circumference of the bole into four quadrants and count the number of damaged quadrants.



To sample cambium, use a punch or a hatchet to view the cambium at each quadrant. Live cambium and phloem is light in color, moist and pliable; it typically separates from the wood as a distinct layer. Dead cambium may be dark, stringy, gummy, or it may be hard to find the distinct layer between the bark and the wood. Sampling unburned trees can give a good sense of what live cambium looks and feels like for different tree species.

Dark dead cambium (left), light live cambium (right) (USFS R6 FHP)

Estimating insect attack and/or infestation: Evidence of bark beetle attack includes brown frass (boring dust) in the bark crevices, pitch streams (Douglas-fir, true firs, etc.) or pitch tubes (pines) on the bole. If this evidence is present on more than 50% of the bole circumference, enough tissue has been girdled by the beetles to result in tree mortality regardless of fire injury.

Red turpentine beetle pitch tube and frass (C. Buhl)

Attacks from red turpentine beetles in pine are an exception, because this insect is usually a secondary pest that indicates high tree stress but does not kill the tree directly. Evidence of attack from this bark beetle occurs lower on the bole and includes quarter-sized pitch tubes and frass the consistency of Grape-Nuts that fall around the base of the tree. A few red turpentine beetle attacks can be ignored although excessive attacks are indicative of significant tree stress or imminent mortality from other agents.

Evidence of woodborer attacks include stringy or powdery white frass and holes in the wood. The presence of this woodborer activity on various locations around the bole usually indicates that the tree is already dead or dying.

Pitch tubes (top left) and brown frass (top right) from bark beetle attacks. Feeding gallery and holes (bottom left) and white frass (bottom right) from woodborers. (C. Buhl)

The last page of this fact sheet contains an abbreviated table for estimating the probability of tree mortality for various Oregon tree species. This table depicts levels of each damage metric that may result in a 50% probability of mortality (higher and lower probabilities are available in the USFS guidance). For example, if a 15" diameter Douglas-fir has 75% crown scorch, the likelihood that it will die is more probable than not. If it has more than 75% (or three quadrants) of charring around the bole circumference then this same tree is more likely to die than not. If this tree has evidence of bark beetle or woodborer attack around more than 50% of the bole circumference it will likely die, regardless of fire damage.

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Timber Salvage After Wildfires factsheet

USFS Forest Health Protection
Report R6-FHP-RO-2020-02

OSU Forestry Extension
http://extensionweb.forestry.oregonstate.edu/

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Quick Marking Guide

November 2020

Species	Criteria	Diameter Class		
		5 – 11.9"	12 – 20.9"	21"+
ABAM: Pacific silver fir	Crown scorch	> 30% volume		> 40% volume
	Bark char	≥ 50% any char		
ABCO: white fir or hybrids	Crown scorch	≥ 70% volume		
	Bark char	≥ 75% deep char		
ABGR: grand fir	Crown scorch	≥ 60% volume		
	Bark char	≥ 50% any char	≥ 75% moderate or deep char	
ABLA: subalpine fir	Crown scorch	> 30% volume		> 40% volume
	Bark char	> 50% any char		
ABMA: red fir	Crown scorch	≥ 70% volume		
	Bark char	> 75% deep char		
CADE: Incense cedar	Crown scorch	≥ 85% volume		
	Bark char	> 75% deep char		
LAOC: Western larch	Crown scorch	If needles on: ≥ 80% crown length If needles off: average char height over entire tree length > 70%		
	Bark char	> 75% deep char	Bole char not a predictive injury indicator	
PIEN: Engelmann spruce	Crown scorch	≥ 75% volume		
	Bark char	> 75% any char		
PISI: Sitka spruce	Crown scorch	≥ 75% volume		
	Bark char	> 75% any char		
PICO: Lodgepole pine	Crown scorch	≥ 40% volume		
	Bark char	≥ 75% any char		
PIAL: Whitebark pine	Crown scorch	≥ 40% volume		
	Bark char	≥ 75% any char		
PILA: Sugar pine	Crown scorch	≥ 70% volume		
	Bark char	> 90% moderate or deep char		
PIMO: Western white pine	Crown scorch	> 30% volume		
	Bark char	≥ 90% any char		
PIPO: Ponderosa pine	Crown scorch	Pre-bud break (volume): • > 85% needles scorched OR • > 40% needles consumed/blackened OR • > 5% and ≤ 40% needles consumed/blackened combined with >50% needles scorched Post-bud break (volume): > 70% crown volume killed (no new growth)		
	Bark char	> 90% deep char		
PSME: Douglas-fir	Crown scorch	> 65% crown volume		
	Bark char	> 50% deep char	> 75% deep char	
THPL: Western red cedar	Crown scorch	> 20% crown volume	> 40% crown volume	> 60% crown volume
	Bark char	> 50% any char		> 75% any char
TSHE: Western hemlock	Crown scorch	≥ 20% crown volume		
	Bark char	≥ 90% any char		
TSME: Mountain hemlock	Crown scorch	≥ 20% crown volume		
	Bark char	≥ 90% any char		

This guide depicts levels of damage (proportion crown scorch and circumference of bole char) that may result in a 50% probability of tree mortality. If there is evidence of bark beetle or woodborer attack around >50% of the bole circumference the tree will die regardless of fire injury. The full marking guide can be found in USFS Report R6-FHP-RO-2020-02.