Forest Health Alert

Fire Injury to Trees

Will the trees live or die?

Predicting tree mortality is a primary concern after fires sweep through forests. Landowners need to assess how badly trees are damaged so they can retain those trees which will recover, yet quickly salvage the trees which are unlikely to survive. Rapid salvage allows financial return and removes potential breeding sites for insect pests. This fact sheet describes the damaging effects of fires on trees. It covers how insects respond to fire-weakened trees. It also provides a system for evaluating whether a fire damaged tree is likely to survive.

Fire behavior and tree mortality

In general, trees are killed outright by crown fires and high intensity fires. Lower intensity fires may leave damaged strands or cause partial tree kill. The recovery and subsequent growth of a fire-damaged tree depends on its capacity to carry out normal physiological processes, especially photosynthesis.

Degree of crown scorch, foliage consumption, bud mortality, and stem damage to the bark and cambium layer (just under the bark) determine whether trees will survive. Crown scorch is caused by hot gases rising from a fire burning along the ground. When scorch is severe the foliage and twigs are “baked” into a directional set that indicates the run of fire. Twigs and foliage with a directional set do not recover, and the foliage tends to remain on the trees for a few years. Trees that have had their needles consumed by the fire also do not survive.

While complete crown scorch causes rapid tree death, many trees with partially scorched crowns survive. A major determining factor in whether a conifer with a crown scorch can survive is the damage to the buds. Buds may not be killed in a tree that has been moderately scorched, in which case the tree would probably recover.

Most long-term studies have shown that fire-related mortality during the second growing season following fires is greater than that observed during the first. Approximately 90% of tree mortality occurs within three years.

In addition, insects, weathering, and fungi cause degradation of fire-killed timber that is intended for salvage. The rate of degradation, size of trees in question, and market conditions determine how long it continues to be economical to salvage dead timber following tree death.

Insects and fire-damaged trees

Freshly killed or fire injured trees are very attractive to certain insects such as bark beetles and wood borers. These insects are well-adapted to locating weakened trees, sometimes attacking trees even before fires have been put out. Severely weakened trees are killed swiftly, providing additional growing space for surviving trees and future wildlife habitat. Wood boring insects introduce bacteria and decay fungi deep into logs and snags, an important role in the initial stages of decomposition. Damage results when bark beetles kill trees that might otherwise survive or when boring insects degrade the wood of fire-killed trees intended for salvage.

Bark beetles consume the nutritious phloem tissue between the bark and wood of dead trees. Most take advantage of dead or severely weakened trees. Bark beetles use communication chemicals and overwhelm tree defenses with high numbers of simultaneous attacks. The beetles also carry fungi which assist in killing the tree and eventually degrade the wood.

Bark beetle induced mortality to fire-injured trees occurs primarily in the first year or two following the fire. Additional mortality may occur when a high beetle population which developed in the fire-injured trees attacks the fire survivors the next year. The extent and duration of this subsequent mortality depends on the size of beetle populations and vigor of remaining trees. Not all bark beetle species have the potential to kill fire survivors.

The best way to reduce the risk of bark beetle-caused tree mortality is to remove dead and dying trees before beetle populations grow large enough to move on and attack uninjured or recovering trees. Very high value trees can be temporarily protected from bark beetle attack by judicious use of chemical pesticides. This technique can be very expensive and should be used in a manner which will preserve natural insect predators.

Wood boring insects enter the wood of fire-killed trees. Their tunnels cause significant degradation of salvaged material. Because they attack trees very quickly following fire, damage generally cannot be eliminated entirely. Rapid salvage and utilization shortens the time these insects live within the wood, reducing the depth and extent of penetrating tunnels.

Evaluating whether trees will survive

Soon after a fire, an initial evaluation can be made to located dead and severely injured trees for immediate salvage. A subsequent survey the following spring can be used to evaluate which of the less severely injured trees allows time for recovery symptoms to become apparent and makes survival predictions more accurate.

When assessing whether a tree will survive a fire, first determine the amount of needle scorch in the crown. Estimate the percentage of the original green crown that has been scorched (example 50 percent).

Next, determine the distribution of mortality throughout the crown by assessing buds and twigs. When the bases of scorched needles are still green, the buds may be alive. Slice a bud longitudinally with a sharp knife or razor to see if it is a succulent bright green inside. Killed buds are usually light tan to brown inside and appear dry. Dead needles are shed from live twigs more rapidly than from dead twigs. The abcission layer of “breakaway cells” at the base of the needles does not form in dead twigs.

Be conservative!

Remove trees with needles consumed by fire, with bud and twig mortality spread throughout the crown or with scorch extending to the top. Retain trees that have less than 70 percent scorch (immediate assessment) or less than 80 percent scorch (spring assessment).

Research has indicated that approximately 40% of ponderosa pine trees with 50% or more crown scorch will be killed by bark beetles. Trees with large numbers of pitch tubes above six feet high on the bole, beetle-containing galleries, or with blue-stained sapwood should be removed.

Fire Injured Trees: Making an Initial Assessment of Whether a Tree is Likely to Die
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Although it can be difficult to discern when a conifer tree actually dies and many systems exist for assessing whether fire injured conifer trees are likely to die, making an *initial* assessment of tree injuries can be very simple. These steps are intended to give affected landowners a place to start. They aren't the whole story.

1. **Were any of the needles consumed or "set" in one direction by the fire?**

   If so, the tree likely received a lethal injury and is dead or will die.

Ponderosa pine with 100% of its live crown scorched and some of the needles consumed. This tree is unlikely to survive its iniuries.

Ponderosa pine sapling with needles "set" in the direction the heat and fire moved past it. This tree is unlikely to survive its injuries.

2. How much of the crown volume was scorched?

Calculate a percentage of the crown that was alive prior to the fire and is now scorched. An undamaged tree has 0% crown scorch. A tree with its entire crown changed to a reddish color has 100% crown scorch. Here are some samples of calculating crown scorch volume. Record each tree's species and DBH when observing the crown scorch.

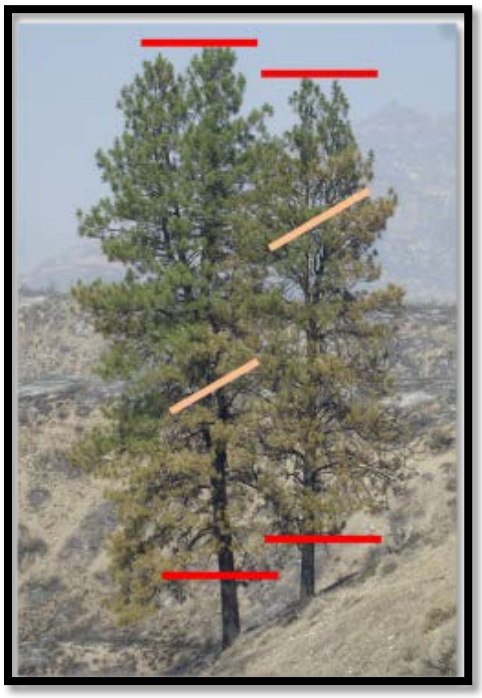
Just about everything above the beige line is fine, so about 75% fine and 25% crown scorch.

First, if that low branch (in the green oval) is mentally moved up above the lower red line, then about 50% of the tree canopy is below the beige line and 50% is above the beige line.

Second, the top half of the crown is pretty much ok. So the tree is at least 50% fine.

Third, of the bottom 50%, about 35% is scorched and 15% is ok. So the tree crown is about 65% fine and 35% scorched.

Tree on the left: Just about everything above the beige line is fine, so about 60%-70% fine and 30%-40% crown scorch.



Tree on the right: Just about everything above the beige line is ok, so about 25% fine and 75% crown scorch.

3. Interpreting what the crown scorch levels mean for tree mortality.

- Large diameter trees have thicker bark and can endure more crown scorch than smaller diameter trees.
- Ponderosa pine (with large buds and very thick bark when it's mature) can endure more crown scorch than other conifer trees of similar size that have smaller buds and thinner bark.
- Use a more detailed reference such as http://www.google.com/url?sa=t&rct=j&q=after%20the%20burn%20idaho&source=web&cd=1&ved=0CCIQFjAA&url=http%3A%2F%2Fextension.oregonstate.edu%2Fsites%2Fdefault%2Ffiles%2Fcommunity_pgs%2Fwildfire_after_the_burn_2011.pdf&ei=pXNbUOrPOqKRiAKU1YG4CQ&usg=AFQjCNEFJfKSucuTVsn-OZ7GlBTIT8NDvQ (tables that chart the probability of mortality by tree species, size and crown scorch start on page 51) to interpret the likelihood a given tree species, size and scorch amount will die.
- In general, trees with less than 50% crown scorch are more likely to survive. Trees with greater than 75% crown scorch are more likely to die.
- Note, this is a VERY rough assessment system and does not take into full consideration the amount of injury that the stem or roots received. Even

a tree with little crown scorch can die if there was a lot of duff or nearby wood debris that burned causing significant root damage or stem char.

- If they were in good health prior to the fire and have good growing conditions during the first few years after the fire, trees are more likely to survive more severe injuries.
- Sometimes landowners want to be more conservative, and wait/monitor even the iffy trees. This is appropriate especially if the land was heavily damaged and there aren't many trees left or if he/she can be attentive to the stand, watching it over time, and removing dying trees as the symptoms manifest themselves. If a landowner really just wants to get all the work done in one operation or the stand was heavily overstocked to start with, he/she might choose to simply remove more of the borderline-survivor trees in a single entry.
- Every forest management activity, including salvage, is an opportunity to improve forest health, address deficiencies that contributed to the damage, and make progress toward your long term goals.
- Give as much thought to the condition you are leaving the forest as to what you are taking away.
- Mimic the effects that idealized natural fire would have had such as increasing the proportion of pine and larch; reducing the proportion of Douglas-fir and other fir; removing the smallest, weakest trees; reducing the impact of dwarf mistletoe and other diseases.