Volume 44 Number 1 Spring 2018

WESTERN ARBORIST

International Society of Arboriculture

Arizona, California, Hawaii, Nevada

Limitations of root pruning

Common abiotic disorders impacting landscape trees

Assessing the viability and risk of trees damaged by fire

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Vol. 44 No. 1
Spring 2018
4,000 copies

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Black oak catkins with male flowers
Photo by Bruce W. Hagen

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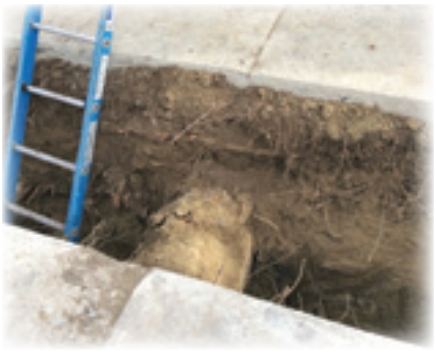

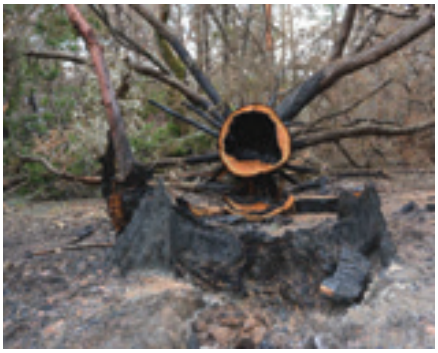

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Assessing the viability and risk of trees damaged by fire: A check list for arborists

James MacNair

WITH THE RECENT devastating wildfires in both Northern and Southern California, arborists have been overwhelmed with requests for assessing the damage and viability of trees in the fire areas. FEMA and local counties have issued large contracts for removal of fire killed and damaged trees as part of the clean-up effort. Of immediate concern are trees near roadways and homes that pose a risk of structural failure due to the fire damage. For trees that are away from high use areas and do not have an immediate target, the question for property owners remains: Is the tree viable with a reasonable chance of surviving and recovering?

For fire-damaged trees that are potentially at risk of failure and a threat to people or property, tree evaluators do not have the luxury of time to wait and evaluate the tree's response to the fire damage. In Sonoma County, trees along roadways and electrical lines were required to be assessed quickly to prevent damage or injury. Unfortunately, trees that may have recovered are being removed because the consequences of structural failure are too high to wait for the months necessary to accurately assess the damage and the likelihood of failure. (Fig. 1)

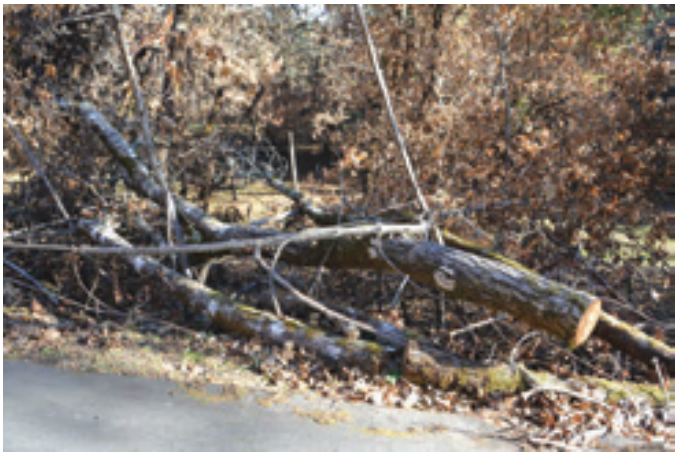
For trees in low-risk target areas, the best approach is to be patient and wait as long as possible to assess the damage before removing a tree. The extent of fire damage is often not apparent until the spring or summer, following the fire. In the immediate months following the fire, surviving trees that lost their foliage will leaf out. For both coniferous and broadleaf species, if the vascular system is damaged and not adequately functioning, the high climatic transpirational demand during late spring and summer months will result in crown dieback. A tree may leaf out in spring, but then dieback during the summer and fall following the damage occurring the previous year. For significantly damaged trees, the decline can occur over a number of years, with boring insects contributing to mortality. (Fig. 2)

Most coniferous species that were crown-scorched will not leaf out if next season's needle buds were killed. If the buds are viable, and the lower trunk cambial tissue is functioning, then the tree will leaf out and the tree will likely recover. In the recent Sonoma County fire, the needle buds of Douglas fir (Pseudotsuga menziesii) were vulnerable because moisture levels in early October were low, and because needle buds are relatively unprotected in Douglas fir, compared to other conifer forest species.

The extent of fire damage is often not apparent until the spring or summer, following the fire.

Figure 1. (Left) Minimally damaged oaks along roadway.

Figure 2. (Right) Coast live oaks with poor vigor, low foliage density and branch/twig dieback 5 years post-fire.



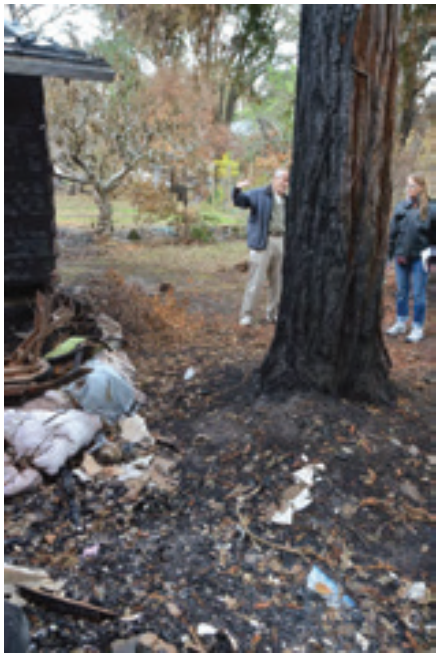


Figure 3. (Left) Coast redwood and Douglas fir are species considered resistant to lower trunk damage.

Figure 4. (Right) Charring on Douglas fir is from a 1964 fire.

The difficulty for early assessment of fire damage is not knowing the degree of damage to the cambium and the amount of trunk circumference affected. Both high temperatures during the fire and the length of time the tree is exposed to lower temperature ground fires and post-fire smoldering can result in tissue death or what looks like severe bark charring, which doesn't necessarily indicate cambium damage. Or, in contrast, limited observable damage may not be reliable if the tree is subjected to prolonged heat that causes cambial damage without severe charring of the bark.

Tree species vary in their resistance to fire damage, depending on bark thickness. Species with thicker bark are more resistant to fire damage than those with thinner bark. Examples of thick-barked native tree species include coast redwood (*Sequoia sempervirens*), Douglas fir and coast live oak (*Quercus agrifolia*). Thinner barked species include California bay laurel (*Umbellularia californica*), blue oak (*Quercus douglasii*), and madrone (*Arbutus menziesii*). (**Figs. 3-6**)

Older trees are, in general, more resistant to trunk damage because their bark tends to be thicker and increases with trunk diameter. The thicker the bark, the greater its insulation value, thus older trees are more likely to sustain less heat damage to their cambium. Younger trees are the most susceptible due to less bark protection. Again, either high temperatures or extended exposure to lower heat can damage and kill the cambial zone tissues and foliage buds in non-sprouting species. (**Fig. 7**)

Initial assessment

Following are basic techniques for assessing damaged trees. These

Figure 7. Douglas fir with shallow charring of outer bark and inner bark protected. Although the charring appears severe, the inner bark was protected.

Figure 5. (Left) Surviving coast live oak with outer bark burned away (San Diego County)

Figure 6. (Right) Close-up of coast live oak with outer bark burned away (San Diego County)

procedures can provide valuable information for determining whether or not a tree needs to be immediately removed or can wait and be re-assessed later.

The first step is to assess the severity of the charring. This assessment evaluates the depth of charring, the vertical extent of the charring (how far up the trunk), and the percentage of trunk circumference affected. All three dimensions need evaluation to understand the extent of the damage.

If the bark is separating, or deeply fissured, then there is a strong likelihood of significant cambial damage.

The condition of the inner bark is evaluated using a hatchet or chisel. If the inner bark is moist and normal in color for the species, then the cambium tissue is likely undamaged. If the inner bark is desiccated, brownish, or pale in color, then the cambium is dead. It is important to check various locations on the trunk (or limb) to determine the extent of the damage. Often only a portion of the trunk circumference is affected, and the tree will survive. Limited cambial damage later manifests as cankers and ultimately cavities that often are manageable. However, if the damage to the trunk cambium is substantial, 40% or more of the trunk circumference, then consider removal if the tree is located

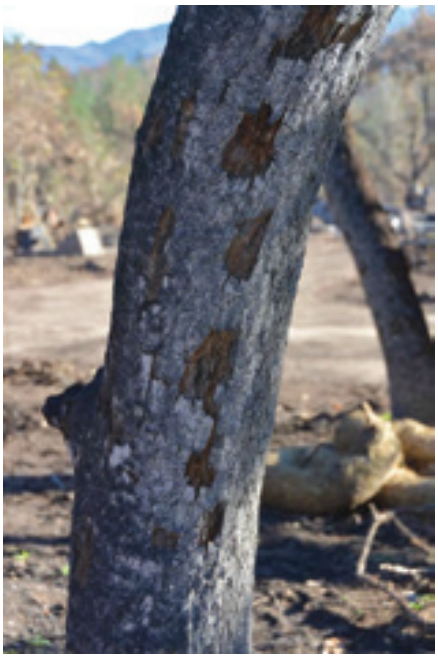
Figure 8. (Left) Valley oak with direct exposure to structure fire. Edge of cambium damage is evident in right image.

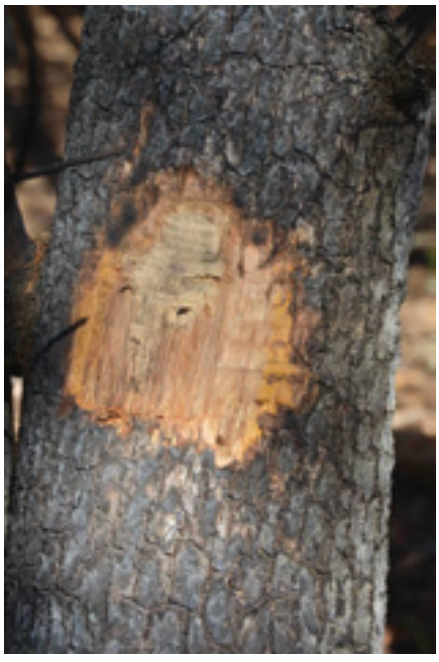
Figure 9. (Right) This edge will likely be where callus/ wound wood will form (red arrow). Dead cambium tissue at lower part of cut is already colonized by a fungus (yellow arrow).

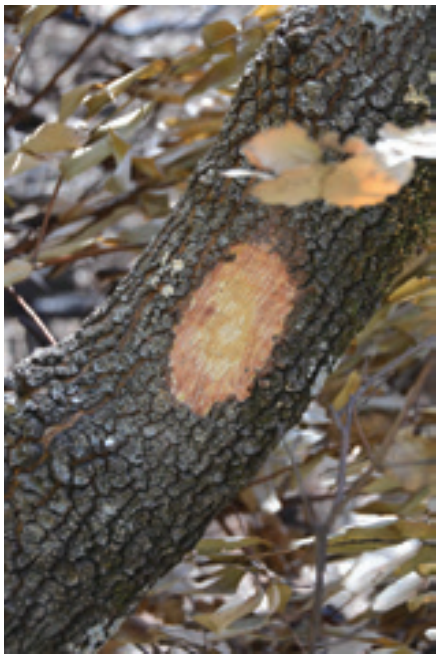
Figure 10. (Left) Blue oak with outer bark separating.

Figure 11. (Center) Valley oak with desiccated inner bark.

Figure 12. (Right) Example of normal coloration and moisture level of inner bark on black oak.







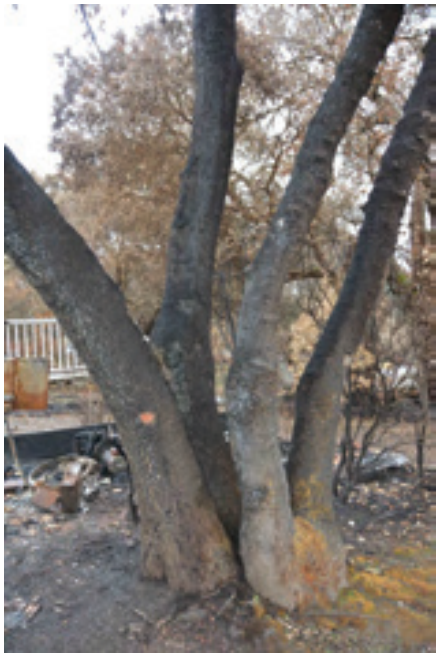


Figure 13. (Left) Black oak with minimal lower trunk charring, but trunk bleeding.

Figure 14. (Right) Arrow indicates bleeding exudate.

in an area where structures or people would be at risk if a structural failure occurred. (**Figs. 8-12**)

The next step of evaluating the trunk is to check for bleeding. This phenomenon was commonly observed in Sonoma County immediately after the fires and occurred in a variety of species including black oak, coast live oak, Douglas fir, and valley oak (*Quercus lobata*). An inspection of the inner bark using a hatchet revealed a consistent layer of dark brown tissue in areas of bleeding. The appearance of the layer is similar to that of Phytophthora infections and the margin of the disease canker, although, in this instance, the discolored tissue is a zone within the phloem. One possibility is that the dark tissue is the result of sugars overheating and expanding through the bark.

The current thought is that trunk bleeding is an indication of prolonged heating of the inner phloem and is probably lethal. Trees with trunk bleeding are currently being monitored and will be re-assessed later in the spring to evaluate their viability. If trunk bleeding is a reliable indicator of cambial death, then this will be a useful tool for evaluating trees immediately after the fire event. (**Figs. 13-18**)

If the lower trunk cambium appears normal, then the mid and upper crown is evaluated for severe charring of secondary trunks and scaffold limbs. When small diameter limbs and twigs are burned away, it's likely that there is severe cambial damage within much of the crown. Therefore, the probability of significant crown dieback and the risk of limb or trunk failure increases over time. Like the lower trunk, the inner bark of limbs can be examined for cambial damage. (**Fig. 19**)

Foliage scorch is usually not damaging to healthy trees and especially for native oaks if the stem damage is not severe. However, as discussed, for many conifers, if the current foliage is entirely scorched or desiccated by heat, the next season's leaf buds are killed, the tree will not produce new needles.

Because of the high crown forms of Douglas fir and other conifers, it is difficult to assess the viability of the needle buds in scorched trees without climbing the trees. Drones could be

Figure 15. (Left) Arrow in center image shows dark line of tissue layer that was consistently observed in areas of trunk bleeding and with various oak species and Douglas fir.

Figure 16. (Right) Right image shows the lower bleeding zone cut compared to the upper cut in an area with no bleeding.

Figure 17. (Left) Douglas fir with lower trunk bleeding (arrows).

Figure 18. (Center) Pronounced line of brown tissue layer (arrows).

Figure 19. The side of the tree's upper crown near the structure was severely burned. Limbs with small diameter branches and twigs burned away are likely to have substantial cambial damage and dieback with an epicormic sprouting response.

useful for viewing the upper crown, but even if the buds appear intact, they may be desiccated. For most properties, the extent of damage to the Douglas firs will not be known until spring. (**Figs. 20 -21**)

Immediate structural risks

Trees with multiple trunks forming at grade, or originating as basal sprouts, are highly susceptible to damage at the base of their stems. As a result, one or more stems may fail. This is a common post-fire issue in woodland areas where there is a history of fire. Oaks, bay laurels, and madrone re-sprout when a tree is cut or top-killed by fire. Multiple stems trees are susceptible to fire damage due to cavities that commonly form on such trees and the flammable debris that accumulates at the base or within the bowl that forms between the stems. (**Fig. 22**)

Likewise, old fire scars can result in cavity formation. It is important to look for wounds or cavities where the fire has entered the trunk or limb and ignited the heartwood. This internal burning frequently occurs and will severely weaken the strength of the trunk or limb, sometimes with minimal external signs of damage. Large trees have been observed to burn internally for weeks after a fire. (**Fig. 23**)

Depending upon the heat and duration of the fire, structural roots can be damaged. If roots are exposed and charred, then anchoring strength could be compromised. When root damage is significant, decay typically begins to develop, and it may take years for it to cause root failure.

For trees with leans or asymmetrical and extended crowns, the extent of trunk damage is important. For broadleaf species, damage on the tension side of the trunk becomes important when evaluating the risk of failure under wind or rain loads. For conifers, the compression side of the lean is critical for trunk strength.

Figure 20. (Left) Douglas fir with needle scorch.

Figure 21. (Right) If needle buds (below image arrow) are killed, then the tree will not recover.

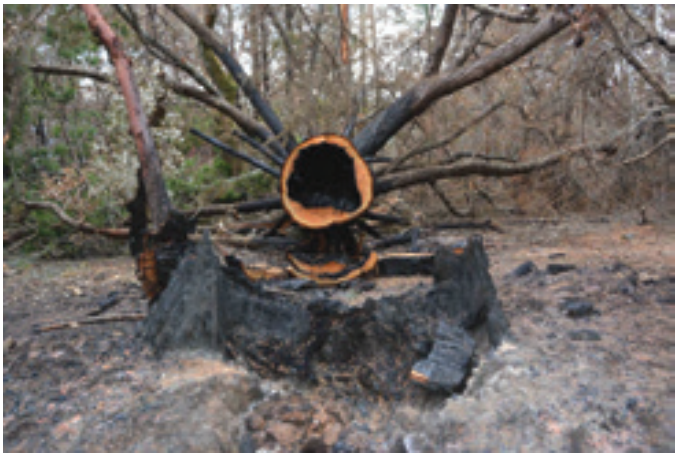


Figure 22. (Left) Bay laurel with fire damage at base of trunk due to pre-existing cavity and debris accumulation.

Figure 23. (Right) Collapsed Douglas fir where fire burned internally within a cavity.

Fire-killed trunks and limbs should be removed as soon as possible. Damaged limbs and branches can be pruned back to where the cambium appears healthy using the chisel or hatchet method to evaluate the inner bark. For smaller branches, a knife is usually sufficient to expose the cambium.(**Fig. 24**)

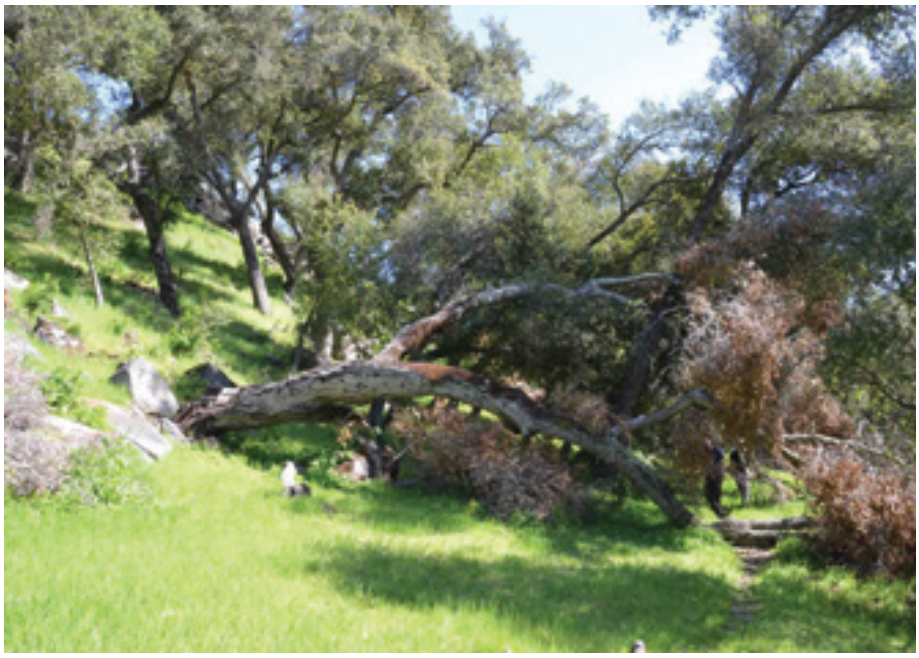
Long-term structural and risk assessment issues

Typical time frames for risk assessments are from one to three years. Fire-damaged trees require a much longer time frame. Structural failure from decay due to fire damage can occur years after the damage. Due to the weakened vigor from reduced photosynthetic capacity and breaching of existing barrier (CODIT) zones, decay can progress faster in fire-damaged trees. The root system, particularly the shallower absorbing roots, can be damaged if the fire is prolonged due to slow-burning vegetation on the soil surface. This type of damage can manifest itself as low vigor and crown dieback due to the reduced capacity for water uptake. Frequent monitoring is required for significantly damaged trees. (**Figs. 25 -27**)

Trunk and crown damage becomes more apparent and easier to evaluate over time. Bark over dead cambium will usually detach or is deeply fissured. Callus tissue forms at the edge of the wound allowing better assessment of the damage and

Figure 24. (Left) Dense foliage can hide significant limb damage.

Figure 25. (Right) Collapse of a mature coast live oak five years after the initial fire damage.



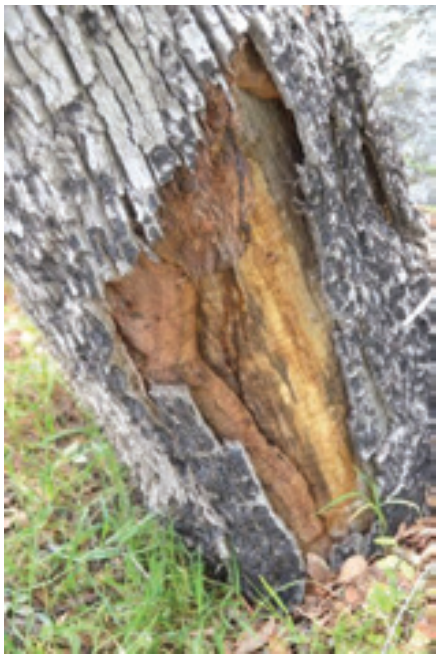


Figure 26. (Above left) Engelmann oak with live crown but with severe lower trunk damage.

Figure 27. (Below left) Engelmann oak with severe lower trunk damage.

Figure 28. (Above center) Mid and upper crown damage becomes more apparent and easier to evaluate over time.

Figure 29. (Below center right) Images four years after the fire.

Figure 30. (Above right) Check for loose bark which can reveal significant trunk damage.

Figure 31. (Below right) Loose bark exposed.

impact on the structural strength of the trunk. Often the fire damage on lower trunks will develop into cavities that result in higher susceptibility to damage when the next fire occurs. (**Figs. 28 -31**)

Damage to the underside of limbs also becomes easier to assess. Decay from this damage may eventually result in limb failure. The threshold for concern is when damage exceeds ⅓ of a limb's circumference.

Long-term management and health issues:

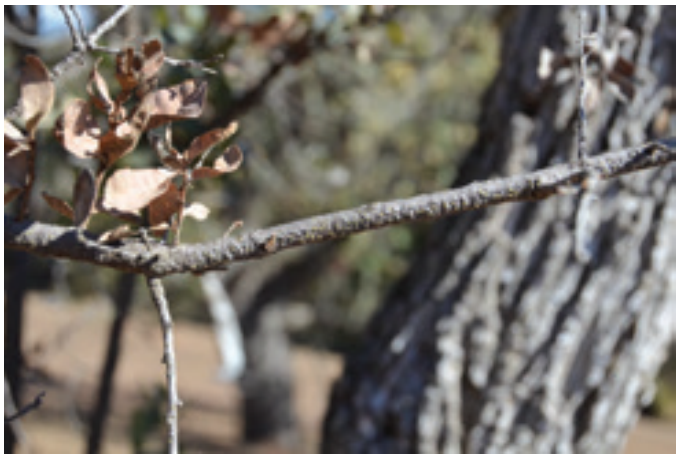
Oaks, and other species that sprout, produce epicormic shoots following significant crown damage. Pruning to restore the crown is an option, although multiple pruning cycles over a number of years may be required. Depending on the level of damage and the vigor of the tree, crown restoration can take from four to eight years using two-year pruning frequencies.

Figure 32. (Above left) Decline from the flat-headed fir borer was a significant problem in Napa and Sonoma Counties before the fire. This insect will be a serious problem for fire damaged trees.

Figure 33. (Above right) Flat-headed fir borer galleries completely girdling stem.

Figure 34. (Below left) Pit scale infestation on Engelmann oak. This pest became a serious problem post-fire in San Diego.

Figure 35. (Below right) Decline of young Engelmann oaks due to pit scale.



Damaged trees are susceptible to attack by bark beetles and wood borers and colonization by sap rot fungi. Fire damage has only exacerbated the stress that native trees have been experiencing as a result of the ongoing drought. Current rainfall totals have been well below normal. Abnormally dry conditions will be a negative impact on tree recovery. For trees in residential or commercial sites, consider starting supplemental irrigation as soon as soil moisture levels are depleted. Consider mulching to conserve soil moisture.

Arborists should expect pest-related issues to worsen this summer. Before the 2017 fires, the flat-headed fir borer (*Melanophila drummondi*) was causing significant mortality of Douglas fir in Sonoma and Napa Counties. This borer is likely to cause significant mortality of fire-damaged trees. After the 2007 San Diego fires, pit scale became a severe problem on Engelmann oaks post-fire, affecting recovery and increasing mortality. Attacks by insects should be expected, and pest control strategies should be implemented for important trees. (**Figs. 32 -35**)

Unless there is a demonstrated soil nutrient deficiency, tree fertilization is not necessary or advisable. Excess nitrogen will stimulate leaf and shoot growth, resulting in further stress for trees with damaged root systems and/or reduced vascular connection. Lack of nutrients is not an issue in fire areas as nutrients are already being provided in the form of ash.

Native oaks and other native trees such as madrone, bay laurel, Pacific big-leaf maple (*Acer macrophyllum*) will sprout from the root collar when the tree is top-killed. The most vigorous sprouts can be selected and trained to replace the tree as opposed to planting a new tree. As long as the selected sprout has good anchorage, the growth will be rapid as long as the original root system is functioning. (**Figs. 36 -37**)

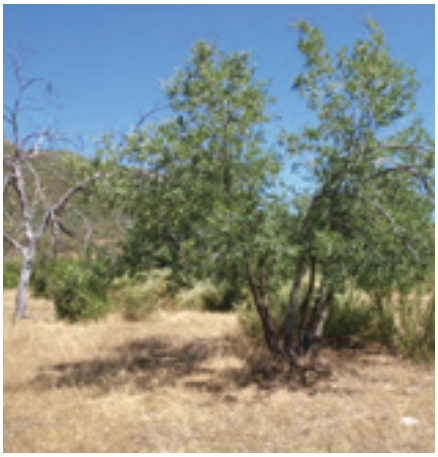


Figure 36 (Above) Root collar sprouting by Engelmann oaks.

Figure 37. (Below) Root collar sprouting by coast live oaks.

As professional arborists, we can provide valuable information and strategies to property owners and managers to allow them to make informed tree management decisions. Working with fire damaged trees is both interesting and challenging. As arborists in the western United States, we need to develop the skills and knowledge to help the recovery of our landscapes and woodland areas.

James MacNair
Photos: James MacNair

Home study for CEUs

You may receive one hour of Certified Arborist and/or WCISA Certified Tree Worker continuing education units (CEUs) for reading the following article and completing the test questions. Copy the question pages and use it to record your answers. Darken the correct letter choices and circle your choice for true and false or correct choice questions. Each question has only one correct answer. Passing score for this test is 20 correct answers (80%).

Next, complete the registration information on this form and send it to:

WCISA Admin. Office
31916 Country Club Drive
Porterville, CA 93257
559-784-8711 fax

Note: If 80 percent or greater of the questions have been answered correctly, the ISA will be notified of the CEU assignment for Certified Arborists and it will be posted by the ISA. The Western Chapter will post the CEU for Certified Tree Workers. If a passing score is not achieved, the test will be returned for corrections. No CEU confirmations will be sent to you.

Registration Information

Name: _____

Cert. # _____

Address: _____

City: _____

State: _____ Zip: _____

Home study for CEUs: Assessing the viability and risk of trees damaged by fire — A check list for arborists

Spring: March 31, 2018 — Expiration date for submitting answer sheet is June 1, 2018. The CEUs from this article can only be applied to the 3-year current certification period.

1. The difficulty for early assessment of fire damage is not knowing the extent of damage to the cambium and the amount of trunk circumference affected.
T or F?

2. Surviving trees that have lost much of their foliage (leaf scorch) typically leaf out within several months or the following spring.
T or F?

3. Injury to the vascular system may result in crown dieback during the following late spring and early summer when transpirational water-loss increases.
T or F?

4. For significantly damaged trees, decline can occur over a number of years, with boring insects contributing to mortality.
T or F?

5. Most conifer species don't recover from crown-scorch because their leaf buds (for next season's needles) are easily damaged.
T or F?

6. Compared to other conifers, the needle buds in Douglas fir are ***well protected*** or ***relatively unprotected*** from injury due to crown scorching.
(**circle correct choice**)

7. Severe bark charring is a good indicator that the cambium is damaged.
T or F?

8. Bark thickness is an important factor determining the extent of cambial damage resulting from exposure to fire.
T or F?

9. When assessing the severity of damage to the cambium when there is charring, what three conditions must be considered?
1. _____
2. _____
3. _____

10. Severe cambial damage can result without there being much charring of the bark when trees are exposed to prolonged heat.
T or F?

11. Even if the inner bark is desiccated, brownish, or pale in color, the cambium may still recover.
T or F?

12. Tree removal should be considered when trunk damages exceeds _____ % of trunk circumference and risk of failure is a concern.

13. Bleeding from charred or fire-damaged areas of the trunk usually indicates that the cambium is largely unaffected.
T or F?

14. Extensive crown dieback is likely when twigs and small diameter limbs within much of the crown have been burned away.
T or F?

15. Foliage scorch (dry, brown leaves) usually indicates severe damage to the branch cambium.
T or F?

16. Multiple trunk trees, originating from basal-sprouts, are highly susceptible to basal damage.
T or F?

17. Old cavities should be checked to see if fire has entered the trunk or limb and ignited the heartwood or core of the tree.
T or F?

18. Tree roots are seldom damaged by intense ground fires.
T or F?

19. When assessing risk, what two conditions are important when cambial damage is on one side of the trunk?
1. _____
2. _____

20. For conifers, the tension side of a leaning trunk is critical for trunk strength.
T or F?

21. Risk assessments and monitoring for fire-damage may take many years due to decay, loss of vigor and/ or root damage.
T or F?

22. The threshold for concern is when fire damage to branches is greater than half of a limb's circumference.
T or F?

23. In general, tree fertilization is recommended for fire damage to speed recovery.
T or F?

24. Most native oaks and many native trees will sprout from the root collar when the tree is top-killed.
T or F?