Fire helps retain California black oak in Sierra Nevada mixed conifer forests

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California black oak (Quercus kelloggii) is a widespread western oak species native to oak woodlands and montane mixed conifer forests in the Sierra Nevada. The species is ecologically valuable due to the cover, habitat and forage it provides for birds and mammals, and is considered a "cultural keystone species" due to its importance as a food source for Native Americans. Black oak is fire-tolerant, able to survive low-to-moderate intensity wildfire, and exhibits a resprouting response following high severity wildfire. These characteristics confer a potential competitive advantage for black oak when conifer competition is reduced. However, black oak is of increasing conservation and management concern due to declines across its range following more than a century of fire suppression, leading to dense, flammable forest stands, and increasing competition with shade-tolerant conifer species such as sugar pine, white fir, incense cedar, and Douglas fir. Scientists at Utah State University used long-term data from the Yosemite Forest Dynamics Plot (YDFP) to evaluate the effects of conifer competition, tree size, and fire intensity (during a 2013 management-ignited fire to limit the spread of the Rim Fire) on black oak recruitment and survival and to identify spatial and temporal patterns in these outcomes.

From 2011-2024, the YFDP was visited annually to track stem-level mortality, record growth metrics such as DBH (Diameter at Breast Height), identify disease and mortality agents, and enter new stems into the database. From 2022-2023, mature black oak individuals, including both single stems and clonal groups, were tagged and measured along with three types of recruits: seedlings growing directly from acorns, seedling-sprouts originating from seedlings that had resprouted after top-kill, and resprouts originating from mature black oak root crowns after top-kill. The historic fire return interval in the region was approximately 30 years, but the 2013 fire was the first to burn through the plot in 113 years.

MANAGEMENT IMPLICATIONS

- Thinning conifers within 10 m of large diameter black oaks prior to prescribed burns can improve resprouting outcomes and reduce local fire intensity to promote post-fire oak survival. Thinning merchantable conifers can also offset the cost of prescribed fire treatments, reduce fuel loads, and promote the health of remaining conifers by releasing them from competition.
- Moderate severity fire did not significantly reduce the spatial extent of oaks within the study area. Given that fire intensity increased oak resprouting probability, multiple-entry low to moderate intensity prescribed fire can be used to reduce competing conifer basal area and promote the health of existing black oak stands without fear of shrinking their extent on the landscape.
- Thinning of resprouts after the application of prescribed fire treatments can promote the growth of single or few-stemmed large diameter oaks, which are more immediately resilient to wildfire and to conifer competition on longer timescales.
- Monitoring the timing and volume of seed production at different sites, as well as creating some unburned micro-refuges for oak seedlings, may help buffer reductions in acorn crops at sites subjected to prescribed fire or fire surrogate treatments.

97% of total mortality – across all species – in the plot over the study period could be attributed to fire effects. Of the over 1000 black oak individuals surveyed, 63% of aboveground stems died in the year immediately after the fire, 12% experienced delayed mortality 2-10 years after the fire, and 24% survived to the end of the study period. Even so, only 13% of the 940 root clonal groups experienced full below ground mortality, suggesting that oak root systems were much more resilient to wildfire than their above ground counterparts. Of the 940 clonal groups, 73% resprouted with an average of four stems. Oak sexual recruitment occurred in the form of seedlings and seedling-sprouts, which appeared at approximately equal densities by the end of the study period but varied in their initial establishment timing. Seedling-sprouts were likely to establish immediately following fire, while establishment from acorns typically lagged by around 2 years. Fire reduced conifer density and basal area by

80% and 40% in the stand, respectively. Finally, oaks experienced 20 times more recruitment than competing conifers and grew 16% faster.

Fire intensity was the strongest predictor of immediate stem-level mortality as well as delayed mortality, though tree size was also significant. Larger diameter stems burning at lower fire intensities were the most likely to survive immediately after the fire and in the long run. Larger tree size also reduced the probability of belowground mortality. Crowding, intensity, and tree size were all of similar strength in predicting delayed mortality probability and resprouting. Crowding by larger diameter conifers significantly predicted both immediate and delayed mortality but not the timing of delayed mortality or likelihood of belowground mortality. Additionally, the authors detected an indirect effect of conifer crowding on fire intensity. Larger size, higher fire intensity, and lower crowding were associated with higher probability of resprouting and a higher number of resprouts produced (Fig. 5). There was also a notable size threshold response, where clonal groups whose largest stem was larger than 7.5 cm DBH had a much higher probability of resprouting and produced more resprouts (Figs. 5B, 5D).

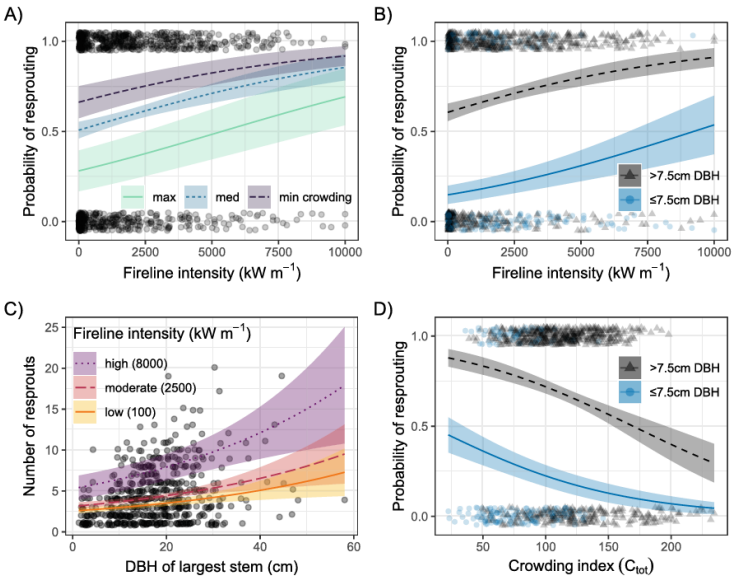


Fig. 5 (Struckman and Lutz 2026). California black oak resprouting responses in the Yosemite Forest Dynamics Plot, California, USA. Above panels show the modeled probability of resprouting (A, B, D) and number of resprouts (C) as a function of variables important to post-fire oak survival and regeneration. Each panel shows multiple curves representing categorical variables, such as size thresholds (7.5 cm DBH), the extent of conifer crowding, and fireline intensity.

Fire mortality reduced the density of adult stems in a given area, but post-fire regeneration quickly filled these spaces and maintained or enhanced oak extent on the landscape. In total the live stem density of oaks increased by a factor of 2.7 over the course of the study. Rapid resprouting, coupled with low belowground mortality, surviving juveniles in unburned fire refuges, and comparatively high conifer mortality, suggests an underlying resilience of the oak population to low-to-moderate severity fire. This finding is promising because the study took place after a mixed severity fire that had burned under more aggressive fire weather than most prescribed burn treatments and under multi-year drought conditions. This should give managers confidence that low to moderate intensity prescribed fire is unlikely to reduce the extent of black oak populations, but rather is likely to improve the resilience of remaining large diameter black oaks by reintroducing fire to the landscape and stimulating regeneration and growth through reduced conifer competition.

Additional Information

This brief is based on the following article: Struckman, Soren, and James Lutz. 2026. Reintroducing fire gives California black oak a chance amid large conifers. Forest Ecology and Management 615: 123845
https://doi.org/10.1016/j.foreco.2026.123845

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Suggested reading: Moghaddas, J.J., York, R.A., Stephens, S.L., 2008. Initial response of conifer and California black oak seedlings following fuel reduction activities in a Sierra Nevada mixed conifer forest. For. Ecol. Manag 255, 3141–3150. https://doi.org/10.1016/j.foreco.2007.11.009.

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