



Research Brief for Resource Managers

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Raking surface fuels can lower sugar pine mortality

Nesmith, Jonathan C.B., Kevin L. O'Hara, Phillip J. van Mantgem, and Perry de Valpine. 2010. The effects of raking on sugar pine mortality following prescribed fire in Sequoia and Kings Canyon National Parks, California, USA. Fire Ecology 6(3):97-116.

<http://fireecology.org/docs/Journal/pdf/Volume06/Issue03/097.pdf>

Raking around sugar pines can reduce mortality following wildfire in certain circumstances.

In a study of three prescribed fires in a mixed-conifer forest at Sequoia and Kings Canyon National Parks, researchers found that the predicted probability of sugar pine survival was 60% for raked trees compared to 7% for un-raked trees when the total fuel depth was greater than 30cm.

Prescribed fire is a common strategy that land managers use to reduce forest fuels and restore ecosystem function. However, sugar pines exhibit high mortality following fire and techniques for reducing that mortality are being actively researched.

The study measured average fuel depth (litter, duff, and surface fuels), tree vigor, bark beetle activity, and blister rust status for all sugar pines greater than 10 cm dbh within their plots. Raking treatments removed all fuels down to mineral soil in a 0.5m radius around the trunks of randomly selected trees. Removed fuels were scattered in the surrounding forest.

The impact of raking was greatest during moderate fires (1-80% crown scorch), because of reduced stem char probability. In areas of high or

Management Implications

- Raking may help reduce sugar pine mortality when fuel depth is greater than 15cm and fire intensity is moderate.
- Raking can reduce char height, which can subsequently reduce bark beetle activity.
- Raking had less impact when fire intensity was high or low, or when fuel depth was less than 15 cm.
- Targeting large trees for raking may be a simple and effective way to increase survival



Workers removed forest fuels from the base of the sugar pine to mineral soil to a distance of 0.5m using hand rakes and loopers. Image courtesy of J. Nesmith.

low intensity fires, raking had no impact on mortality.

By reducing stem char, raking reduced the tree's susceptibility to bark beetle attack by 29% three years after the fire, regardless of burn intensity.

Of the 457 sugar pines in the study, 33% died in the three years following prescribed burning. This suggests that while raking can have some effect, alternate methods may need to be tried for areas where burn intensity is expected to be high. The researchers suggest: pruning, thinning, modifying ignitions techniques, changing the season of the burn, or shortening the time interval between burns.

Additionally, only 10% of trees in the study met the conditions that signified a higher probability of survival, suggesting that raking is best as a targeted activity to specific trees.

The researchers returned within a month following the prescribed fire to measure crown scorch, stem char, and fuel consumption. The study continued for three years to report on tree vigor and beetle activity.

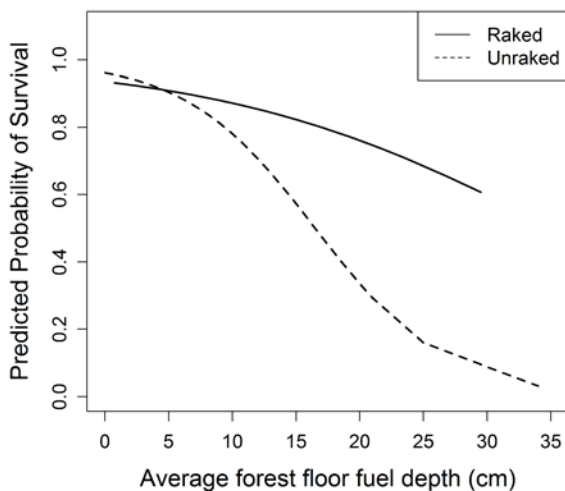


Figure 3. Effect of average forest floor fuel depth on predicted probability of survival of raked vs. unraked sugar pines three years following prescribed fire in Sequoia and Kings Canyon national parks, California, USA, using logistic mixed effects regression. Predicted probabilities assume the site is Wall Spring and dbh is 50 cm.

Suggestions for further reading

Hood, S.M. 2010. Mitigating old tree mortality in long-unburned, fire-dependent forests: a synthesis. USDA Forest Service General Technical Report RMRS-GTR-238, Rocky Mountain Research Station, Fort Collins, Colorado USA.

Laudenslayer, W.F., Jr., G.N. Steger, and J. Arnold. 2008. Survivorship of raked and unraked trees through prescribed fires in conifer forests in northeastern California. USDA Forest Service General Technical Report PSW-GTR-189:73-81, Pacific Southwest Research Station, Albany, California, USA.

Parker, T.M., K.M. Clancy, and R.L. Mathiasen. 2006. Interactions among fire, insects, and pathogens in coniferous forests of the interior western United States and Canada. *Agricultural and Forest Entomology* 8: 167-189. [doi: 10.1111/j.1461-9563.2006.00305.x](https://doi.org/10.1111/j.1461-9563.2006.00305.x)

van Mantgem P.J., and M.W. Schwartz. 2004. An experimental demonstration of stem damage as a predictor of fire-caused mortality for ponderosa pine. *Canadian Journal of Forest Research* 34: 1343-1347. [doi: 10.1139/x04-001](https://doi.org/10.1139/x04-001)