CALIFORNIA FIRE SCIENCE CONSORTIUM

JOINT FIRE SCIENCE PROGRAM

Research Brief for Resource Managers

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Contact: Zack Steel

Email: zlsteel@ucdavis.edu

Sierra Nevada Fire Science Delivery Consortium | One Shields Avenue, Davis, CA 95616

High-severity wildfire effects on carbon stocks and emissions in fuels treated and untreated forest

North, M. and M. Hurteau. 2011. ***High-severity wildfire effects on carbon stocks and emissions in fuels treated and untreated forest.*** *Forest Ecology and Management. 261: 1115-1120.*
http://www.plantsciences.ucdavis.edu/affiliates/north/Publications/Wildfire effects on C in fuels treated and untreated forest North Hurteau FEM.pdf

Forest ecosystems—particularly large, long-lived trees—store large amounts of carbon in plant material. The preservation of these carbon stocks and the removal of atmospheric carbon through forest growth can help offset global CO_2 emissions from the burning of fossil fuels and deforestation. However, carbon can also be emitted from forests as a consequence of wildfire and from fuels reduction efforts to reduce fire risk and severity. North and Hurteau (2011) investigated the forest carbon tradeoffs of wildfire in treated and untreated mixed-conifer forests, as well as the carbon cost of implementing fuels reduction treatments.

The authors considered 20 fuels treatment areas and corresponding paired untreated areas that were burned by a total of 12 wildfires. Field measurements and forest structure reconstruction methods were used in conjunction with allometric equations relating plant characteristics (e.g., trunk diameter at breast height) with total plant carbon to calculate the carbon stock of treated and untreated stands before and after wildfire. Subsequently, the amount of carbon emitted during the fire was calculated using the difference between pre- and post-fire carbon stocks.

Management Implications

- Direct emissions from wildfire are greater in untreated forests, but the additional carbon removed during fuels treatments result in a greater total reduction of carbon within treated forests in the short-term.
- Long-term emissions due to wildfire may be greater in untreated forests due to higher tree mortality and a transition of carbon into snags and other fuels that will continue to decompose for decades.
- The interaction of fuel treatments and wildfire and their effect on carbon stocks likely vary by forest type and treatment method.

Although there are many methods of reducing fuels, this investigation selected areas treated with the common 'thin from below' method. Furthermore, the treatments assessed were limited to whole tree removal and/or pile and burn activities, where carbon contained in the removed fuels is released back into the atmosphere in the short-term. This approach is intended to represent an upper bound of carbon loss. Results would likely vary if considering different fuel treatment types such as mastication and prescribed burning. Likewise, the effects of fuels treatments and wildfire on carbon storage and emissions would likely vary among forest types.

Immediate emissions from wildfire were significantly greater in untreated stands (67.8 Mg C / ha) than treated stands (29.7 Mg C / ha), showing that treatments intended to decrease fire severity also decrease carbon emissions at the time of a fire. However, when the carbon lost due to treatments (50.3 Mg C / ha) is added to the emissions total, carbon loss in the short-term is greater in treated/burned sites than untreated/burned sites.

Importantly, when considering the long-term 'fate' of carbon in the system, it is possible that the dynamic is reversed and untreated forests exceed treated forests in total emissions. North and Hurteau note that it is necessary to also consider in which pools (e.g., live trees, shrubs, snags etc…) the carbon is distributed within the stand. The study showed that of the remaining carbon following a burn in the untreated sites, 70% transitioned to decomposing pools (snags and fuels), while the treated forests only saw a 19% transition. This was most clearly shown by the percentage of post-burn tree mortality in untreated (97%) and treated (53%) sites. These results suggest that the untreated forests, burning at high severity, have the potential to act as carbon sources (emitters) for decades following a fire and at worst could lose almost double the amount of carbon emitted during the fire due to subsequent decomposition. Conversely, higher survivorship within treated areas will likely decrease the time necessary to re-capture the carbon lost during the fire through tree growth.

Suggestions for further reading:

Dore, S., Kolb, T.E., Montes-Helu, M., Sullivan, B.W., Winslow, W.D., Hart, S.C., Kaye, J.P., Koch, G.W., Hungate, B.A. (2008). Long-term impact of a stand-replacing fire on ecosystem CO2 exchange of a ponderosa pine forest. *Global Change Biology.* 14: 1–20.

Hurteau, M.D., North, M.P. (2009). Fuel treatment effects on tree-based forest carbon storage and emissions under modeled wildfire scenarios. *Frontiers in Ecology and the Environment*. 7: 409–414.

North, M., M. Hurteau, & J. Innes. (2009). Fire suppression and fuels treatment effects on mixed-conifer carbon stocks and emissions. *Ecological Applications*, 19(6): 1385-1396.

van Mantgem P.J. & N. L. Stephenson. (2007). Apparent climatically induced increase of tree mortality rates in a temperate forest. *Ecology Letters*, 10: 909–916.

Winford, E.M., & J. C. Jr. Gaither. (2012). Carbon outcomes from fuels treatment and bioenergy production in a Sierra Nevada forest. *Forest Ecology and Management,* 282: 1–9.

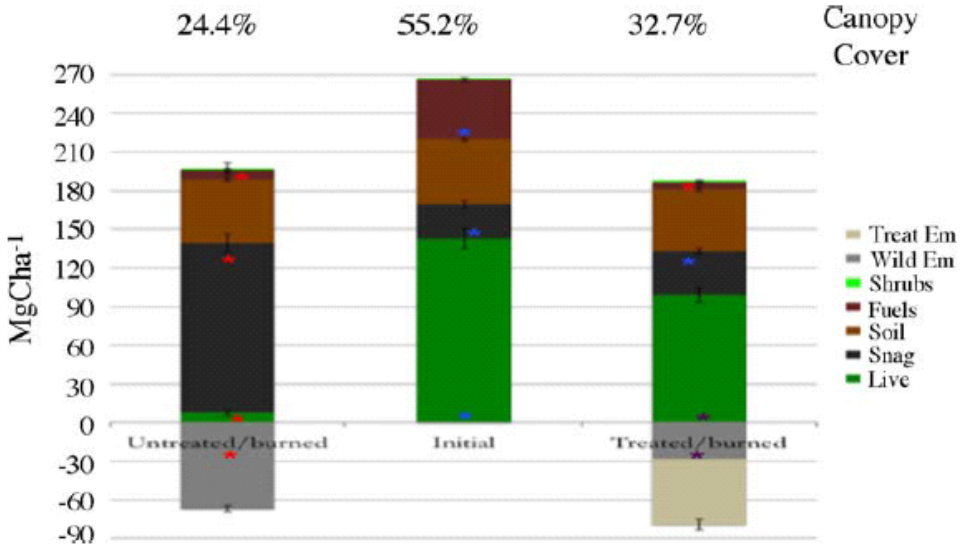

Fig. 3. Canopy cover (%) and carbon (Mg C ha−1) stores and losses in untreated/burned, initial, and treated/burned stands. Negative values are carbon losses from the site due to biomass removal (Treat em) and wildfire emission (Wild em).