The True State of Sierra Nevada Forest Carbon

Forests are identified as California's largest carbon sink by the California Air Resources Board. In 1990, it was estimated that our forested areas were removing 13 million metric tons of carbon dioxide in a year. However, many of today's forests are overgrown, and have suffered unprecedented tree mortality from bark beetle, drought, an increase in high-severity wildfire, and they are no longer the reliable carbon sink that California has depended on.

Recent tree mortality will have both immediate and long-term impacts on the stability of carbon in Sierra Nevada forests.

- The Sierra Nevada Conservancy estimates that 53 MMTCO2e of live tree carbon shifted to the dead pool due to tree mortality from beetles and drought in the Southern Sierra in 2016. Those dead trees will decay, and their emissions will equal what 11.2 million cars emit in a year.
- Over 50 million trees – many of them large trees that were storing and absorbing large amounts of carbon -- in the southern Sierra are no longer actively sequestering carbon, with nothing to replace that loss over the short-to-medium term.
- Beetle-killed forests take much longer than other disturbance areas to become net sequesterers (See Figure A).

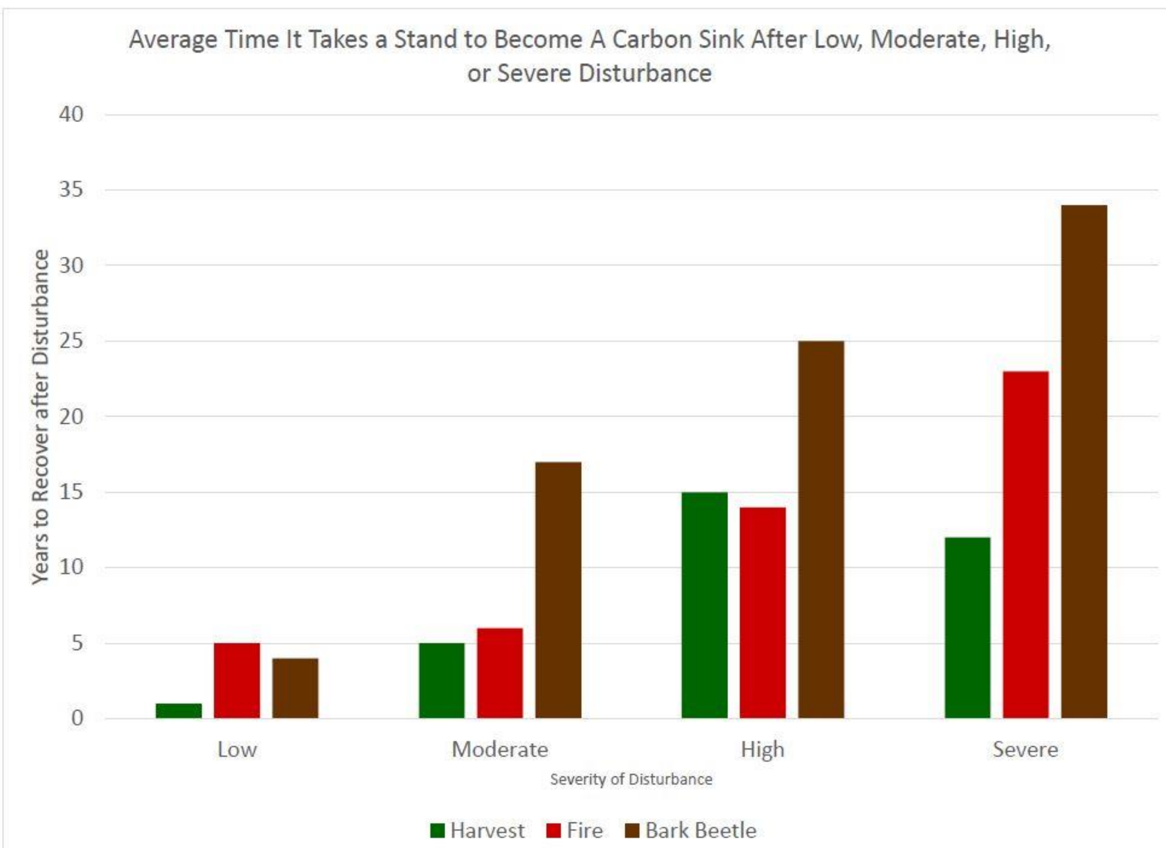

Figure A: Adapted from Raymond 2015.i

An increase in high severity fire is having long term implications on carbon storage.

- Between 1984 and 2010, there was a significant increase in the number of acres within a wildfire burning at high severity, from an average of 20 percent in the mid-1980s to over 30 percent by 2010. 40 percent of the 2013 Rim Fire burned at high severity, and almost 50 percent of the 2014 King Fire burn at high severity.

- High severity wildfires emit millions of metric tons of CO2e in their plume during the fire event. However, the true impact to the atmosphere from fire occurs after the event. The plume emissions are estimated to represent up to 15 percent of the pre-fire aboveground forest carbon in the burn area, the remaining 85 percent is emitted as the trees decay or burn in subsequent fire.
- High severity fire kills the large trees that are responsible for the majority of the sequestration and begins to release their stored carbon back to the atmosphere, turning the area from a net sink to a net source of GHGs. **One study found that a forest burned at high severity was still a net source of carbon to the atmosphere 15 years after the fire occurred, and was expected to continue to be so for more years to come.**[ii]
- The Rim Fire released more greenhouse gas emissions in its smoke plume than the City of San Francisco produces in a year, and those emissions represent only 15 percent of what will be released from the burn footprint as dead trees decay.
- A study on California forests from 2001-2010, found that prior to the drought, California forest carbon stocks were already decreasing due primarily to larger and more severe fires[iii]. Forest conditions have worsened since the study, suggesting the decline may be getting worse.

We can't count on post-fire regrowth to balance carbon emissions from fire events anymore.

- In some areas of the Sierra Nevada, forests that burned at high severity are not regrowing as forest.[iv] More and more areas are experiencing a change in vegetation type from forest to shrub or grasslands, which can reburn at high severity in less than a decade[v] and store less than 10 percent of the carbon that the forests they replace did.
- In the Lake Tahoe Basin, 51% of the plots in untreated stands that burned at high severity had no natural tree regeneration occurring even 3 years after the fire.[vi] In other large California fires, over 50% of the research plots in the high severity burned areas had only 1 seedling growing, or none at all, 5 years after the fire.[vii]

Today's forests contain 25 percent less carbon than forests of 150 years ago, even though there are more trees. [viii] **Reducing competition for resources has a carbon cost, but that cost is outweighed by the benefit of growth and sequestration.**

- A recent study in the Sierra Nevada highlighted the carbon benefits of recently treated, healthy forests compared to overgrown forests. Over a 10 year period starting in 2002, all treated areas gained in sequestered carbon while the untreated areas actually lost carbon.[ix] These observations come from before the drought and the gap between treated and untreated has likely grown significantly since.
- Recent research has found that even though low and moderate severity fires emit carbon in the short term, they help to store more carbon in the long term by reducing mortality due to fire and drought, and increasing the density of older, larger trees.

Healthy forests, even during drought, can continuing sequestering carbon from the atmosphere at a significant rate,[x] **and the larger the tree the more carbon it will pull from the atmosphere on an annual basis.**[xi]

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[i] Raymond, C. L., Healey, S., Peduzzi, A., Patterson, P. 2015. Representative regional models of post-disturbance forest carbon accumulation: Integrating inventory data and a growth and yield model. Forest Ecology and Management. 336: 21-34. http://dx.doi.org/10.1016/j.foreco.2014.09.038.

[ii] Dore, Sabina, et al. "Recovery of ponderosa pine ecosystem carbon and water fluxes from thinning and stand-replacing fire." Global change biology 18.10 (2012): 3171-3185.

[iii] Gonzalez, Patrick, et al. "Aboveground live carbon stock changes of California wildland ecosystems, 2001–2010." Forest Ecology and Management 348 (2015): 68-77.

[iv] Coppoletta, Michelle, Kyle E. Merriam, and Brandon M. Collins. "Post-fire vegetation and fuel development influences fire severity patterns in reburns." Ecological Applications 26.3 (2016): 686-699.

[v] Coppoletta, Michelle, Kyle E. Merriam, and Brandon M. Collins. "Post-fire vegetation and fuel development influences fire severity patterns in reburns." Ecological Applications 26.3 (2016): 686-699.

[vi] Carlson, Chris H., Solomon Z. Dobrowski, and Hugh D. Safford. "Variation in tree mortality and regeneration affect forest carbon recovery following fuel treatments and wildfire in the Lake Tahoe Basin, California, USA." Carbon balance and management 7.1 (2012)

[vii] Welch, Kevin R., Hugh D. Safford, and Truman P. Young. "Predicting conifer establishment post wildfire in mixed conifer forests of the North American Mediterranean-climate zone." Ecosphere 7.12 (2016).

[viii] North, M., M. Hurteau, and J. Innes. 2009. Fire suppression and fuels treatment effects on mixed-conifer carbon stocks and emissions. Ecological Applications, 19, pp. 1385–1396.

[ix] Wiechmann, Morgan L., et al. "The carbon balance of reducing wildfire risk and restoring process: an analysis of 10-year post-treatment carbon dynamics in a mixed-conifer forest." Climatic Change 132.4 (2015): 709-719.

[x] Dore, Sabina, et al. "Recovery of ponderosa pine ecosystem carbon and water fluxes from thinning and stand-replacing fire." Global change biology 18.10 (2012): 3171-3185.

[xi] Stephenson, Nathan L., et al. "Rate of tree carbon accumulation increases continuously with tree size." Nature 507.7490 (2014): 90-93.