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, and an increase in high-severity wildfire – they are no longer the reliable carbon sink that California has depended on.

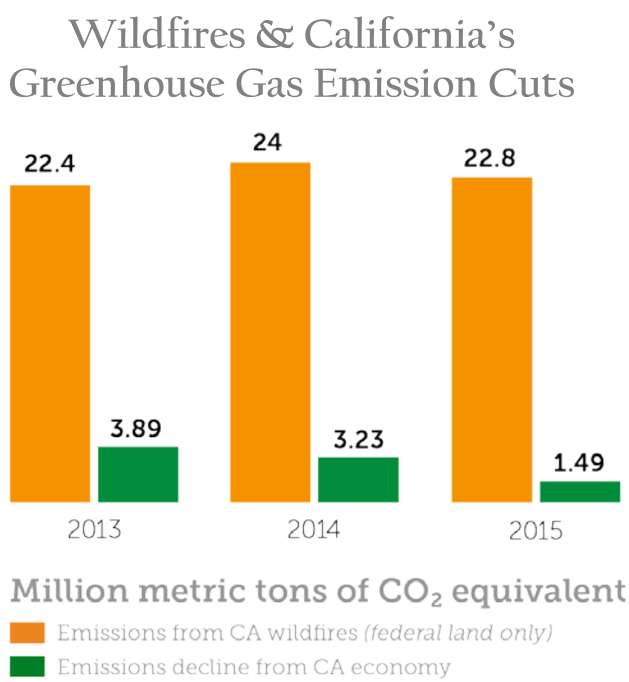
"Trees in California should absorb CO_2, not generate huge amounts of black carbon and greenhouse gas as they do today when forest fires rage across the land."

Governor Edmund G. Brown Jr.

Research shows that between 2001 and 2010, California's forests emitted more carbon than they sequestered,[i] and since then, forest conditions have only gotten worse. Between 2010 and 2017, drought, insects, and disease have been responsible for the death of 112 million trees in the Sierra Nevada, and wildfire has killed an additional 100 million trees.[ii]

High-severity wildfires are offsetting California's greenhouse gas (GHG) reduction efforts.

- For example, the smoke plume of the 2013 Rim Fire released what 2.57 million cars emit in a year.[iii] This is more than the City of San Francisco emitted in one year.[iv]



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- Wildfires are reported as the source of more than 50 percent of California's black carbon emissions, but new research suggests that particulate matter emissions from wildfires may have been underestimated by three times.[vi] Thanks to California's current programs, industrial and vehicle particulate emissions continue to decrease. Without action, however, wildfire emissions are expected to continue to grow.[vii]

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

- In 2016, 52 million metric tons of CO_2 equivalent moved to the dead pool due to drought and insect-related tree mortality in the Southern Sierra.[viii] This is greater than the emissions reductions California's economy made over the prior three years combined.[ix] Those dead trees will decay, and their emissions will equal what 11.2 million cars emit in a year.
- Over 112 million trees in the Sierra – many of them large trees that were storing and absorbing large amounts of carbon -- are no longer actively sequestering carbon and nothing will replace this loss for many decades.
- Beetle-killed forests take much longer than other disturbance areas to become net sequesterers. (See Figure A.) Bark beetles target the largest trees – our most effective carbon storage and sequestration tools.[x] Big trees can take centuries to replace, if they come back at all.

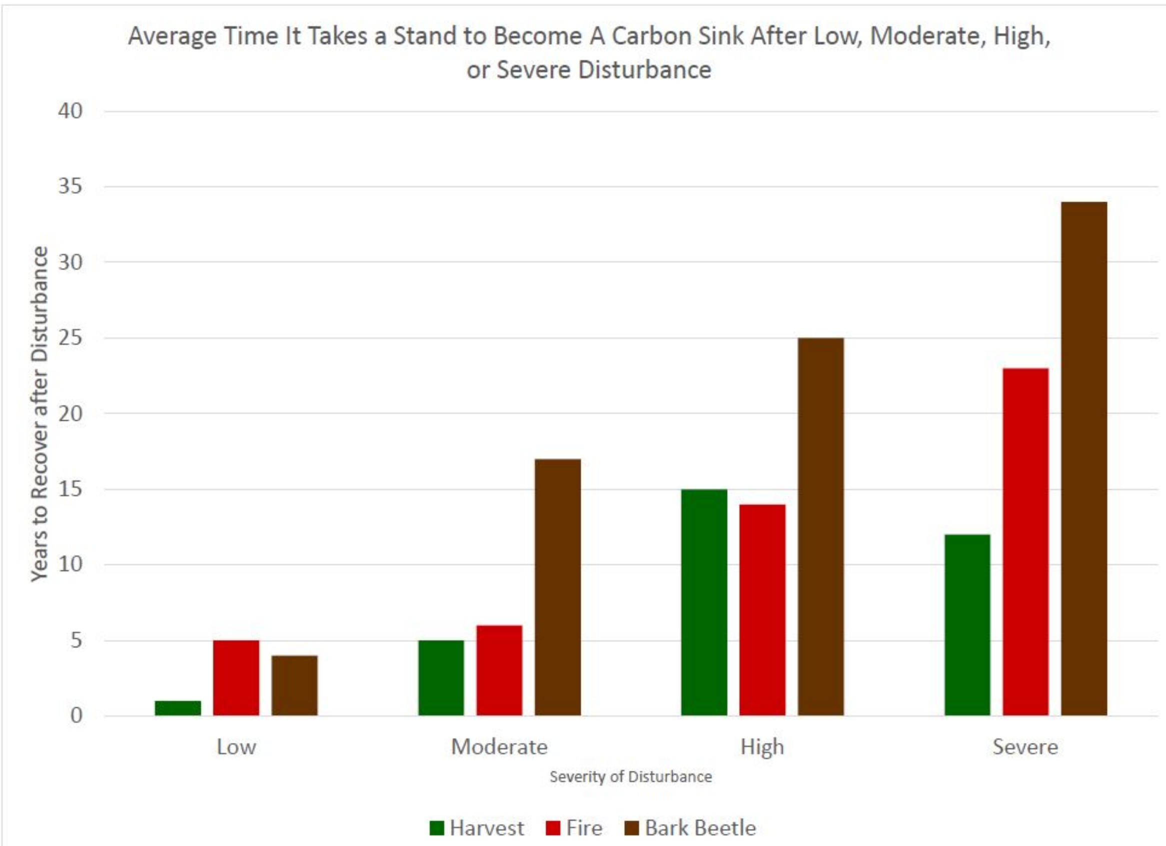

Figure A: Adapted from Raymond 2015.[xi]

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

- Research indicates that, if current fire trends continue, all Sierra Nevada forested areas with dense canopy cover – or those that most effectively sequester and store carbon – will be gone within 75 years.[xii]
- 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. Forty 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 CO_2 equivalent 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 only a fraction of the pre-fire aboveground forest carbon in the burn area, and the

remaining aboveground carbon is emitted as the fire-killed trees decay or burn in subsequent fire. For example, 40 percent of the Rim Fire burned at high severity. As the trees killed in the high-severity zone decay, they will emit an amount greater than the plume emissions for the entire fire.[xiii]

- High-severity fire kills the large trees that are responsible for the majority of the sequestration in our forests. Once killed, these trees stop sequestering carbon and begin 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.**[xiv]

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

- Forests that burned at high severity in recent megafires are showing less post-fire regeneration than normal.[xv] This suggests they are at risk of being replaced with shrub and grasslands, which frequently burn at high severity[xvi] and store only ten percent of the carbon than the forests they replaced.[xvii]
- In the Lake Tahoe Basin, 51 percent of the plots in untreated stands that burned at high severity had no natural tree regeneration occurring even three years after the fire.[xviii] **In other large California fires, over 50 percent of the research plots in the high-severity burned areas had only one seedling growing, or none at all, five years after the fire**.[xix]

Reducing the risk for high-severity fire and tree mortality protects carbon storage and sequestration. Forest restoration activities, such as thinning and prescribed and managed fire, reduce fire severity, insect- and drought-related tree mortality, and lower emissions.

- Fuel, more than weather, is driving these large, high-severity wildfires.[xx]
- Areas treated prior to the Rim Fire burned at much lower severity than their dense, untreated counterparts. Isolated treatments protected the areas immediately within the treatment boundary despite the intensity of the Rim Fire. However, research shows that treating 40 percent of the landscape would have altered fire severity at the landscape-scale. [xxi]
- In 2014, restored areas near Yosemite National Park experienced little to no tree mortality from insects and drought, while adjacent, untreated areas experienced much higher levels of mortality.[xxii]
- Acres burned in prescribed or managed fires produce fewer emissions than if those same acres burn in megafires.[xxiii] Modeling done in the Mokelumne River watershed showed that fuel treatments can reduce carbon emissions from wildfires by 38 to 77 percent.[xxiv]
- 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.[xxv] These observations come from before the drought and the gap between treated and untreated has likely grown significantly since.
- **Utilizing waste material from forest restoration activities in a new biomass facility instead of burning it in piles reduces particulate matter emissions by 98 percent.**[xxvi]
- Smoke from the Rim Fire is estimated to have impacted the equivalent of 7 million person-days. The Rim Fire also is estimated to have had five times greater impact per acre burned than two fires that were managed for resource benefit in the same airshed.[xxvii]

Healthy forests capture and store more carbon.

- Healthy trees in an open forest stand sequester much more carbon than unhealthy, overcrowded trees because they have space and resources to grow.[xxviii]
- Healthy forests, even during drought, can continue sequestering carbon from the atmosphere at a significant rate,[xxix] and the larger the tree the more carbon it will pull from the atmosphere on an annual basis.[xxx]

- Restoration treatments allow the safe return of frequent, rejuvenating fire behavior that keeps the forest healthy and stabilizes carbon storage. A healthy fire cycle promotes storage in large, old trees rather than in many small trees that are much more vulnerable.[xxxi]

Healthy forests make California's water supply more reliable.

- Reducing high-severity fire can help store more snow in the Sierra. One study in the eastern Sierra Nevada showed that areas burned at high severity retained only 22 percent of the snowpack that unburned areas stored.[xxxii]
- In an area of Yosemite National Park where managed fire has been used to restore forests over the last few decades, water yield has been maintained, and potentially increased. In adjacent forests where no ecological restoration has been done, water yield has decreased.[xxxiii]
- In 2015, The Nature Conservancy published a meta-analysis of 150 existing studies on forest management and water supply and analyzed the impacts on potential water yield from a number of diverse forest management strategies. The analysis found an increase in up to six percent in overall potential yield,[xxxiv] an amount that will be significant under a warmer, drier future.

The situation in the Sierra Nevada is cause for serious alarm, but it's not too late. If we acknowledge that extreme fire and tree mortality are major problems for our climate, we can apply the most effective solutions to address them. California is currently making decisions on how to best meet our greenhouse gas reduction targets, and the opportunity exists now to elevate forests as a key program. If we don't, Sierra Nevada forests will continue to offset California's greenhouse gas reduction progress and make our current investments less effective.

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