Research Summaries: Sierra Nevada Forests and Carbon

Sierra Nevada Conservancy (SNC) staff is regularly tracking research that has relevance to the work of the organization and Sierra Nevada Region. Below are some examples of research of which staff has recently become aware (emphasis added):

Wildfire and Drought Dynamics Destabilize Carbon Stores of Fire-Suppressed Forests

By: J. Mason Earles, Malcolm P. North, and Matthew D. Hurteau – 2014

Climate change has led to an increase in droughts, wildfire size, and wildfire severity in the Sierra Nevada region - a trend that is expected to continue. This research looked at how two different forest types will store and manage carbon in the long-term under a variety of potential future drought and wildfire conditions. The forests studied were (1) fir-dominated, overgrown stands that are common in the Sierra Nevada (from decades of fire suppression and selective logging), and (2) pine-dominated forests with an active fire management regime more representative of historic conditions. The researchers asked the following questions: how do the current fire-suppressed forests compare to historic conditions with regards to their carbon storage capacity and storage longevity, and how do these forests respond to increased levels of drought and wildfire? To answer the questions, they used models to simulate carbon sequestration over 300 years under a variety of conditions. They found that when drought and fires are infrequent, fir-dominated forests held more carbon than pine-dominated forests, but the additional carbon was largely stored in dead wood rather in living trees. When fire and drought increased in frequency, the fir forests lost a considerable amount of their carbon storage, while pine forests lost very little. **"As fire frequency increases, the carbon carrying capacity of fir-dominated forests is substantially more uncertain than pine-dominated forests, leading to greater risks of large-scale carbon losses due to combined fire and drought-induced mortality."** In essence, pine-dominated forests are more resilient to climate change impacts, and, as we look to store carbon in the long-term, they offer a more stable carbon storage bank than our current fire-suppressed and fir-dominated forests. The authors conclude: **"Continued suppression reinforces this [fir-dominated forest] altered state, perpetuating a condition that is less fire- and drought-tolerant. Fire actively maintains the dominance of a fire- and drought-tolerant species, providing a more stable and permanent carbon sink. In these forests, ecologically appropriate fire may benefit carbon stability and permanence."**

Fuel Treatment Effects on Tree-based Forest Carbon Storage and Emissions Under Modeled Wildfire Scenarios

By: Matthew Hurteau and Malcolm North – 2009

"Our objective was to model the amount of live- and dead-tree-based [carbon] stored and released over a century with and without wildfire in Sierra Nevada mixed-conifer forests after fuel reduction treatments." The authors added historical forest conditions (1865) to the comparisons to get a sense how fire suppression (current conditions) may have changed carbon storage in our forests. They compared live versus dead carbon stocks under control, historic, and treatment scenarios, and introduced wildfire at year 50 of the 100 year modeling runs. The historical conditions stored the most carbon at year 0, while at year 100 without any wildfire, current conditions and the burn-only treatments stored the greatest amount of carbon. However, when wildfire was introduced at year 50, the burn-only treatment and historic conditions plus burn treatment stored the most carbon by year 100 and were the only two scenarios that recovered to at least year 0 carbon storage by 50 years after the fire. In other words, 50 years was not long enough for the stands to recover to their pre-fire carbon stocking levels. The wildfire emissions were greatest under current conditions, but the emissions from the five prescribed fire events in each burn scenario (modeled to have prescribed fire on them once every 20 years to maintain the stand) roughly equaled the current conditions wildfire emissions. The difference is the amount of dead tree and snag carbon in the current conditions forest scenario post-wildfire – much of that will decay and be released to the air over decades and is not captured in the immediate emissions release measurements. The authors conclude**: "The consistently high storage and low emissions of the 1865 reconstruction suggest that a low-density forest, dominated by large, fire-resistant pines, may be a desired stand structure for stabilizing tree-based [carbon] stocks in wildfire-prone forests,"** and that the California Climate Action Registry Forest Sector Protocol be changed to include accounting from wildfire emissions just as the IPCC 2006 guidelines do.

Fire Suppression and Fuels Treatment Effects on Mixed-Conifer Carbon Stocks and Emissions

By: Malcolm North, Matthew Hurteau, and James Innes – 2009

Under California Climate Action Registry Guidelines, forest managers are penalized if they reduce fuel loads to reduce fire risk, but wildfire emissions themselves are not accounted for. This research looked at current conditions (fire suppressed & overstocked forests), a variety of treatment options, and historical conditions to determine how carbon emissions and storage differ between them. First, emissions from the equipment necessary to do treatments and/or to haul logs to a mill or biomass facility were a small percentage of overall emissions from thinning and/or burning. Critically, **"…because of the lack of the big trees that dominated historic forests, today's fire-suppressed forests are found to store approximately 25% less carbon than they did pre-fire suppression."** Because current forests are overgrown, bigger trees are more susceptible to bark beetle attacks and diseases, severely limiting their abundance. To get back to historic conditions, ecological treatments would be necessary, which would initially remove carbon from the stand. As a result, the authors conclude that our century of "…fire suppression may have incurred a double carbon penalty by reducing stocks and contributing to potential emissions with fuels treatment activities or inevitable wildfire combustion. …We have found rapid growth of large trees after past fire events that presumably reduced stand density. Thinning and prescribed-fire treatments that reduce small-tree densities may influence stand development by redirecting growth resources and carbon storage into more stable stocks such as large, long-lived fire-resistant pines."