Perspectives from a Long-Term Study of Fuel Reduction and Forest Restoration in the Sierra Nevada, by Brandon M. Collins, Scott L. Stephens, and Robert A. York

Forest management in much of the Sierra Nevada has undergone a significant redirection in recent decades. Prior to this, fire was largely absent from many foresters' credo; it was neither considered as a tool for management nor viewed as an inherent ecological component for sustaining basic forest processes. Yet fire has been a part of these forests for millennia, and its removal has slowly but markedly changed forests in unintended ways. The cumulative effects of removing fire for over 100 years are manifested in the large and uncharacteristically severe fires that are now happening annually. Additionally, the recent drought in California spotlighted another major vulnerability of Sierra Nevada forests, large-scale tree mortality from bark beetles and possibly other yet-unseen insect and pathogen outbreaks. While climate certainly had a role in recent fire and tree mortality events, current forest conditions are undoubtedly contributing to both. Our great challenge in Sierra Nevada forests is to reintroduce the role once played by fire – a fundamental ecosystem process, while also considering the reality of social, ecological, and economic constraints that exist in California. This means proactively trying and constantly evaluating all possible management approaches. In this article we present findings from a robust study of different approaches to reducing wildfire hazard in these historically fire-adapted forests.

Historical forest conditions in the Sierra Nevada were quite different from those typical of contemporary forests. The forest we see today does not look like the forest that existed in previous centuries. We will simplify the findings from numerous forest reconstruction studies to a few key points: historical forests had much lower tree density, larger trees, greater variability in structure and spatial patterns, less fuel accumulated on the forest floor, and greater understory plant diversity. These historical conditions were a product of frequent fire (every 10-15 years) that generally burned on the forest floor with occasional torching of individual trees, so called "low- to moderate-severity." Due to the large departure in contemporary forests there has been a push to restore forest structure and composition to that akin to historical conditions. Forest restoration can be done by mechanically removing trees (with chainsaws or heavy equipment), with fire (either prescribed fire or intentional use of naturally ignited wildfire), or a combination of the two. The intent with these methods is reduce tree density by removing smaller and mid-sized trees, and in case of fire use, consume accumulated fuels on forest floors. The dual benefit achieved with forest restoration is that it also mitigates wildfire hazard.

The Fire and Fire Surrogate Study at Blodgett Forest (near Georgetown, CA) was initiated in order to study the effectiveness and overall ecological impacts of these different forest restoration/fire hazard reduction treatments. Through the combined commitment of the forest managers and researchers at UC Berkeley, the study has been maintained continuously since its onset in 2001. While 18 years is a relatively short time frame relative to the lifespan of trees, the study is nonetheless a uniquely long-term look at forest management options and their effectiveness.

The Fire and Fire Surrogate study at Blodgett Forest is comprised of a network of twelve stands (35-70 acres each) that were randomly assigned to four treatments representing the basic range of forest restoration/fire hazard reduction options. The treatments were:

- Control: no active management.
- Mechanical-only: commercial timber harvest, which removed mid-sized trees, followed by mastication, which chipped/shredded smaller trees in place. Initial treatment was completed in 2002, with a second mastication done in 2017.
- Fire-only treatment: prescribed fires applied in 2002, 2009, and 2016.
- Mechanical+fire treatment: same mechanical treatment described previously, followed by prescribed fire. Initial treatment was completed in 2002, with second mastication and prescribed fire applied in 2018.

The initial effects of the different treatments followed a somewhat expected pattern. Both treatments involving fire were quite effective at reducing modeled wildfire hazard, even under fairly extreme weather conditions. This was due to the high consumption of fuel on the forest floor (called surface fuel) and to the considerable reduction in small trees and low branches (called ladder fuel). The effectiveness of the mechanical-only treatment at reducing wildfire hazard was not obvious initially. While this treatment largely eliminated ladder fuels, it did so at the expense of augmenting surface fuels (from the masticated material left on site).

By 2009 it was apparent that the treatments were on distinct and somewhat surprising trajectories. The most surprising finding was that the augmented surface fuel in the mechanical-only stands was gone, presumably from natural decomposition. As a result, the modeled wildfire

Mechanical only | **Fire only** | **Mechanical + fire**

2001 (Pre-treatment)

2003 (Post-treatment)

2009

2015

hazard decreased significantly. Hence, the mechanical treatment "aged well" from a hazard perspective. The second most surprising finding was the vigorous understory shrub response in the mechanical+fire stands. The increased light to the forest floor from the commercial thinning, coupled with the removal of surface fuels and the heat/smoke stimulus from fire allowed for rapid establishment of large stature shrubs, mainly *Ceanothus* species. The mechanical+fire treatment was still effective at reducing wildfire hazard in 2009, but this was likely to be compromised as the shrubs got taller and denser. The fire-only stands started to accumulate surface fuels as the small to mid-sized trees killed by the initial fire began to fall to the forest floor, hence the need for a second prescribed fire applied in the fall of 2009. This emphasized an important distinction between the two mechanical treatments and the fire-only treatment related to the fate of killed trees.

It would take multiple "entries" to entirely remove those unwanted trees with fire alone; whereas with mechanical methods they could be removed immediately.

The distinction among treatments got even more interesting over time. Tree growth was accelerated in the mechanical-only stands. This was evident in diameter and crown expansion for overstory trees remaining after thinning, as well as for regenerating trees in the understory. This increased growth in overstory trees had a noticeable effect of increasing individual tree vigor relative to the other treatments (as studied from tree ring widths). Tree regeneration in the understory was so strong that another mastication was warranted in 2017 to maintain low fire hazard. Similarly, the shrub growth in the mechanical+fire warranted another mastication before a second prescribed fire could be applied. This was done because it would have been difficult and quite risky to burn the shrubs effectively without torching the entire stand. The fire-only stands continued to "recruit" dead trees into the surface fuels, but an interesting phenomenon became apparent. After two burns the fire-only stands were developing a "patchy" pattern of tree clumps, openings with shrubs, and large isolated individual trees. This pattern appears to be a common characteristic of historical forests that experienced frequent fire. It is also thought to provide a suite of habitat types for wildlife species that are adapted to distinct structural/compositional environments. Recent research also suggests there may be additional benefits of this patchy pattern tied to snow retention and water yield.


Photo: Tim Van Wagner


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The state of California recently put forth some unequivocal statements (and funding) on the need for large-scale forest restoration/fire hazard reduction. So, which treatments examined in this nearly 20-year study should be used in this effort? The answer that we offer is 'all of the above.' Each of the treatments we studied had direct benefits for forest restoration/fire hazard reduction and several co-benefits (e.g., wood products, habitat improvement, water yield, reduce wildfire emissions, stabilizing forest carbon). On many forest-dominated landscapes the different land management, ownership, and societal constraints requires a diversified approach to forest restoration that includes prescribed burning, commercial thinning, and mastication. In fact, landscape-level restoration will also need to include managing naturally ignited wildfires, hand thinning (removing only small diameter trees), pile-burning, and grazing. The uncharacteristically high vulnerability to wildfire and drought exists at such great scale throughout California forests that action is warranted now, even if our current scientific understanding is imperfect. We know enough from studies like the Fire and Fire Surrogate Study at Blodgett to move forward competently with large-scale forest treatment, recognizing that we'll likely need to continue to study treatment impacts and adjust future treatments. This approach, called Active Adaptive Management, has been recognized for decades as a solution to large environmental problems like the one faced in the Sierra Nevada. Yet it has been difficult to accomplish. California now has the opportunity to succeed in the face of this great challenge.