The Science Behind Forest Restoration in the Sierra Nevada
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As one fire expert told me ‘I don’t believe that equipment and development alone will show us how to keep having the relatively few big fires… Researchers must let their imaginations soar for answers that today would seem fantastic’.
Historical Fire Effects

Mixed-conifer and ponderosa pine forests:
Show and Kotok (1924):

“California pine forests* represent broken, patchy, understocked stands, worn down by the attrition of repeated light fires.”

“Extensive crown fires…are almost unknown to the California pine region.”

“The virgin forest, subjected to repeated surface fires for centuries has been exposed to… cumulative risk.”
Fire Suppression

- Begins around 1905
- Approximately 80,000 fires/year today
- 98-99 percent of all wildland fires out at less than 5 acres in size
- 95% of area burned today is from 1-2% of the fires that escape initial attack
- Before 1800, fires burned approximately 1.1 million acres of forests annually in California in an average year, 4.5 million acres total (*Stephens et al. 2007 For. Ecol. Man.*)
  - Lightning and Indigenous ignitions
  - Today we burn 10-25% of this area
- How have forests changed in Sierra Nevada?
The 1911 Historical Data

San Bruno Federal Archive
<table>
<thead>
<tr>
<th></th>
<th>Stanislaus NF &amp; Yosemite NP</th>
<th>Sequoia (Kern) NF Greenhorn Mts.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transects</td>
<td>294</td>
<td>378</td>
</tr>
<tr>
<td>Trees</td>
<td>20,700</td>
<td>18,052</td>
</tr>
<tr>
<td>Survey area (ac)*</td>
<td>41,496</td>
<td>28,405</td>
</tr>
</tbody>
</table>

*no prior timber harvesting, ~3% sample of total area
Stanislaus NF, Sampling 1911 Location
(15-Jul-2013)
Same Field Plot Within Rim Fire
Post-fire (25-Sep-2013)
Field Plot Within Rim Fire
Post-fire (August-2016)
Field plot within Rim Fire

Pre-fire (15-Jul-2013)  Post-fire (25-Sep-2013)
Field plot within Rim Fire

Pre-fire (15-Jul-2013)

Post-fire (25-Sep-2013)

Black Oak critical resource for Sierra Nevada Tribes Managed for Oaks
### Stanislaus-YOSE Historical vs. current: re-measurement of 1911 timber surveys

<table>
<thead>
<tr>
<th>Year</th>
<th>Basal area (ft² ac⁻¹)</th>
<th>Tree density (ac⁻¹)</th>
<th>Pine proportion</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>&gt; 6 in.</td>
<td>&gt;36 in.</td>
</tr>
<tr>
<td>1911</td>
<td>87</td>
<td>22</td>
<td>5</td>
</tr>
<tr>
<td>2013</td>
<td>173</td>
<td>101</td>
<td>5</td>
</tr>
</tbody>
</table>

**Collins et al. 2011, 2017**

1911 Canopy cover estimates 25% over 40 acres
Forest management implications:

• Contemporary stand-replacing fire is outside historical range of variability
  - Most pronounced in mixed-conifer and yellow pine types
  - Not only proportions, patch sizes as well

• Coordinated landscape treatments can mitigate uncharacteristic fire behavior (and effects)
  - Strategic treatments across 15-20% of landscape seems optimal
  - Cannot continue to use treatments to STOP fire
  - Manage landscapes to incorporate fire
  - Ecological Effects of Treatments
What do treatments look like?

- 3 Control
- 3 Mechanical only
  - Thin and mastication
- 3 Mechanical plus fire
  - Same as mech + fire
- 3 Prescribed fire only
- All units 40-70 ac in size
- Pre-treatment all units had very high fire hazards
Mechanical Only – Pre-Treatment (2001)

Watch
Rotary Masticator in Central Sierra

Crown thin, commercial thin from below, mastication
Mechanical Only – Post-1st Treatment (2003)
Mechanical Only – Post-1st Treatment (2010)
Very effective at reducing potential fire behavior
Mechanical + Fire – Pre-Treatment (2001)

Watch
Mechanical + Fire – Post-Thin and Mast (2002)
Mechanical + Fire – Post-1st Treatment (2003)
Mechanical + Fire – Post-1st Treatment (2010)
Same tree
Crown damage/tree mortality higher than desired
Fire Only – Pre-Treatment (2002)

Watch
Fire Only – During 2^{nd} Ignition (2009)
Fire Only – Post- 2nd Prescribed Fire (2010)
Fire Only – Post-2^{nd} Fire 8 years (2017)
Fire Only – During 3rd Ignition (2017)
Desirable forest structure needed 3 fires
Fuel Consumption After 3rd Prescribed Fire

Green 1st fire    Red 2nd fire    Blue 3rd fire
More variability in fuel consumption in 3rd fire
Fuel Consumption with Multiple Prescribed Fires

- Overall fuel consumption across the three burns averaged 45% of pre-burn levels.
- Consumption rates were highest for the first burn at 65%.
- Decreasing by 15-20% with each successive burn.
- Fuel consumption was highly variable by fuel type, stand, and tree species composition.
- This variability may be advantageous for managers seeking to foster structural diversity and resilience in forest stands.
Fuels Treatments Impacts on Carbon

*Foster et al. 2020*

**Graph Description**

- **Title**: Fuels Treatments Impacts on Carbon
- **Author**: Foster et al. 2020
- **Graph Type**: Bar chart
- **X-axis**: Treatment (Control, Mech, Burn, MechBurn)
- **Y-axis**: Mg C / ha
- **Years**: 2001 Pretreatment, 2003 Post_1, 2009 Post_7, 2016 Post_14
- **Treatments**:
  - Control
  - Mech
  - Burn
  - MechBurn
- **Legend**:
  - Control
  - Mech
  - Burn
  - MechBurn
  - Stable Live Tree C
  - Total Live Tree C
Total Aboveground Carbon by Treatment and Annual Wildfire Probability (dashed lines today)
Restoration and Fuels Treatments

- All forest treatments successful in reducing fire hazards and fire effects in frequent fire forests
  - Reduction of **Surface and Ladder Fuels Critical** (Agee and Skinner 2005)
    - Treatments can increase the vigor/resistance/resilience of remaining trees to improve adaptation to climate change (Collins et al. 2015)
  - All fuel treatments: Most ecosystem components exhibit very subtle effects or no measurable effects at all (soils, small mammals and birds, vegetation, bark beetles) (Stephens et al. 2012)
    - Longevity of treatments 15 - 20 years (Stephens et al. 2012)
    - Treatments never end – lightning fire maintenance in some areas
  - Forest carbon more stable with fire treatments but mechanical and controls also important
    - fire probabilities increasing, control fire severity likely underestimated
    - Scale of treatments continues to be relatively low in CA - **Problem**
Summary

California mixed conifer forests have changed

– Tree density increased 2.75 times since 1900, canopy cover 1.5x higher, large tree deficit (Safford and Stevens 2017)
– Forest change has decreases resiliency
– Climate change makes worse – not biggest issue

Need increased restoration treatments and wildfire for ecological benefit

Answer to Nathaniel Kenney from 1956 (imaginations soar – fire back and mechanical restoration treatments, more work with Tribes for innovation)

California has increased resources for fuels management

Need to invest in fire extension program state-wide, Western US Prescribed Fire Training Center, increase pace and scale of treatments (Feinstein Bill released)

Next 1-2 decades absolutely critical
We are running out of time – Still hopeful
Acknowledgements

Danny Foster, Brandon Collins, Danny Fry, Jason Moghaddas, John Battles, Bob Heald, Rob York, Ariel Thompson

Funding from US Joint Fire Sciences Program and Cal Fire competitive grants

Papers available at: www.cnr.berkeley.edu/stephens-lab/

Email: sstephens@berkeley.edu
Permanent Backlog:
2.9 million acres (60% of USFS acreage) will always remain fuel loaded
2/3’s of this acreage is pine-dominated and mixed-conifer forest types

North, Collins, Stephens. 2012, J. Forestry