Long-Term Dead Wood Changes in a Sierra Nevada Mixed Conifer Forest: Habitat and Fire Hazard Implications

Eric Knapp
U.S. Forest Service, Pacific Southwest Research Station
Redding, California
Snag habitat

- Nesting, roosting and resting structures for many bird and mammal species
- Source of food: bark beetles and other wood boring insects
- Bigger is generally better
Coarse woody debris (CWD)

- Dead and down wood also has ecological value
  - Shelter/ cover
  - Fungi, insects = Food
  - Nutrient cycling

J. Sullivan
Dead wood is flammable and can contribute to extreme fire behavior
How much dead wood is sufficient to meet ecological/wildlife needs, yet not so much that it becomes a fire hazard?
Historical Methods of Cutting plots

1929 stand maps

Duncan Dunning
USFS Forester (1915-1950)
Methods of Cutting study plots
Established in 1929

Stanislaus-Tuolumne Experimental Forest

Stanislaus National Forest

MC11
Heavy cut

MC10
Light economic thin

MC9
USFS thin
79 years of forest change: live trees

Productive mixed conifer forest
Elevation: 5800 ft
NW-facing aspect

<table>
<thead>
<tr>
<th></th>
<th>1929</th>
<th>2008</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trees ac(^{-1}) (≥ 4 in)</td>
<td>127</td>
<td>299</td>
</tr>
<tr>
<td>Basal area ft(^2) ac(^{-1})</td>
<td>235</td>
<td>302</td>
</tr>
<tr>
<td>% Pine</td>
<td>37</td>
<td>21</td>
</tr>
</tbody>
</table>
Plot 9 – USFS thin

Live trees in 1929 post-logging

Live trees in 1929 prior to logging

DBH 1929 (in)
- 0 - 10
- 10 - 20
- 20 - 40
- 40 - 76

DBH 2008 (in)
- 0 - 10
- 10 - 20
- 20 - 40
- 40 - 76
Potential causes of forest change: effect of logging treatment.
Historical role of fire in the Sierra Nevada

Fire history from the Pinecrest/Strawberry area

Median fire return interval: 6 years
Last major fire: 1889
“So continuous and widespread are these fires, that except where some natural barrier or chance has prevented, they keep a very large percentage of the seedling growth down.”

“Dense stands of yellow pine 25 to 50 years old suffer a thinning every time surface fires run through them, and not infrequently the younger stands succumb entirely.”

- Sudworth (1900)

Forest change in absence of fire

Clark Fork, Stanislaus NF
Photo: A.E. Wieslander, 1931
Snag density change 1929 – 2008
(≥ 4 inches in diameter)

<table>
<thead>
<tr>
<th></th>
<th># Snags ac⁻¹</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1929 - pre</td>
</tr>
<tr>
<td>Plot 9 – USFS cut</td>
<td>3.7</td>
</tr>
<tr>
<td>Plot 10 – Light Economic cut</td>
<td>4.8</td>
</tr>
<tr>
<td>Plot 11 – Heavy cut</td>
<td>10.0</td>
</tr>
<tr>
<td>Average</td>
<td>6.2</td>
</tr>
</tbody>
</table>
Snag size change

Management standard for wildlife: 4 or more snags/acre (>15 in.)

<table>
<thead>
<tr>
<th></th>
<th>No. ac⁻¹</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1929</td>
</tr>
<tr>
<td>Snags 4 -15 in</td>
<td>1.8</td>
</tr>
<tr>
<td>Snags &gt; 15 in</td>
<td>4.4</td>
</tr>
<tr>
<td>% &gt; 15 in</td>
<td>72%</td>
</tr>
</tbody>
</table>
## Snag basal area 2008

<table>
<thead>
<tr>
<th>Plot</th>
<th>Small (4 – 15 in)</th>
<th>Medium (15 – 30 in)</th>
<th>Large (&gt;30 in)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plot 9 – USFS cut</td>
<td>19.2</td>
<td>20.9</td>
<td>9.1</td>
</tr>
<tr>
<td>Plot 10 – Light Economic cut</td>
<td>22.2</td>
<td>22.2</td>
<td>44.0</td>
</tr>
<tr>
<td>Plot 11 – Heavy cut</td>
<td>10.9</td>
<td>23.5</td>
<td>3.9</td>
</tr>
</tbody>
</table>
Methods of Cutting plots 9-11, Stanislaus NF
Percentage of standing trees that were dead

<table>
<thead>
<tr>
<th>Species</th>
<th>% Dead 1929</th>
<th>% Dead 2008</th>
</tr>
</thead>
<tbody>
<tr>
<td>White fir</td>
<td>4.1</td>
<td>18.2</td>
</tr>
<tr>
<td>Incense cedar</td>
<td>3.7</td>
<td>8.0</td>
</tr>
<tr>
<td>Sugar pine</td>
<td>3.8</td>
<td>37.5</td>
</tr>
<tr>
<td>Ponderosa pine</td>
<td>6.0</td>
<td>9.3</td>
</tr>
<tr>
<td><strong>AVERAGE</strong></td>
<td><strong>4.0</strong></td>
<td><strong>15.9</strong></td>
</tr>
</tbody>
</table>
Methods of Cutting plots 9-11, Stanislaus NF
Percentage of standing trees dead by size - 2008

Tree diameter (in)
5 10 15 20 25 30
% Standing dead (2008)
0 10 20 30 40 50 60
White fir
Incense cedar
Sugar pine
Ponderosa pine
Methods of Cutting plots 9-11, Stanislaus NF
% death between 1929 and 2008

% dying 1929 - 2008

Tree diameter (in) -1929

White fir
Incense cedar
Sugar pine
Ponderosa pine
Methods of Cutting plot 10
Live white fir by size class 1929 to 2008

Basal Area (ft$^2$ ac$^{-1}$)

- 1929 old growth
- 1929 post harvest
- 2008

Size classes:
- 4 to 8
- 8 to 12
- 12 to 16
- 16 to 20
- 20 to 24
- 24 to 30
- 30 to 36
- 36+
Basal area and tree mortality

Coarse woody debris change 1929-2012

MC9 – 1929 prior to logging

MC9 – 2012

A. 1929

B. 2012
## Coarse woody debris change 1929 - 2012

<table>
<thead>
<tr>
<th></th>
<th># Logs $\text{ac}^{-1}$</th>
<th>Log diam. inches</th>
<th>Log mass tons $\text{ac}^{-1}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plot 9 – USFS cut</td>
<td>6</td>
<td>28</td>
<td>38.6</td>
</tr>
<tr>
<td>Plot 10 – Light Economic cut</td>
<td>8</td>
<td>40</td>
<td>34.1</td>
</tr>
<tr>
<td>Plot 11 – Heavy cut</td>
<td>20</td>
<td>25</td>
<td>26.5</td>
</tr>
<tr>
<td><strong>Average</strong></td>
<td><strong>11</strong></td>
<td><strong>31</strong></td>
<td><strong>33.7</strong></td>
</tr>
</tbody>
</table>

$P = 0.042$  
$P = 0.019$  
$P = 0.105$
Snags, CWD and fire behavior

- Snags loft embers
- Consumption
  - Small diameter > large diameter
  - Decayed > sound
- Decayed wood – receptive to embers
- More logs = more jackpots
- Torching and extreme fire behavior
How fires once burned

“…the only food for these fires is the scanty fall of pine and fir needles, irregular patches of low conifer seedlings, and chaparral. In general, these materials limit the fires to surface burning.”

- Sudworth (1900)

Versus now

Rim Fire – 2013
Re-thinking the role of CWD in seasonally dry western forests

• Slow decomposition, but less CWD can accumulate with frequent fire

• Unstable resource: wildlife may not be as dependent on CWD in frequent fire forests
  – (Sollman et al. 2015. Mammalian Biology 80:247-254)

A.E. Wieslander
Near Butte Lake, Lassen County (1941)
Conclusions

• With forest densification in absence of fire:
  – Many more snags and more downed logs today than in 1929
  – Mortality shifted from large size/old age to smaller size/ younger age
    • Density dependent mortality
    • White pine blister rust

• Current situation with smaller snags and logs – lower habitat value: potential fire hazard ratio

• To restore dead wood condition:
  – Reduce stand density/ basal area
    • Reduced mortality
    • Larger tree size = larger snag size = larger CWD
  – Re-introduce periodic fire to consume dead wood
Acknowledgements

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• PSW field crews 2007-2012

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