The Life Cycle of Dead Trees

April 12, 2022

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Snag Management in Forestry: Wildlife and Wildfire

Hot Drought = 147M Dead Trees

What's killing California's forests?
Since 2000
- Fires
- Pests & drought

[Map of California's trees with colors indicating fires and pests/drought]
1. Habitat value of snags recognized and their retention stipulated in Forest Practice Rules.

2. Snags present a risk to forest operations and wildfire hazard mitigation.

3. Need better understanding of dead wood cycle to inform forest management.
Dead wood cycle

Live tree → death → Dead tree (Snag) → degrade and fall → 1000+ hour fuel (CWD, DD) → CO₂
Snags are ephemeral*

Keen 1929, 1955; Raphael and Morrison 1987, 1993 Battles et al. 2015

*Histogram from Hilger et al. 2012
Decay rates are exponential


![Graph showing mean bole density over time for Abies concolor.](image)

**Fig. 1.** Mean density of *Abies concolor* boles as a function of time since falling. The density of boles on the ground for more than 24 years was adjusted to reflect volume losses.
Blodgett Forest Research Station

Blodgett Forest Managers

Percy Barr: 1934 – 1955
Rudy Grah: 1958 – 1960
Herb Sampert: 1960 – 1976
Frieder Schurr: 2006 - 2007
Robert York: 2007 – 2018
Ariel Roughton: 2019 –
Compartment 160: Snag demography study
Compartment 160: 2018-2020
Analytical approach

Strength: 2,600+ trees observed over 37 years

Weakness: Long intervals between inventories; interval censored data

Accelerated Failure Time (AFT) Model

- The effect of a fixed covariate $Z$ is to act multiplicatively on the failure time $T$ or additively on $Y = \log T$.

$$ Y = \log T = \alpha + \beta^T Z + \sigma \varepsilon $$

- $\exp(\beta)$: regression parameter which can be interpreted as the ratio of failure time per unit change in covariate.
- AFT model postulates a direct relationship between failure time and covariates.
- “Accelerated failure time model are in many ways more appealing because of their quite direct physical interpretation” – Sir David Cox.
Failure time analysis: Species group

1. Cedar remains standing longest
2. Fir falls the fastest
Failure time analysis: Tree size class

1. Larger trees remain standing longer

2. Smallest trees fall fastest
   (sub < 7.9 in DBH)
Failure time analysis: Decay class

Stubs remain standing a long time

Nest trees tend to fall the fastest
Median Fall Rates

Weibull additive model with species group and size class was the best model

<table>
<thead>
<tr>
<th>Species</th>
<th>DBH</th>
<th>Fall Times (years)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>median</td>
</tr>
<tr>
<td>CEDAR</td>
<td>sub</td>
<td>17.9</td>
</tr>
<tr>
<td>CEDAR</td>
<td>small</td>
<td>19.1</td>
</tr>
<tr>
<td>CEDAR</td>
<td>med</td>
<td>18.4</td>
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<tr>
<td>CEDAR</td>
<td>large</td>
<td>17.2</td>
</tr>
<tr>
<td>PINE</td>
<td>sub</td>
<td>16.4</td>
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<tr>
<td>PINE</td>
<td>small</td>
<td>12.7</td>
</tr>
<tr>
<td>PINE</td>
<td>med</td>
<td>13.5</td>
</tr>
<tr>
<td>PINE</td>
<td>large</td>
<td>18.6</td>
</tr>
<tr>
<td>OAK</td>
<td>sub</td>
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</tr>
<tr>
<td>OAK</td>
<td>small</td>
<td>14.8</td>
</tr>
<tr>
<td>OAK</td>
<td>med</td>
<td>14.2</td>
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<td>OAK</td>
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</tr>
<tr>
<td>FIR</td>
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<td>13.6</td>
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<tr>
<td>FIR</td>
<td>large</td>
<td>14.4</td>
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</table>
Decay progression
(wildlife snags only)

<table>
<thead>
<tr>
<th>Decay Class</th>
<th>Longevity (years)</th>
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<tbody>
<tr>
<td></td>
<td>mean</td>
</tr>
<tr>
<td>1</td>
<td>2.0</td>
</tr>
<tr>
<td>2</td>
<td>2.1</td>
</tr>
<tr>
<td>3 &amp; 4</td>
<td>6.8</td>
</tr>
<tr>
<td>5</td>
<td>9.3</td>
</tr>
</tbody>
</table>

Decay Class 1 - Tree is recently dead. Top is intact. Most fine branching is still present. Bark is intact.

Decay Class 2 - Top is intact. Most of the fine branches have dropped. More than 50% of the coarse branches are left. Bark may begin to loosen.

Decay Class 3 - Top is intact. Fewer than 50% of the coarse branches are left. Depending on the species, bark may (e.g. white pine) or may not (e.g. white birch) have sloughed off.

Decay Class 4 - Top is broken. No coarse branches remain. Bark may or may not have sloughed off. Height at least 6 m.

Decay Class 5 - (stub) Top repeatedly broken. No coarse branches remain. Bark may or may not have sloughed off. Height less than 6 m.
EMC Application

Snags typically remain standing for 15 years.

Only 9 years of their 15 year median “lifetime” do snags provide critical wildlife habitat.

At Blodgett, it takes a minimum of 20 years to grow a tree big enough to provide wildlife habitat.

Current snag retention guidelines do not consider longevity of existing snags.

Guidelines do not include provisions for snag recruitment in harvested stands.

Results suggest that one matching live tree should be retained for every snag retained to “recruit” replacements for snags that fall.
Decay rate of coarse woody debris

Log cemeteries established in 2018

Initial samples collected

Initial samples processed for wood density

2019: Monumented logs for the long-term
Retrospective Analysis of Wood Decay by Species in Sierran Mixed Conifer
The Plan

Approach

Conduct a field inventory of downed logs

Match records of fall; Evaluate current decay status

Use paired information to estimate decay rate
Paired observations

The graph illustrates the change in density (g/cm³ yr⁻¹) over time (years) for different species groups: Cedar, Hardwood, and Softwood.
Rates of decay

<table>
<thead>
<tr>
<th>Species Group</th>
<th>n</th>
<th>Decay Rate (g/cm³ yr⁻¹)</th>
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</thead>
<tbody>
<tr>
<td>Softwood</td>
<td>62</td>
<td>0.013 (0.002)</td>
</tr>
<tr>
<td>Cedar</td>
<td>60</td>
<td>0.007 (0.002)</td>
</tr>
<tr>
<td>Hardwood</td>
<td>28</td>
<td>0.017 (0.004)</td>
</tr>
</tbody>
</table>
Decay rates at Blodgett: Slower than expected
Goal: Improve dead wood cycle in forest growth models

Existing models:

1. Underestimate snag fall rates
2. Overestimate CWD decay rates

**Major Challenge: Generalize**