Wildfire, Climate and Management in Western US Forests: Historical Consequences and Current Dilemmas

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With many thanks to:
Adam Pfleeger, Beth Hoover, Rob Schantz, Brian Tandy, Dan Donato, John Campbell, Darrin Moore, James Irvine, Theresa Johnson, Michael Chuko
Federal Legislation

1991 - USFS declared in violation of Ntl Forest Management Act by failing to implement Spotted Owl habitat management in old growth forests - result: logging prohibited in 17 national forests (Washington, Oregon, N. California). The short- and long-term consequences:
  • Rural economy in many areas of the Pacific northwest were devastating: Over 100 mills closed, unemployment rate of up to 25%.
  • Increased forest density, providing near-term sustainable habitat for the spotted owl in old growth.

1995 - Federal Wildland Fire Management Policy: Wildland and prescribed fire incorporated into land management

2002, 2003: The Healthy Forest Initiative and Healthy Forest Restoration Act proposed to improve regulatory process. Goal: more timely decisions, greater efficiency, and better results in reducing the risk of catastrophic wildfires by restoring forest health. The Act is based upon an assumption that forest thinning and other logging activities can solve many forest health problems, that an economic value can be found for the small diameter trees, and that regulatory processes need to be streamlined to increase efficiency of forest restoration.
Recent Drought: Co-Variation of $\Delta T$ and $\Delta PPT$

Dai et al. 2005

Very warm and dry 1998-2003 (Hoerling and Kumar)
US with significant C uptake in two modes: lowland ecosystems and montane forests.

Exaggerated in western US because of aridity

From Schimel et al. 2002

Note:

• Differences in scale between NEE (orange) and NPP (green)

• High elevation disproportionate with respect to NEE

ACME:

Airborne Carbon in the Mountains Experiment
Stand Replacing Disturbance in Western Oregon 1972-2002

Year and Type of Stand Replacing Disturbance:

- Harvest 2000-02
- Harvest 1995-00
- Harvest 1991-95
- Harvest 1988-91
- Harvest 1984-88
- Harvest 1977-84
- Harvest 1972-77
- Multiple Disturbances 1972-2002

Additional Information:

- Eyerly (9200 ha)
- Biscuit (>200,000 ha)
The Eyerly Fire north of Sisters, OR burned in July of 2002, scorching over 9200 ha of forest and rangelands.

Estimated total source ~4.1TgC compared to ~0.1 TgC y\(^{-1}\) during late 1990's for Oregon forests (Law et al. 2004).
Average Annual (1971-2000) = 360mm

Data courtesy of NOAA Cooperative stations, obtained from Oregon Climate Service
<table>
<thead>
<tr>
<th>Forest Type of Analysis</th>
<th>Ecosystem Component</th>
<th>Combustion Loss (%)</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>TempCon Wildland Mass Loss Auto</td>
<td>Bole/Branch</td>
<td>50-75</td>
<td>This study</td>
</tr>
<tr>
<td>TempCon Wildland Kjehldahl</td>
<td>Soil N</td>
<td>39</td>
<td>Grier (1975)</td>
</tr>
<tr>
<td>TempCon Prescribed Mass Loss</td>
<td>Woody Fuels</td>
<td>42</td>
<td>Busse et al. 2000</td>
</tr>
<tr>
<td>TempCon Prescribed CHN Auto</td>
<td>Forest Floor C</td>
<td>44-61</td>
<td>Caldwell et al. 2002</td>
</tr>
<tr>
<td>TempCon Prescribed Mass Loss</td>
<td>Woody Fuels</td>
<td>ca 40</td>
<td>Landsberg 1992</td>
</tr>
<tr>
<td>TempCon Wildland Mass Loss</td>
<td>Woody Fuels/Crn</td>
<td>76</td>
<td>Cromack et al. 2000</td>
</tr>
<tr>
<td>TempCon Wildland Mass Loss</td>
<td>Forest Floor/Crn</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>TempCon Wildland Mass Loss</td>
<td>Woody Fuels/Surf</td>
<td>92</td>
<td></td>
</tr>
<tr>
<td>TempCon Wildland Mass Loss</td>
<td>Forest Floor/Surf</td>
<td>75</td>
<td></td>
</tr>
<tr>
<td>Boreal Wildland Inverse w/ dual isotope</td>
<td>Needle/fbrch/brk</td>
<td>70-75</td>
<td>Schuur et al. 2003</td>
</tr>
<tr>
<td>Boreal Wildland Inverse w/ dual isotope</td>
<td>cbrch/cone</td>
<td>20-30</td>
<td></td>
</tr>
</tbody>
</table>
Many studies have compared and contrasted prescribed/wildland fires to unburned recovery, but few have investigated mechanisms or processes driving changes.

- Long-term (>1yr) assessments of changes in soil biogeochemistry AND forest succession following wildland fire are limited.

- Quantitative assessments of pre- and post-fire management impacts on carbon stocks and fluxes in forest ecosystems are largely unknown.
Eyerly Fire: Mixed/Moderate and Stand Replacement Fire
Pre-Fire Management

Thinning

Control Burn: Understory
Post-Fire Management: Planting and Seeding
Post-Fire Management: Tortuous Salvage

2004:
August: ROD/Emergency status declared/no bids for salvage
September: Emergency status lost

2005:
January: Salvage repackaged/no bids
August: legal injunction against salvage

2006:
March: Limited winter salvage occurred
Intensive Plot Measurements

Tree & Woody Stump Survey
- Coarse and Fine Woody Debris Transects
- Understory Survey and Herbaceous Clip
- Tree Cores for Age/Wood Density
- Litter; Standing Stocks and Seasonal Leaf Area Index (LAI)
- Soil Carbon, Nitrogen: Total, Inorganic N
- Soil Respiration Transects
- Soil Temperature, Moisture
Post-Fire Seedling Regeneration:

Average = 98/ha ± 104
Range = 0 - 350/ha

Species:
*Pinus Ponderosa*
*Calocedrus decurrens*
*Psuedotsuga menziesii*

From Hibbard et al. in prep.

Top: bole wood production (m ha\(^{-1}\)) and bottom: living trees (ha\(^{-1}\)) from Irvine et al submitted to GCB
Initial chemistry from surficial (0-10cm) soils. X indicates significant difference in treatment (P<0.05).

No significant difference between moderate versus stand replacement or young, mature stands.

Time of sample dates were 4, 10 and 16 months post fire; significance indicates difference between unburnt vs. moderate/stand replacement over all sample dates.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Inorganic N (NH₄⁺; NO₃⁻)</th>
<th>Total Carbon</th>
<th>Total Nitrogen</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Burn vs. Unburned</strong></td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td><strong>Age Structure</strong></td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td><strong>Time of Sample</strong></td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>
Live aboveground biomass (gC m⁻²)
trees, shrubs, grasses, forbs:
Severely Burnt: 470(599)
Moderate: 3942(4610)

Data from Irvine et al. submitted

<table>
<thead>
<tr>
<th>Age Class</th>
<th>Fire Intensity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mixed/Moderate</td>
</tr>
<tr>
<td>Young</td>
<td>50%</td>
</tr>
<tr>
<td>Mature</td>
<td>76%</td>
</tr>
</tbody>
</table>

Stand Age and Intensity: Loss due to combustion of bole carbon (gC m²) in burned relative to unburned plots by age class (Hibbard et al. in prep).
NPP, NEP, Hr from Irvine et al. submitted; Methods after Law et al. 2003
In the case of stand origin by wildfire, carbon uptake is achieved later and reaches a lower peak.

Biome-BGC: Disturbance and Carbon
### BIOME-BGC: Unburned Ecosystem Carbon Fluxes and LAI

<table>
<thead>
<tr>
<th>METHOD</th>
<th>NEP</th>
<th>NPP</th>
<th>LAI</th>
</tr>
</thead>
<tbody>
<tr>
<td>OBSERVED(^1)</td>
<td>-64(11)</td>
<td>235(46)</td>
<td>1.00(0.13)</td>
</tr>
<tr>
<td>BGC-AGESTATE</td>
<td>31(58)</td>
<td>537(54)</td>
<td>1.98(0.17)</td>
</tr>
</tbody>
</table>

\(^1\) Data from Law et al. 2003

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### Preliminary BIOME-BGC NEP Estimates

Time of fire after clearcut (Y)

<table>
<thead>
<tr>
<th>Combustion loss (%)</th>
<th>20</th>
<th>50</th>
<th>150</th>
<th>&gt;200</th>
</tr>
</thead>
<tbody>
<tr>
<td>50</td>
<td>-216 (17)</td>
<td>-147 (26)</td>
<td>-178 (32)</td>
<td>-165 (91)</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>4</td>
<td>7</td>
<td>&gt;10</td>
</tr>
<tr>
<td>75</td>
<td>-293 (58)</td>
<td>-367 (19)</td>
<td>-403 (23)</td>
<td>-490 (67)</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>3</td>
<td>7</td>
<td>&gt;10</td>
</tr>
</tbody>
</table>
Climate & Ecosystem Implications:

- Consider changes in
  - Temperature ALSO
  - The seasonality, magnitude, character and frequency of precipitation

- For instance:
  - Rates of shrub and seedling establishment and proliferation
  - Dynamics of snowpack and rain on snow
  - Interaction of climate and growing season
  - Human forcings: fire suppression x policy
Within the Context of Ecosystem Feedbacks

Fire suppression:

- Increase in extent, frequency of catastrophic fire
- Increase in NOx, particulate transport during catastrophic fires (bigger plumes; stronger injection).
- Altered fire regimes in western forests have and may alter vegetation structure and function.
Management and Modelling

• BBC and BGG models must account for land cover/use; potential vegetation cannot account for historic changes and recent thresholds that have been crossed.

• Balance between management for desirable habitat versus minimize catastrophic events an unenviable position of resource managers.

• Urban/peri-urban development and encroachment into bush/veld/wildlands putting new pressures on how we manage natural resources/ecosystem goods and services.
Conceptual diagram of ecosystem changes and thresholds

from Archer et al. 2001