Severity patterns and drivers of repeat fires along a fire interval gradient in the Klamath Mountains

Jeffrey Kane
Zawisza Grabinski
Rosemary Sherriff
Recent Changes in Fire Activity

- Increasing frequency and size of wildfires
- Increasing fuel availability and expansion of the fire season

Westerling 2016

Abatzoglou and Williams 2016
Need for More Fire

- Majority of fire-prone areas still in a fire deficit
- Increased recognition for the need of managed wildfire
- Need to assess and learn from the patterns and impacts of modern fires
Repeat Fires

• Areas that experience two or more fires that spatially overlap

• More repeat fires is ultimately desired

• Increased frequency may result in shorter fire return intervals than historical conditions

• Potential for altered fire severity patterns
Modern Fire Severity

- Some concerns for increased high severity fire

Miller et al. 2012
Controls of Fire Severity

Vegetation/Fuels
- composition
- structure

Topography
- Slope
- Slope Pos.
- Aspect

Weather
- Temp./RH
- H₂O Deficit
- Wind

Fire Behavior

Fire Severity

Vegetation Change Detection (RdNBR)
Controls of Reburn Severity

Vegetation/Fuels
- composition
- structure

Topography
- Slope
- Slope pos.
- Aspect

Weather
- Temp./RH
- H₂O Deficit
- Wind

Fire Behavior

Prior Fire Severity

Reburn Severity

Time Between Fires

Vegetation Change Detection (RdNBR)
Patterns of Reburn Severity

Increasing

“Self-Regulating”

Decreasing

Gila-Aldo Leopold Wilderness, New Mexico (13 fires, 3-12 yrs, 50,004 ha) – Holden et al. 2012
Gila-Aldo Leopold Wilderness, New Mexico (50,0004 ha) – Parks et al. 2014
Frank-Church River of No Return Wilderness, Idaho (91,671 ha) – Parks et al. 2014
Northern Sierra Nevada, California (4 fires, 1-11 yrs, 36,423 ha) – Coppoletta et al. 2015
Iillouette Creek Basin, Yosemite NP, California (9 fires w/ 2+, 8,000 ha) – van Wagtendonk et al. 2012
Northern Rocky Mountains (204 fires, 0-23 yrs, 138,061 ha) – Harvey et al. 2016
Patterns of Reburn Severity

- Changes in reburn severity must consider multiple drivers across different temporal and spatial scales
- Need to interpret change with vegetation type, fire regime, and desired future conditions
Objectives

• Examine temporal patterns of area burned and reburn severity in repeat fires
  – Patterns by year (1996-2012)
  – Patterns along fire interval gradient (2-25 yr)

• Determine the relative importance of factors that influence reburn severity at different scales
Repeat Fires in the Klamath Mountains in California

- 28 repeat fires between 1996 and 2012
- Wildfires only
- Total area = 79,112 ha (195,490 acres)
- Reburn Area: 397 – 11,818 ha
- Elevation: 194-2,221 m
- Time between repeat fires ranged from 2 to 25 years
- Historical Fire Return Interval - median 12-19 yr
  Taylor and Skinner 1998
Annual Reburn Patterns

- No observed annual trend with reburn area ($R^2 = 0.08$, $P = 0.14$)

- No observed annual trend with reburn severity ($R^2 = 0.001$, $P = 0.86$)
Time Between Fire Patterns

- Reburn area increased with time between fires ($R^2 = 0.24$, $P = 0.009$)

- No pattern observed with reburn severity ($R^2 = 0.028$, $P = 0.397$)
Time Between Fire Patterns

- Smaller reburn area with shorter interval repeat fires ($F = 5.9$, $P = 0.02$)

![Box plot showing comparison of fire areas between shorter and longer intervals.](image)

**Shorter Interval**
- Mean area: 1466 ha

**Longer Interval**
- Mean area: 4185 ha
Prior and Reburn Severity Trends

All 28 repeat fires combined
Fire Severity by Elevation

Proportion

Elevation Class

Low (194 - 869 m)

Moderate (870 - 1545 m)

High (1546 - 2221 m)

Prior Fire

Reburn Fire
Severity patterns with fire interval classes

Shorter Interval (2-14 y)  Longer Interval (19-25 y)

Shorter Interval 29.8% increase
Longer Interval 14.3% increase
7 of 14 Decreasing Range: -367 to +171

11 of 14 Increasing Range: -129 to +201

Shorter Interval (2-14 y)

Longer Interval (19-25 y)
Controls of Reburn Severity

All 28 repeat fires combined
## Reburn Severity Model Comparison

### Predictor Variables

<table>
<thead>
<tr>
<th>Predictor</th>
<th>All Fires</th>
<th>Short (2-14 yr)</th>
<th>Long (19-25 yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prior Severity</td>
<td>20%</td>
<td>15%</td>
<td>25%</td>
</tr>
<tr>
<td>Elevation</td>
<td>10%</td>
<td>5%</td>
<td>15%</td>
</tr>
<tr>
<td>Aspect</td>
<td>5%</td>
<td>3%</td>
<td>8%</td>
</tr>
<tr>
<td>Slope</td>
<td>3%</td>
<td>2%</td>
<td>5%</td>
</tr>
<tr>
<td>TPI</td>
<td>7%</td>
<td>6%</td>
<td>8%</td>
</tr>
<tr>
<td>Can. Cover</td>
<td>12%</td>
<td>10%</td>
<td>15%</td>
</tr>
<tr>
<td>Cover Type</td>
<td>8%</td>
<td>7%</td>
<td>10%</td>
</tr>
<tr>
<td>Diameter</td>
<td>6%</td>
<td>5%</td>
<td>8%</td>
</tr>
<tr>
<td>CWD</td>
<td>4%</td>
<td>3%</td>
<td>5%</td>
</tr>
<tr>
<td>Max Temp</td>
<td>3%</td>
<td>2%</td>
<td>4%</td>
</tr>
</tbody>
</table>

### Variance Explained

- Prior Severity: 20% (All Fires), 15% (Short), 25% (Long)
- Elevation: 10% (All Fires), 5% (Short), 15% (Long)
- Aspect: 5% (All Fires), 3% (Short), 8% (Long)
- Slope: 3% (All Fires), 2% (Short), 5% (Long)
- TPI: 7% (All Fires), 6% (Short), 8% (Long)
- Can. Cover: 12% (All Fires), 10% (Short), 15% (Long)
- Cover Type: 8% (All Fires), 7% (Short), 10% (Long)
- Diameter: 6% (All Fires), 5% (Short), 8% (Long)
- CWD: 4% (All Fires), 3% (Short), 5% (Long)
- Max Temp: 3% (All Fires), 2% (Short), 4% (Long)

### Categories

- **Topography**: Elevation, Aspect, Slope, TPI
- **Vegetation**: Can. Cover, Cover Type, Diameter, CWD
- **Climate**: Max Temp

---

**Note**: The chart above illustrates the percentage of variance explained by different predictor variables across different fire duration categories. Variance explained values are calculated for each category and are indicated separately for short-term (2-14 years) and long-term (19-25 years) fires.
Summary and Implications

- No pattern of increased reburn severity or area over time

- Shorter interval repeat fires smaller and maybe self-limiting
  - but will depend on fire weather
  - potential to inform Rx fire and managed wildfire treatments locations
Summary and Implications

Collins et al. 2009
Summary and Implications

• Prior and reburn severity positively related
  – Self-regulating?
  – Shorter interval > Longer Interval

• Modest increases in reburn severity
  – Shift to more moderate severity

• Multiple potential interpretations for modest increases in reburn severity
  – Need for increased severity? (Huffmann et al. 2017)
  – Increased shrub/open forest representation
Implications

Initial fire

High severity: overstory removed, shrub colonization, increased surface fuels

Moderate severity: overstory partially removed, increased surface fuels & shrub colonization

Low severity: overstory intact, reduced surface fuels, increased tree regeneration

High severity: shrub replacement, snags removed

Moderate severity: overstory partially removed, increased surface fuels & shrub colonization

Low severity: overstory intact, reduced surface fuels & tree density

Initial condition: fire excluded, mixed-conifer forest

Negative feedback, greater stability

Positive feedback, decreased stability, potential state change

Coppoletta et al. 2016
Summary of Findings

• Reburn severity is a complex result of multiple factors
  – Prior fire severity (longer > shorter interval)
  – Vegetation factors (longer > shorter interval)
  – Climatic factors (shorter > longer interval)
  – Topography factors lowest impact (no change with fire interval)
Summary and Implications

• Repeat fires still represents a small fraction of area burned

• Reburn severity is a complex result of multiple factors across temporal and spatial scales
  – Improves understanding and model development
  – Difficult to make concrete management suggestions
Future Research Needs

• Need for field-based observations to examine post-repeat fire vegetation and fuel changes

• Assess severity patch-sizes and heterogeneity

• Set clear and measureable desired conditions that can be used to interpret the impacts of repeat fires
USDA Forest Service, Klamath National Forest

Dan Blessing
Ramona Butz
Clint Isbell
Jay Miller

Carl Skinner
Eric Knapp
Jonathan Thompson
James Graham
Phil van Mantgem
Apologies:

This presentation did not have enough fire photos