HOW MIGHT DIFFERENT WILDFIRE RESPONSE POLICIES AFFECT THE LANDSCAPE OVER TIME?
CAN WE SAVE MONEY ON WILDFIRE SUPPRESSION BY INVESTING IN FUEL TREATMENTS AND PRESCRIBED FIRE INSTEAD?

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HOW MIGHT DIFFERENT WILDFIRE RESPONSE POLICIES AFFECT THE LANDSCAPE OVER TIME?

MODELING ALTERNATIVE FIRE RESPONSE

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THE NEED TO EXPAND THE FOOTPRINT OF MANAGED FIRE

- Increasingly recognized by land managers

- Reasons
  - Ecological benefits
    - Widely recognized since the 1972 Leopold Report
    - Evidence has continued to mount since then
  - Reduce hazard
    - On average, 18 firefighters killed annually during the past decade

Black-backed woodpecker (Picoides arcticus)
TRENDS IN AREA BURNED AND COST


Fig. 6 Areas of the United States (forest, non-forest and total) estimated to have burned annually in wildfires. Early rates of burning were based on pre-European burning rates reported in the literature; areas of forest burned after 1926 were obtained directly from USDA (1926–90). The methods for estimating the transition between pre-European and post-1926 rates are described in the text.
TRENDS IN AREA BURNED AND COST

Area burned:
Likely increasing but variable

Federal fire costs (billions US $):
Increasing and less variable
IMPACT TO FOREST SERVICE’S PUBLIC LAND MANAGEMENT MISSION

Effect on other USFS programs
- Veg management: -22%
- Facilities: -67%
- Roads: -46%
- Deferred maintenance: -95%

Figure 1: The Cost of Wildland Fire (Preparedness, Suppression, FLAME, and related programs) as a Percentage of the Forest Service’s Annual Budget
2002-2011 saw 7x increase in insured loss compared with prior decade
THE FIRE PARADOX

- **Decades of fire suppression efforts** → increased fuel loads and continuity in many forested landscapes.
- **Increasing ex-urban development** → substantially increased human values that may be negatively affected by fire.
- **Climate change** → increased fire season length.
- **Result**: increased loss and associated management cost.
- **Firefighter fatalities** do not appear to be declining, despite focused investment in safety.
CHALLENGES IN EXPANDING THE FOOTPRINT OF MANAGED FIRE

• Challenges: a system of perverse incentives
  – Managers tend to face retribution if a fire damages homes or infrastructure
  – However, they tend to be rewarded for aggressively fighting fires
  – Pay is often linked to fighting fire
  – Public opinion

“Old Faithful Lodge during firestorm”, 1988
STRIDES IN EXPANDING THE FOOTPRINT OF MANAGED FIRE

• Currently, spatial fire planning is now being integrated into:
  – landscape assessment and planning efforts
  – Land and Resource Management Plans (many National Forests are entering Forest Plan revision process)

• Current fire simulation models and risk assessment methods make this possible
THE ROLE OF FIRE MODELING AND RISK ASSESSMENT

- Fire modeling and risk assessment can help with some of the challenges
  - Identify probability that fire will affect values at risk
    - Benefit
    - Loss
  - Can be used during incidents
  - Now applying it also in a pre-fire planning context

During incidents (FSPro) → firefighting tactics
Critical gap is ability to understand and project how alternative response policies/strategies would lead to different outcomes on the landscape.

**Scenario 1:** Full suppression on all fires
- Of all fires, Everywhere, All the time

**Scenario 2:** No suppression on lightning-caused fires, full suppression on human-caused fires
- Of all fires, Everywhere, All the time

Managed fires
- Some fires, Some places, Some times

Potential for Conflict +

Degree of Uncertainty +

Fire Manager Decision Space
STUDY DESIGN

• Case study landscape: Sierra National Forest, California
  – Part of broader Southern Sierra Risk Assessment
  – Well-studied area
    • fuel treatment opportunities and backlog (North et al)
    • fuel treatment opportunities (Scott et al.)
    • spatial response planning (Thompson et al.)

STUDY DESIGN: LARGE FIRE SIMULATOR = FSIM

INPUTS
- Spatial Fuels Data (Static Condition: LandFire)
- Fire Weather: Time Series Analysis
- Large Fire Occurrence (Historical Records)

MODEL COMPONENTS
- Fire Behavior (Spread Rate, Fireline Intensity)
- Large Fire Ignition

OUTPUTS
- Burn Probabilities
- Intensity probabilities
- Fire Perimeters

FIRE SUPPRESSION IN FSIM

• Three options:
  – Fire suppression on:
    • Determines fire duration based on probability of containment. Fire growth is unrestricted until containment.
  – Fire suppression plus perimeter trimming:
    • The fire’s perimeter is successively contained, beginning with the area where fire intensity is lowest. While the suppression algorithm determines the duration, perimeter trimming restricts the spatial extent.
    • Trimming parameter can be adjusted to affect the rate of containment. (Alpha~2.4 in Western US)
  – No suppression:
    • Fires are extinguished by a period of wet or cool days (below 70th percentile ERC). Number of days is set by user; we chose 5.

ANNUAL BURN PROBABILITY IN FSIM

Year 1

Year 2

Year 1 & 2

1 out of 2 chance of burning = 50% = 0.5

2 out of 2 chance of burning = 100% = 1.0

1 out of 2 chance of burning = 50% = 0.5

0 out of 2 chance of burning = 0% = 0.0
RESULTS

SCENARIO 1

Mean bp = 0.0048 (Observed = 0.0053)

Mean bp = 0.1751

SCENARIO 2
FEEDBACKS IN AREA BURNED

- Future fire ignition and spread limited in recently burned areas (Parks et al)
- Type 1 feedbacks: a future fire that wouldn’t have ignited because it fell on a recently burned area
- Type 2 feedbacks: a future fire wouldn’t have been able to spread into a recently burned area
- Method: assume feedbacks last 5 or 10 years. Sample 6 or 11 years of fires from Fsim randomly. (5000 random draws)

References:

<table>
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<tr>
<th></th>
<th>Scenario 1</th>
<th>Scenario 2</th>
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<td>Without feedbacks</td>
<td>Min. 0</td>
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<td>Max. 100</td>
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CONCLUSIONS

• Alternative fire suppression policies have the potential to impact burn probabilities and fire sizes

• While implementing a no suppression policy on lightning fires is likely to increase burn probability by more than an order of magnitude in the short term, feedbacks would soon begin to act as a self-limitation in area burned

• Thus, there is an opportunity for managed fires to act as fuel treatments, in some locations, especially those where fire can produce benefit on the landscape
CAN WE SAVE MONEY ON WILDFIRE SUPPRESSION BY INVESTING IN FUEL TREATMENTS AND PRESCRIBED FIRE INSTEAD?

OPTIMIZING FUEL TREATMENTS BASED ON RISK REDUCTION AND BUDGET CONSTRAINTS

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² University of Montana, Missoula, Montana
WHY USE FUEL TREATMENTS?

• Restoration of stands where timber harvest and/or fire exclusion have occurred
• Reduction of intensity and/or probability of future fires
• Safer areas for firefighters to work to control fires
• Etc.

• Can they be used:
  – To reduce risk to highly valued resources?
  – To produce savings in preparedness and suppression costs?
MECHANICAL FUEL TREATMENTS

Treatment = meant to simulate a combination of mechanical and Rx fire to reduce flame length and crown fire potential (after Scott et al 2016)

- Canopy base height: raised to 1.5 times the current level, with a minimum of 2m
- Canopy cover: only where greater than 35%, mild reductions of 5-20% proportional to cover
- Canopy bulk density: reduced by 0.75
- Fuel model: changed to reduce intensity and/or rate of spread (grass not treated as it can quickly regrow)

FUEL TREATMENT SCENARIOS

• treat all feasible pixels
• choose places to treat based on risk to highly valued resources at four different budget levels
  – $10 million
  – $20 million
  – $30 million
  – $40 million
• wildfire as a fuel treatment
HIGHLY VALUED RESOURCES OF THE SIERRA N.F.

- Human habitation
- Inholdings (private timber companies and state land)
- Major infrastructure (e.g. transmission lines)
- Recreation-administration infrastructure
- Scenic byways
- Habitat (sage grouse, owl, fisher, goshawk)
- Timber
- Watershed
- Vegetation condition (is there enough or too little of a certain type of vegetation?)
WHERE FIRE IS A BENEFIT, OR LOSS

• Conditional Net Value Change = the change in Highly Valued Resources expected if the pixel burns

\[ cNVC = \sum_{i}^{n} FLP_i \times RF_i \]

Description:
Strong benefit at low fire intensity decreasing to a strong loss at very high fire intensity.
• Potential Operational Delineations (PODs) are areas within which a fire might be expected to be contained

• We calculated the mean Net Value Change for each POD

• Treatments were optimized based on two factors:
  • Where resources were most negatively affected by fire (eNVC)
  • Timber volume from thinning
CALCULATING TREATMENT COSTS

- We matched forest inventory plots to each pixel of raster landscape data using random forests. This provided the number, size, and species of trees at each pixel.

- Applied a thin-from-below in the Forest Vegetation Simulator (FVS) to determine which trees would be cut.

- Treatment costs determined by the Fuel Reduction Cost Simulator (FRCS)

Spatial Stratified Cost Index (Hand et al. 2016)
Regression equations built on 406 fires that occurred on USFS land between 2006-2011 that were larger than 300 acres

Predictors:
- final fire size
- Aspect
- Elevation
- Proportion of fire in different slope categories
- Proportion of fire in different fuels categories (grass, brush, timber, and slash),
- Proportion of fire in different land management categories (Wilderness, roadless, other specially designated)
- Proportion of fire in different land ownership categories (USFS, DOI)
- Housing value within 5, 10, and 20 miles
- Energy Release Component maximum and standard deviation (related to fuel dryness)
- USFS geographic region

BURN PROBABILITY RESULTS

Mean = 0.0048
Median fire size = 992 acres

Mean = 0.0036
Median fire size = 880 acres

Reduction of:
• 25% in burn probability
• 11% in median fire size
Fuel treatments can reduce risk from wildfire to highly valued resources.
## FUEL TREATMENTS CAN REDUCE THE SIZE OF FUTURE WILDFIRE AND PRODUCE SUPPRESSION COST SAVINGS

<table>
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<th>Investment at $20 million in fuel treatments</th>
<th>Roughly equivalent to projected suppression cost savings</th>
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<tbody>
<tr>
<td>Mean large fire size (ac)</td>
<td>Mean number of large fires/year</td>
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<tr>
<td>Baseline</td>
<td>2619</td>
</tr>
<tr>
<td>$10 million in fuel treatments</td>
<td>2543</td>
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<tr>
<td>$20 million in fuel treatments</td>
<td>2455</td>
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<td>$30 million in fuel treatments</td>
<td>2389</td>
</tr>
<tr>
<td>$40 million in fuel treatments</td>
<td>2338</td>
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<tr>
<td>Treatment with 5 years of wildfire at average number of acres burned</td>
<td>2529</td>
</tr>
</tbody>
</table>
• The bulk of substantial investment in fuel treatments can likely be largely if not entirely offset by savings in suppression (shown below) and preparedness costs (not modeled in this analysis)
CONCLUSIONS

• The new methodology presented here allows treatment locations to be optimized based on their potential to reduce risk to highly valued resources, making efficient use of limited funding.
• Strategically located treatments can reduce the probability that highly valued resources will burn, and the likely fire intensity.
• There is potential for treatments to “pay for themselves” by reducing preparedness and suppression costs.
• Managed fires likely have potential to “treat” more acres, but the locations of managed fires are based on lightning ignitions and thus are uncertain.
Prescribed Fire, Banff Park

QUESTIONS?
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