RESILIENCE OF RESTORED COASTAL SAGE SCRUB AND GRASSLAND SYSTEMS FOLLOWING WILDFIRE

Priscilla Ta, Michelle dela Cruz, Jessica Rath, Rubeen Khunkun, BryAnna Wertz, Robert Freese, Nathan Gregory, Sarah Kimball
We aimed to investigate the post-fire resilience of restored coastal sage scrub and grassland communities at Bee Flat Canyon.
BEE FLAT CANYON
Site preparation
• Thatch removal followed by grow/kill cycles

Seeding – CSS
• Drill-seed diverse plant palette in forb/shrub strips

Maintenance
• Intensive weed control with supplemental seeding when necessary

Total 84 acres native habitat restored
• 27 acres coastal sage scrub
RECOVERY TACTICS

Crown Sprouting

Seedling Recruitment

CSS fire ecology graphic credit: Meghmik Vosghanian
1. **SHRUB RECOVERY**: How does the abundance of crown-sprouts and recruits compare across restoration treatment?

2. **HERBACEOUS RECRUITMENT**: How does herbaceous cover compare across restoration treatments?
POST-FIRE RESILIENCE
COASTAL SAGE SCRUB

Legend:
- Degraded
- Restored
- Intact

Degraded
Restored
Intact
1. EVALUATING POST-FIRE SHRUB RECOVERY

Fall 2021

1 x 5 m quadrat

Count and compare shrub crown sprout and recruit abundance across 3 restoration treatments:
2. EVALUATING POST-FIRE HERBACEOUS RECRUITMENT

Spring 2021 and 2022

1 x 1 m gridded quadrat; point-intercept method

Compare native and non-native herbaceous cover across 3 restoration treatments:
SHRUB RECOVERY
FORB RECRUITMENT

Native Forbs

Non-Native Forbs

Average % Cover of Native Forbs/Plot

Degraded       Restored       Intact

Treatment

Average % Cover of Non-native Forbs/Plot

Degraded       Restored       Intact

Treatment
GRASS RECRUITMENT

**Native Grasses**

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Average % Cover of Native Grasses/Plot</th>
</tr>
</thead>
<tbody>
<tr>
<td>Degraded</td>
<td>A</td>
</tr>
<tr>
<td>Restored</td>
<td>A</td>
</tr>
<tr>
<td>Intact</td>
<td>B</td>
</tr>
</tbody>
</table>

**Non-native Grasses**

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Average % Cover of Non-native Grasses/Plot</th>
</tr>
</thead>
<tbody>
<tr>
<td>Degraded</td>
<td>A</td>
</tr>
<tr>
<td>Restored</td>
<td>B</td>
</tr>
<tr>
<td>Intact</td>
<td>C</td>
</tr>
</tbody>
</table>
POST-FIRE RESILIENCE – COASTAL SAGE SCRUB

SHRUB RECOVERY

• Restored areas contained more crown sprouts
• Intact areas contained more recruits that germinated from seed

HERBACEOUS RECRUITMENT

• Restored and intact areas contained similarly high native forb cover
• Intact areas containing the highest native grass cover
BEE FLAT CANYON

2010 – 2020

Site preparation
• Thatch removal followed by grow/kill cycles

Seeding – GL
• Drill-seed diverse plant palette

Maintenance
• Intensive weed control with supplemental seeding when necessary

Total 84 acres native habitat restored
• 35 acres grassland
GRASSLAND
HOW DOES PLANT COVER OF RESTORED GRASSLANDS CHANGE OVER TIME DUE TO FIRE, TEMPERATURE, AND RAIN?

Spring 2015 – 2022

50m point-intercept transects

Assess restored grasslands for changes in plant cover over time in relation to fire, temperature, and precipitation
GRASSLAND VEGETATION COVER
GRASSLAND CONCLUSIONS

• Native forbs are more resilient to fire compared to native grasses

• *Stipa pulchra* cover failed to increase after fire

• Fire and non-native competition drive changes in grassland vegetation cover
KEY FINDINGS

• Restored coastal sage scrub communities at Bee Flat Canyon are resilient to fire

• Restored native grasslands at Bee Flat Canyon are not resilient to fire
SPECIES COMPOSITION
SPECIES COMPOSITION

Melica imperfecta

Lupinus bicolor

Status
- Degraded
- Restored
- Intact

Year
- 2021
- 2022

Axis 1

Axis 2
CNPS
2022 CONFERENCE
ROOTING TOGETHER
Two Decades of Prescribed Fire within the Grasslands at the Santa Rosa Plateau Ecological Reserve

Hailey Laskey
Preserve Manager
Center for Natural Lands Management

Zach Principe
Project Manager
The Nature Conservancy
Grassland Vegetation Management Units

- Murrieta, CA
- ~10,000 acres
- 3,534 acres of grassland
- Vegetation Management Plan with CALFIRE
- 14 management units
- 2 control units
- 83 transects
Characteristic Grassland Species

Stipa pulchra bunches and Calochortus splendens

Avena species, Bromus diandrus, and Hirshfeldia incana

Sisyrinchium bellum
Clarkia purpurea
Dichelostemma capitatum

Lasthenia californica
Escholtzia californica
Fritillaria biflora

Aegilops cylindrica
Erodium species
Role of Prescribed Fire

- Reduce thatch and cover of non-native grasses
- Manage non-native forbs
- Promote growth of native species
- 30 years of fire
- 21 years of data
SRPER Vegetation Cover 2001-2022

NF, NNF, NG, NNG cover significantly changed over time.
SRPER Vegetation Cover 2001-2022

NF, NNF, NG, NNG cover significantly changed over time

NF, NNF, NNG, and Total cover significantly changed with precipitation
Vegetation Management Units Sampling
Santa Rosa Plateau Ecological Reserve, Murrieta, CA
Control Units

- **NNF, NG, NNG, and Total** cover significantly changed over time.
- **NNF, NNG, and Total** cover significantly changed with precipitation.
- **NNG** increased, **NG** decreased.
Clay Hill Vegetation Cover

2001-2019

- Prescribed Fire in 2013
- NG, NF, NNF, and NNG cover significantly changed over time
- NF, NNG, & Total cover significantly changed with precipitation
Functional Group Cover after Prescribed Fire

- **Means of Native Forb Cover After Fire**
- **Means of Non-native Forb Cover After Fire**
- **Means of Native Grass Cover After Fire**
- **Means of Non-native Grass Cover After Fire**

- **NNG** was only significantly different than pre-fire cover one year, and six years after fire.
- \( F(6, 41) = 13.49, \ p < 0.001 \)
Functional Group Cover after Prescribed Fire and Wildfire

- **NG** cover significantly changed over time
- **NNG** cover significantly changed with precipitation
- **Prescribed Fire** in 2016
- **Tenaja Fire** 2019

![Graph showing research area vegetation cover from 2016 to 2022](chart)
Native grass cover decreased continually after prescribed fire and is variable 3 years after wildfire.

NNG, NF, NNF cover increased after prescribed fire and wildfire.
Role of Drought in Managing NNG

- **Native grass** cover higher than before prescribed fire in 2017
- Drought 2018, 2021, 2022
Summary

• No noticeable increase in native grass cover over the last 20 years, only decrease, with and without management action
• Native grass cover is not significantly related to precipitation
• Fire reduces native grass cover one year after fire, but recovers within ~6 years
• Increase in non-native grass cover over time and with precipitation
• Native forb cover steady over time, with a low seed bank
Future Research

• Investigate *Stipa pulchra* bunch size and density
• Sample size concerns, more transects?
• More detailed plot-based studies
• Vapor pressure deficit (aridity)
• Fire intensity with Rx vs wildfire
• Fire return interval tricky with prescribed fire
• Considered grazing, logistics difficult
• Low native seed bank and low native recruitment
Thank you!

Contact for additional questions:
Hailey Laskey
hlaskey@cnlm.org
CNPS
2022 CONFERENCE
ROOTING TOGETHER
Reestablishment of Natural Fire Regimes Facilitates Ecological Restoration of California’s red fir forests

Marc Meyer\textsuperscript{1}, Kyle Merriam\textsuperscript{1}, Michelle Coppoletta\textsuperscript{1}, Becky Estes\textsuperscript{1}, Ramona Butz\textsuperscript{1}, Anthony Caprio\textsuperscript{2}, Calvin Farris\textsuperscript{3}, and Malcolm North\textsuperscript{4}

\textsuperscript{1}USDA Forest Service, Region 5 Ecology Program, \textsuperscript{2}Sequoia and Kings Canyon National Parks, \textsuperscript{3}National Park Service, \textsuperscript{4}USDA Forest Service, Pacific Southwest Research Station
Background

- Red fir (*Abies magnifica*) forests are unique
  - Dominant across upper montane zone
  - High forest biomass
  - Associated with high snowpack
  - Remoteness provides opportunities to manage wildfires
Background

• Declining health trends in CA
  – Higher mortality rates & crown loss
    • Dwarf mistletoe
    • Cytospora canker
    • Fir engraver
  – Ongoing since 2011
Potential Drivers

• Increased moisture stress
  – Warming trends & drought
  – Fire exclusion
  – Higher tree densities (i.e., competition)

• Use of wildland fire may restore the structure and health of red fir forests
Benefits of Fire Reintroduction

• Structure — Reduced tree densities and cover
• Diversity — Increased understory diversity
• Health — Moisture stress, insects, pathogens
Objectives

- Compare red fir stands in fire-excluded and active fire regime landscapes
  - Structure, Diversity, and Health
  - Evaluate potential to use wildland fire as a management tool
Approach

• Contemporary reference landscapes

• Criteria
  – Burned in two overlapping fires*
    • Most recent fire since 1984
    • Little to no fire return interval departure
Approach

• Contemporary reference landscapes
• Criteria
  – Dominated by red fir
  – Never logged
Forest Inventory

• 80 plots established (0.05 ha) in Sierra Nevada
  – Across 32 overlapping wildfires

• 32 plots in the Cascade-Klamath
  – Across 7 overlapping wildfires
Sierra Nevada
80 plots

Cascade-Klamath
32 plots
Data

- **Structure:** Tree density by size class, mean diameter
- **Diversity:** Shrubs, tree regeneration, herbaceous plants*

*Herb diversity sampled in a subset of 3 fire pairs and 3 fire severity classes in Yosemite NP (27 plots total)
Data

- **Structure**: Tree density by size class, mean diameter
- **Diversity**: Shrubs, tree regeneration, herbaceous plants*
- **Red Fir Health**
  - Crown Loss Rating (CLR)
    - Based on Hawksworth Dwarf Mistletoe Rating: 0-6
    - Indicator of tree moisture stress & DM abundance
Data Analysis

• Comparison of stand variables between unburned and twice burned plots
  – Additional comparison with Natural Range of Variation (NRV)
    • Based on independent data sources (e.g., historical inventories; VTM)
Data Analysis

• Comparison of stand variables between unburned and twice burned plots
  – Additional comparison with Natural Range of Variation (NRV)
    • Based on independent data sources (e.g., historical inventories; VTM)
  – Evaluation of causal factors: GLMM & AIC
    • Fire, topography, site productivity (basal area)
Results
Tree Density (no./ha)

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Tree Density</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Burn</td>
<td>1600</td>
</tr>
<tr>
<td>Burn</td>
<td>200</td>
</tr>
<tr>
<td>NRV</td>
<td>200</td>
</tr>
</tbody>
</table>

$P < 0.001$
Mean DBH (cm)

- Unburn
- Burn
- NRV

$P < 0.001$
Based on 1 m inter-tree spacing, the percentage of trees in clusters showed a significant difference between the Unburn, Burn, and NRV treatments. The Unburn treatment had a significantly higher percentage of trees in clusters compared to the Burn and NRV treatments, with a p-value of 0.001.
Species Richness

Shrubs

Tree Regeneration

$P < 0.001$

$P = 0.013$
$P = 0.014$

$P = 0.146$
## Model Selection Results from Generalized Linear Mixed Model (Crown Loss Rating)

<table>
<thead>
<tr>
<th>Model</th>
<th>$K$</th>
<th>$\log (L)$</th>
<th>$\text{AIC}_c$</th>
<th>$\Delta \text{AIC}_c$</th>
<th>$w_i$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elevation + LMU</td>
<td>4</td>
<td>-89.04</td>
<td>221.69</td>
<td>0.00</td>
<td>0.424</td>
</tr>
<tr>
<td>Constant (base)</td>
<td>2</td>
<td>-91.73</td>
<td>223.03</td>
<td>1.34</td>
<td>0.217</td>
</tr>
<tr>
<td>Elevation + LMU + Burn</td>
<td>5</td>
<td>-88.90</td>
<td>223.62</td>
<td>1.92</td>
<td>0.162</td>
</tr>
<tr>
<td>Burn</td>
<td>3</td>
<td>-91.53</td>
<td>224.90</td>
<td>3.20</td>
<td>0.086</td>
</tr>
<tr>
<td>Live basal area</td>
<td>3</td>
<td>-91.73</td>
<td>225.03</td>
<td>3.33</td>
<td>0.080</td>
</tr>
<tr>
<td>Burn + Live basal area</td>
<td>4</td>
<td>-91.53</td>
<td>226.90</td>
<td>5.20</td>
<td>0.031</td>
</tr>
</tbody>
</table>
77% difference
77% difference*

*Significantly greater % difference in total tree density between SN and CK
Patterns:
(1) Greater overall differences in Sierra Nevada than Cascade-Klamath
(2) Tree densities lower in burned vs. VTM (except largest size class)

*VTM – historical Vegetation Type Mapping inventories conducted in the 1920’s and 1930’s (Wieslander)
# Potential Explanatory Factors of Ecoregional Difference

<table>
<thead>
<tr>
<th>Variable</th>
<th>Sierra Nevada</th>
<th>Cascade-Klamath</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fire Return Interval Departure (% FRID)</td>
<td>69 (high departure)</td>
<td>61 (moderate departure)</td>
</tr>
<tr>
<td>Snowpack (mm/yr)</td>
<td>437&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1023&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>AET (mm/yr)</td>
<td>285&lt;sup&gt;a&lt;/sup&gt;</td>
<td>366&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>CWD (mm/yr)</td>
<td>521&lt;sup&gt;a&lt;/sup&gt;</td>
<td>341&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Slope (%)</td>
<td>17&lt;sup&gt;a&lt;/sup&gt;</td>
<td>31&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
</tbody>
</table>
Conclusions

• Lower tree densities, greater mean tree diameter, and fewer tree clusters in burned than unburned RF stands
• Greater heterogeneity in burned RF stands
Conclusions

• Greater understory plant diversity
  – herbs, shrubs, tree regeneration

• Red fir crown loss rating positively related to increased topographic moisture stress
Conclusions

- Greater fire effects in the Sierra Nevada than the Cascade-Klamath
  - Shown by burn/unburn and burn/historical comparisons
  - Likely a consequence of greater FRID in SN
  - Warmer and drier conditions
    - Increase the availability of fuel to burn
    - Susceptibility of trees to fire-related mortality
Management Implications

• Fire has little affect on red fir health
  – Especially in areas of greater projected climate exposure
• Fire can restore RF forest structure and diversity
Management Implications

• Fire use builds adaptive capacity in RF forests
  – Increases regeneration diversity
  – Enhances structural complexity
  – Retains key habitat structures
Management Implications

• Combination of local fire return interval departure data and historical stand data most informative
  – More robust understanding of reference (i.e., target) conditions

• Contemporary reference landscapes are ideal for establishing target stand conditions
For More Information:

Structure, diversity and health of Sierra Nevada red fir forests with reestablished fire regimes

Marc D. Meyer(1), Ken Beier (2), Agronina Wurzbach(1), Reynold Balch(3), Aleksandra Stucky(1), Douglas F. Smith(1) and Anthony C. Capo(1)

(1) USDA Forest Service, Pacific Southwest Region, 351 Panoche Lane, Fresno, CA 93714, USA.
(2) USDA Forest Service, Pacific Southwest Region, 550 Road Road, Roseville, CA 95747, USA.
(3) USDA Forest Service, Pacific Northwest Region, 7705 Road 275, North Porto, WA 98903, USA.

Abstract: The reestablishment of natural fire regimes may benefit forest ecosystems by restoring their functional attributes. The structure and diversity of the forest landscape is controlled by the fire regime, the rate and severity of fires, and the time since the last fire. The structure and diversity of the forest landscape is controlled by the fire regime, the rate and severity of fires, and the time since the last fire. Forested landscapes are comprised of a mosaic of fire-resilient and fire-sensitive trees, with fire-resistant species typically occurring on disturbed sites and fire-sensitive species occurring on undisturbed sites.

Keywords: fire, forest health, fire regime, diversity, red fir

Reestablishing natural fire regimes to restore forest structure in California’s red fir forests: the importance of regional context

Kyle E. Merritt(1, 2), Marc D. Meyer(2), Michelle Coppoletta(3), Rainon Burt(4), Becky L. Bones(5), Cudine A. Pizzuto(4), Malcolm P. North

(1) USDA Forest Service, Pacific Southwest Region, 351 Panoche Lane, Fresno, CA 93714, USA.
(2) USDA Forest Service, Pacific Southwest Region, 550 Road Road, Roseville, CA 95747, USA.
(3) USDA Forest Service, Pacific Southwest Region, 7705 Road 275, North Porto, WA 98903, USA.
(4) USDA Forest Service, Pacific Southwest Region, 7705 Road 275, North Porto, WA 98903, USA.
(5) USDA Forest Service, Pacific Southwest Region, 7705 Road 275, North Porto, WA 98903, USA.

Abstract: The reestablishment of natural fire regimes may benefit forest ecosystems by restoring their functional attributes. The structure and diversity of the forest landscape is controlled by the fire regime, the rate and severity of fires, and the time since the last fire. Forested landscapes are comprised of a mosaic of fire-resilient and fire-sensitive trees, with fire-resistant species typically occurring on disturbed sites and fire-sensitive species occurring on undisturbed sites.

Keywords: fire, forest health, fire regime, diversity, red fir
Acknowledgements

• USFS Pacific Southwest Region
• Yosemite Field Station
Searching for Good Fire:

Does managed wildfire support both fuels reduction goals and native plant diversity?

Raphaela E. Floreani Buzbee
PhD Candidate, Ackerly Lab
Environmental Science, Policy and Management
University of California, Berkeley

Zachary Steel
Research Biological Scientist
Wildlife and Terrestrial Ecosystems
USDA Forest Service Rocky Mountain Research Station
Acknowledgements

Advisors
David Ackerly
Scott Stephens
Brandon Collins

Stephens Lab
Danny Foster
Andrew Johnson
Nat MacMillan
Marianne Cowherd

Ackerly Lab
Kyle Rosenblad

2021 and 2022 Field Crews
Nat MacMillan
Katie Low
Jasen Rodriguez
Natalie Coy
Gracie Williams
Michael Hahn
Aiden Grundy-Reiner

And many more!
Land Acknowledgement

• Bishop Paiute Tribe
• Bridgeport Indian Colony
• Mono Lake Kutzadika’a Tribe
• North Fork Rancheria of Mono Indians of California
• Picayune Rancheria of Chukchansi Indians
• Southern Sierra Miwuk Nation
• Tuolumne Band of Me-Wuk Indians

The Southern Sierra Miwuk Nation and the Mono Lake Kutzadika’a Tribe are currently seeking federal acknowledgement to achieve recognition by the U.S. Government

• You can submit a letter of support of the Southern Sierra Miwuk Nation to the Department of the Interior by November 11
Outline

• Managed wildfire and pyrodiversity
• Project overview
• Study sites and field methods
• Preliminary results
• Next steps
Managed Wildfire

- Naturally ignited lightning fires are allowed to burn in order to accomplish resource management objectives
- Primarily used in unpopulated wilderness areas and under safe burning conditions
- Many ecological implications of managed wildfire are understudied such as forest carbon dynamics and biodiversity
Pyrodiversity

• Overlapping fire histories
• Spatial and temporal variability in fires over a landscape (intervals between fires, seasonality, extent, fire severity, etc.)
• Results in heterogeneous landscapes
• Hypothesized (and sometimes demonstrated) positive relationship between pyrodiversity and biodiversity
Pyrodiversity & Biodiversity

• Evidence that pyrodiversity promotes biodiversity in California forest ecosystems but more research is needed

• Zack’s research uses a more standardized approach and looks at biodiversity across taxa: plants, birds, bats
Research Questions

1. Do areas with managed wildfire have higher native plant diversity?

2. Is there a relationship between understory plant species richness and total fuel loads?

3. What factors or conditions influence plant species richness?
Study Site: Badger Pass

- Badger Pass Ski Area, Yosemite National Park
- Elevation: 2000 – 2300 m
- Reference site; No recorded fires in recent history
- Red fir, montane chaparral, lodgepole pine, moist mixed conifer, Jeffrey pine
Study Site: North-fork San Joaquin River Basin

• Ansel Adams Wilderness, Sierra National Forest
• Elevation 1500 – 4000 m
• Full fire suppression policy until recently
• Some small recent fires plus majority burned in 2018 Lion’s fire
• Red fir, montane chaparral, lodgepole pine, moist mixed conifer
Study Site: Illilouette Creek Basin

- Yosemite Wilderness, Yosemite National Park
- Illilouette is a garbled representation of Southern Sierra Miwok \textit{títílwiyak}, literally “something shiny”
- Elevation: 1300 – 3600 m
- Managed wildfire policy since 1972, near natural fire regime
- Research area
- Moist mixed conifer, dry mixed conifer, montane chaparral, lodgepole pine, Jeffrey pine, red fir
Study Site: Illilouette Creek Basin

Field Methods

All plots (n = 143):
• Tree data
  • DBH, canopy closure, tree regeneration
• Fuels data (Brown’s transects)
  • Brown’s transects: fine woody debris by size 3 size classes (< 7.6 cm diameter) and large woody debris (> 7.6 cm)
  • Litter, duff, surface fuel depths

A subset of plots (n = 81):
• Botanical data
  • Species composition: richness and abundance

Each plot is ~ 500 m²
Study Sites

Yosemite Valley

Badger Pass

Illilouette Creek Basin

North-fork San Joaquin River Basin
# Field Summary

<table>
<thead>
<tr>
<th>Site</th>
<th>All Surveys</th>
<th>Botany subset</th>
<th>Species count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Badger Pass</td>
<td>15</td>
<td>9</td>
<td>~ 70</td>
</tr>
<tr>
<td>North-fork San Joaquin River Basin</td>
<td>66</td>
<td>42</td>
<td>&gt; 250</td>
</tr>
<tr>
<td>Illilouette Creek Basin</td>
<td>62</td>
<td>30</td>
<td>&gt; 200</td>
</tr>
<tr>
<td><strong>Totals</strong></td>
<td><strong>143</strong></td>
<td><strong>81</strong></td>
<td><strong>&gt; 500</strong></td>
</tr>
</tbody>
</table>
1. Do areas with managed wildfire have higher native plant diversity?

Figure 1. Species richness by site

Figure 2. Species richness by fire history

# species: ~71 >250 >200
P values: 0.0014182 0.0003568
2. Is there a relationship between understory plant species richness and total fuel loads?

Total fuel load = Ground fuels (duff) + Surface fuels (litter fuel + woody fuel).

P-value = 0.0005392
3. What factors or conditions influence plant species richness?

Candidate predictors:
- Slope
- Aspect
- Number of fires
- Years since last fire
- Elevation
- Fire return interval
- Fire severity
- Area burned in most recent fire
- Litter depth
- Duff depth
- Surface fuels
- Fine fuels
- Large woody debris
- log(Total fuel load)
- % Canopy cover

Selected predictors:
- Duff depth
- Number of fires
- % Canopy cover
- log(Total fuel load)
- Years since last fire

AIC model selection
3. **What factors or conditions influence plant species richness?**

<table>
<thead>
<tr>
<th>Coefficient</th>
<th>Estimate</th>
<th>P-values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duff depth</td>
<td>3.9349</td>
<td>0.01930</td>
</tr>
<tr>
<td>Number of fires</td>
<td>-2.8346</td>
<td>0.00629</td>
</tr>
<tr>
<td>% Canopy cover</td>
<td>-3.1814</td>
<td>0.06527</td>
</tr>
<tr>
<td>log(Total fuel load)</td>
<td>-4.6314</td>
<td>0.00157</td>
</tr>
<tr>
<td>Years since last fire</td>
<td>-5.4993</td>
<td>0.00000157</td>
</tr>
</tbody>
</table>

![Figure 5. Standardized effects and 95% confidence intervals](image_url)
Key Take-Aways

• Areas with different implementation of managed wildfire have greater variability of native plant diversity compared with unburned sites, but not always higher species richness
• Understory plant species and total fuel loads have an inverse relationship
• Plant species richness is likely influenced by duff depth, the number of fires, canopy cover, total fuel load, and years since last fire
• Preliminary evidence that managed wildfire could support both fuels reduction goals and native plant diversity
Next Steps

• Use AIC to test different hypotheses

• Analyze plant community composition across plots and sites to calculate diversity metrics

• Use remote sensing products to see how different areas are responding to fire over time
Support from:

CAL FIRE
SINCE 1885

The University of California, Berkeley

Berkeley Forests
Thank you!

Raphaela E. Floreani Buzbee
PhD Candidate, Ackerly Lab
Environmental Science, Policy and Management
University of California, Berkeley
refb@berkeley.edu

Zachary Steel
Research Biological Scientist
Wildlife and Terrestrial Ecosystems
USFS Rocky Mountain Research Station
zlsteel@berkeley.edu
FIRE REGIME ALTERATION IN NATURAL AREAS

The need to restore a key ecological process

Michelle Coppoletta, Ecologist, Sierra Cascade Province, USDA Forest Service
RESEARCH NATURAL AREAS (RNAs) IN CALIFORNIA

Part of a national network of permanently protected areas on public lands set aside for:

1. Research and monitoring
2. Education
3. Biological diversity
4. Reference areas
• 64 Established RNAs (Forest Service Lands)
  • 36 recommended or proposed

• 74 acres to > 7,400 acres

• Wide geographic and elevational range

• Best representation of
  • Dominant vegetation types
  • Unique species assemblages
  • Rare species

< 0.5% of Forest Service lands
GUIDING PRINCIPLE IN RNA
MANAGEMENT:
ALLOW NATURAL PHYSICAL AND
BIOLOGICAL PROCESSES TO
PREVAIL WITHOUT HUMAN
INTERVENTION
(FOREST SERVICE MANUAL)
THE DILEMMA

- Ecosystems are dynamic!
- Disturbances (like fire) are an essential process in many California plant communities

RNAs are embedded within:
- larger managed landscapes
- Near urban areas

YET...

Restricts our ability to allow disturbance processes to proceed unencumbered
Are California RNAs departed from their natural fire regime?

- **Fire frequency**
  - Are RNAs burning more or less frequently than they would have historically?

- **Fire severity**
  - When RNAs burn, are fire severity patterns similar to what we would expect under the pre-settlement fire regime?
How often are RNAs burning?

- 24 RNAs (37%) have had no fire recorded since at least 1908
- 21 RNAs (32%) burned in the last decade; 17 in the last 4 years (26%)
- 15 RNAs have burned at least twice since 1984; two have burned four times

~ 2/3 of RNAs have burned in the last 100 years
Are California’s RNAs departed in terms of fire frequency?

68% of the area within RNAs is considered moderately to highly departed. For moderately and highly departed:

- 91% are burning less frequently
- 9% are burning more frequently
PATTERNS OF DEPARTURE

Yellow pine and mixed conifer forest (35% of RNAs)

FAR FEWER FIRES
1970-2021
Time between fires 2-4 times LONGER than historically

Oak woodlands (3% of RNAs)

MORE FREQUENT FIRES
1970-2021
Fires burning 2-4 times as often as they were historically

Chaparral and serotinous conifers (13%)

Coastal sage scrub (<1%)
Are fire severity patterns similar to pre-settlement estimates?

Examined: 66 Fires, 42 RNAs

Focus: plant communities historically characterized by frequent, low-moderate severity fire

Areas that were MORE departed had greater proportions (23%) of the landscape burn at high severity

Areas that were LESS departed had lower proportions (6-11%) of the landscape burn at high severity

Historically: % high severity fire in yellow pine-mixed conifer forests rarely exceeded 10% (range 3-15%)

Safford and Stevens (2019)
ALTERATIONS TO THE NATURAL FIRE REGIME HAVE RESULTED IN:

- **Fewer fires** in vegetation types that historically experienced frequent, low severity fire.
- When fires re-enter highly departed systems after a long fire-free period, there is increased risk that they will **burn at high severity**.

**More frequent fires** in vegetation types that once burned infrequently with high severity fire effects.

Significant impacts to RNA target elements.
INDIANA SUMMIT RNA
Inyo National Forest

- 1,162 acres
- Elevation: 7800-8500 ft
- Oldest RNA (1932)
- Never logged

Target Element: Jeffrey pine
- frequent, low-severity fire
- Mean FRI: 11 years (range 5-40)
Small lightning-ignited fire - 40 acres (1986)

Prescribed fire - 74 acres (1994)

The remainder hadn’t had fire for 100+ years
2016 Clark Fire

- Burned entire RNA
- 35% high severity (75%-100% loss of canopy cover)
- One large (284 acre) high severity patch covered 25% of the RNA

2021 Dexter Fire

- Reburned a small portion of the RNA (57 acres)
- Area had previously burned at low-moderate severity
- 93% burned at low-moderate severity in Dexter Fire
PRESCRIBED BURNING BEFORE A WILDFIRE

• 50% loss of large trees
• More severe fire behavior

Post-fire tree density: 140 trees/hectare
• historic stand inventory: 144 trees/hectare
• High survival of large trees
• Moderated fire behavior

Take home:
Prescribed burning and/or managed wildfire within an RNA can moderate future wildfire behavior and effects
BLACK BUTTE RNA
Los Padres National Forest

- 540 acres
- Santa Lucia Wilderness
  - Less than 2 miles from Hwy 101
- Target Elements:
  - knobcone pine (serotinous)
  - chaparral
- Fire regime group IV
  - Infrequent, high-severity fire
  - Mean FRI: 55 years (Range 30-90)
BLACK BUTTE RNA
Fire history
WHEN FIRE EXCLUSION MAY BE NECESSARY

Increased risk of localized extinction of obligate seeding shrubs and serotinous knobcone pine

75% of the RNA is burning 2 - 3 times more frequently than expected

Take home: Fire suppression will be necessary to reduce the threat of frequent fires and maintain the target elements in the RNA.

After the 1984/1994 fires, 20% of the landscape lacked knobcone pine regeneration (Keeley et al. 1999)
So, how do we restore the fire regime within these natural areas?
ENCOURAGE RESEARCH AND MONITORING
DEVELOP WILDFIRE MANAGEMENT STRATEGIES.... BEFORE THEY BURN

Where feasible, and where conditions are suitable, allow wildfires to burn

In areas threatened by too much fire, consider fire suppression, using minimum impact suppression tactics
Consider proactive restoration to increase resilience to future disturbance.
Natural areas like RNAs offer some of our best approximations of minimally disturbed ecosystems on public lands.

However, alteration of the natural fire regime has the potential to put many of these areas at risk of degradation or loss.

Monitoring and in some cases, proactive stewardship, may be necessary to ensure that disturbance processes like fire can proceed in an ecologically beneficial manner.