Fire Hazard Reduction and Resource Protection on Chaparral Landscapes

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Photo: Chris Doolittle
Surface-fire regime

- lightning ignited
- low intensity surface fires
- fire suppression = fire exclusion
- a century of fuel accumulation
- restoration of historical fire regimes
- frequent fire regimes are compatible with plant and animal life histories

Fire Hazard Reduction is Compatible with Resource Protection

Crown-fire regime

- anthropogenic
- high intensity crown fires
- limited fire exclusion
- chaparral is threatened by short fire return intervals

Fire Hazard Reduction is sometimes Incompatible with Resource Protection
Fire history in the region

Impact of Fires & Fire Management on Resources

Effectiveness of fuel treatments (Rx & Mechanical)

Future fire regimes and appropriate management
Adenostoma fasciculatum (chamise)
Fire history

(Keeley et al 2009)
Figure 2. (a) Generalized daily spread of the Arroyo Seco (1896), Mt. Lowe (1898), and Santa Anita Canyon (1900) fires.

(Minnich 1987)
<table>
<thead>
<tr>
<th>Year</th>
<th>Fire</th>
<th>County</th>
<th>Month</th>
<th>Acres</th>
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<td>166,600</td>
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Largest Fires (>5,000ha), 1960-1997
Santa Monica Mtns (Ventura/L.A.)
Drought

(Keeley & Zedler in press)
Impact of fire and fire management
Not just fire-adapted but fire-dependent!

<table>
<thead>
<tr>
<th>Species</th>
<th>Life form</th>
<th># sites</th>
<th>Chaparral</th>
<th>Sage scrub</th>
<th>Percentage by year</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>X ± S.E.</td>
<td>X ± S.E.</td>
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<tr>
<td><strong>Obligate-Seeders</strong></td>
<td></td>
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<tr>
<td>Ceanothus crassifolius</td>
<td>s</td>
<td>10</td>
<td>62,100 ± 17,800</td>
<td>3</td>
<td>1,500 ± 800</td>
</tr>
<tr>
<td>C. greggii</td>
<td>s</td>
<td>8</td>
<td>18,500 ± 18,500</td>
<td>1</td>
<td>1,000</td>
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<tr>
<td>C. megacarpus</td>
<td>s</td>
<td>9</td>
<td>55,700 ± 24,200</td>
<td>2</td>
<td>11,000 ± 7,000</td>
</tr>
<tr>
<td>C. oliganthus</td>
<td>s</td>
<td>6</td>
<td>103,900 ± 95,500</td>
<td>0</td>
<td>-</td>
</tr>
<tr>
<td>C. tomentosus</td>
<td>s</td>
<td>2</td>
<td>56,300 ± 700</td>
<td>0</td>
<td>-</td>
</tr>
<tr>
<td>Dendromecon rigida</td>
<td>ss</td>
<td>1</td>
<td>53,000</td>
<td>0</td>
<td>-</td>
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<tr>
<td>Helianthemum scoparium</td>
<td>su</td>
<td>12</td>
<td>33,500 ± 17,500</td>
<td>3</td>
<td>109,200 ± 75,200</td>
</tr>
<tr>
<td>L. scoparius</td>
<td>su</td>
<td>39</td>
<td>46,100 ± 8,400</td>
<td>43</td>
<td>77,600 ± 33,900</td>
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<tr>
<td><strong>Faculative Seeders</strong></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adenostoma fasciculatum</td>
<td>s</td>
<td>31</td>
<td>104,500 ± 22,800</td>
<td>11</td>
<td>23,700 ± 12,700</td>
</tr>
<tr>
<td>Artemisia californica</td>
<td>ss</td>
<td>12</td>
<td>11,600 ± 4,800</td>
<td>41</td>
<td>31,500 ± 10,600</td>
</tr>
<tr>
<td>Calystegia macrostegia</td>
<td>su</td>
<td>25</td>
<td>49,700 ± 12,100</td>
<td>34</td>
<td>38,630 ± 7,200</td>
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<tr>
<td>Ceanothus spinosus</td>
<td>s</td>
<td>9</td>
<td>56,600 ± 25,100</td>
<td>1</td>
<td>2,000</td>
</tr>
<tr>
<td>Encelia farinosa</td>
<td>ss</td>
<td>0</td>
<td>-</td>
<td>8</td>
<td>21,100 ± 8,500</td>
</tr>
<tr>
<td>Eriodictyon crassifolium &amp; E. trichocalyx</td>
<td>ss</td>
<td>4</td>
<td>3,100 ± 800</td>
<td>1</td>
<td>1,000</td>
</tr>
<tr>
<td>Eriophyllum confertiflorum</td>
<td>su</td>
<td>25</td>
<td>168,700 ± 42,900</td>
<td>30</td>
<td>24,000 ± 8,500</td>
</tr>
</tbody>
</table>

(Keeley, Fotheringham & Keeley 2006)
Antirrhinum coulterianum (annual)
Emmenanthe penduliflora (annual)
Romneya coulteria (subshrub)
Silene multinervia (annual)
Phacelia grandiflora (annual)
Salvia mellifera (shrub)

postfire endemics
Chaparral species are not adapted to all fires, rather to a particular fire regime:
- high fire intensity
- fire return intervals 30 – 130 years

(Minnich & Chou 1997 ~ 70 yrs)

Fire is a natural ecosystem process
Disturbances are perturbations to this regime:

1) Insufficient fire,
2) Not enough fire
Senescence Risk
► due to long fire return intervals
► resprouters loose vigor
► seed production declines
► soil seed banks deteriorate

Immaturity Risk
► due to short fire return intervals
► seeders fail to replenish soil seed bank
► resprouters do not replenish burls

(terms from Zedler 1995)
Ancient chaparral 90 – 150 yrs old at time of McNally Fire
Mature chaparral 50 – 60 yrs old

(a) Total cover
(b) Herbaceous cover
(c) Woody cover

USGS
Immaturity Risk

- due to short fire return intervals
- seeders fail to replenish soil seed bank
- resprouters do not replenish burls

Senescence Risk

- No lack of fire
- Resilient to long fire intervals

(terms from Zedler 1995)
Early modeling studies by Charles Philpot (1974) were interpreted to mean immaturity risk was not a factor.... *no chaparral will burn before its time*

But: It only considered live/dead fuels in shrubs and used data from prescription burns
San Diego County --- 2003 & 2007 fires

~20,000 ac reburned

~27,000 ac reburned

~18,000 ac reburned
Fires 4 years apart

(a) Prefire age 3 years

(b) Prefire age 24 years

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**Fires 4 years apart**

<table>
<thead>
<tr>
<th>Year</th>
<th>Density (x1000 ha⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2004</td>
<td>500</td>
</tr>
<tr>
<td>2005</td>
<td>700</td>
</tr>
<tr>
<td>2008</td>
<td>1000</td>
</tr>
<tr>
<td>2009</td>
<td>1200</td>
</tr>
</tbody>
</table>

- **a) Native annuals**
  - $P < 0.001$

- **b) Alien annuals**
  - $P < 0.001$  
  - Cedar
  - Witch

---
Extent to which 20th & 21st century fires have burned at frequencies similar to pre-Euroamerican settlement

(Safford & van DeWater in review)
Fires occurring less than 15 - 20 years apart can convert chaparral to weedy annual grasslands

**Impacts:**

- 😞 Increases grazing for livestock and game
- 😞 Reduces floral and faunal biodiversity
- 😞 Alien plant invasion increases
- 😞 Alters watershed hydrology and slope stability
- 😞 Decreases fire intensity (but can be dangerous!)
- 😞 Increases fire frequency
Ignitions

(Logistic output (probability of presence))

Urban  Grass  Grass & Shrub  Shrub  Forest

(Syphard, Brennan & Keeley in review)
Resources and Fire Management

- Prescription burning has limited capacity for enhancing resources, i.e., Rx not a ‘win-win proposition’
  It needs to be evaluated solely on its effectiveness for fire hazard reduction

Immaturity Risk

- Prescription burning adds to fire-load and could, but not always, have negative impacts

- What about mechanical treatment impacts?
Aerial Views of Crushing

Leona Divide Crushing, 2006-2007
Angeles National Forest

Leona Divide-Crushing, 2008 & Mastication 2009
Angeles National Forest
Study Site Locations

- Angeles National Forest
  - 7 Treatments, 33 Study Sites

- Los Padres National Forest
  - 15 Treatments, 61 Study Sites

- San Bernardino National Forest
  - 18 Treatments, 78 Study Sites

- Cleveland National Forest
  - 24 Treatments, 61 Study Sites
### Goals

**Effects on resources**

- Effectiveness in altering fire behavior
- Quantifying flame lengths/spread
- Developing custom fuel models

### All Forests (64 treatments)

<table>
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<tr>
<th>Treatment Type</th>
<th>1-4</th>
<th>5-8</th>
<th>Total</th>
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</thead>
<tbody>
<tr>
<td>Mastication</td>
<td>85</td>
<td>64</td>
<td>149</td>
</tr>
<tr>
<td>Mastication with Rx Burn</td>
<td>11</td>
<td>8</td>
<td>19</td>
</tr>
<tr>
<td>Mastication with Rx Burn &amp; Wildfire</td>
<td>3</td>
<td>3</td>
<td></td>
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<tr>
<td>Mastication with Wildfire</td>
<td>5</td>
<td>4</td>
<td>9</td>
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<tr>
<td>Repeat Mastication</td>
<td>1</td>
<td>13</td>
<td>14</td>
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<tr>
<td>Repeat Mastication with Rx Burn</td>
<td>1</td>
<td>1</td>
<td></td>
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<tr>
<td>Crushing</td>
<td>12</td>
<td>2</td>
<td>14</td>
</tr>
<tr>
<td>Crushing with Rx Burn</td>
<td>2</td>
<td>2</td>
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<tr>
<td>Wildfire</td>
<td>19</td>
<td>3</td>
<td>22</td>
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<tr>
<td><strong>Total # of study sites</strong></td>
<td>133</td>
<td>100</td>
<td>233</td>
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### Forest (# of treatments)

<table>
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<td><strong>ANF (7)</strong></td>
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<tr>
<td>1-4</td>
</tr>
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<td>ANF (7)</td>
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<td>BDF (18)</td>
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<td>CNF (24)</td>
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<td>LPF (15)</td>
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<td><strong>Total by forest</strong></td>
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<tr>
<td>33</td>
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Mechanical treatments:

- Not generally damaging to resprouting shrubs,
- Significant negative impacts on seeding shrubs
- Does not include postfire endemics
- Invasives annuals favored

Ω May cause some degradation in resources
What About Effectiveness of Mechanical treatments:

Proximal impact: Reduce flame lengths

Ultimate impact:

► During severe fire weather conditions, treated areas generally do not provide barriers to the fire front, but are sometimes valuable for controlling flanks.

► Under moderate weather conditions fires may stop at fuel treatments, or provide defensible space for backfires... but not always and this is an area in need of further research.
What about fuel breaks?

(Brennan, Keeley and Pfaff, unpublished)
Before Cedar Fire: Extensive fuel breaks on the Elliot Reserve
After the Cedar Fire: Fire crossed entire reserve and burned deep into the urban environment.
Role of Fuel Breaks in SoCal USFS lands

Syphard, Keeley, and Brennan

Forest Ecology and Management 2011
International Journal of Wildland Fire 2011
What is the role of fuel breaks in controlling large fires & what factors influence this role?

GIS overlay and analysis

Personal interviews
The Role of Fuel Breaks

Most fires didn’t encounter a fuel break.

Fires that encountered a fuel break had behavior altered only when they were accessed by fire suppression crews.

Strategic placement of fuel breaks is likely to be most cost-effective when located near resources at risk, eg WUI.

A potential strategy is to shift from wildland vegetation management to focus from the home out.
Does clearance need to be to bare earth to be effective?

What is the impact on soil erosion?

Is clearance beyond 100’ justified?

How does it impact resource sacrifice?
Defensible Space

(Syphard, Brennan, Keeley in review)
Defensible Space

• Low slope properties

• High slope properties
What does the future hold?

Climate change?

In southern California we need to think more broadly in terms of global changes.

>99% of all lands are burned by human-ignited fires.

In the next several decades populations will increase by more than 50% while temperatures are predicted to increase 2-3%.
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Drought (Keeley & Zedler in press)
California

USFS

Area burned (1000-ha / million ha)

Decade

1920 1940 1960 1980 2000

USFS

CalFire

Area burned (1000-ha / million ha protected)

Decade

1920 1940 1960 1980 2000

9Keeley & Syphard in preparation)
### A) USFS

- **Winter**
  - \( r^2 = 0.00 \)
  - \( P = 0.814 \)
- **Spring**
  - \( r^2 = 0.00 \)
  - \( P = 0.938 \)
- **Summer**
  - \( r^2 = 0.01 \)
  - \( P = 0.367 \)
- **Autumn**
  - \( r^2 = 0.00 \)
  - \( P = 0.644 \)

### B) Cal Fire

- **Winter**
  - \( r^2 = 0.04 \)
  - \( P = 0.662 \)
- **Spring**
  - \( r^2 = 0.22 \)
  - \( P < 0.001 \)
- **Summer**
  - \( r^2 = 0.00 \)
  - \( P = 0.956 \)
- **Autumn**
  - \( r^2 = 0.00 \)
  - \( P = 0.665 \)
Land Use Planning

Syphard et al. 2012, PLoS ONE
Syphard et al. 2007, Ecological Applications
Syphard et al. 2009, Conservation Biology
CONCLUSIONS:

Vegetation treatments designed to alter fuels generally represent resource sacrifice.

However, fire hazard reduction benefits may pre-empt resource issues, if there is a clearly demonstrable value to such treatments.

Treatments are least effective under severe Santa Ana wind conditions.

Strategic placement of treatments and effectiveness under moderate weather conditions is badly in need of study.

In terms of protection of values at risk, focus should be from the home out (e.g., Ventura Co Fire Department).
The Poetry of D.H. Rumsfeld
—Feb. 12, 2002, Department of Defense news briefing

The Unknown

As we know,
There are known knowns.
There are things we know we know.
We also know
There are known unknowns.
That is to say
We know there are some things
We do not know.
But there are also unknown unknowns,
The ones we don't know
We don't know.
Thanks to colleagues, CJ Fotheringham, Richard Halsey, Tess Brennan, Anne Pfaff, Paul Zedler, Hugh Safford, Phil Rundel, Max Moritz, Marti Witter, Mike Rohde, Steve Davis, Anna Jacobson, among many others.....