2003 Fires in Southern California: Impact of Fuel Age on Fire Severity and Vegetation Recovery

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INTRODUCTION

This JFSP funded project takes advantage of the unique opportunities provided by the Oct 2003 fires in southern California to answer three questions:

This Satellite image taken October 27, 2003 illustrates the Santa Ana wind conditions.

1. What role does fuel age play in determining fire severity?
2. Does fire severity affect postfire recovery?
3. How do field estimates of fire severity compare to LANDSAT remote image fire severity assessments?

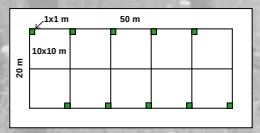
As fire intensity (defined as energy output from a fire) increases, it is thought that fire severity (the ecosystem impact) also increases.

For wildfires, fire intensity measurements are seldom available but post hoc measurements such as char bowl height in forests or twig diameter in shrublands are considered surrogate measures of fire intensity or of fire severity.

Empirical measures of fire severity necessarily vary with the ecosystem, for example tree mortality is a useful indicator of impact in forests with a surface fire regime, but aboveground mortality is a poor indicator in shrublands with a crown fire regime, where total plant cover in the first growing season may be a better indicator of ecosystem impact.

FIELD STUDY METHODS

Two hundred and fifty tenth hectare study sites were selected from within the Cedar, Grand Prix/Old, Otay, and Paradise Fires representing a range of prefire stand ages from young to old and stratified by our estimate of fire intensity/severity based on extent of biomass consumption. Within each 1000-m² site were 10 nested non-overlapping 100-m² plots, each containing a nested 1-m² subplot.

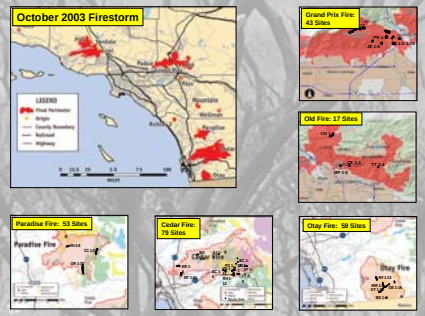


Sampling design.

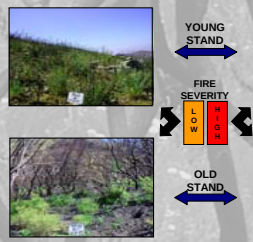
- Species cover and density were recorded in each 1-m² subplot and a list of additional species were recorded from the surrounding 100-m² plot for the first two growing seasons following the fires.
- Soil samples were collected from each site and analyzed for texture, total soil nitrogen and extractable phosphate.
- Stand age prior to the fires was based on ring counts from stem samples collected at each site and pre-fire shrub density was recorded for each shrub species within all 100-m² plots using morphological traits to identify charred skeletons.
- Our surrogate measures of fire severity were made on the two *Adenostoma fasciculatum* skeletons nearest to each 1-m² subplot by measuring diameter of the smallest twig remaining (measure #1) and height above-ground (measure #2).

Stem samples used to determine pre-fire stand age.

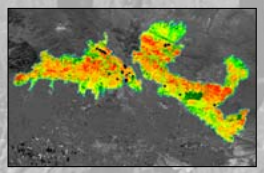
STUDY SITE LOCATIONS



FIRE SEVERITY vs. STAND AGE



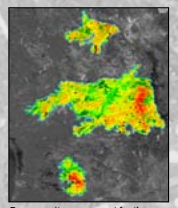
LANDSAT BURN SEVERITY ASSESSMENT



Burn severity assessment for the Grand Prix and Old fires using Landsat images from April 11, 2004.

Burn severity assessments for the Oct 2003 fires were made using differenced normalized burn ratios (DNBR) between prefire and postfire growing season Landsat imagery, provided to us by the NPS-USGS fire severity mapping project.

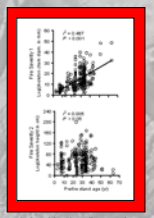
Color	DNBR Value	Severity
Dark Green	0-20	Unburned to low
Light Green	21-96	Low to moderate
Yellow	97-173	Moderate
Orange	174-249	Moderate to high
Red	250	High



Burn severity assessment for the Paradise, Cedar and Otay fires using Landsat images from April 11, 2004.

RESULTS

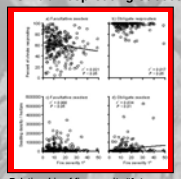
1. Relationship of Stand Age to Surrogate Measures of Fire Severity



Relationship of prefire stand age to two surrogate measures of fire severity; n = 250 sites (ave)

- Regression analyses between physical site variables show a strong significant relationship between prefire stand age and our surrogate fire severity #1 measure based on twig diameter.
- There was no significant relationship between prefire stand age and our surrogate fire severity #2 measure (skeleton height).

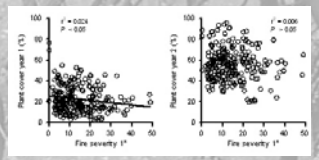
2. Relationship of Surrogate Measures of Fire Severity to Postfire Shrub Resprouting Success and Seedling Recruitment



Relationship of fire severity #1 to resprouting (a) facultative seeding shrubs and (b) obligate resprouting shrubs and to seedling densities of (c) facultative seeding shrubs and (d) obligate seeding shrubs; n = 250. [* Skeleton stem diameter in mm]

- Regression analyses between our fire severity measure #2 and shrub resprouting and seedling recruitment gave no significant relationships.
- Fire severity measure #1 exhibited (a) a negative relationship with facultative seeder resprouting, but no significant relationship with (b) resprouting success of obligate resprouters.
- Fire severity measure #1 also exhibited (d) a positive relationship with seedling density of obligate seeder shrubs, but not with (c) facultative seeder species.

2 (cont.) Relationship of Surrogate Fire Severity Measures and Postfire Cover and Species Richness



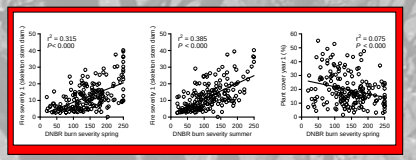
- In the first postfire year plant cover was only weakly related to our fire severity measure #1 and not at all related to measure #2.
- In the second year there were no significant relationships with #1 or #2.

Environmental Parameters	Regression Coefficients for Total Species Richness					
	2004	2005	2004	2005	2004	2005
	1m^2		100m^2		1000m^2	
Fire severity 1: skeleton stem diam.	-0.475***	-0.450***	-0.632***	-0.245***	-0.378***	-0.166**
Fire severity 2: skeleton height	-0.009*	-0.014*	---	-0.032***	-0.023**	-0.030***
Prefire stand age	-0.320***	-0.341***	-0.309***	---	-0.209**	---
Elevation	0.139*	-0.171**	---	-0.441***	-0.142*	-0.449***
Insolation	---	---	---	-0.151*	---	-0.169*
Rock cover (log)	0.261***	0.215**	0.236***	---	0.152*	---
Soil:						
% Rock (log)	---	---	-0.236***	-0.212**	-0.315***	-0.234***
% Clay (log)	---	0.235***	---	---	---	---
% P (log)	-0.277***	-0.275***	-0.199**	-0.142*	-0.156*	---
% N (log)	-0.127*	---	-0.193**	---	-0.212**	---
Precipitation	---	-0.197**	-0.226***	-0.357***	-0.212**	-0.372***

***P<0.001, **P<0.01, *P<0.05, R not shown for P>0.05.

- Species richness at all scales and in both years was negatively related to fire severity #1 and #2.
- Species richness was negatively related to stand age at all scales in 2004 and only at the smallest scale in 2005.

4. Comparison of Field Collected Surrogate Measures of Fire Severity to the LANDSAT Fire Severity Assessment



Relationship of field collected surrogate measures of fire severity to burn severity estimated using differenced normalized burn ratios (DNBR) calculated from Landsat images taken in spring (April 11) and summer (June 14) of 2004; n = 189 (includes only points in the Cedar, Otay & Paradise fires).

- Regression analyses showed (a) a highly significant positive relationship between field collected surrogate measures of fire severity (#1) and DNBR burn severity values calculated from Landsat images taken in spring of 2004.
- The relationship was slightly stronger for DNBR burn severity values calculated from Landsat images taken in the summer of 2004.
- A weak but significant negative relationship (r^2=0.075) was observed between percentage ground covered by plant growth in the spring of the first postfire year and spring DNBR burn severity. Summer DNBR was not significantly correlated with first postfire year plant cover measured in the field.

CONCLUSIONS

1. Our surrogate measures of "fire severity" were strongly correlated with prefire stand age, which likely is tied to fuel load and thus fire intensity.
2. Our surrogate measures were only weakly or not at all correlated with postfire plant cover.
3. Our surrogate measures were negatively correlated with postfire species richness.
4. Our surrogate measures were very strongly correlated with DNBR.
5. Postfire cover in the first growing season was very weakly correlated with spring DNBR and not correlated with summer DNBR
6. Much more thought needs to be given to what these different field parameters and remote imaging signals are measuring relative to fire intensity and fire severity.

COOPERATORS

- National Park Service
- Bureau of Land Management
- USFS, Cleveland National Forest
- USFS, San Bernardino National Forest
- United States Border Patrol
- UC San Diego, Elliott Reserve
- Cuyamaca State Park
- County of San Diego Open Space Preserves