Modeling fuel treatment impacts on suppression costs: Where are we?

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US Forest Service

Support & Collaboration

WWETAC
Western Wildland Environmental Threat Assessment Center

JOINT FIRE SCIENCE PROGRAM
FIRESCIENCE.GOV
Research Supporting Sound Decisions

NASA

Geographic Information Science Center of Excellence
South Dakota State University
SDSU
USGS

Outline

- Motivation
- Basic Framework
- Case Studies
- Future Work

Motivation
Escalating Costs

Prestemon et al. (2008)

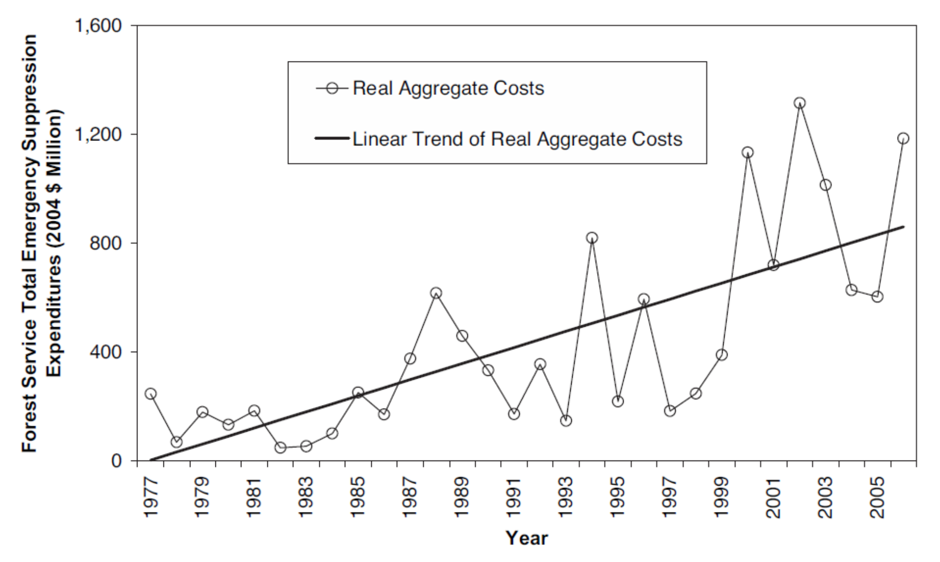
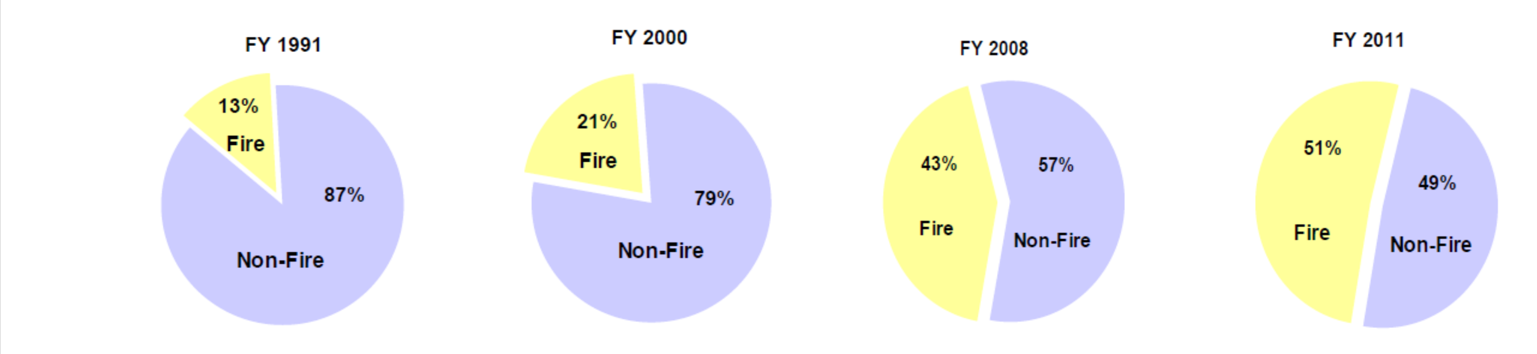


Figure 1. USFS suppression spending, 1977–2006, with a linear trend line, in fiscal year 2004 dollars.

"…[Borrowing] not only disrupts the ability of FS to plan their work overall, but severely impacts their accomplishments in Research, S&PF, and National Forest Programs."

(Peterson et al. 2008, p. 331)



Fire & Aviation Management Fiscal Year 2008 Accountability Report

Motivation
Damages

NATIONAL GEOGRAPHIC Daily News

Home Animals Ancient Energy Environment Travel/Cultures Space/Tech Water Weird News Ph

Colorado Wildfires Threaten Water Supplies

As fires are contained, water managers assess the damage, draw more on the Colorado River, and try to prepare for a dry future.

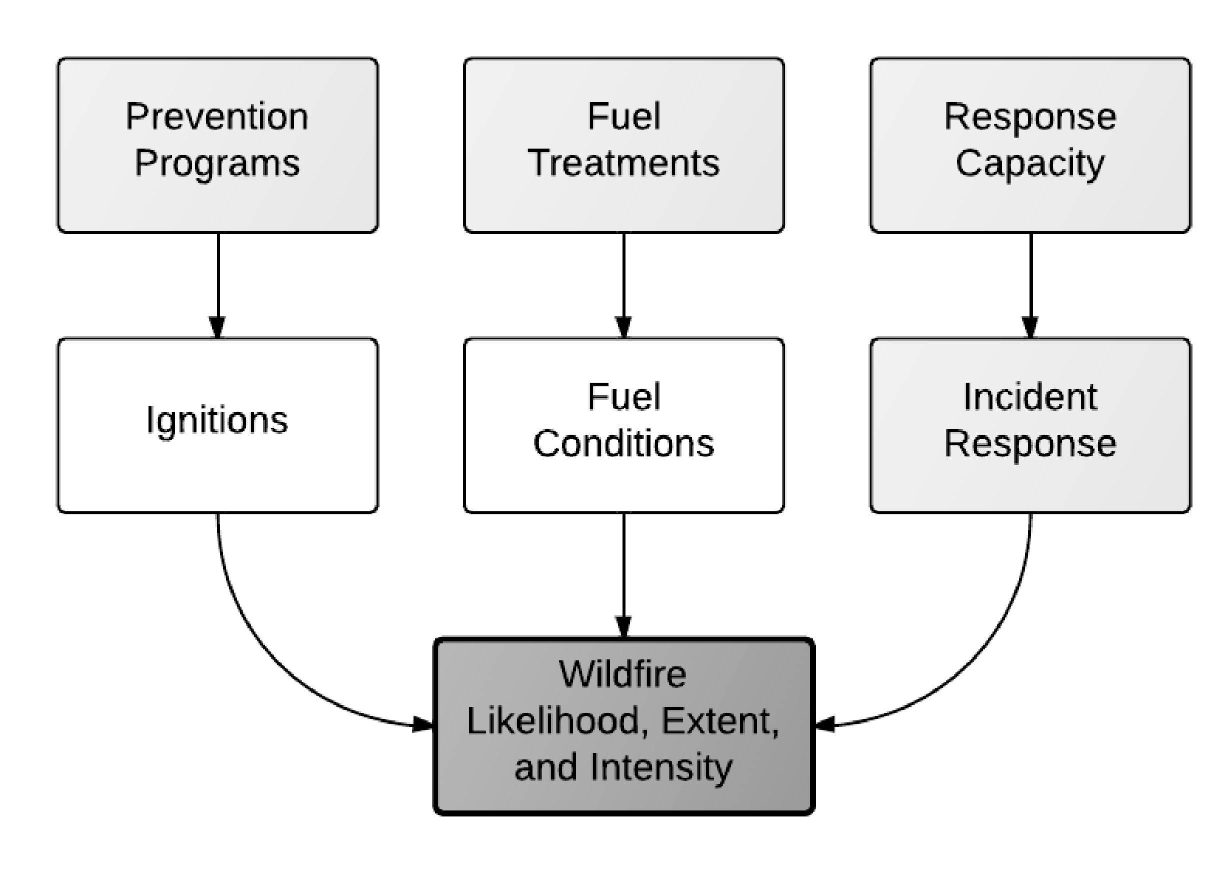
Smoke rises around Rampart Reservoir from Waldo Canyon Fire in this aerial photograph taken in Colorado Springs, Colorado, on June 27, 2012.

Photograph by John Wark, Reuters

Stratton 2012; inciweb.org

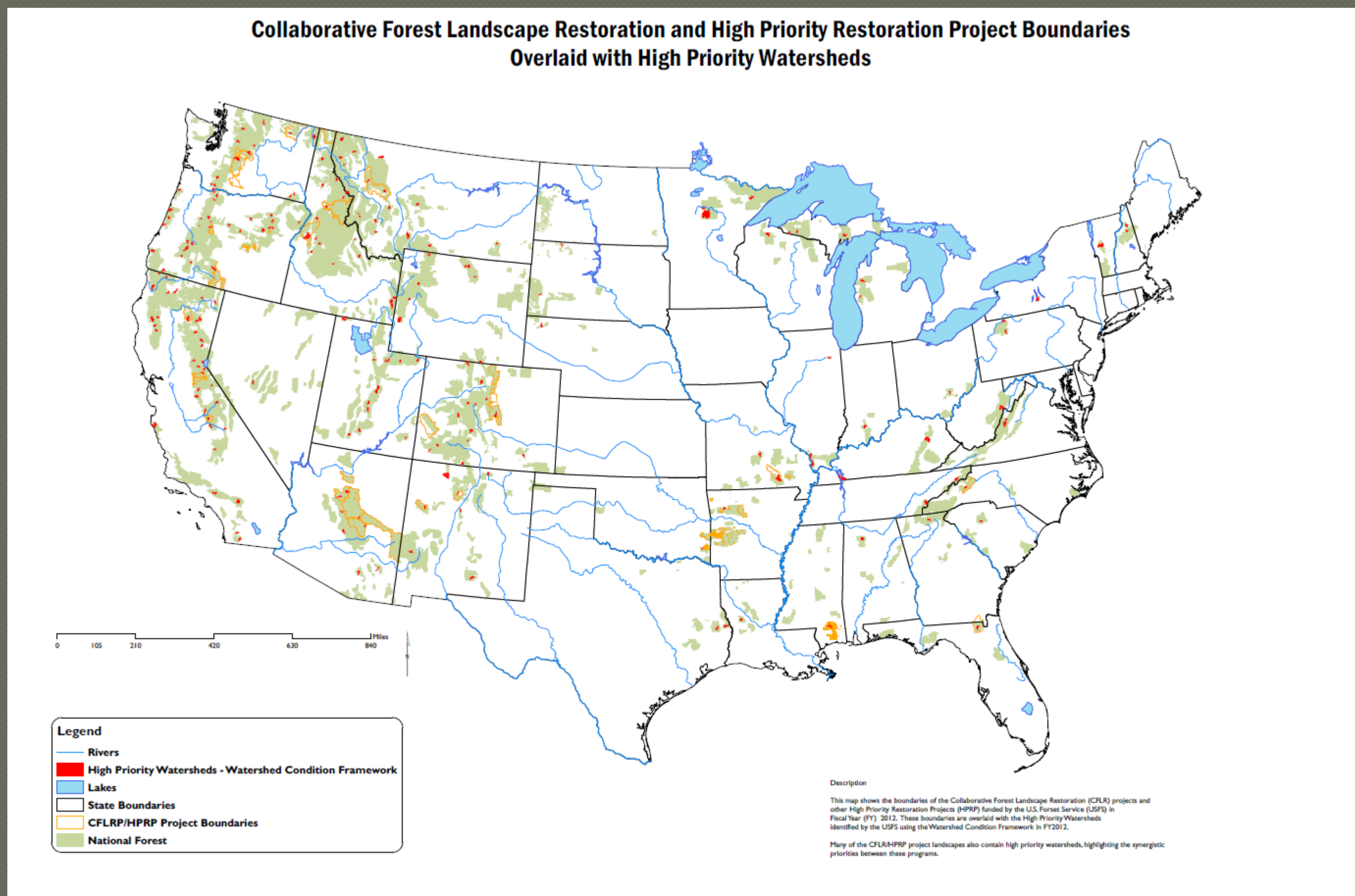
Motivation
Programmatic Tradeoffs

- Balance investments to minimize C+NVC



Motivation
CFLR

“facilitate the reduction of wildfire management costs, including through reestablishing natural fire regimes and reducing the risk of uncharacteristic wildfire”



fs.fed.us/restoration/CFLRP/index.shtml

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Basic Framework
First Principles

Reduce surface fuels
Increase the height to live crown
Decrease crown density
Retain large fire-resistant trees
(Agee and Skinner 2005)

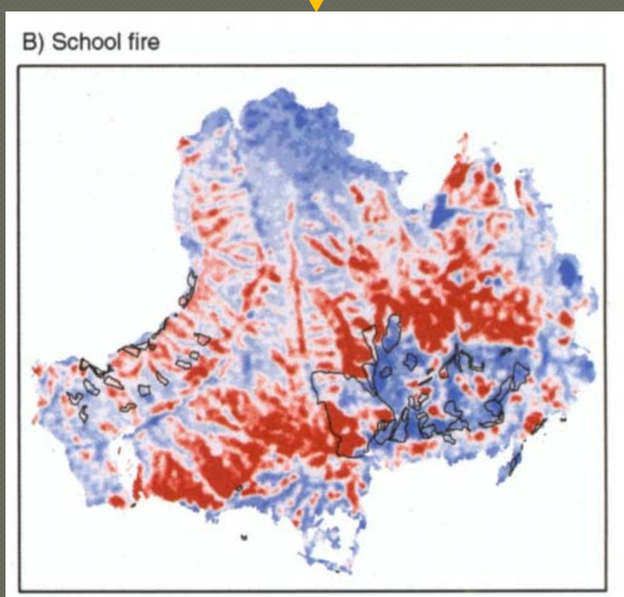
Reduce fire intensity

Basic Framework
Severity, Size, & Suppression

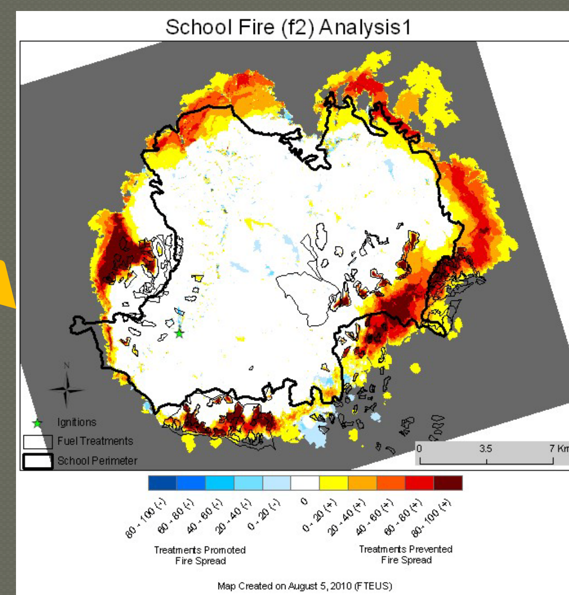
Change in Localized Fire Intensity

> We saw hundreds of instances where fuel treatments offered firefighters environments where suppression efforts could be more successful and safer.

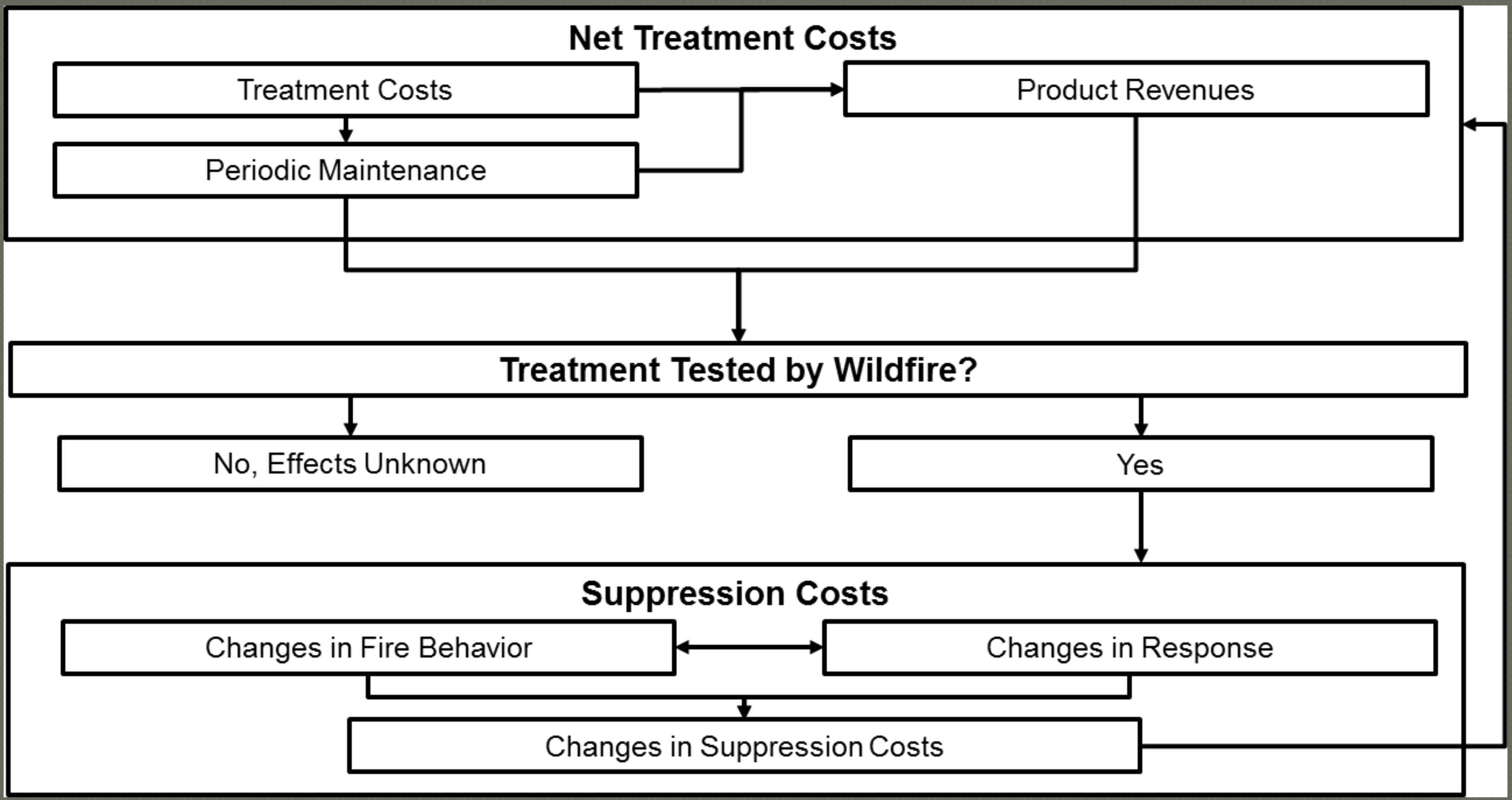
Romero and Menakis 2013



Wimberley et al. 2009



Basic Framework
Conceptual Financial Model



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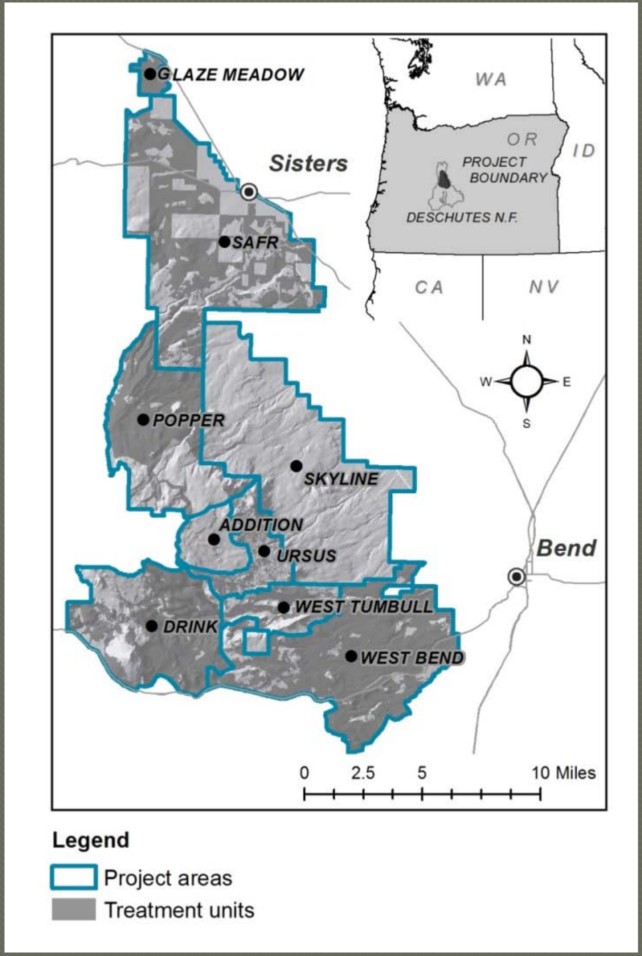
Case Study
Deschutes Collaborative



- Pilot study for RCAT package (Thompson et al. 2013)
- Set stage for CFLRA-funded projects
- Premised on locally-generated treatment & project details

Case Study
Fuel Treatments & Fire Size

- Fire size is primary determinant of fire costs
    - CPF ↑ @ decreasing rate
    - CPA ↓ @ constant rate
- Fuel treatments can influence fire size

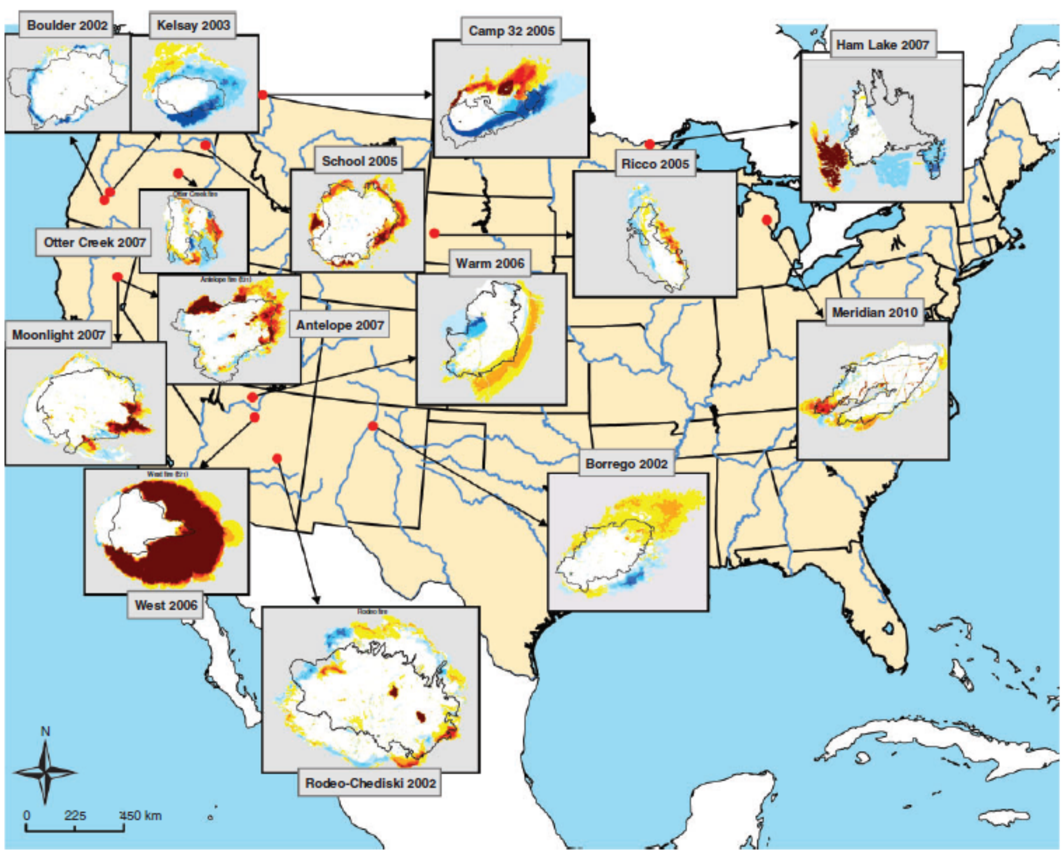
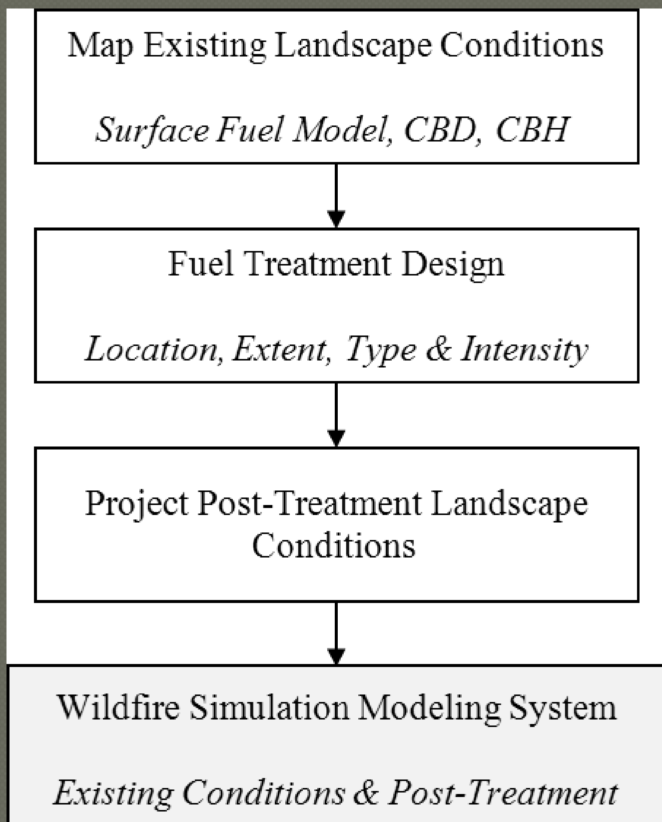
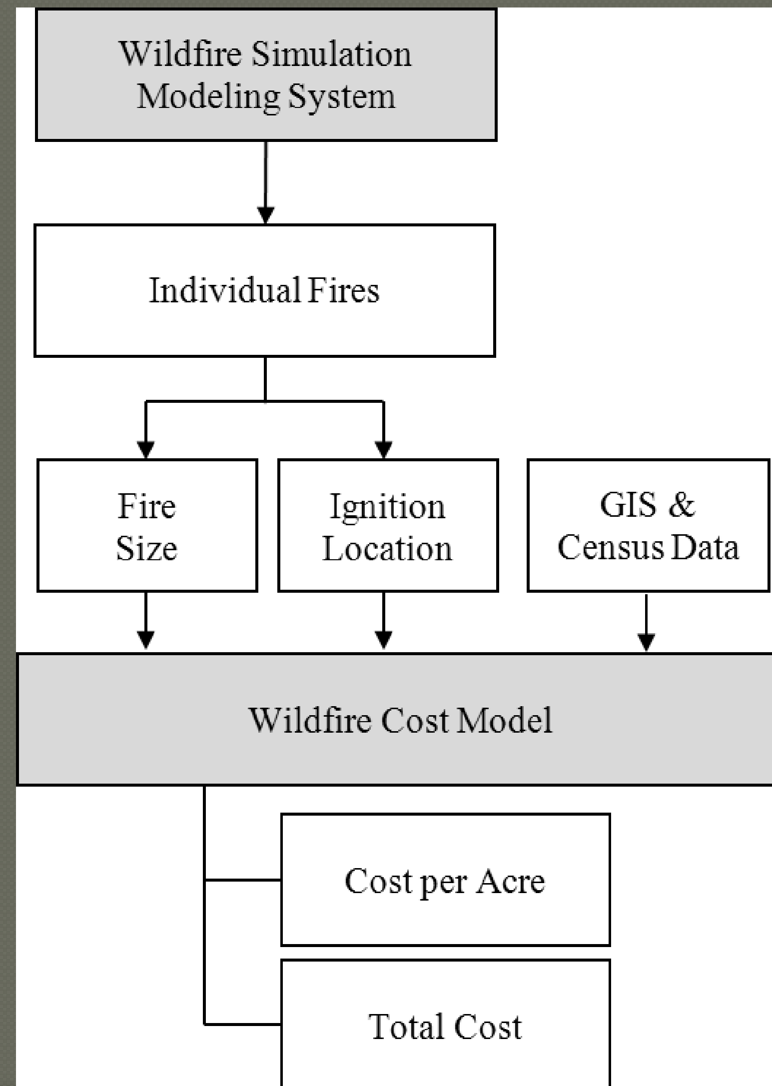


Fig. 2. Location and maps of changed fire risk for the 14 large wildfires that were simulated in this study. Probability of fire prevention (warm colours) and fire promotion (cool colours) because of fuels treatments encompassed by the wildfires (black lines) are greater for darker colours. Areas in white experienced no change in fire risk due to treatments.

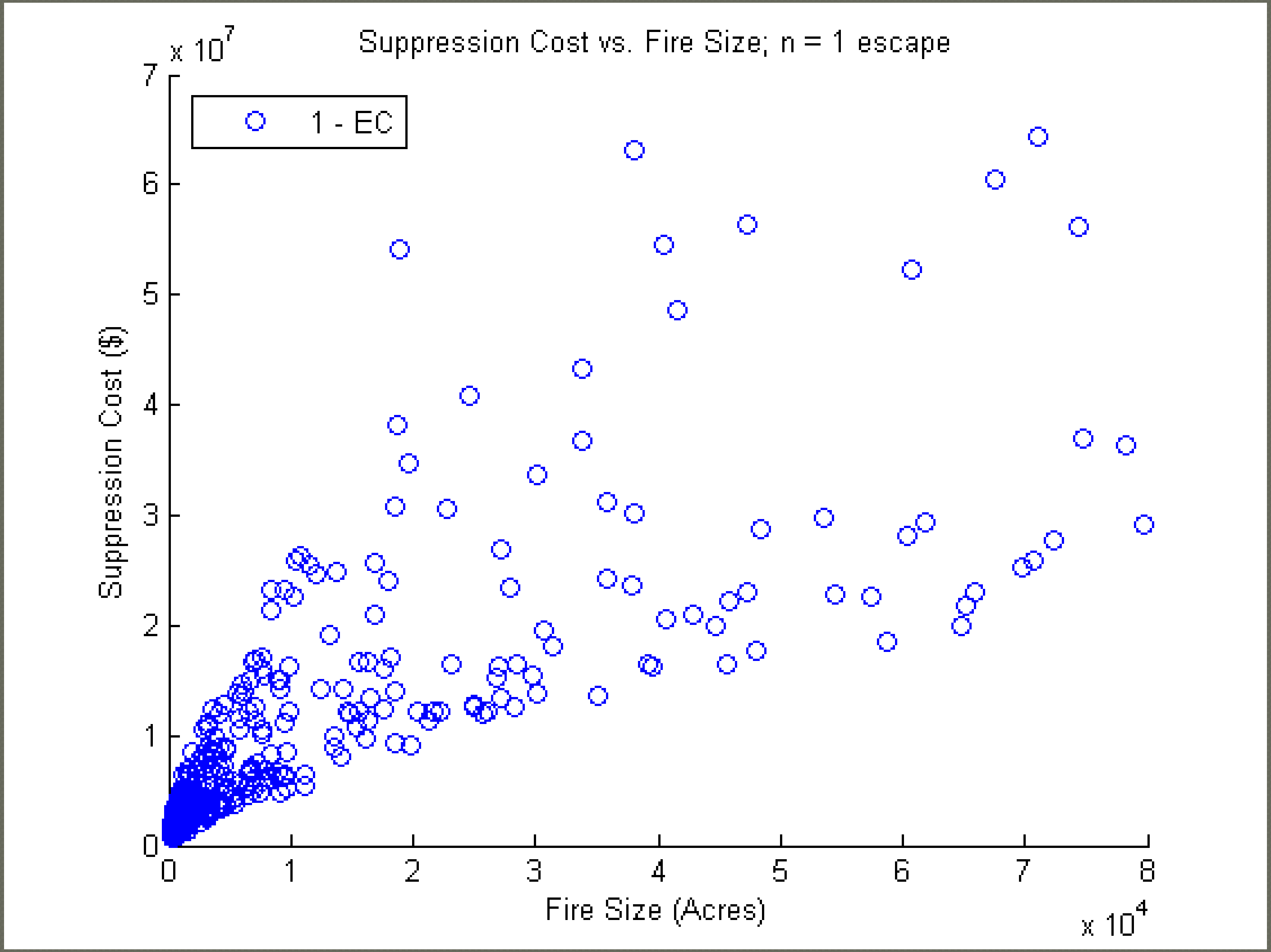
Cochrane et al. 2012

Case Study
Modeling Approach

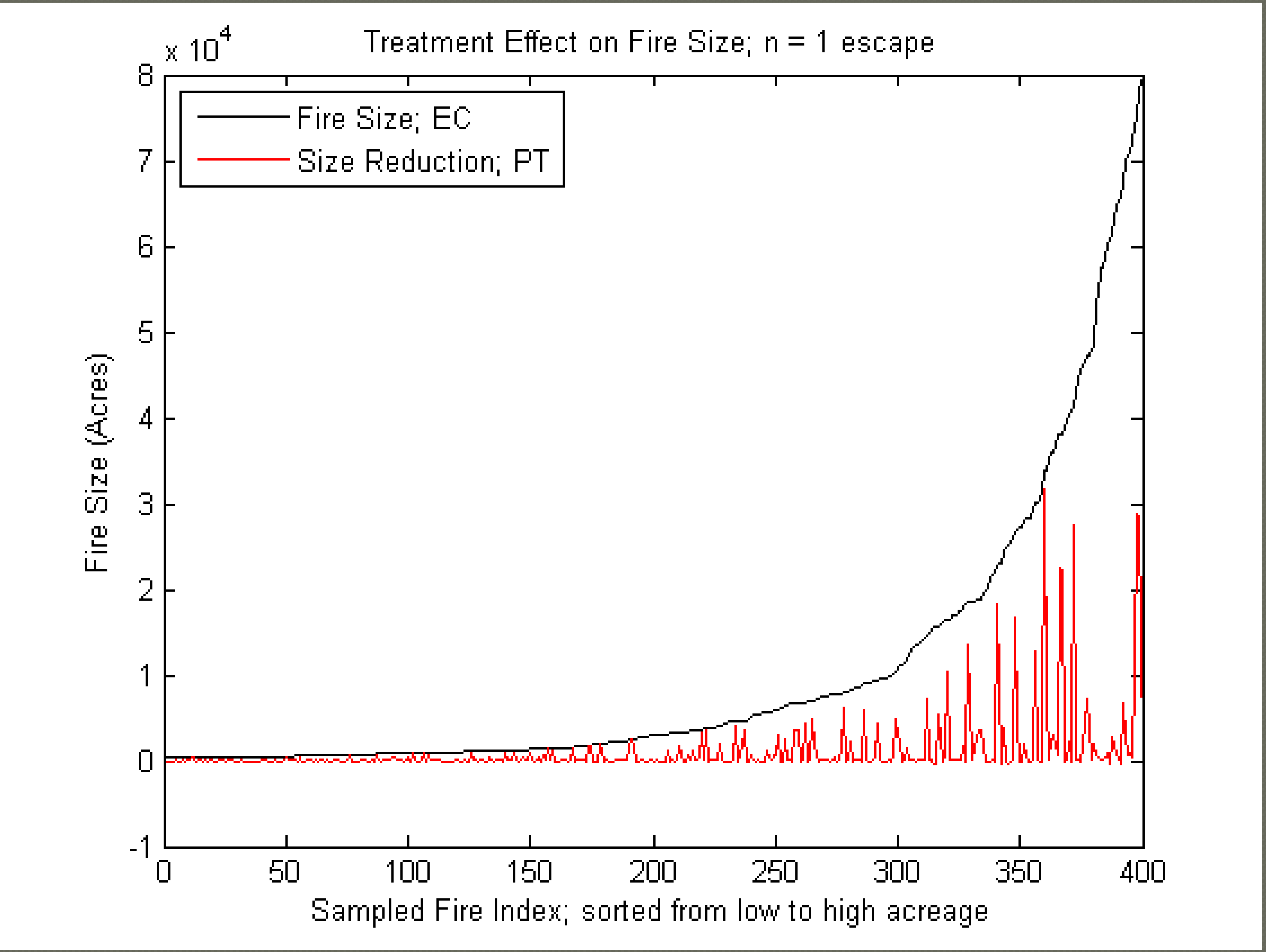




Case Study
Fire Size & Cost



Case Study
Treatment Effects on Fire Size



Case Study
Fire-level Results

Table 1—*Percentage reductions to fire size, cost per acre, and cost per fire resulting from treatment, across all large fires igniting within three overlapping landscape areas of increasing size (within treated areas, within a 2-mile buffer of treated areas, and across the entire study area).*[1]

	Treated areas	2-mile buffer	Entire study area
	percent change		
Size			
Mean	17.08	11.30	4.68
Median	22.24	14.97	5.55
Min	0.66	0.66	0.74
25th percentile	12.12	5.97	2.78
75th percentile	23.13	13.20	7.06
Max	12.84	3.78	0.58
Cost per acre			
Mean	-2.24	-0.60	0.53
Median	0.26	0.28	1.00
Min	-6.73	-0.43	-0.17
25th percentile	-0.30	1.40	1.22
75th percentile	-3.18	-1.04	0.35
Max	-1.74	0.00	0.00
Cost per fire			
Mean	15.86	10.78	6.71
Median	17.58	10.63	5.21
Min	-0.48	0.25	-0.78
25th percentile	18.60	11.30	5.05
75th percentile	20.57	12.91	7.04
Max	5.64	1.06	2.72

[1]*Treatment effects dampen as the area increases, owing to the increasing proportion of fires that do not interact with treatments.*

Case Study
Season-level Results

Table 2.—*Mean annual area burned and suppression costs across all 10,000 simulated fire seasons, across fires igniting within three overlapping landscape areas of increasing size (within treated areas, within a 2-mile buffer of treated areas, and across the entire study area).*

	Treated areas			2-mile buffer			Entire study area		
	EC	*PT*	*Reduction*	*EC*	*PT*	*Reduction*	*EC*	*PT*	*Reduction*
Area burned	1,315 ac	838 ac	36.25%	2,494 ac	1,911 ac	23.37%	5,398 ac	4,799 ac	11.08%
Suppression cost	$1,610,806	$1,042,147	35.30%	$2,848,653	$2,195,551	22.93%	$5,093,335	$4,432,626	12.97%

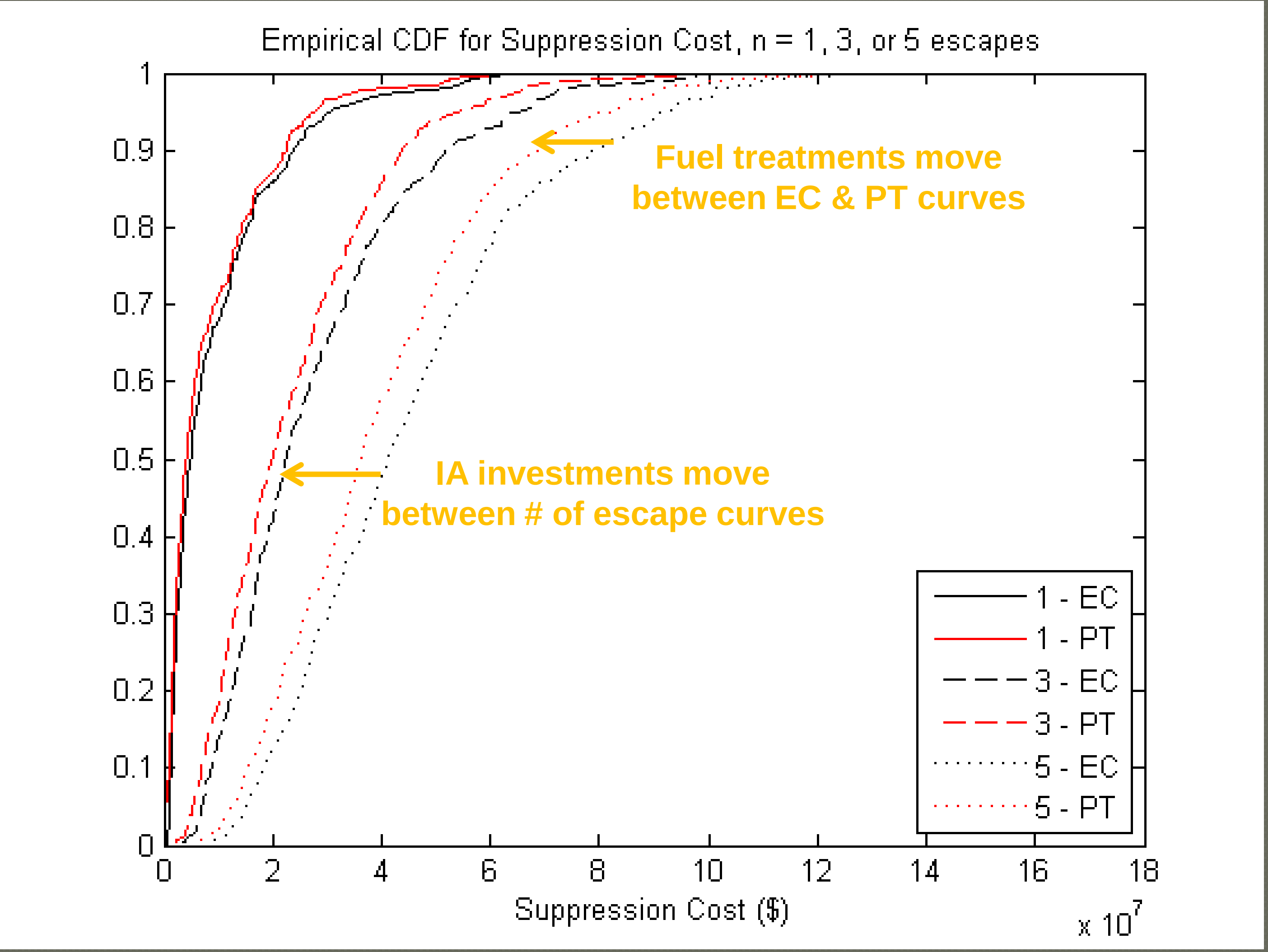
EC = Existing conditions. PT = Post-treatment landscapes.

Median savings = $0

Large wildfires occurred only on 36% of simulated seasons

Annual savings only realized with 25% probability

Case Study
Investment Interactions



Case Study
Filling in the Gaps

Burn severity
Fitch et al. (2013)

Four Forest Restoration Initiative, Arizona

Landscape-scale analysis

Single fire event burns entire project area

Severity >> cost

Temporal dynamics
Taylor et al. (2013)

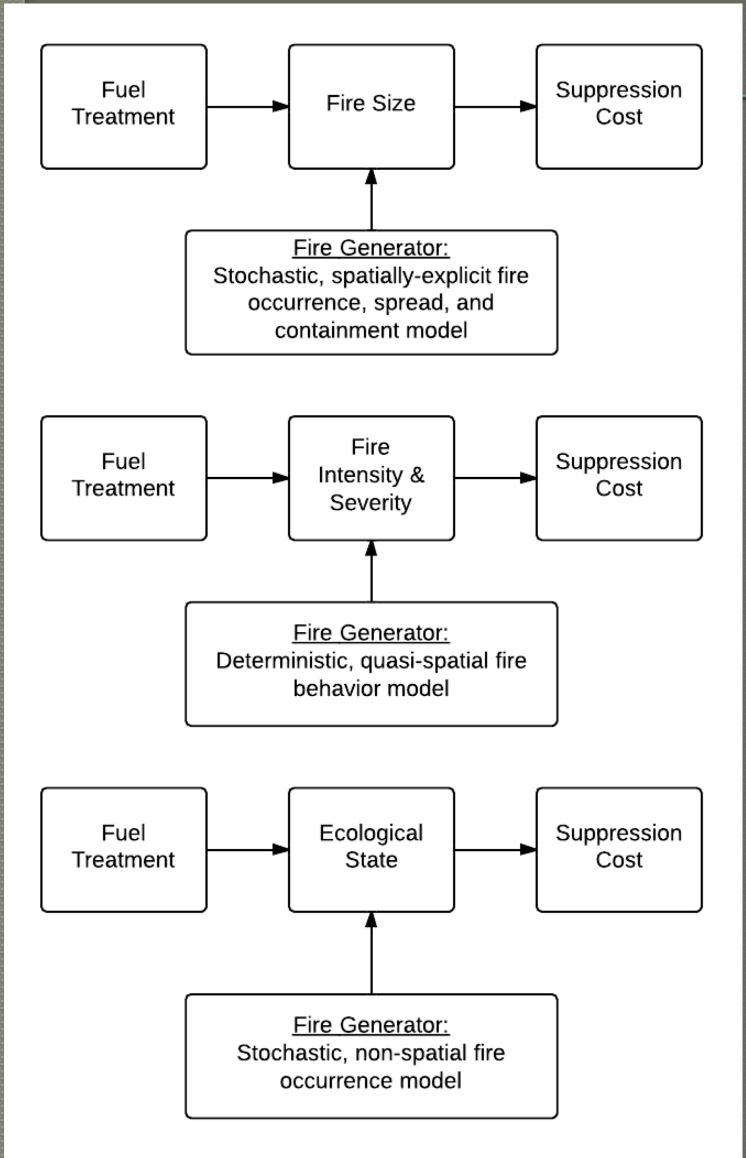
Great Basin sagebrush ecosystems

Per-acre analysis

200 fire seasons; annual fire event

Ecological state >> cost

Case Study
Model Comparison



Study Attributes	Thompson et al. (2013)	Fitch et al. (2013)	Taylor et al. (2013)
Cost Model			
Approach	Econometric regression model	Econometric regression model	Assigns historical costs on basis of fuel model
Cost Summary	Per-acre, per-fire, and per-season cost	Per-acre and per-fire	Per-acre
Summary Results (generalized to positive/negative)			
Per acre cost	+	-	-
Per fire cost	-	-	N/A
Per season cost	-	N/A	N/A

Case Study
Lessons Learned

Key Point #1:
Recognizing the inherent uncertainty of wildfire, evaluation of return on fuel treatment investment needs to occur within a spatial, risk-based framework

What is the probability of treated areas interacting with wildfire during their effective lifespan?

Case Study
Lessons Learned

Key Point #2:
The relative rarity of large wildfire on any given point on the landscape and the commensurate low likelihood of any given area burning in any given year suggest a need for large-scale treatment

Treatment-fire interaction, significant effects on fire behavior, integrated info incident response

In order to save large amounts of money on suppression, do land management agencies need to spend large amounts of money on landscape-scale fuel treatment?

Case Study
Lessons Learned

Key Point #3:

The need for large-scale treatments coupled with the difficulty in financing such treatments with agency resources suggests a commensurate need for offsetting treatment costs with forest product revenues, in addition to suppression cost savings

Which landscapes can support environmentally effective and financially feasible treatment strategies? Can suppression savings be accounted for and credited towards fuel investments?

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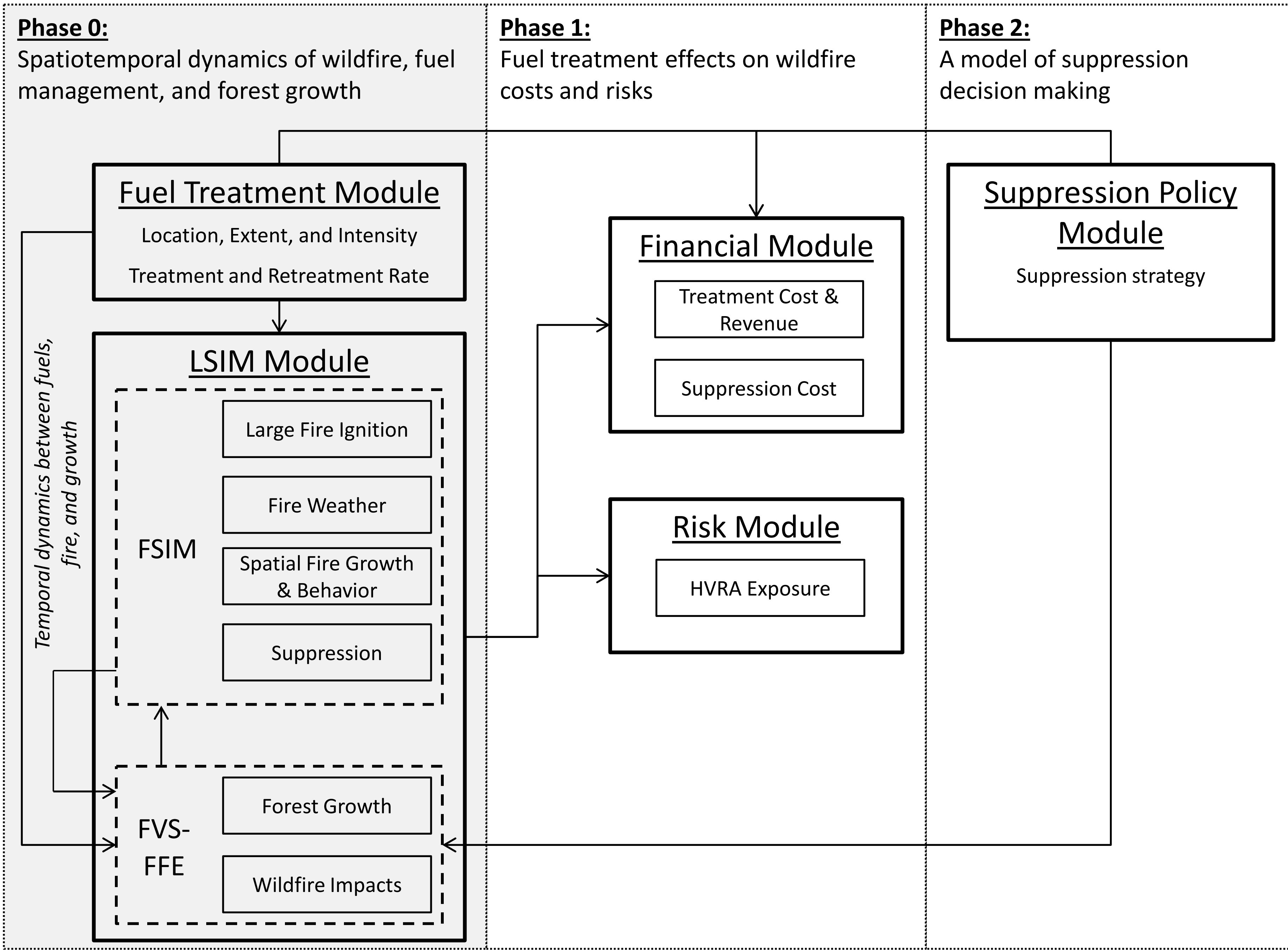
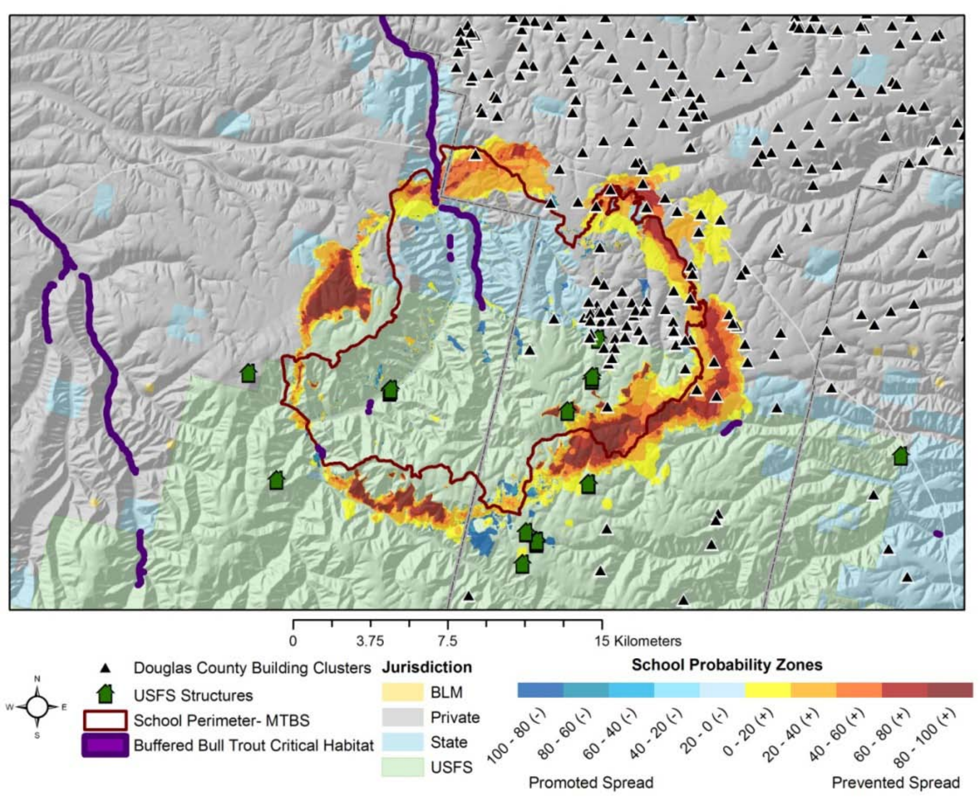
Future Work

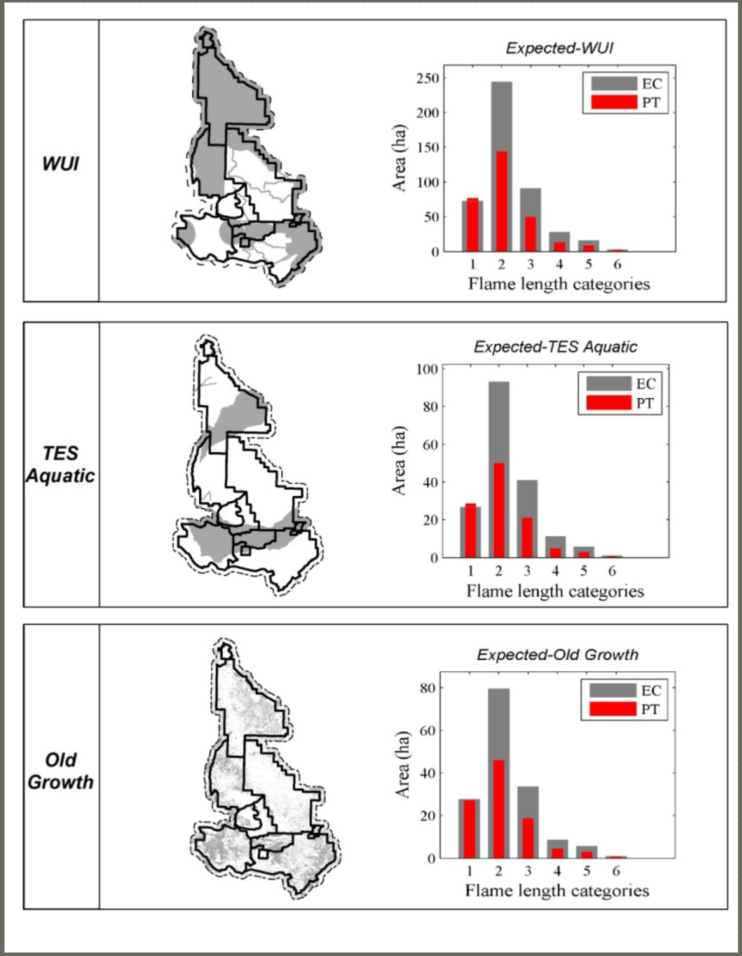
- Wildfire as a treatment
  - Self-limiting behavior & costs (Houtman et al. 2013)
- Range of treatment objectives
  - Expanded models of burn severity impacts on costs
  - Spatially explicit cost modeling (Hand et al. 2014)
- Spatiotemporal dynamics
  - Ongoing JFSP-funded project (Ager & Thompson PIs)



Phase 0:
Spatiotemporal dynamics of wildfire, fuel management, and forest growth
Phase 1:
Fuel treatment effects on wildfire costs and risks
Phase 2:
A model of suppression decision making
Fuel Treatment Module
Location, Extent, and Intensity
Treatment and Retreatment Rate
Financial Module
Treatment Cost & Revenue
Suppression Cost
Suppression Policy Module
Suppression strategy
Temporal dynamics between fuels, fire, and growth
LSIM Module
FSIM
Large Fire Ignition
Fire Weather
Spatial Fire Growth & Behavior
Suppression
Risk Module
HVRA Exposure
FVS-FFE
Forest Growth
Wildfire Impacts

Future Work
Quantifying Changes in Risk





Questions?

Ask at your own peril