Tools for archaeologists

- Estimating fuel loads
- Calculating first order fire effects
- Post-fire erosion modeling

Rachel Loehman, USGS
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Surface fuel sampling: The Photoload sampling technique

USDA
United States Department of Agriculture
Forest Service
Rocky Mountain Research Station
General Technical Report RMRS-GTR-190
April 2007

The Photoload Sampling Technique:

Estimating Surface Fuel Loadings From Downward-Looking Photographs of Synthetic Fuelbeds

Robert E. Keane and Laura J. Dickinson

Fire: From fuels to fire effects

Fire environment

Terrain

Weather

Fuels

- Size, shape
- Moisture content
- Quantity
- Spatial arrangement (vertical and horizonal)

Fire behavior

- Depth of burn
- Residence time
- Temperature
- Combustion byproducts
- Oxidation, reduction

Fire effects

Fire environment: Fuels

Vegetation/Fuels Description:

On-site fuels data: Ponderosa Pine is the dominate forest cover, covering 73% of the project area. About 13% is mixed conifer forest (on cool moist slopes), 13% pinon-juniper woodlands and 1% shrub or grass cover. The Fuel Models for this project will be FM 9, FM 10 and FM 6.

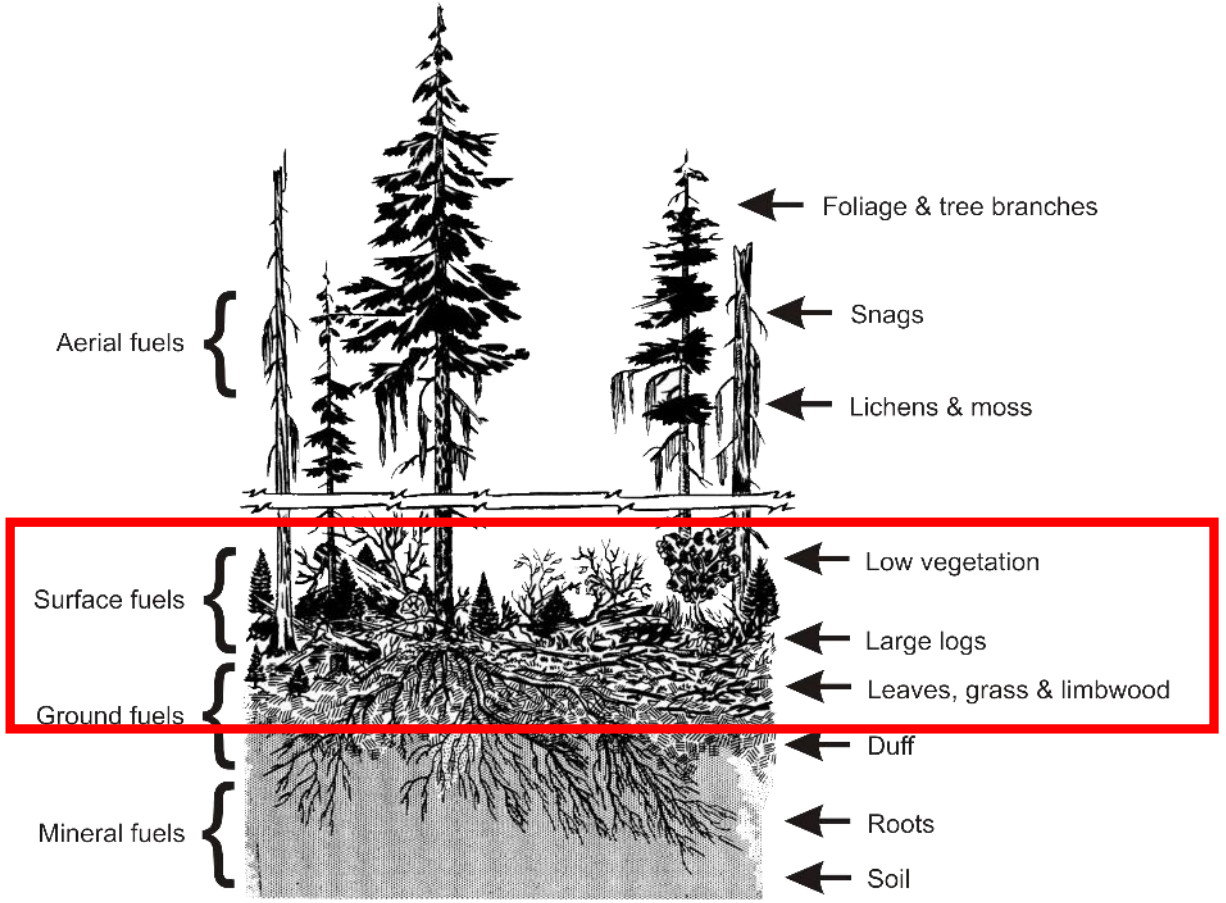
Fuel Model 9 73% of project area

Total Fuel Load, < 3-inch dead and live, tons/acre	3.5
Dead Fuel Load, ¼- inch, tons/acre	2.9
Live Fuel Load, Foliage, tons/acre	0
Fuel bed depth, feet	0.2

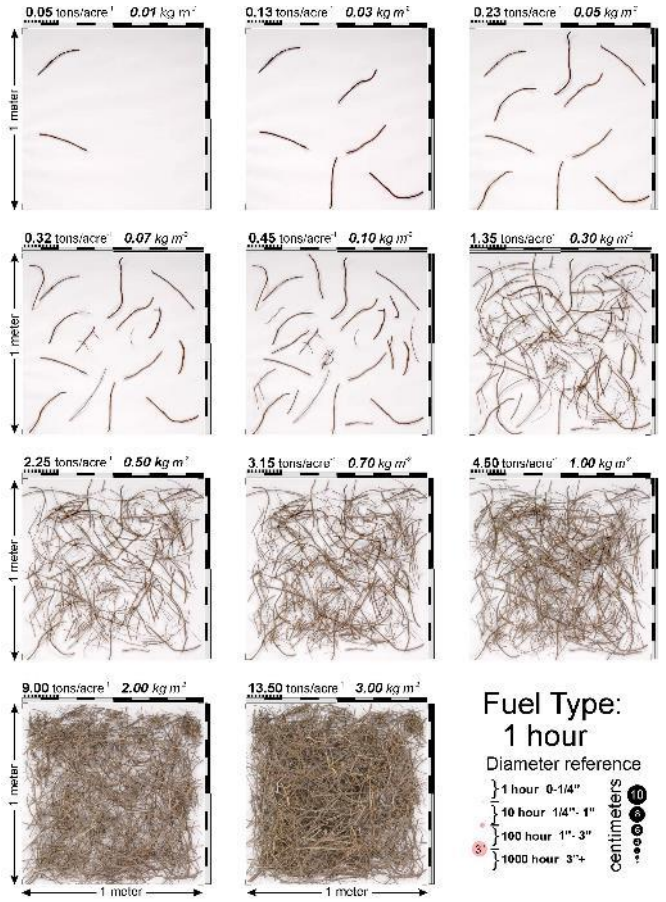
Fuel Model 10 13% of project area

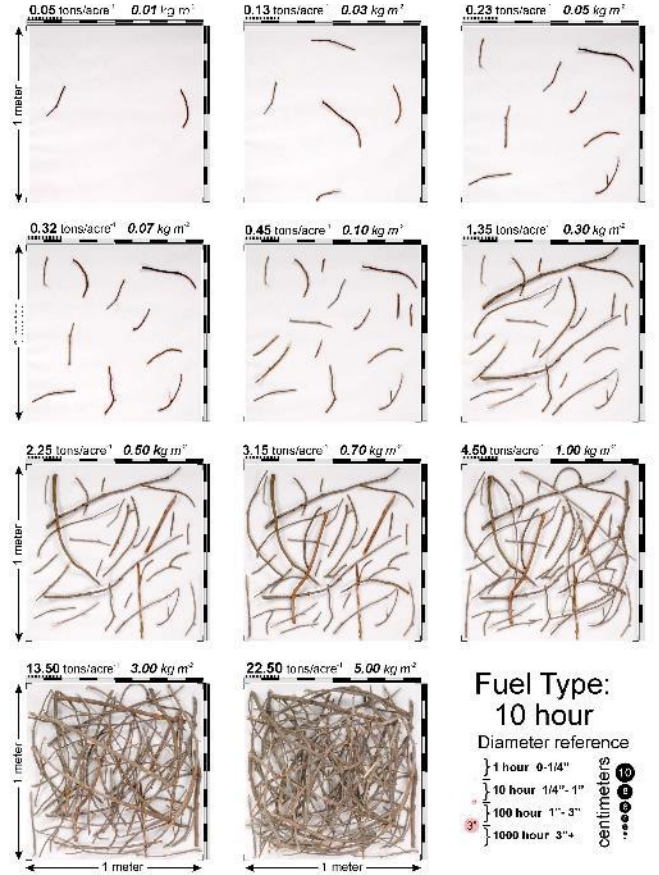
Total Fuel Load, < 3-inch dead and live, tons/acre	12.0
Dead Fuel Load, ¼- inch, tons/acre	3.0
Live Fuel Load, Foliage, tons/acre	2.0
Fuel bed depth, feet	1.0

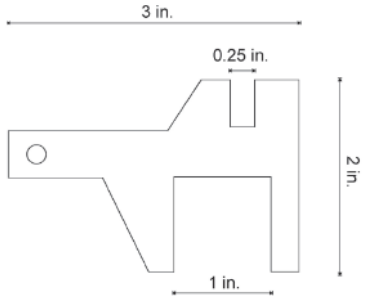
Dead woody class			Piece diameter	Piece diameter
			inches	*cm*
DWD				
	FWD	1-hr	0–0.25	0–0.6
		10-hr	0.25–1.0	0.6–2.5
		100-hr	1.0–3.0	2.5–8.0
	CWD	1,000-hr and greater	3.0 and greater	8.0 and greater



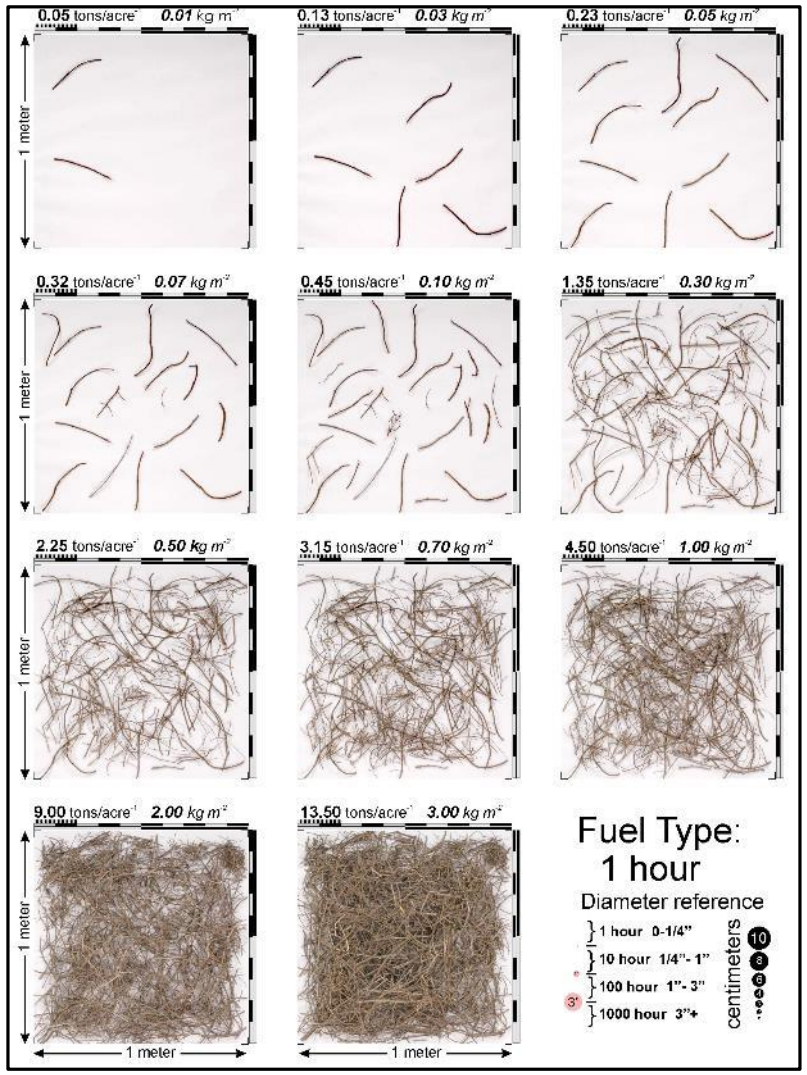
Photoload: Visual fuels estimation method

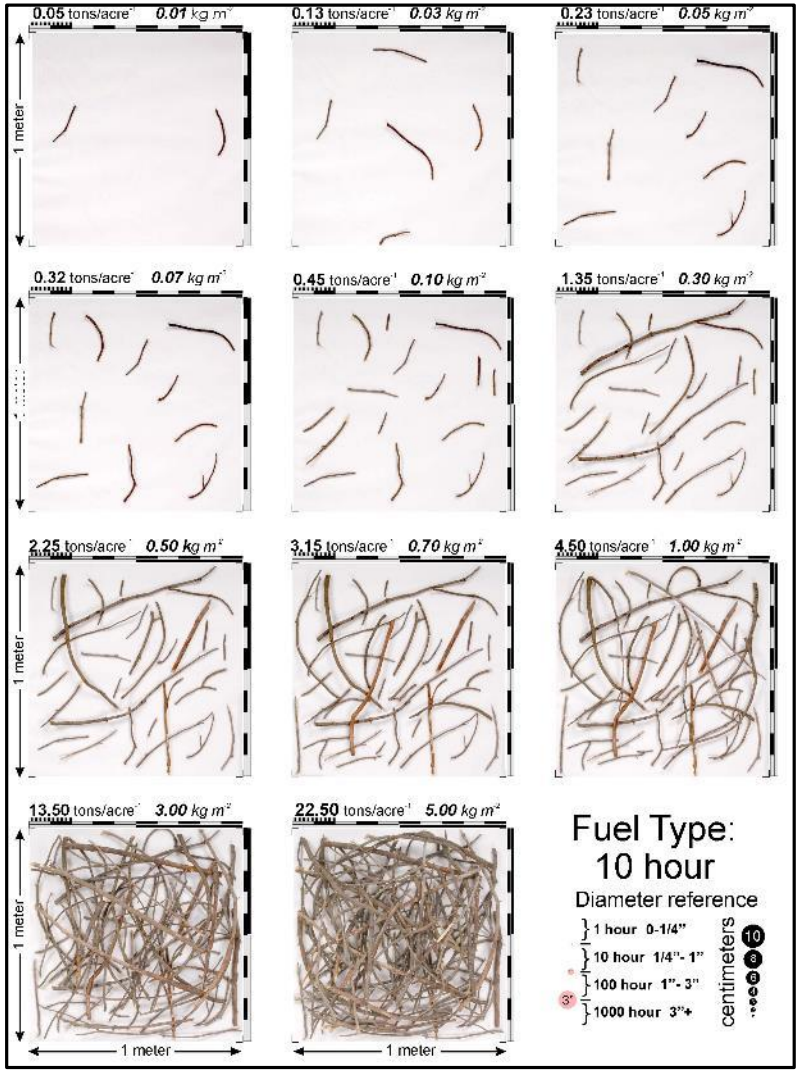


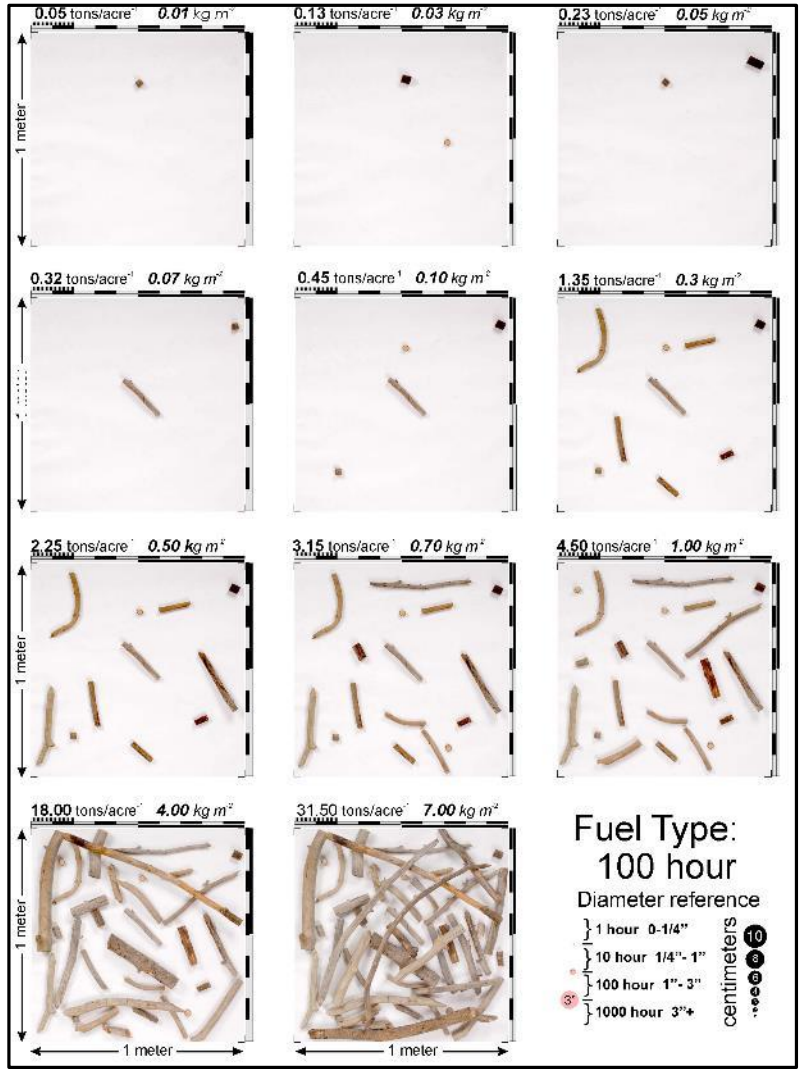




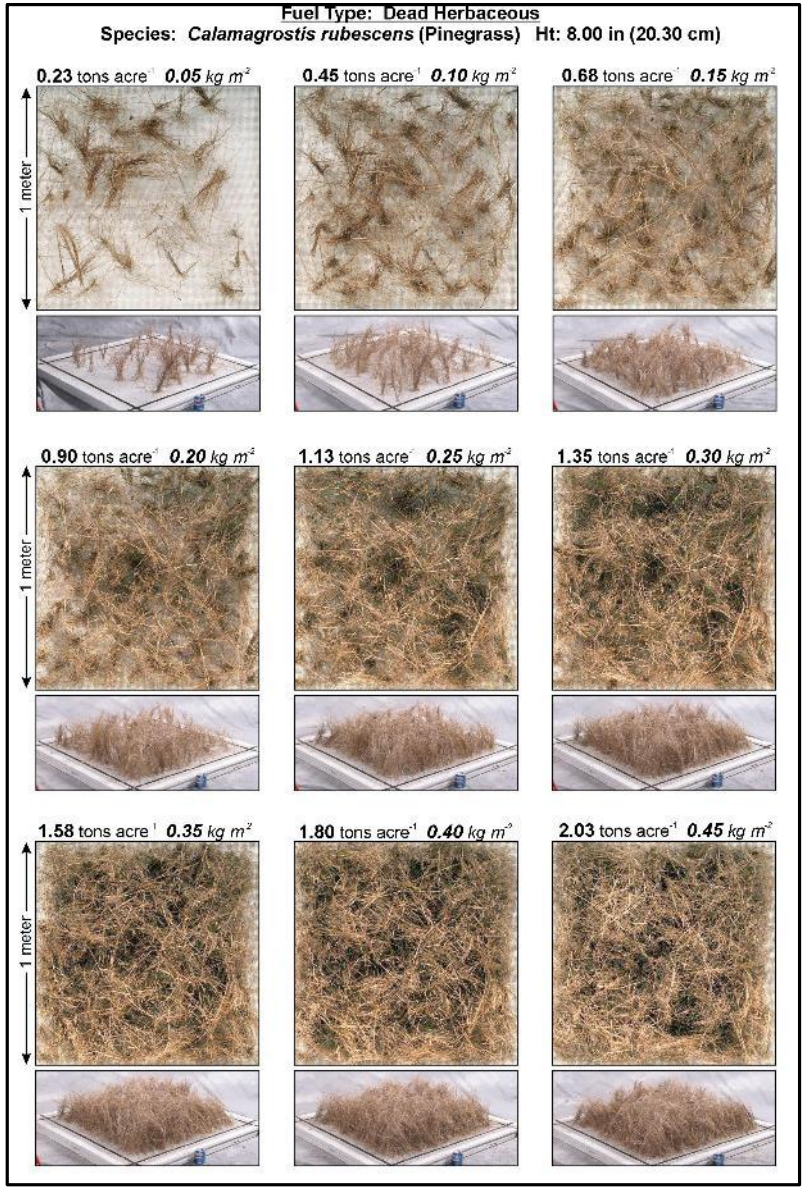
Photoload: 1, 10, and 100-hour fuels

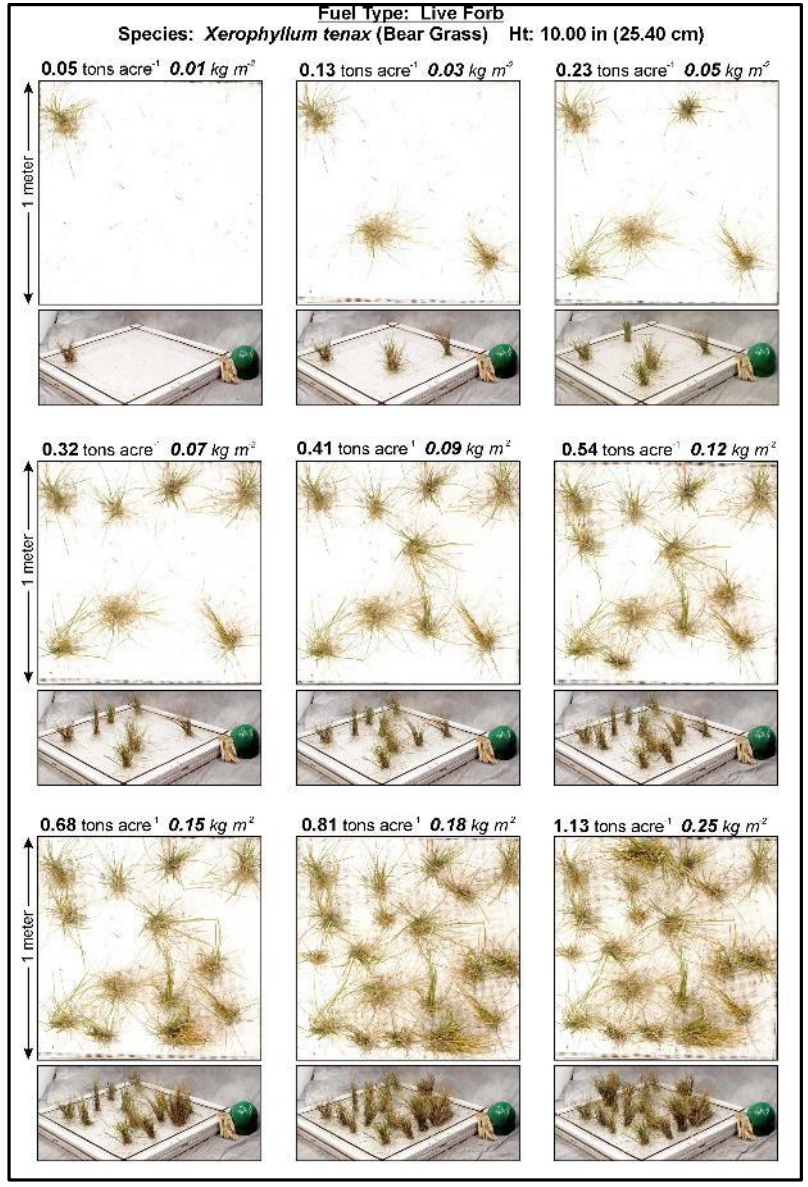


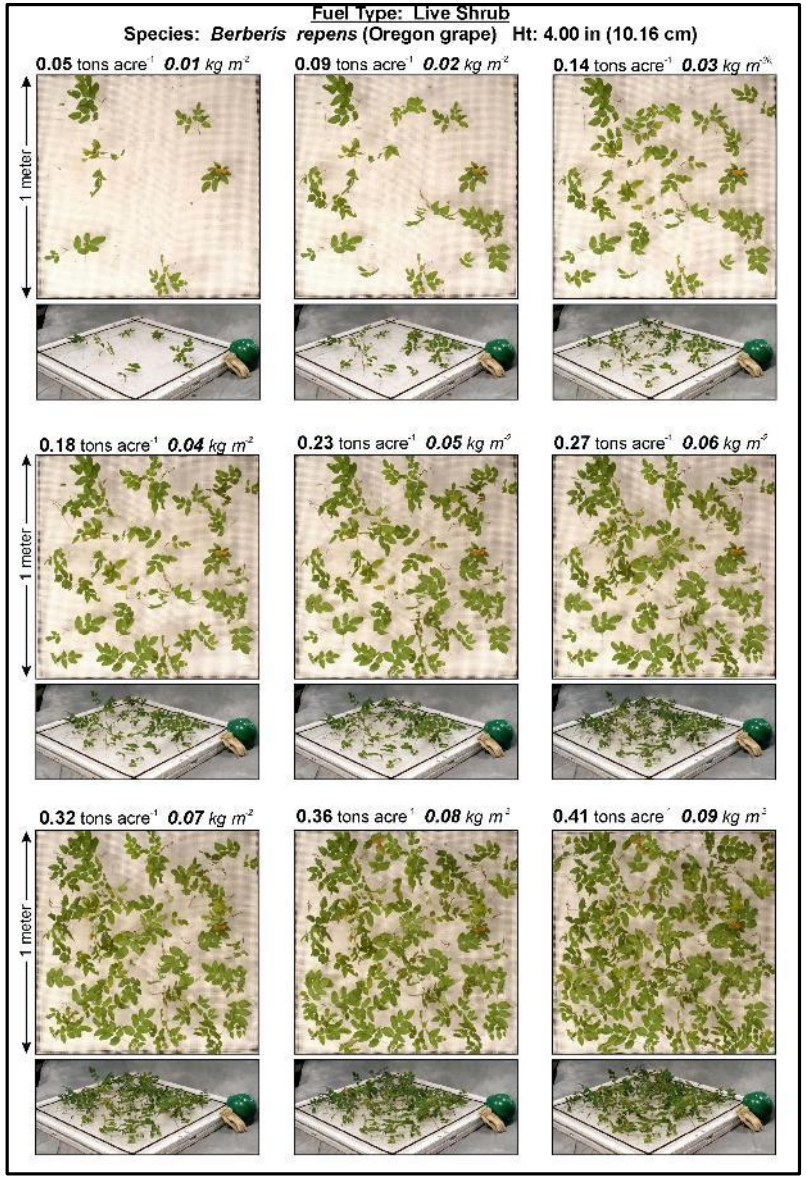




Photoload: Shrub and herbaceous fuels







Date: Examiner:

Sample Unit			Photoload Loadings (kg m^{-2} or T $acre^{-1}$)						
Stand	Plot	Subplot	1hr	10hr	100hr	1000hr	Shrub	Herb	Other

Consider several plots per site to capture range of conditions

Pre-fire loadings

Immediate post-fire loadings

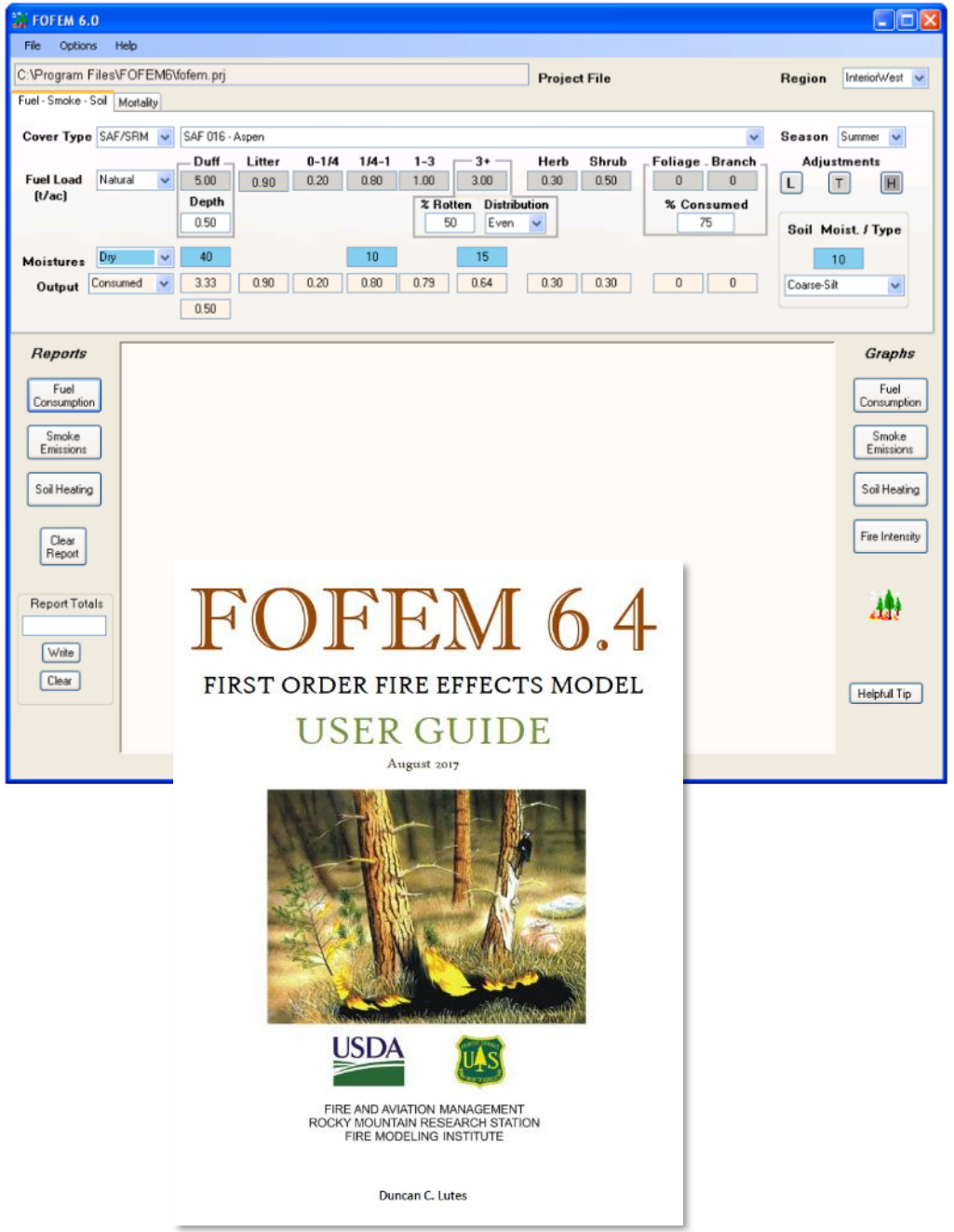
1 year post-fire loadings

FOFEM: First Order Fire Effects Model

https://www.firelab.org/project/fofem

First order fire effects – immediate, direct or indirect consequences of a fire.

FOFEM tool calculates consequences for prescribed fire or wildfire using four separate metrics: **tree mortality, fuel consumption, emissions or smoke production, and soil heating**.



Inputs

- Geographical region
- Forest type
- Season of burn and general burning conditions
- Fuel type, fuel loading by size class, fuel moisture
- Duff depth and moisture
- Soil texture and soil moisture percentage

Outputs

- Preburn fuel loading, fuel consumed, postburn loading
- Tree mortality by species and size, pre- and postfire canopy cover
- Mineral soil exposure
- Emissions from flaming and smoldering combustion
- Soil layer maximum temperatures and duration of heating

TITLE: Results of FOFEM model execution on date: 10/1/2012

FUEL CONSUMPTION CALCULATIONS

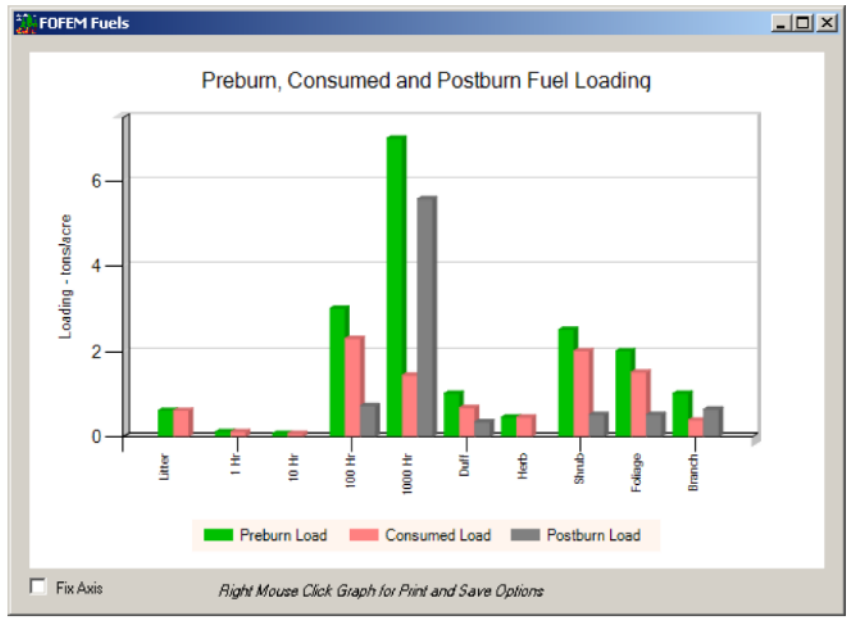
Region: PacificWest
Cover Type: SRM 210 - Bitterbrush
Fuel Type: Natural
Fuel Reference: PMS-830

FUEL CONSUMPTION TABLE

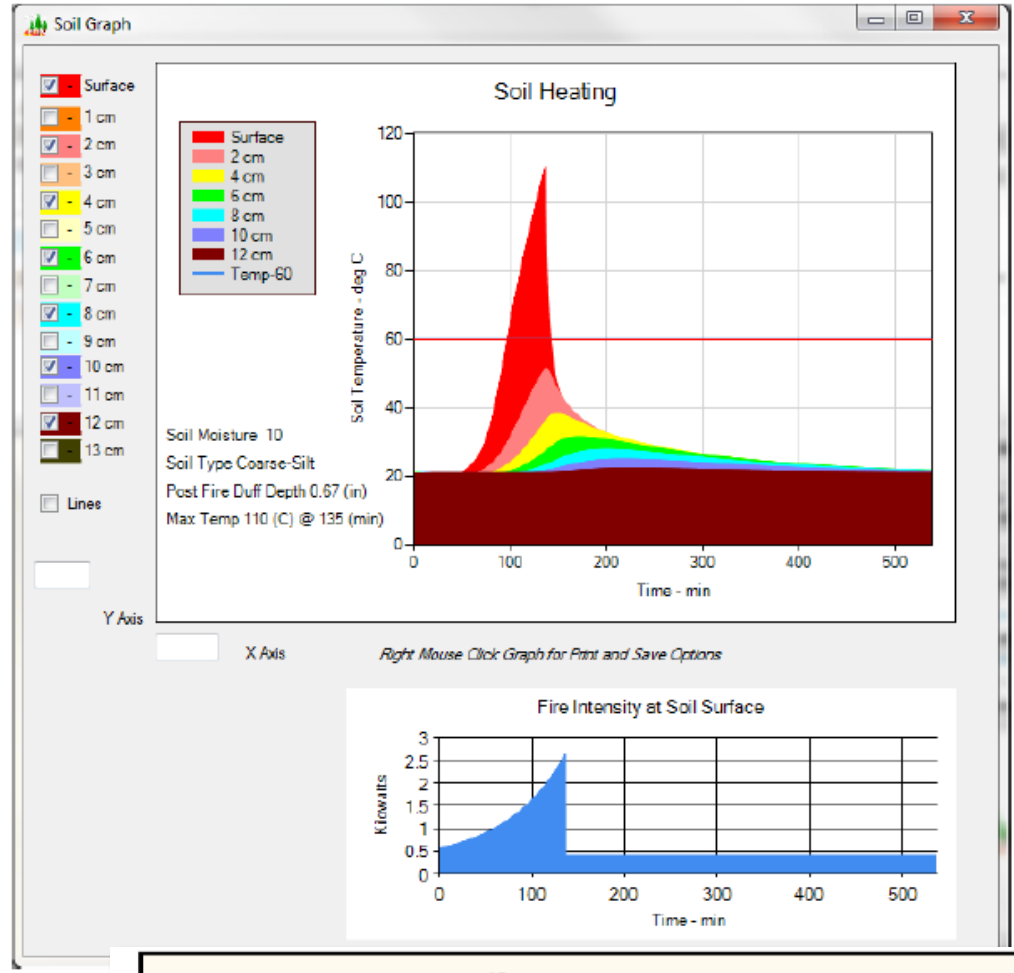
Fuel Component Name	Preburn Load (t/acre)		Consumed Load (t/acre)	Postburn Load (t/acre)	Percent Reduced (%)	Equation Reference Number	Moist. (%)
Litter	0.60	u	0.60	0.00	100.0	999	
Wood (0-1/4 inch)	0.15	+	0.15	0.00	100.0	999	
Wood (1/4-1 inch)	0.06		0.06	0.00	100.0	999	10.0
Wood (1-3 inch)	3.00	u	2.29	0.71	76.5	999	
Wood (3+ inch) Sound	3.50	u	0.49	3.01	14.0	999	15.0
3->6	0.88		0.28	0.59	32.4		
6->9	0.88		0.12	0.76	13.6		
9->20	0.88		0.06	0.81	7.2		
20->	0.88		0.03	0.85	2.9		
Wood (3+ inch) Rotten	3.50	u	0.94	2.56	26.8	999	15.0
3->6	0.88		0.46	0.42	52.5		
6->9	0.88		0.26	0.61	30.1		
9->20	0.88		0.15	0.73	17.1		
20->	0.88		0.07	0.81	7.6		
Duff	1.00	u	0.67	0.33	66.7	2	40.0
Herbaceous	0.44		0.44	0.00	100.0	22	
Shrubs							
Crown foliage							
Crown branchwood							
Total Fuels							

'u' Preburn Load is
'+' Preburn Load is
'-' Preburn Load is

Fuel Consumption Graph



Soil Heating Graph



Soil Heat Report

Region: InteriorWest
Cover Type: SAF 213 - Grand Fir
Fuel Type: Natural
Fuel Reference: FOFEM 071
Duff Depth.....: Pre-Fire: 3.56 cm., Post-Fire: 0.73 cm.

Soil Layer Maximum Temperature

Depth (cm)	0	1	2	3	4	5	6	7	8	9	10	11	12	13
Temp (C)	223	173	129	99	73	68	63	57	52	46	40	33	27	21
Time (min)	165	176	209	221	223	227	238	248	257	265	272	277	280	1

Max Depth Having 60 degrees: 6
Max Depth Having 275 degrees: - None -

Why use FOFEM for archaeology?

Planning:
Model calculates expected fire effects from field conditions (your data)

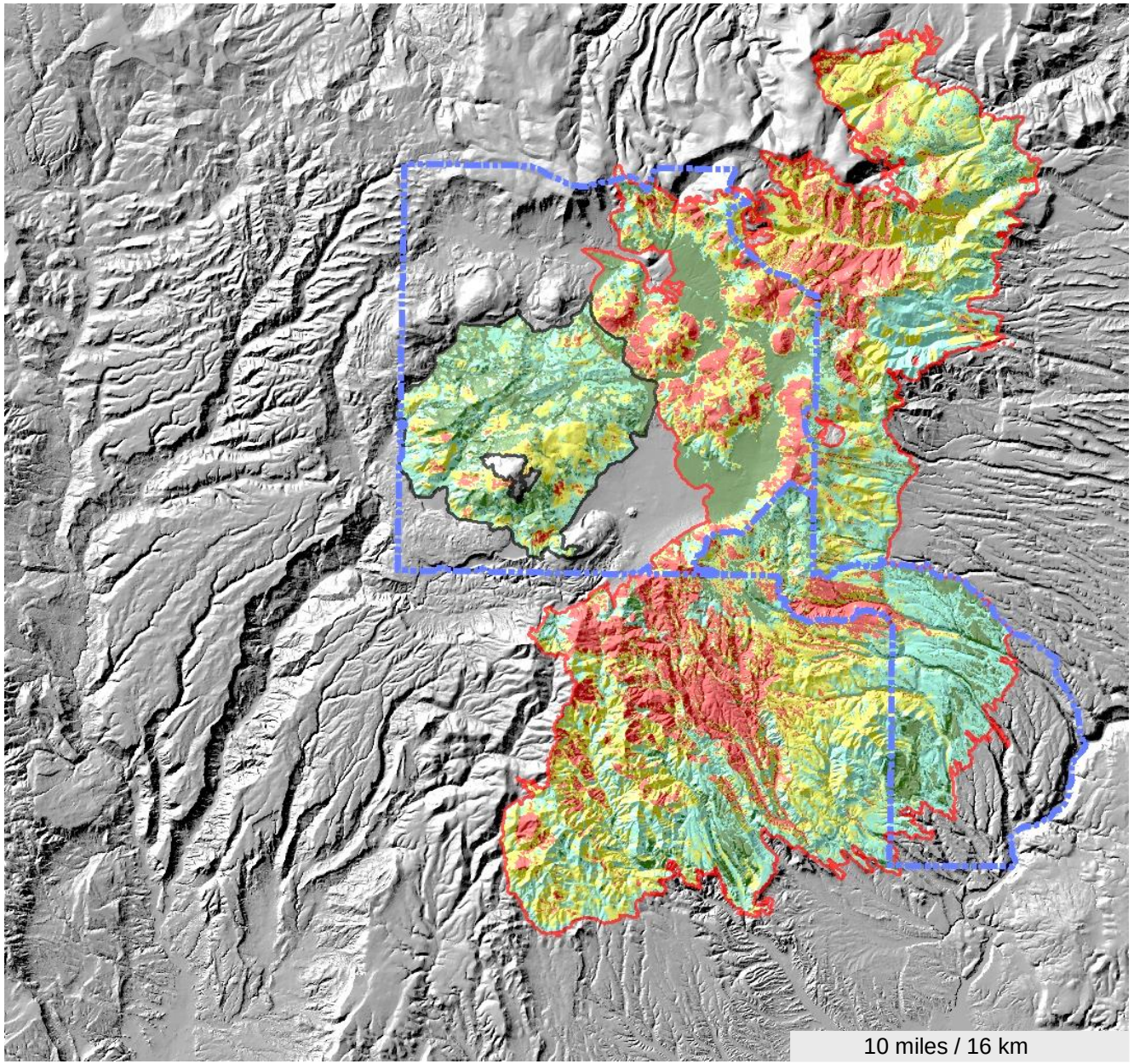
Prediction:
Model generates a range of field conditions that may lead to a specified set of desired (or unwanted) effects

Quantifies important fire effects for resource preservation – tree mortality, flame lengths, fuel consumption, surface and subsurface heating

Aids in design of post-fire surveys and rehabilitation projects – identify where greatest impacts might be

?? OTHER IDEAS ??

Post-fire Erosion Modeling: 2nd Order Effects



2011 Las Conchas Fire & 2013 Thompson Ridge Fire

Jemez Mountains, New Mexico

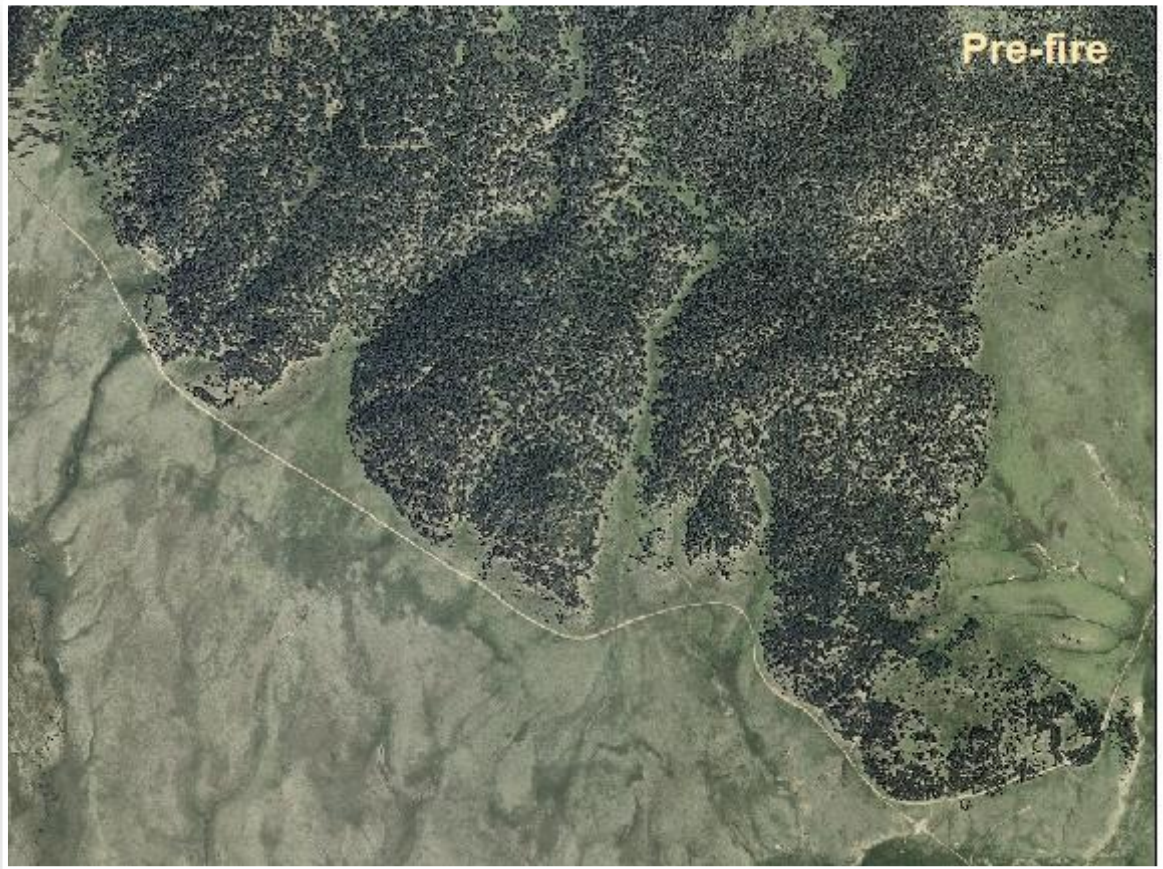
Burn Severity

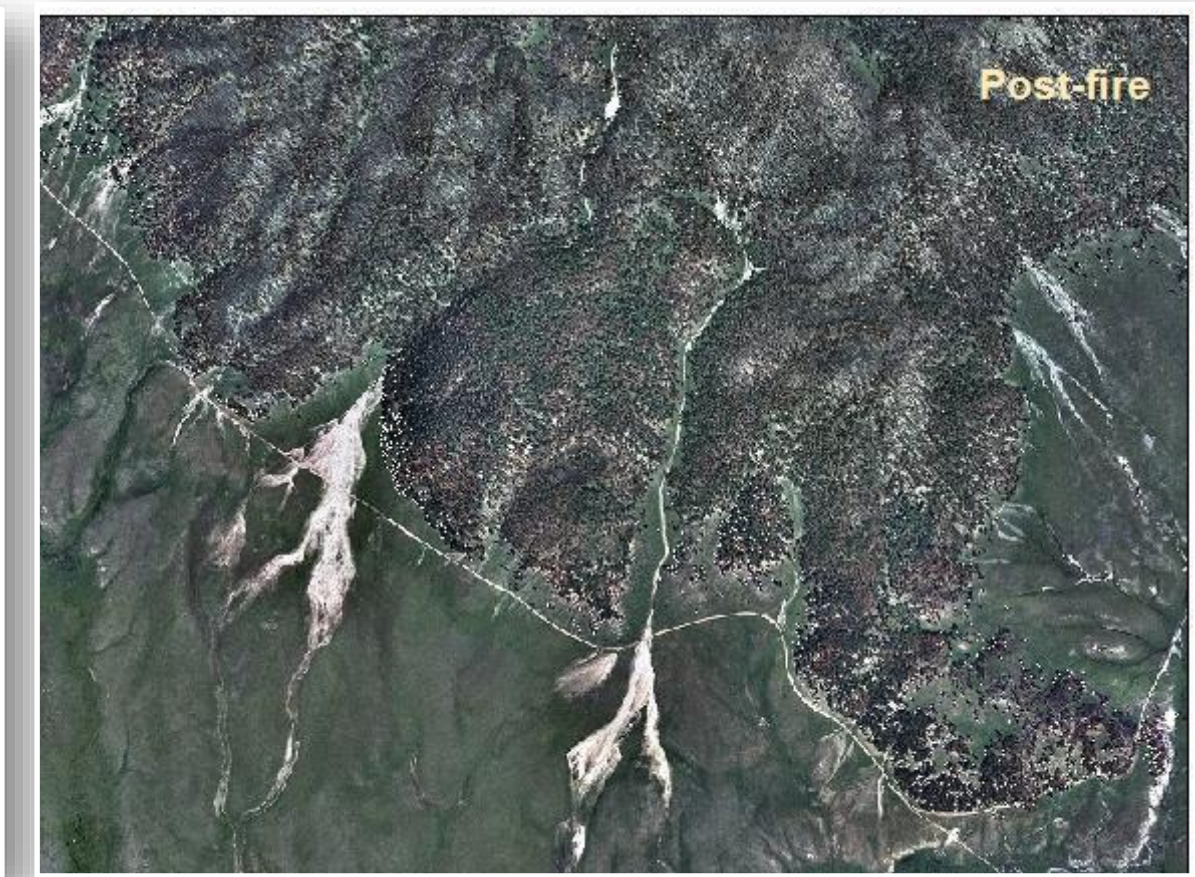
- High
- Moderate
- Low
- (unchanged)

Indirect effects: Post-fire erosion

Cerro del Medio post-fire debris flows

Cerro del Medio post-fire erosion fans





1 mile

1 km

VALLES CALDERA
NATIONAL PRESERVE

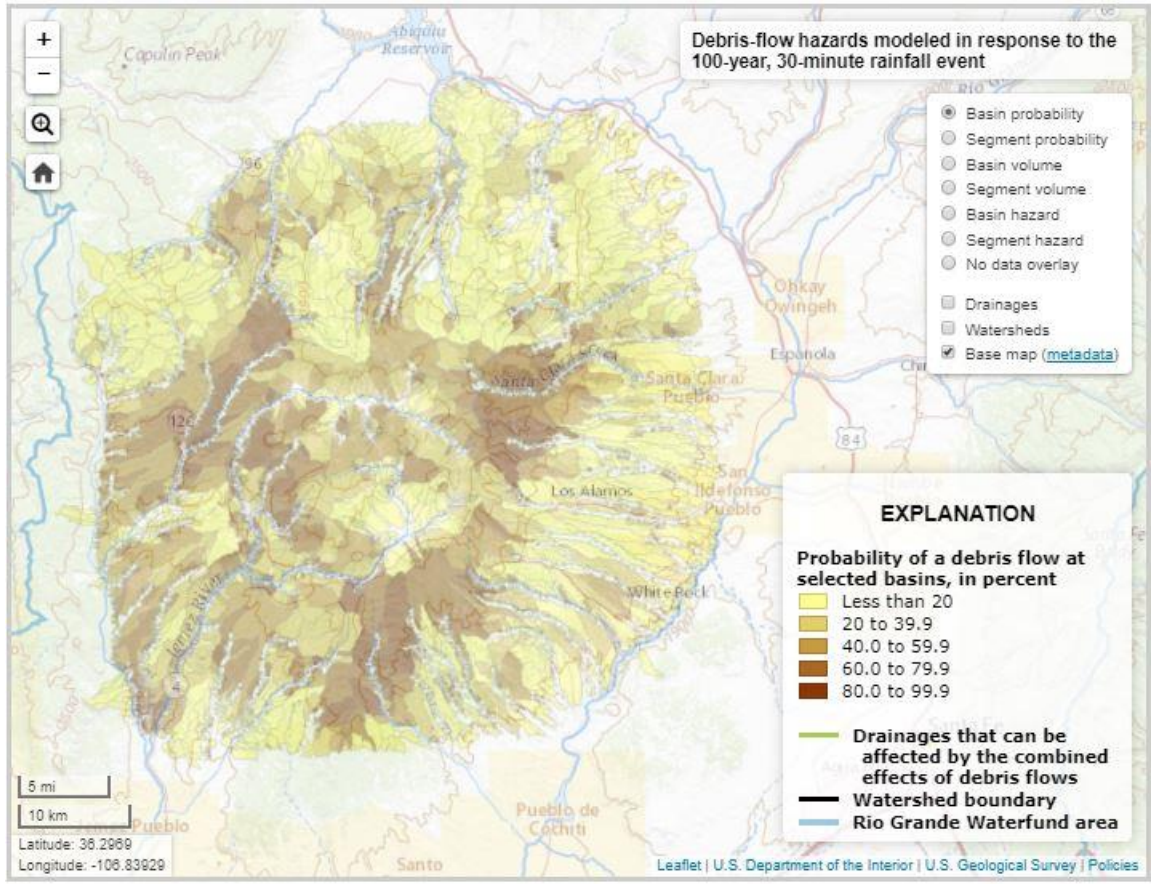
Cerro del Medio
post-fire erosion trenches

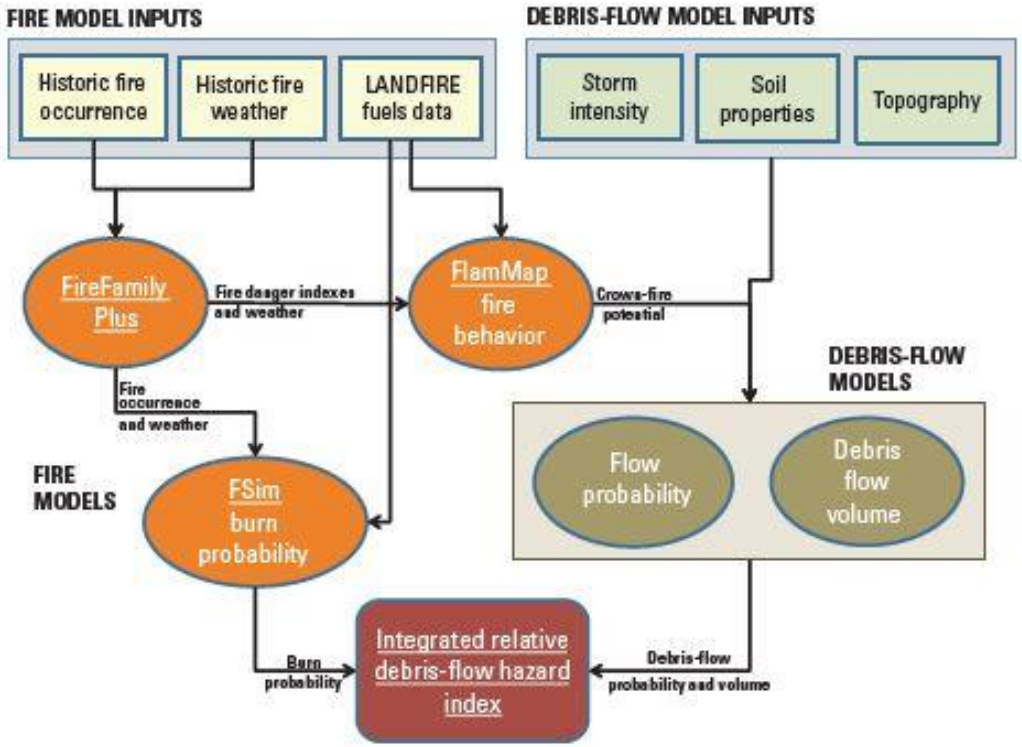
2011

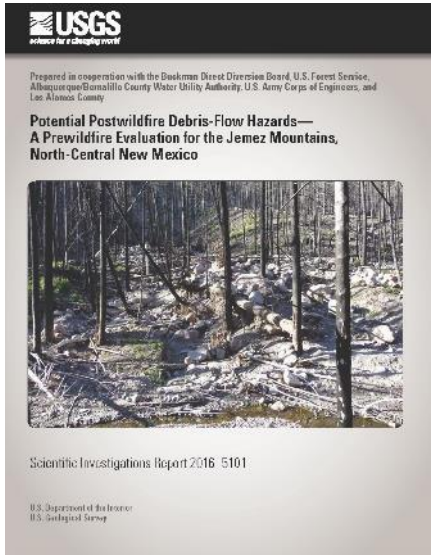
2012

2013

Modeling debris flow probability

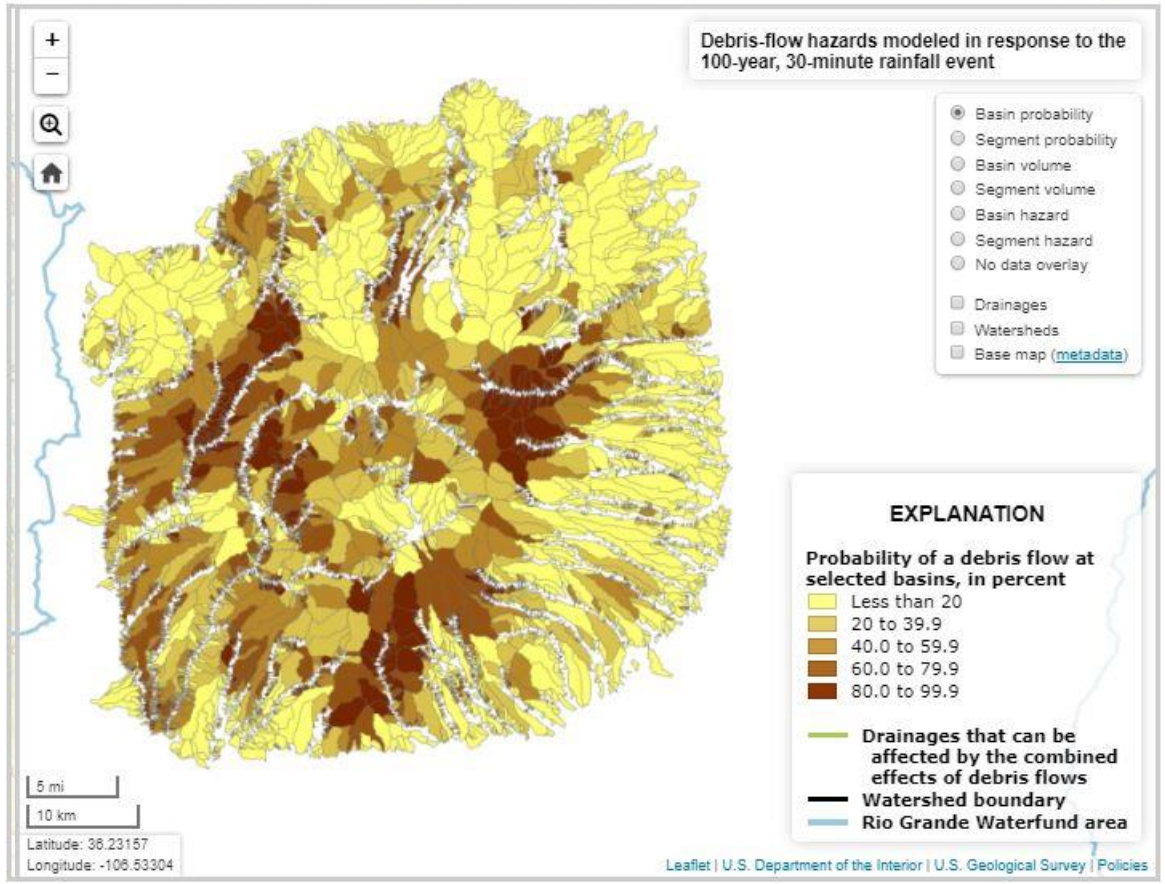


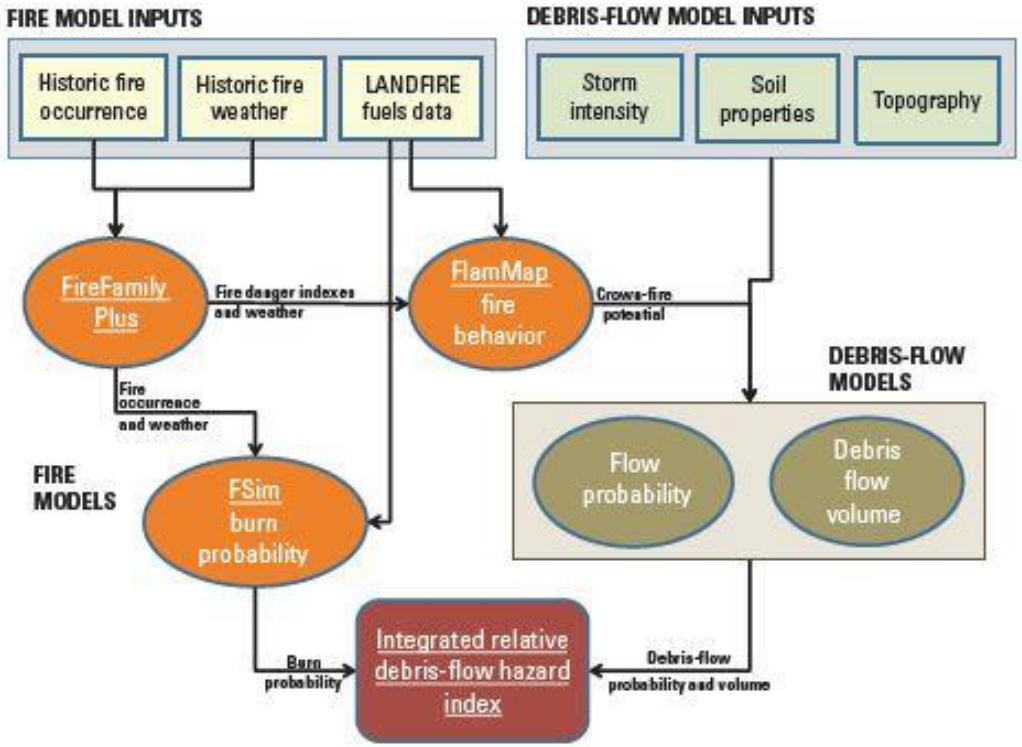


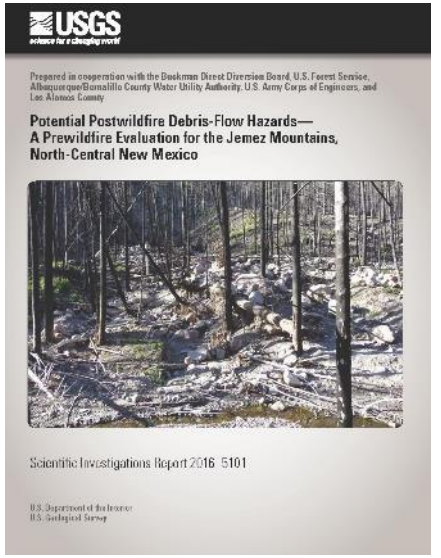


Tillery, A.C., and Haas, J.R., 2016, *Potential postwildfire debris-flow hazards—A prewildfire evaluation for the Jemez Mountains, north-central New Mexico: U.S. Geological Survey Scientific-Investigations Report 2016-5101* http://dx.doi.org/10.3133/sir20165101

Modeling debris flow probability







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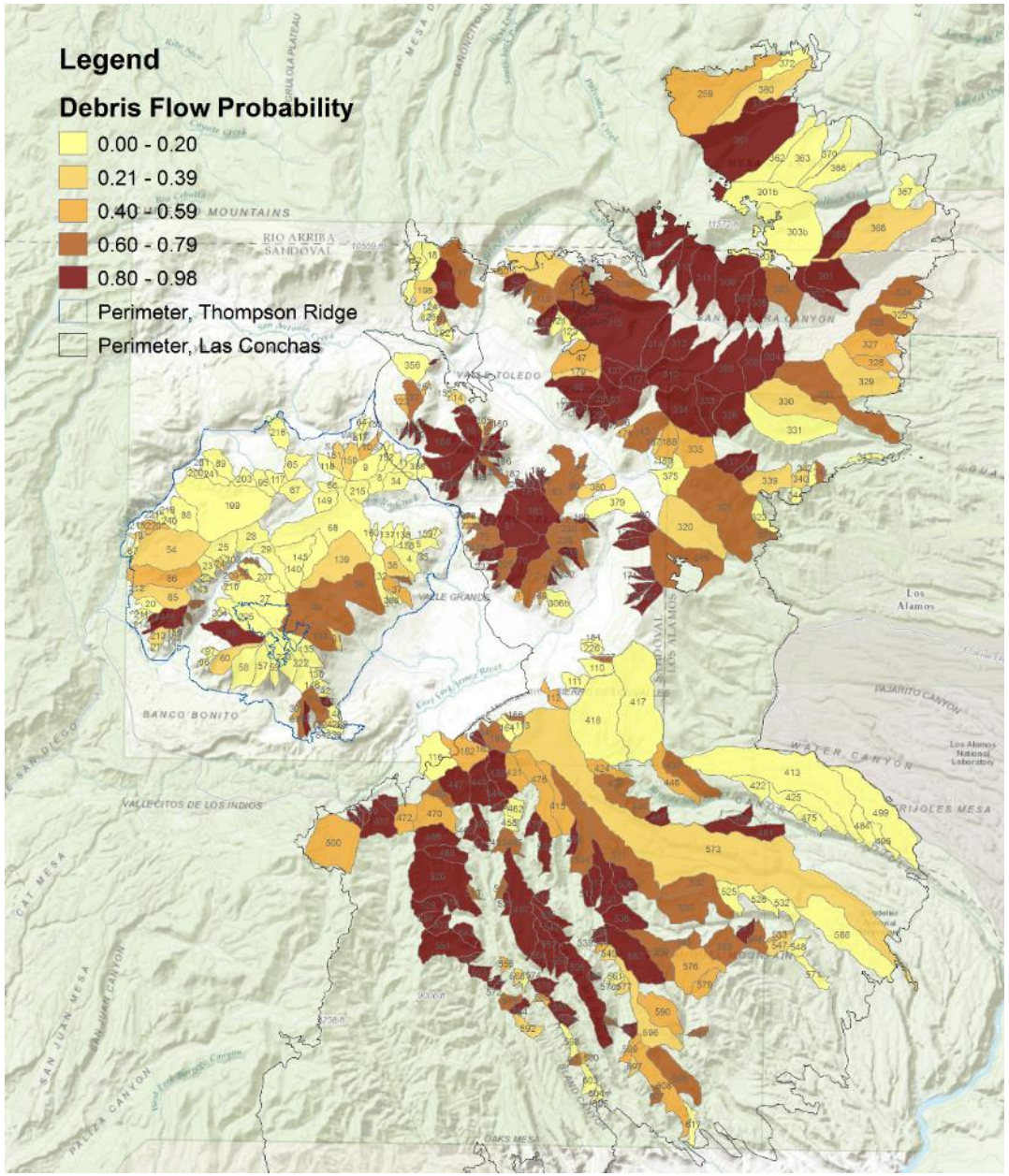
Modelling debris flow probability

Megan Friggens, USFS Rocky Mountain Research Station

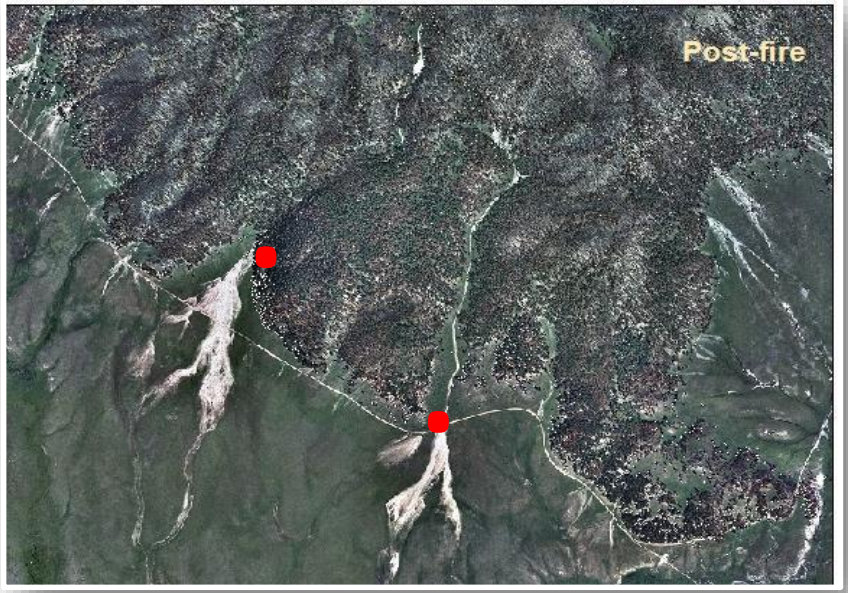
ArcBurn Project

Inputs:

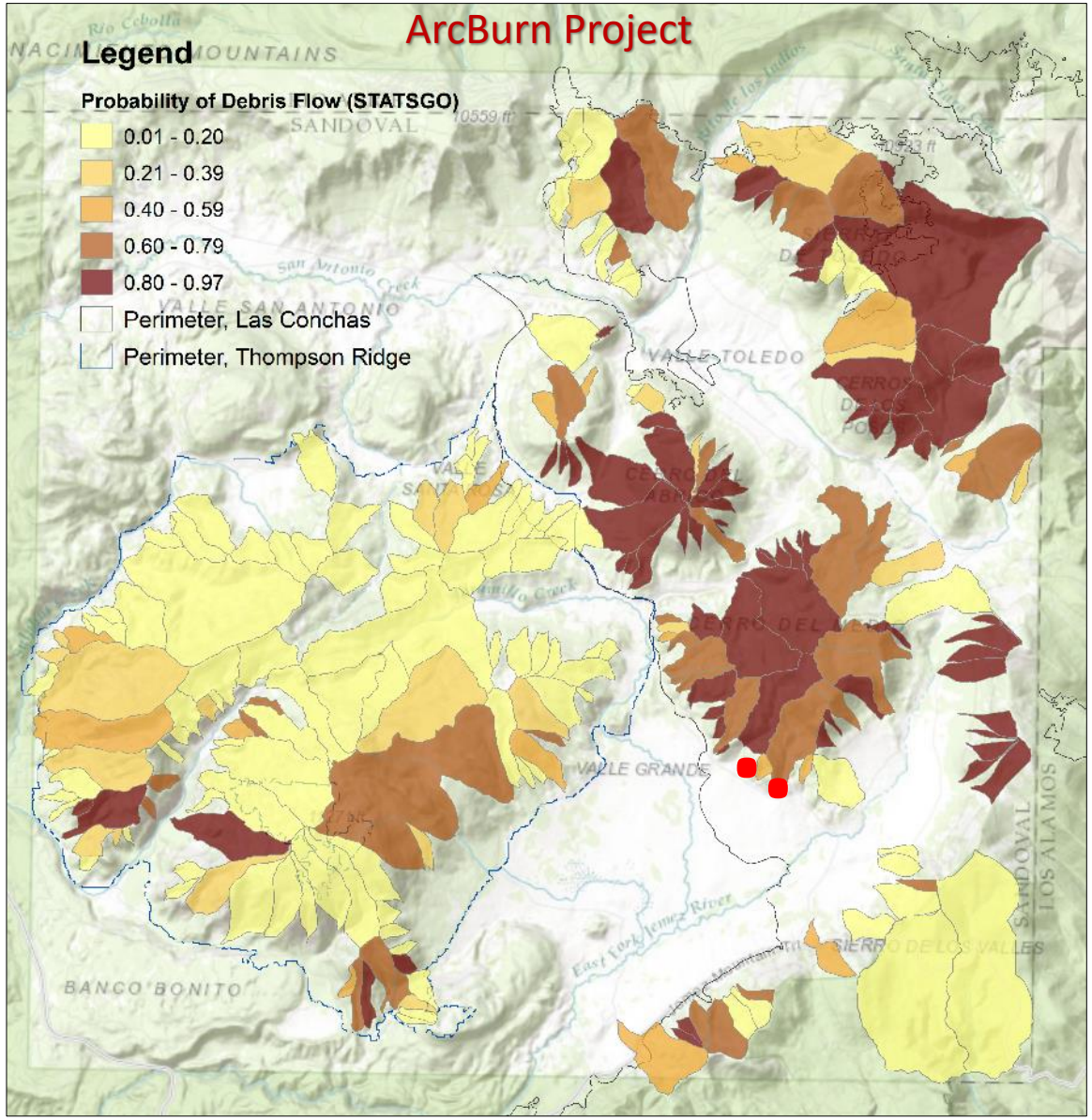
- Topography
- Watershed areas
  - Watershed Boundary Datasets: hydrologic units https://water.usgs.gov/GIS/huc.html
- Soils
  - Soils data for US: https://water.usgs.gov/GIS/metadata/usgswrd/XML//ussoils.xml
- Burn severity
- Range of precipitation conditions



- Identify sites at risk for erosion damage
- Understand past/prehistoric debris events



Megan Friggens, USFS Rocky Mountain Research Station



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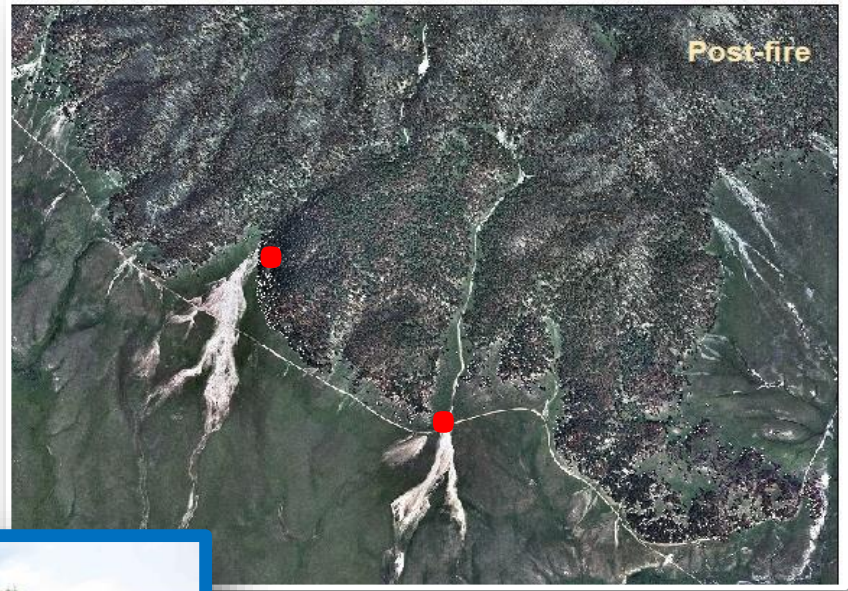

Megan Friggens, USFS Rocky Mountain Research Station