Burning pixels, points, and polygons

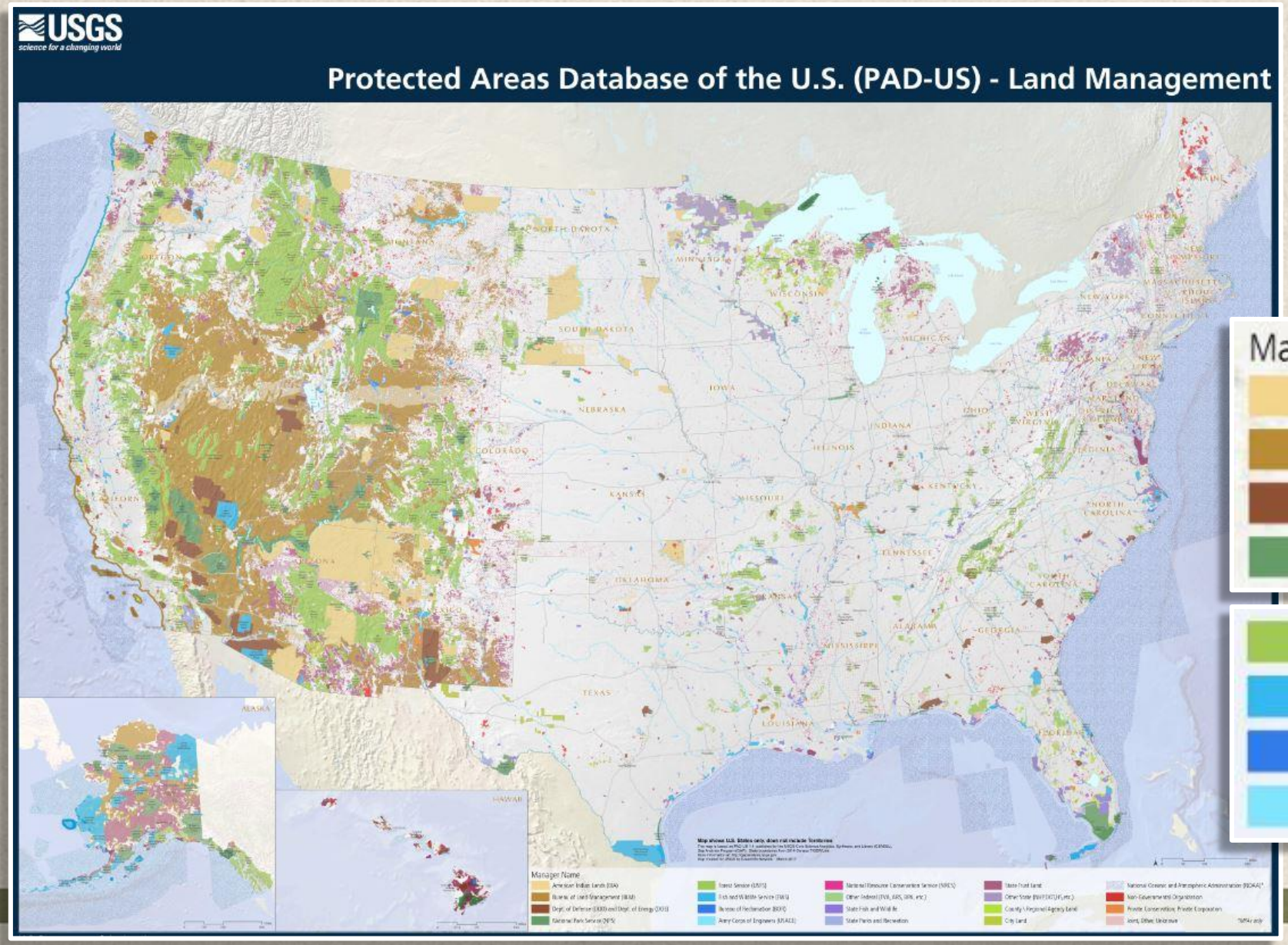
The role of spatial data in wildfire research and management in the U.S.

Greg Dillon
USDA Forest Service, Rocky Mountain Research Station, Fire Modeling Institute
Missoula, Montana, USA

Universität Bayreuth
BayCEER Kolloquium
Bayreuth, Germany
July 18, 2019

United States Department of Agriculture
Forest Service

Land Management Agencies in the U.S.



Wildfire in the U.S.

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Outline for today…

- Context: A brief history of wildfire management and research in the U.S.
- Current Research: The Missoula Fire Sciences Lab
- A Culture Shift: Mapping wildfire hazard and risk

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Timeline of Wildfire Management

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U.S. Forest Service is founded under the Department of Agriculture

Photo: Forest History Society

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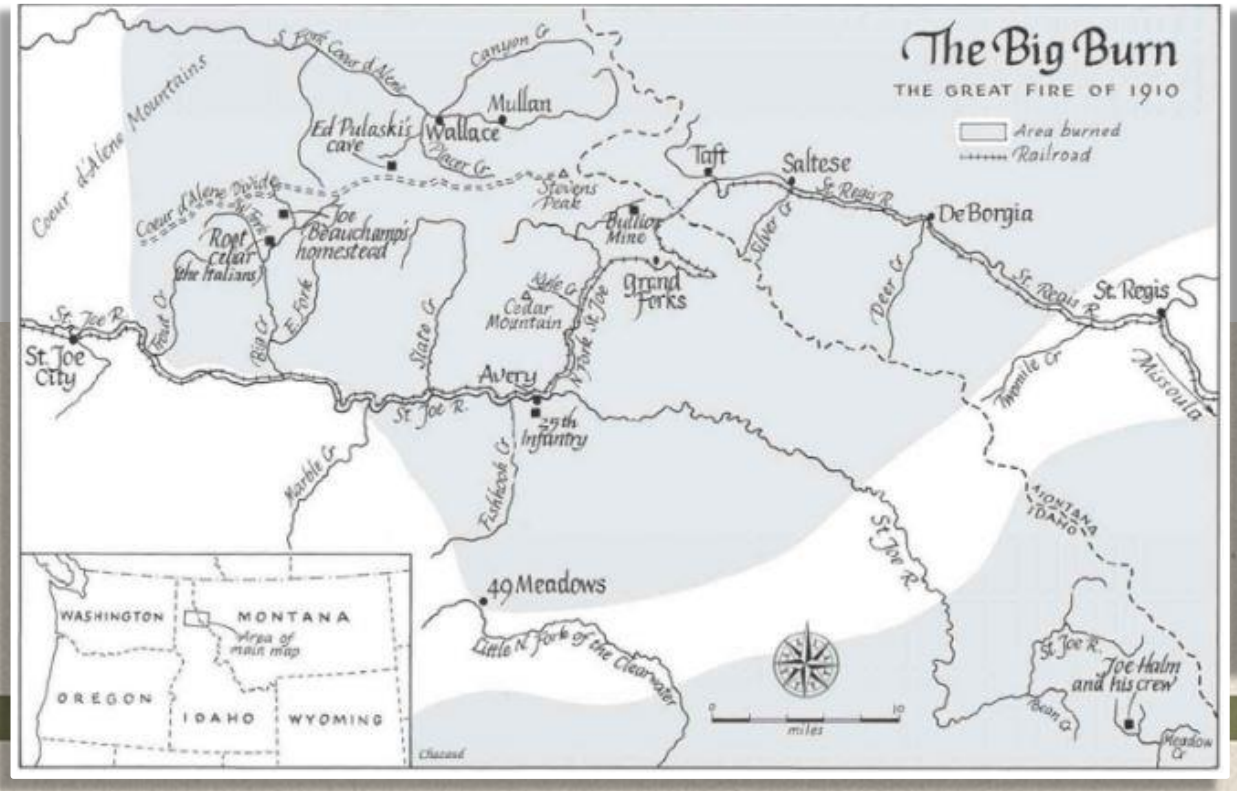
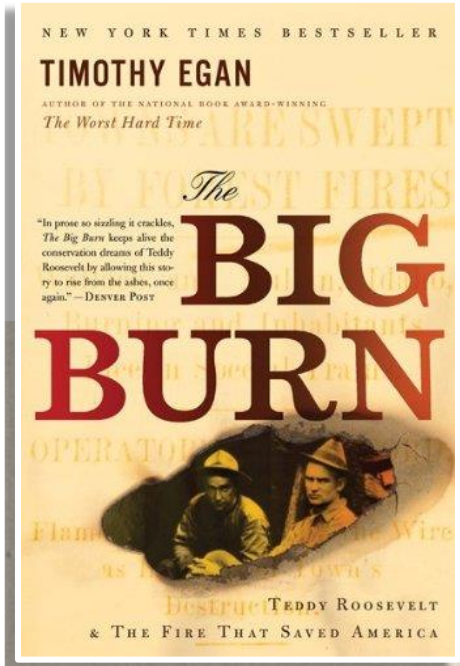
The Big Burn scorches 3 million acres of Montana and Idaho





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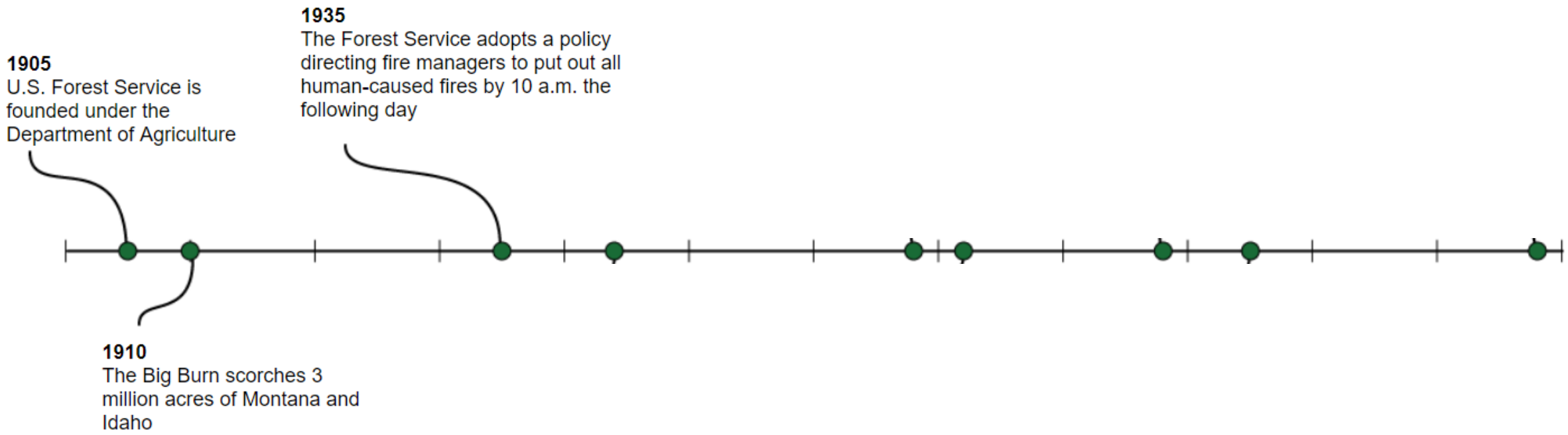

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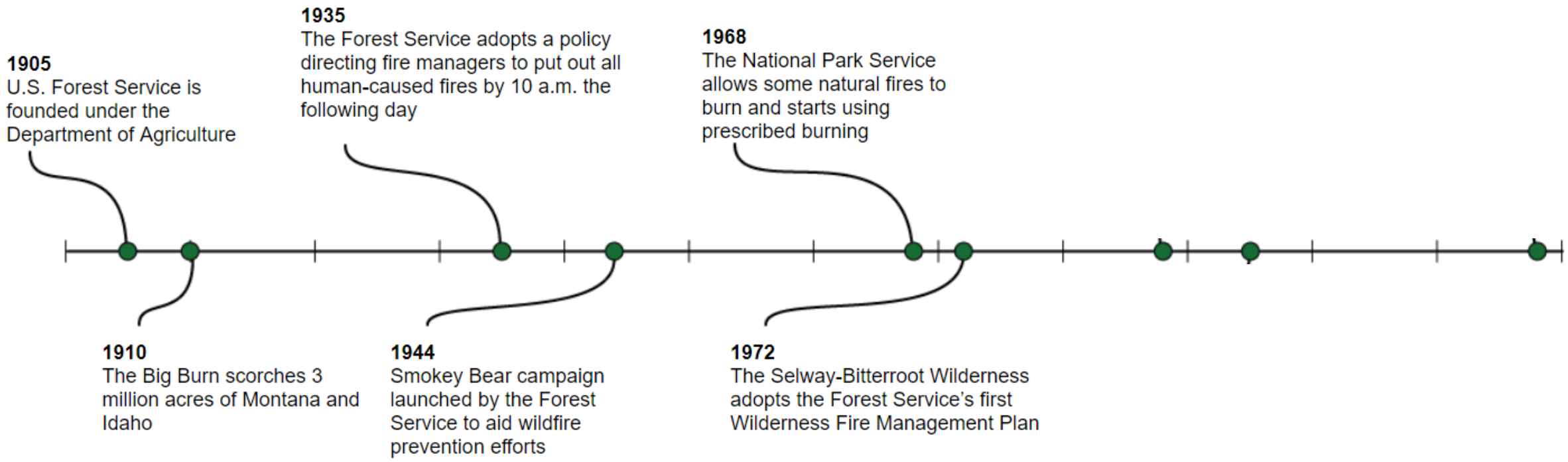
Smokey Bear campaign launched by the Forest Service to aid wildfire prevention efforts

Photos: Smokeybear.com

Timeline of Wildfire Management



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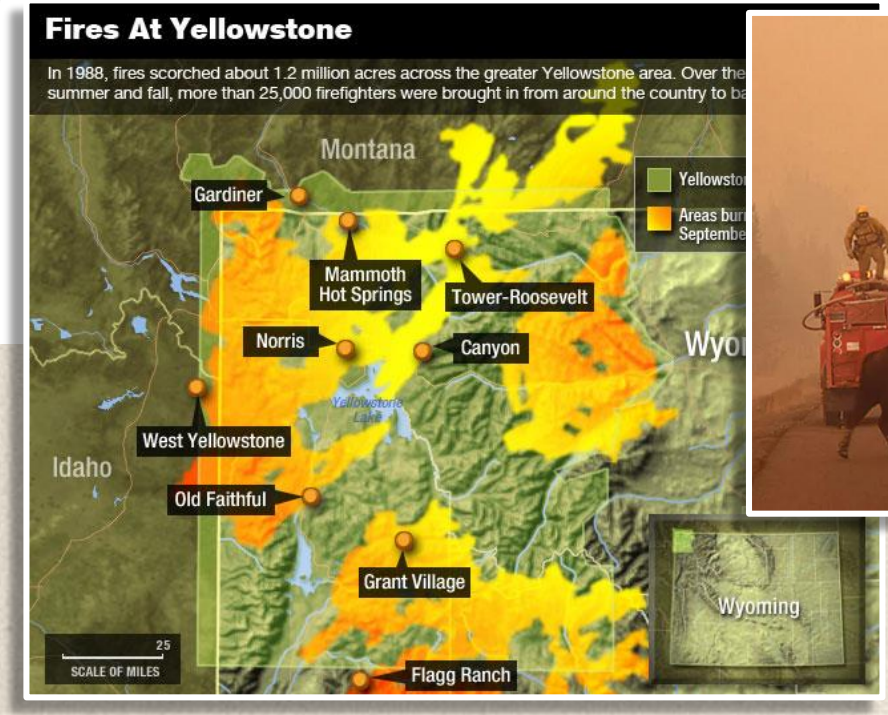
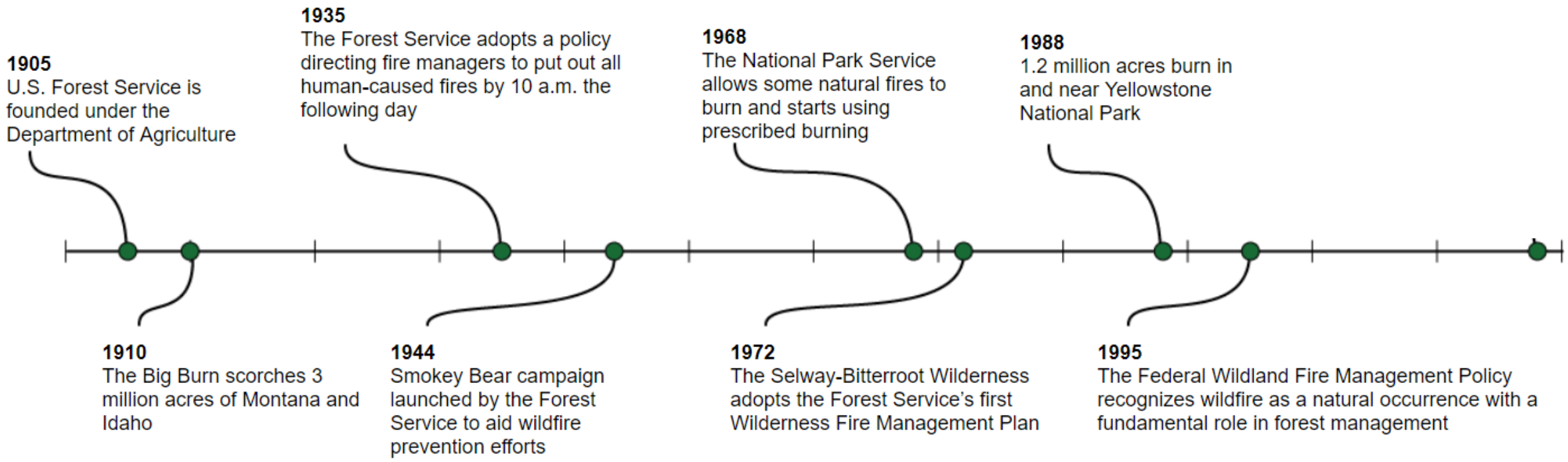
1.2 million acres burn in and near Yellowstone National Park



Photos: National Park Service
Map: NCPR

Photos: Smokeybear.com

Timeline of Wildfire Management



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The Selway-Bitterroot adopts the Forest Ser Wilderness Fire Mana

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2018
The federal government spends a record-breaking $3.1 billion on wildfire suppression

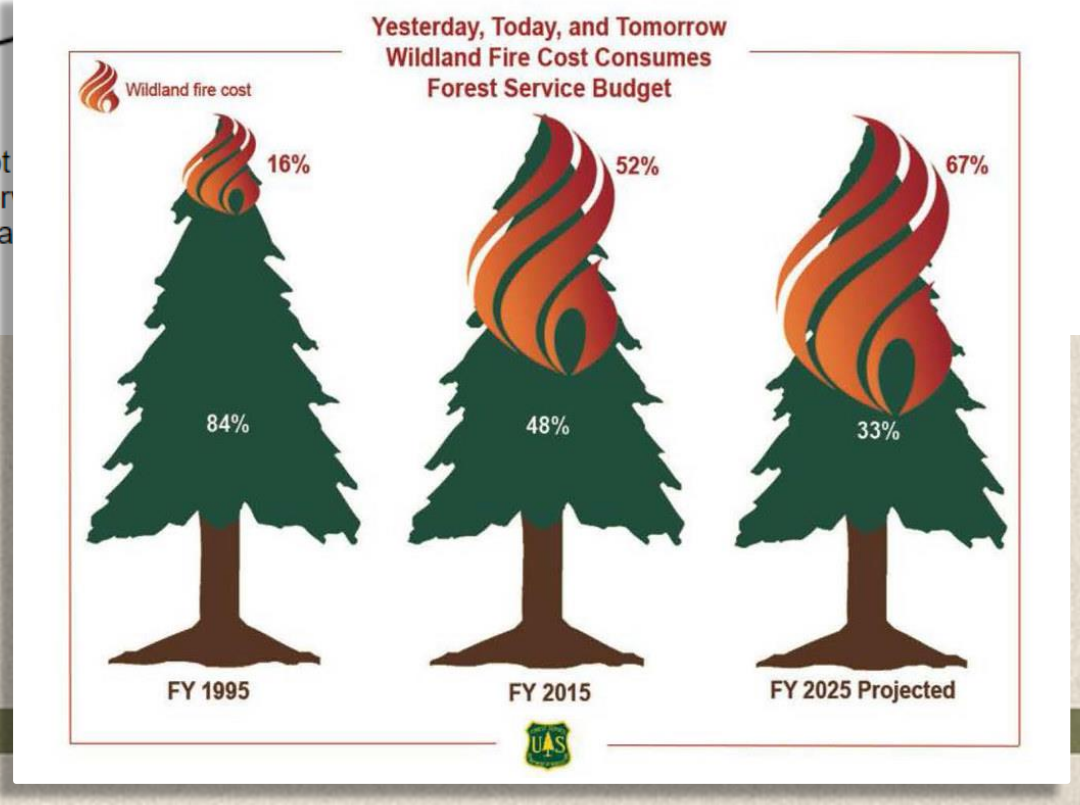

Image: USDA Forest Service

Timeline of Wildfire Research Spatial

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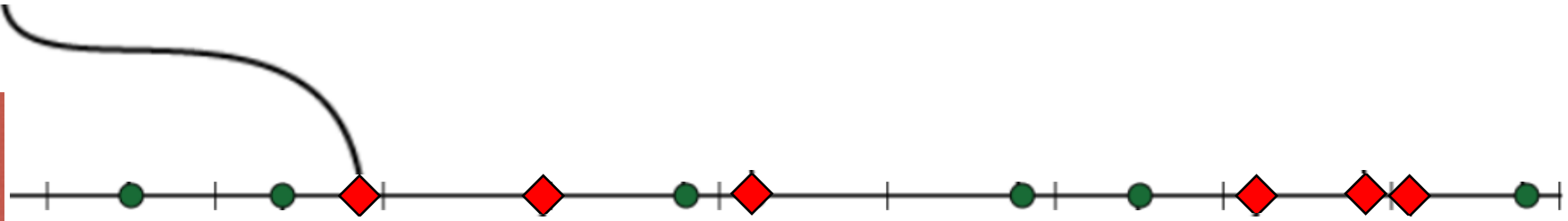
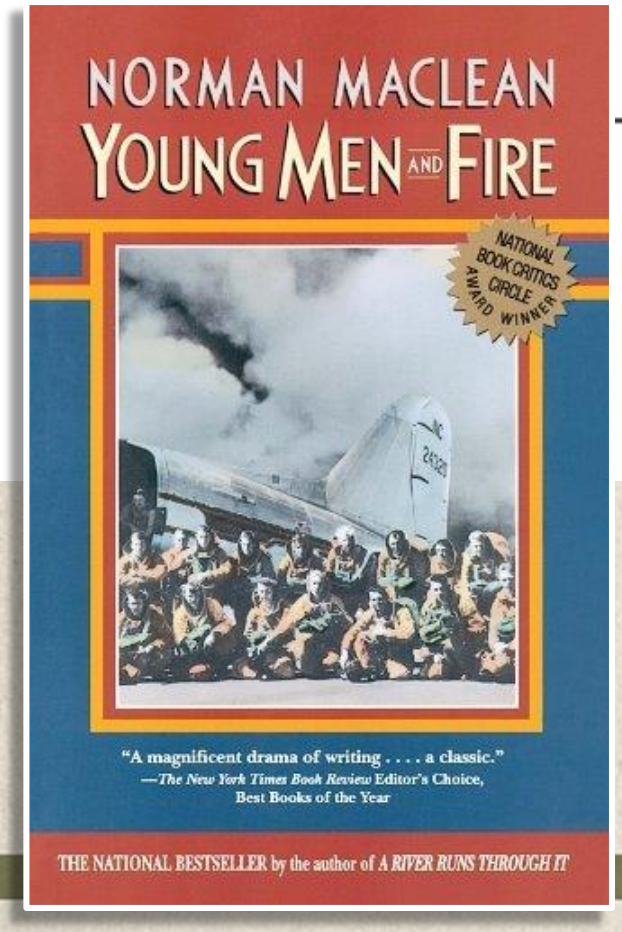
Mann Gulch Fire – First tragedy for Smokejumper program, 13 firefighters killed





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$$R = \frac{I_R \xi (1+\phi_w+\phi_s)}{\rho_b \epsilon Q_{ig}}$$

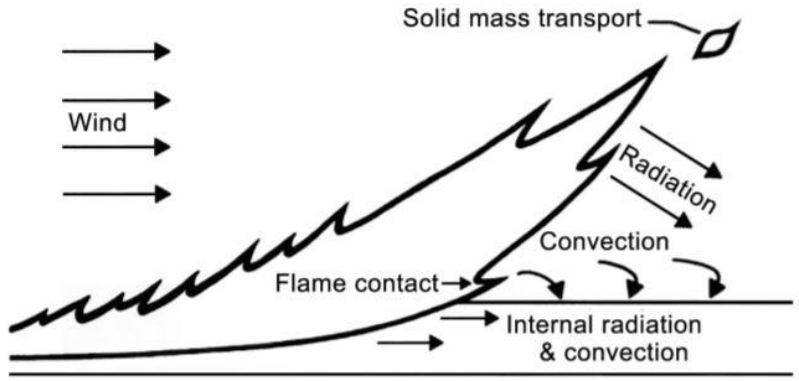

Image: Andrews 2018

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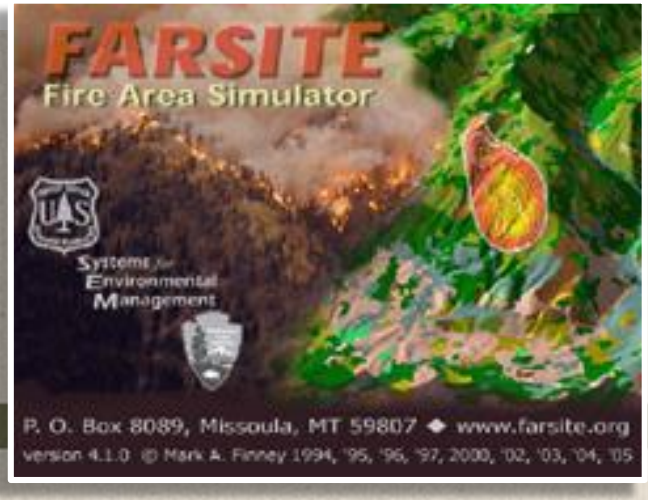

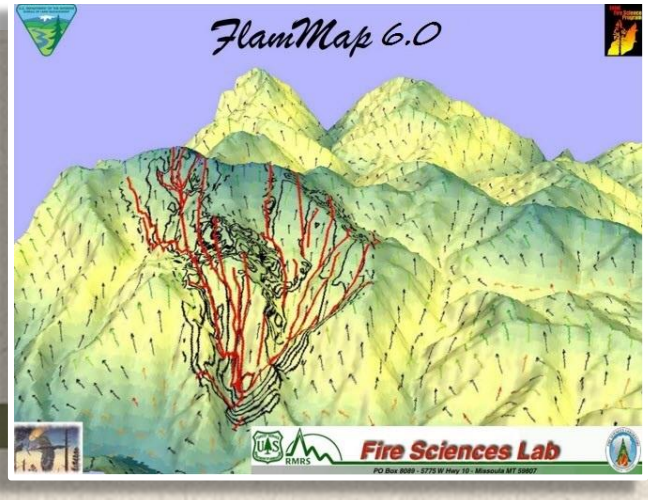

Images: USDA Forest Service

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LANDFIRE™

Images: LANDFIRE Program

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2010 - 2011
National Cohesive Wildland Fire Management Strategy

The National Cohesive Wildland Fire Management Strategy is a collaborative process to seek national, all-lands solutions to wildland fire management issues, focusing on three goals:

- Restore and maintain resilient landscapes;
- Create Fire Adapted Communities; and
- Safe and effective wildfire response

Images: Forestandrangelands.gov

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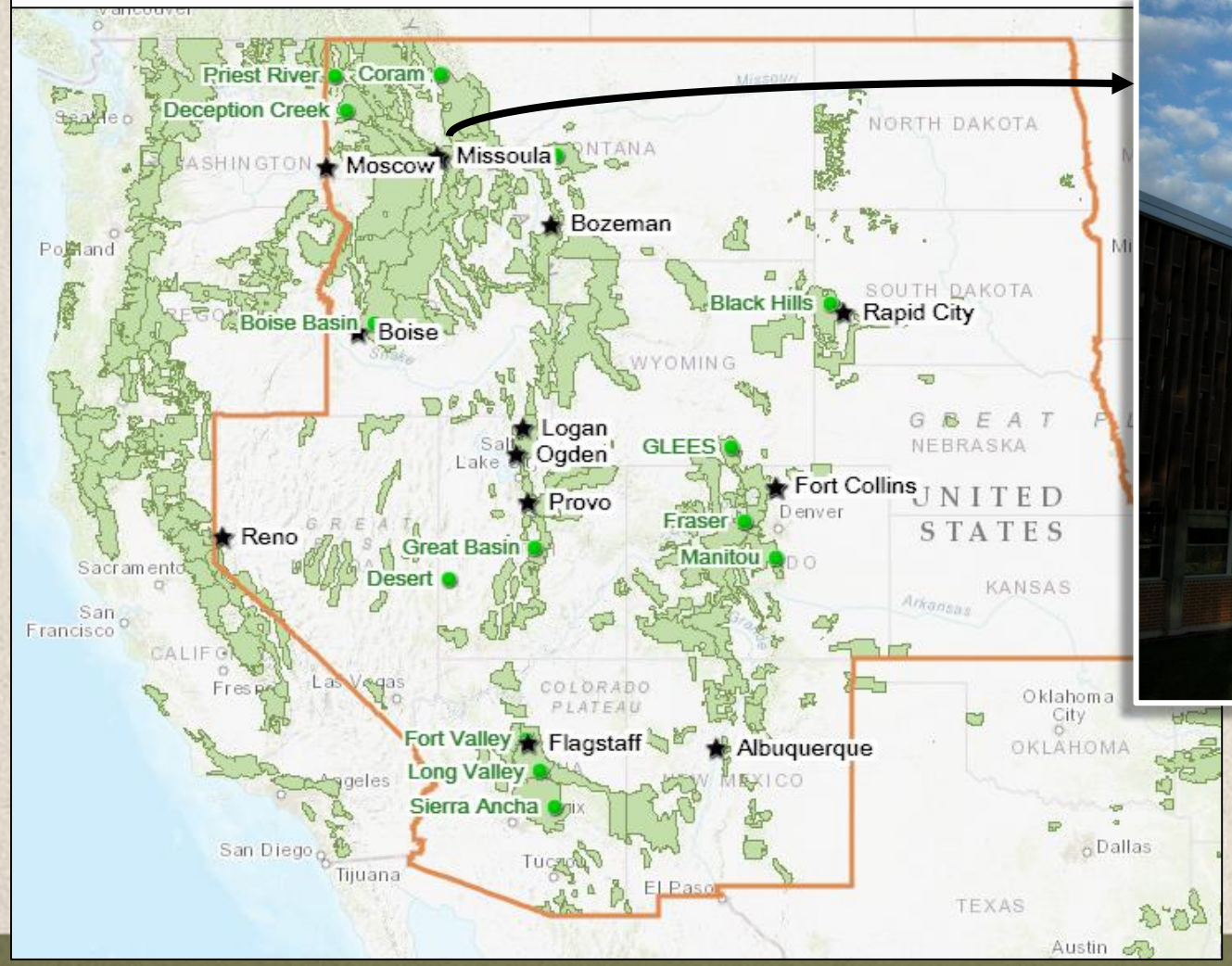
The Missoula Fire Sciences Lab

USDA U.S. FOREST SERVICE
Caring for the land and serving people
United States Department of Agriculture

Rocky Mountain Research Station



[The Mysterious Science of Fire](#)
(The Antlantic, 2014)

The Missoula Fire Sciences Lab

https://www.firelab.org/

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Quantifying Risk

Bernoulli's equation, 1700's (simplified)

Gilbert, D. 2005. Why we make bad decisions. TEDGlobal 2005. 33:38.

Expected Value = (odds of some outcome) X (value of that outcome)

Image Credit: Wikipedia

Likelihood of a particular intensity or severity

Fire effects on any resource or asset at that intensity level

Finney's equation, 2005

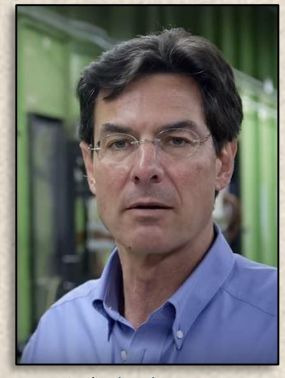

Image Credit: The Atlantic

$$E[\text{nvc}] = \sum_{i=1}^{N}\sum_{j=1}^{n} p(F_i)[B_{ij} - L_{ij}]$$

- Summed across:
  - Fire intensity levels (i)
  - Resources or assets that are potentially "at risk" (j)

Finney, MA. 2005. The challenge of quantitative risk analysis for wildland fire. Forest Ecology and Management 211: 97-108.

Integrated Wildfire Risk Assessment: Framework Development and Application on the Lewis and Clar National Forest in Montana, USA

Matthew P Thompson,* † Joe Scott, ‡ Don Helmbrecht, § and Dave E Calkin †
†Rocky Mountain Research Station, US Forest Service, Missoula, Montana 59807, USA
‡Pyrologix, LLC, Missoula, Montana, USA
§TEAMS Enterprise Unit, US Forest Service, Missoula, Montana, USA

(Submitted 25 June 20

ABSTRACT

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INTRODUCTION

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* To whom corresp

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E-mail

0378-1127
doi:10.101

USDA
United States Department of Agriculture

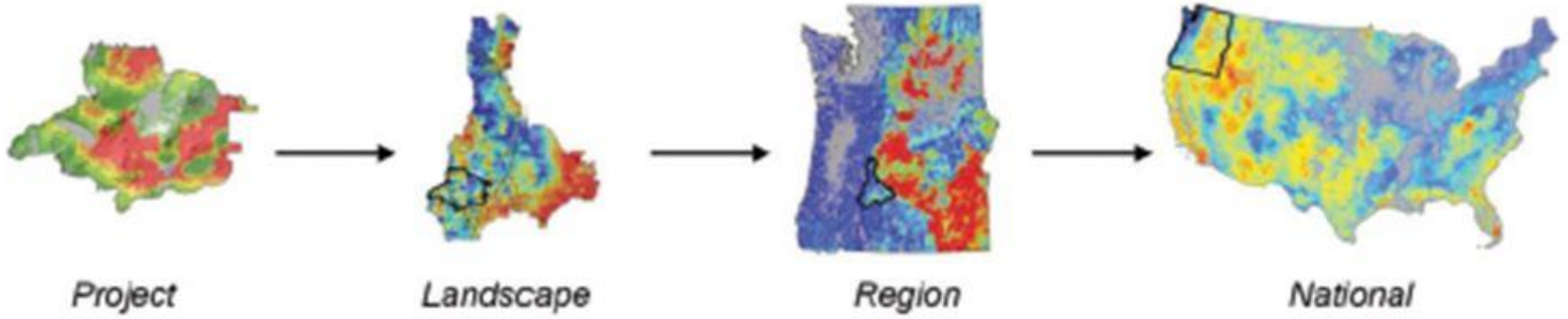
Risk Terminology Primer: Basic

Brenda Wilmore, Fuels Program Manager
United States Forest Service
Northern Region

September 25, 2017

Pacific Northwest

COMPARATIVE RISK ASSESSMENT ACROSS MULTIPLE SCALES



In the western U.S. and elsewhere, new pa
deemphasize fire exclusion, expand application of prescribed and managed natural fire, and foster resilience and adaptation to fire [1–4]. The National Cohesive Wildland Fire Management Strategy in the U.S. focuses on making meaningful progress towards attainment of resilient landscapes, fire adapted communities, and safe and effective response to fire [5]. Our focus here is the goal of safe and effective response to fire, and is based on the premise that how fires are managed—not just how landscapes are managed and communities respond before and after fires occur—is a key determinant of long-term socioecological resiliency and the ability to "live with fire" [6–8].

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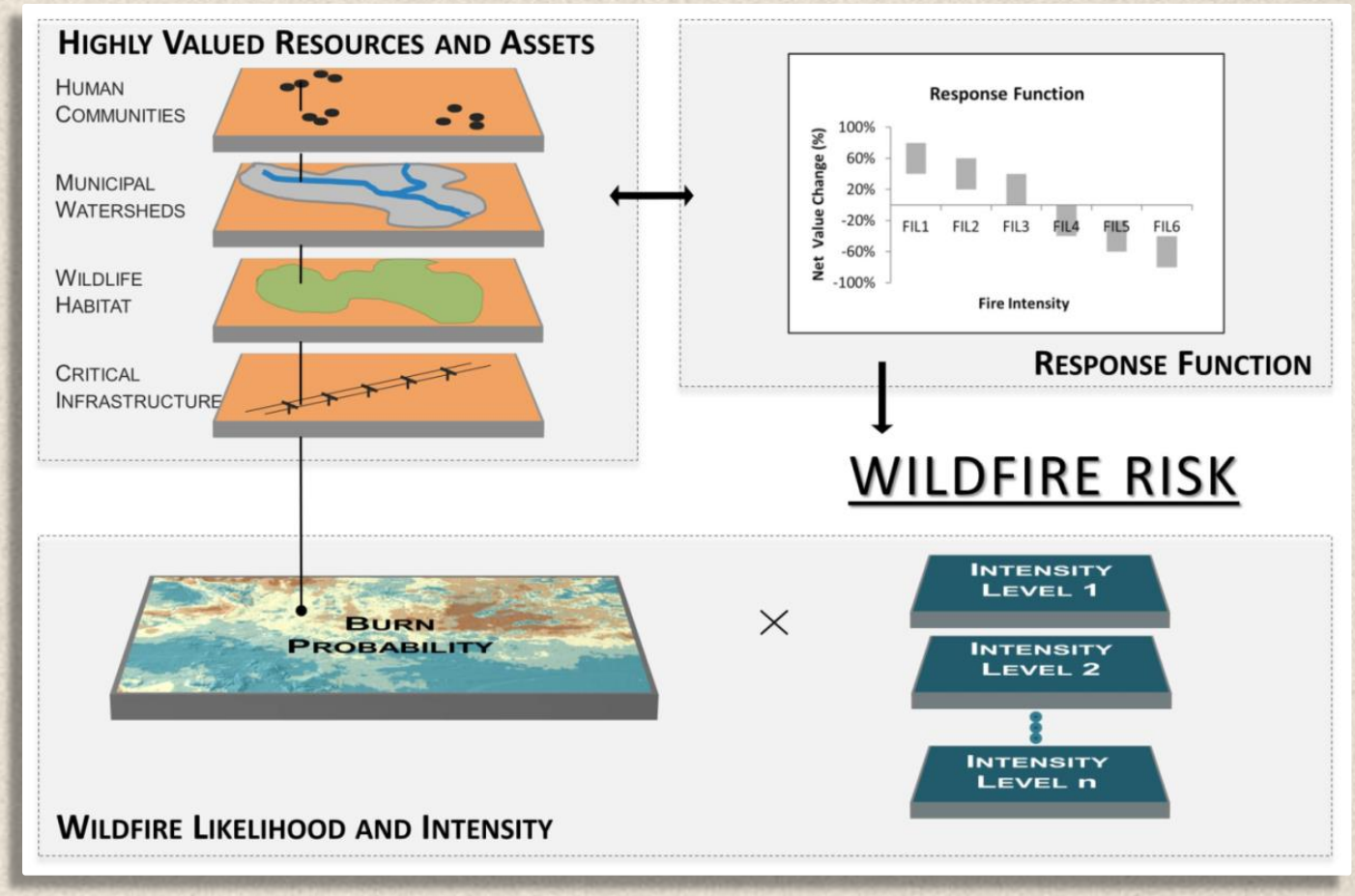
substantial variation in
throughout the Region,

What is a Wildfire Risk Assessment?

Wildfire Risk: A measure of the probability and consequences of uncertain future wildfire events.



Inputs for a Risk Assessment

Fuels

Topography

Weather

Fire Occurrence

Fire Modeling

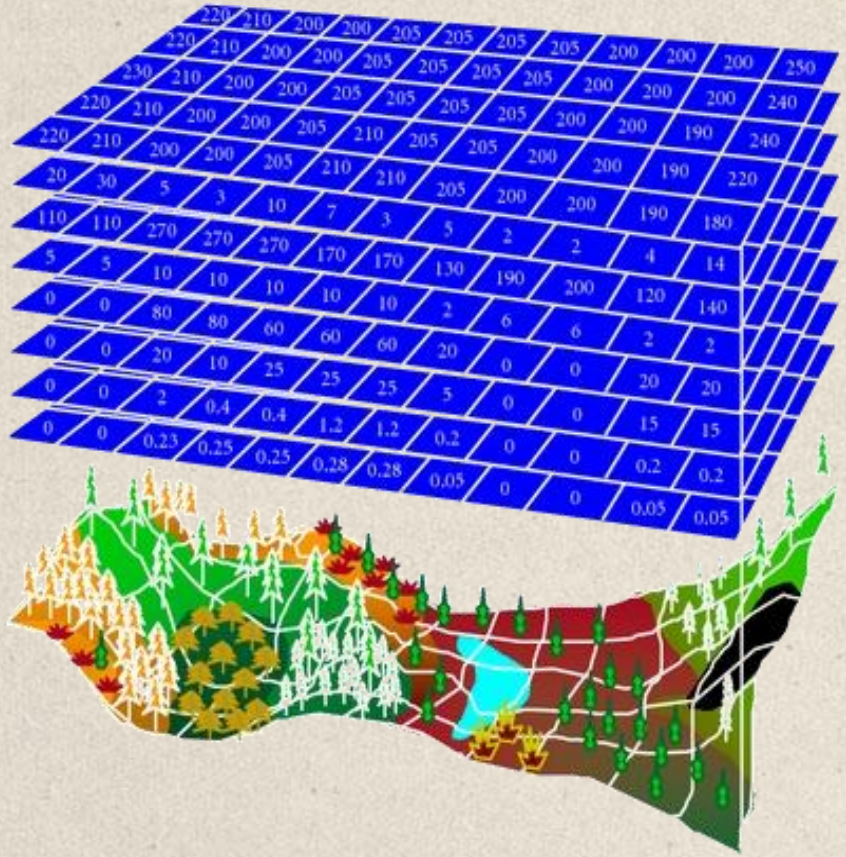
Likelihood

Intensity

Community Information

Resources and Assets

Inputs for a Risk Assessment

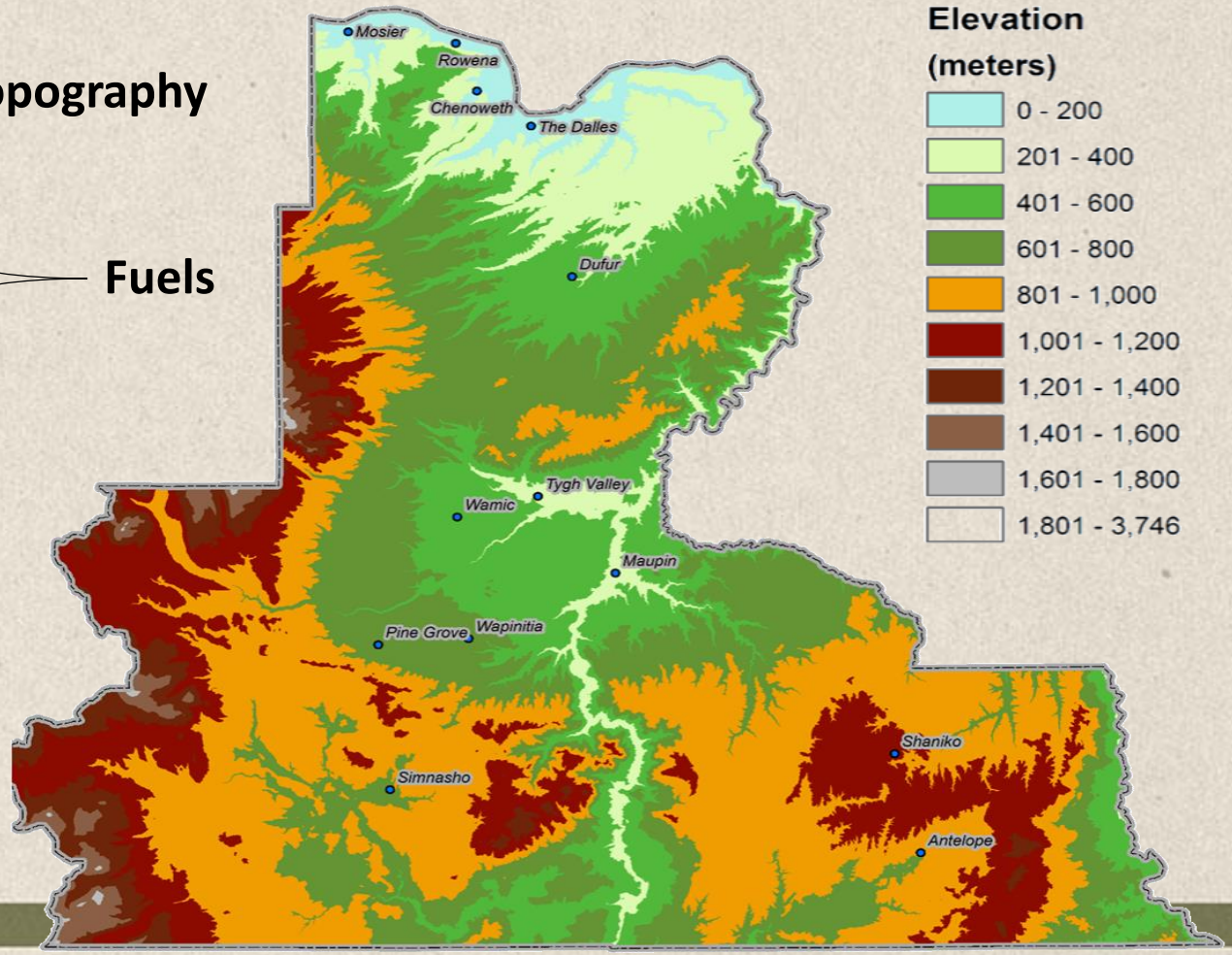


Elevation
Slope
Aspect

Topography

Fuel model
Canopy cover
Canopy height
Crown base height
Crown bulk density

Fuels



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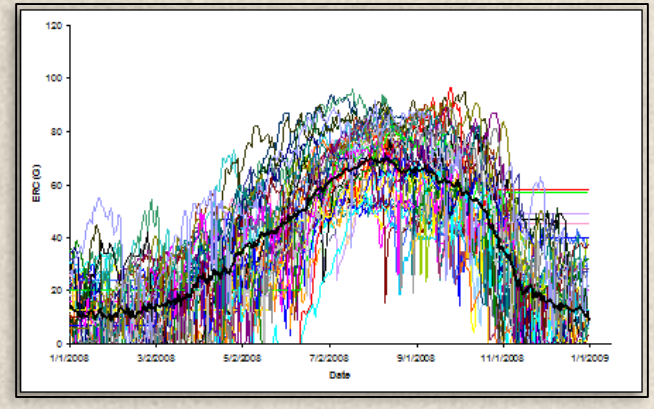
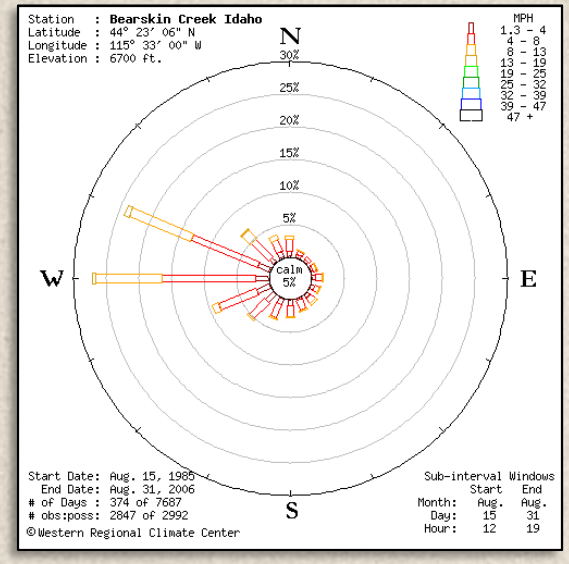


FSim

Models a wide range of conditions over an entire season

1,000s of Iterations



FlamMap

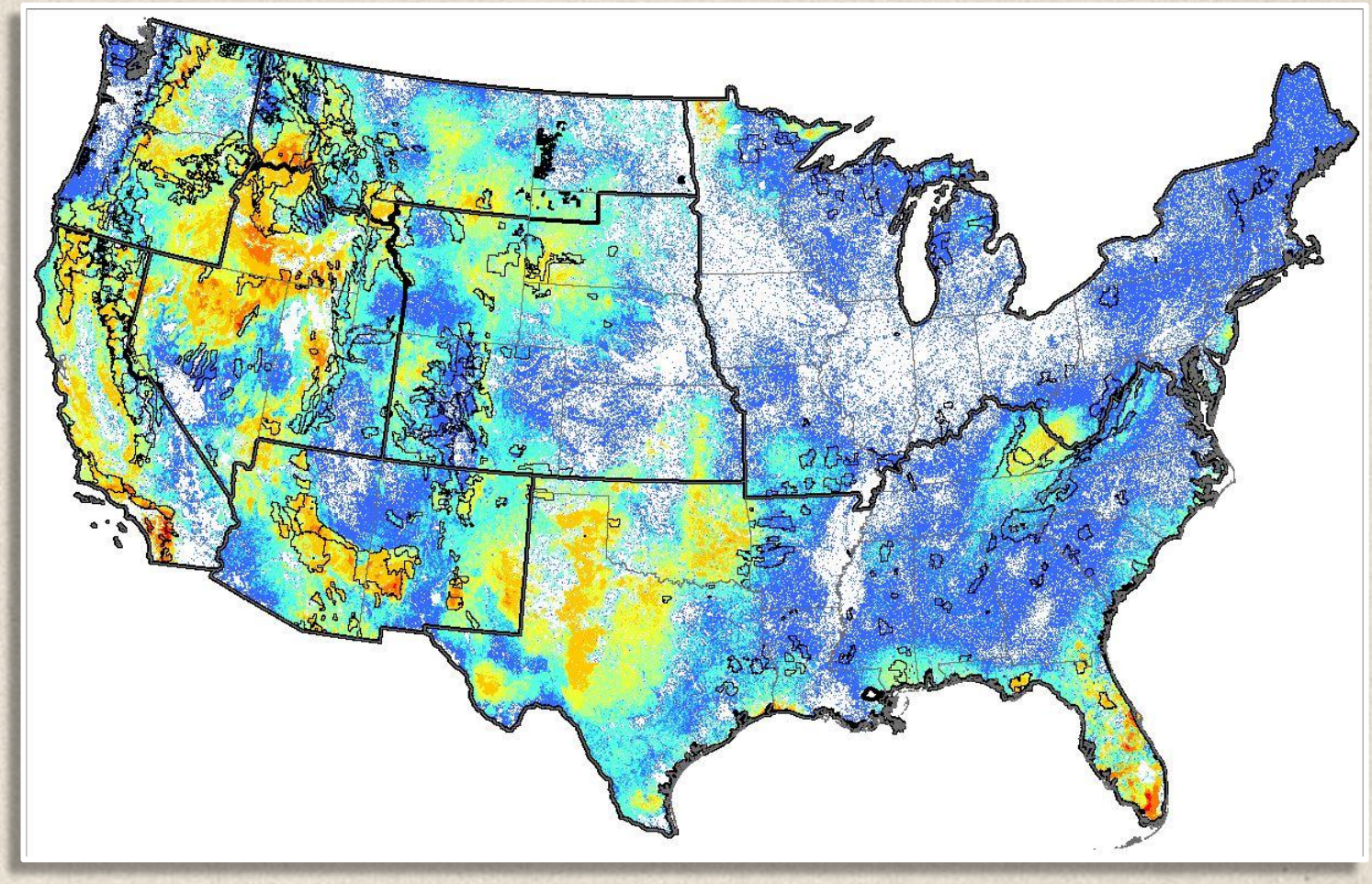
Models a specific weather scenario

1,000s of Iterations

Wildfire Simulation

Likelihood

- Annual probability of wildfire occurrence for every pixel
- Calibrated to fire occurrence records since 1992
- Spatial resolution varies
  - 270 m for national scale
  - 180 m for regional scale
  - 30 – 90 m for local scale



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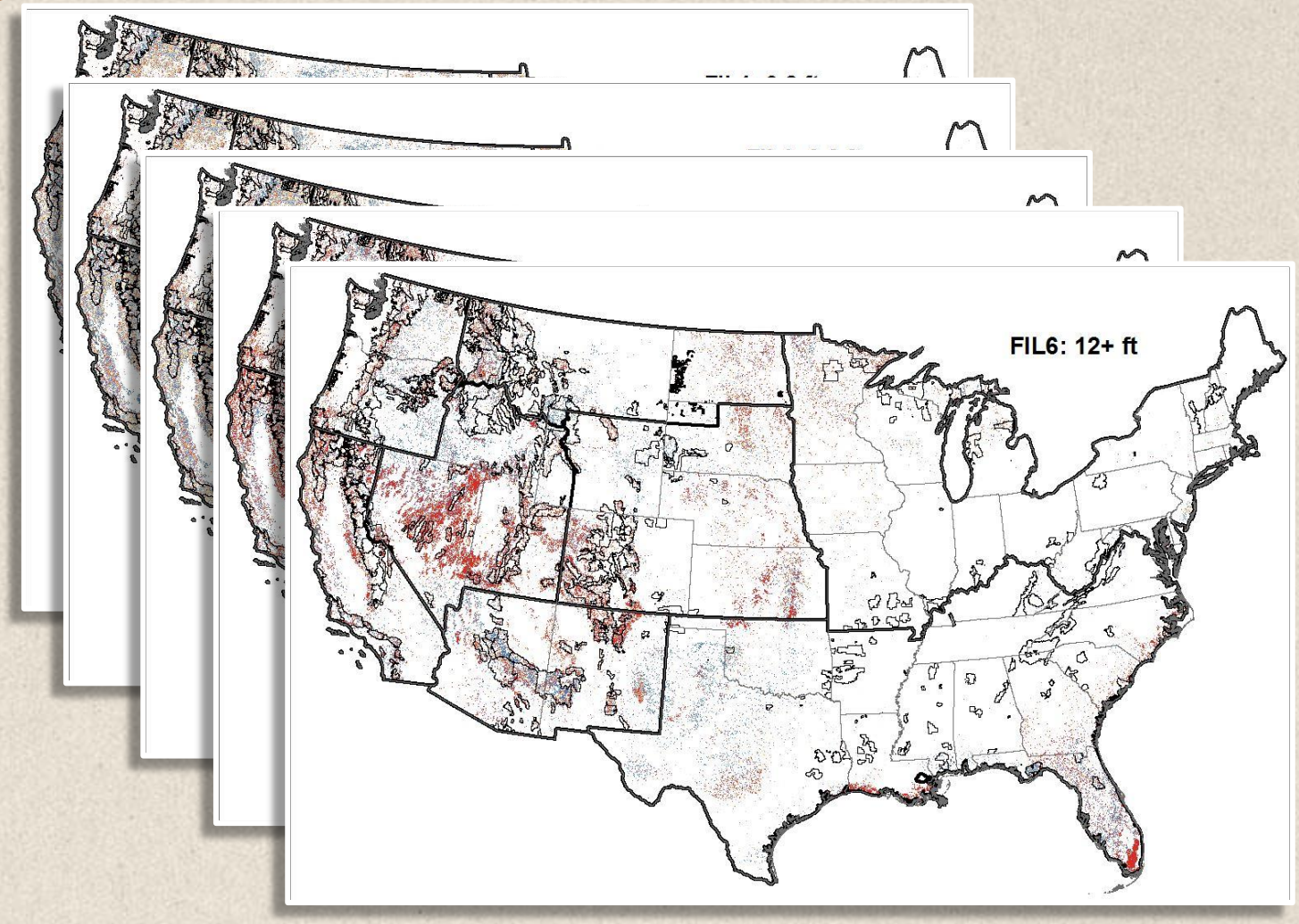
Wildfire Simulation

Intensity

- Flame lengths grouped into 6 fire intensity levels
- Values across all 6 intensity levels sum to 1



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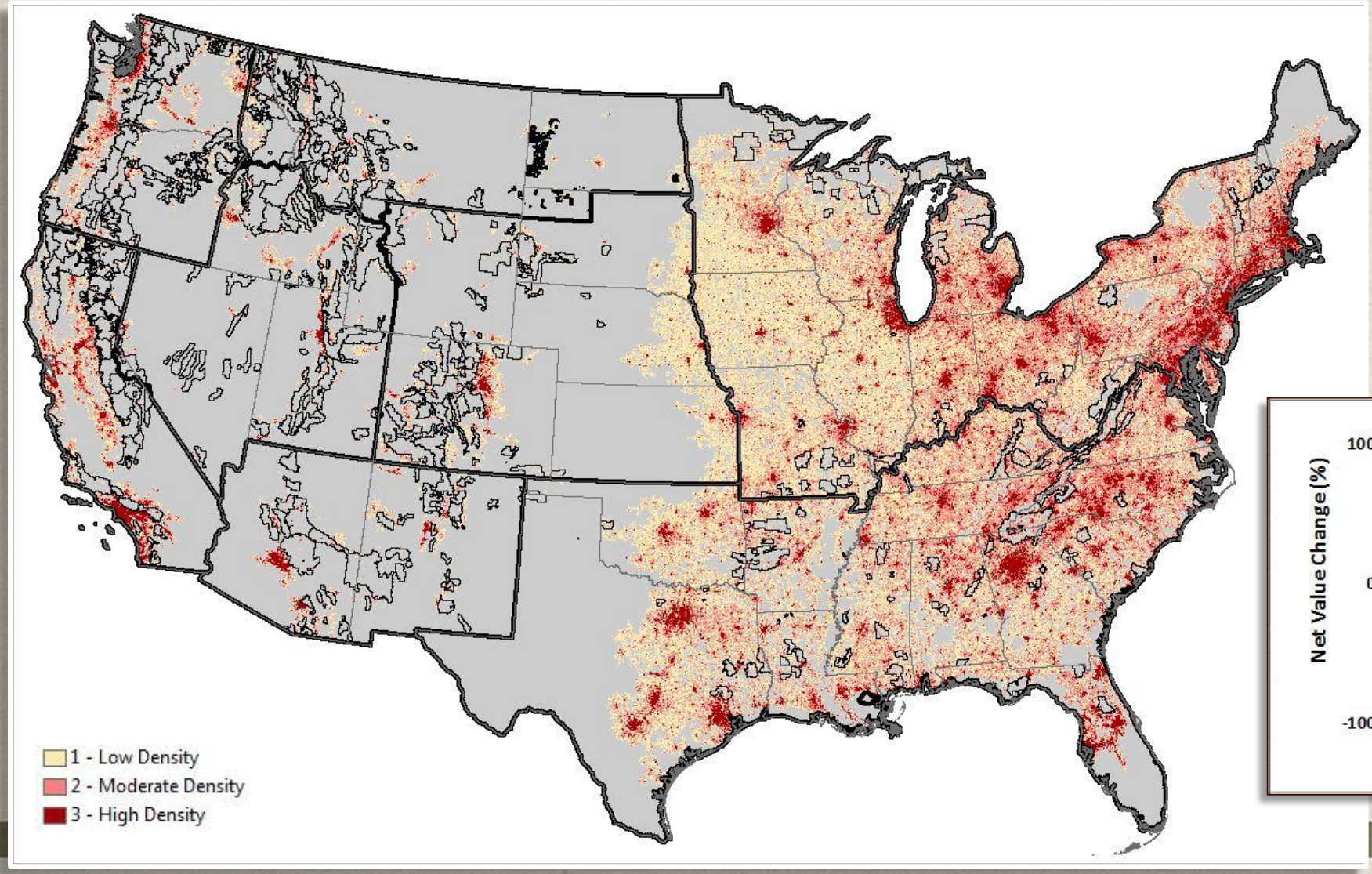
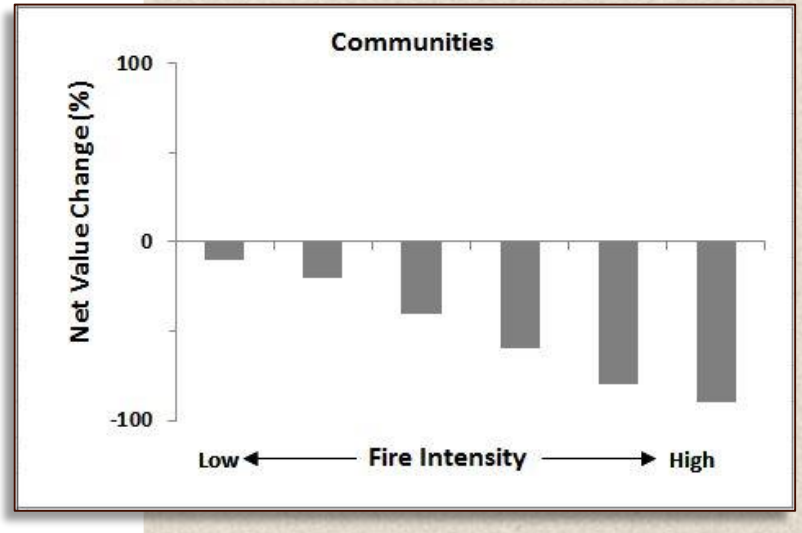
What is at Risk?

	Highly Valued Resources and Assets (HVRAs)			
	Primary	**Secondary**	**Variant**	**Data Sources**
Assets	Communities	High Density (>35 people/100 acres)		Residentially Developed Populated Areas (RDPA)
		Moderate Density (4 - 35 people/100 acres)		
		Low Density (0.05 - 4 people/100 acres)		
	Infrastructure	Powerlines		Homeland Security Infrastructure Program
		Communication Sites		Wildland Fire Decision Support System
		High Investment Buildings and developed recreation sites		USDA FS corporate spatial datasets for buildings and recreation sites
		Low/Moderate Investment Buildings and developed recreation sites		
Resources	Surface Drinking Water	< 10th percentile		Forests to Faucets index of importance to surface drinking water supply, by 12-digit Hydrologic Unit Code watersheds
		10th - 19th percentile		
		20th - 29th percentile		
		30th - 39th percentile		
		40th - 49th percentile		
		50th - 59th percentile		
		60th - 69th percentile		
		70th - 79th percentile		
		80th - 99th percentile		
		90th - 99th percentile		
	Ecosystem Function		Groups of ecological communities that have similar historic fire regimes and response to fire	LANDFIRE Biophysical Settings
	Air Quality		Low Emissions	Potential PM2.5 emissions estimates, compiled from CONUS-wide emissions modeling outputs from research efforts at the USDA FS Rocky Mountain and PNW Research Stations
			Moderate Emissions	
			High Emissions	

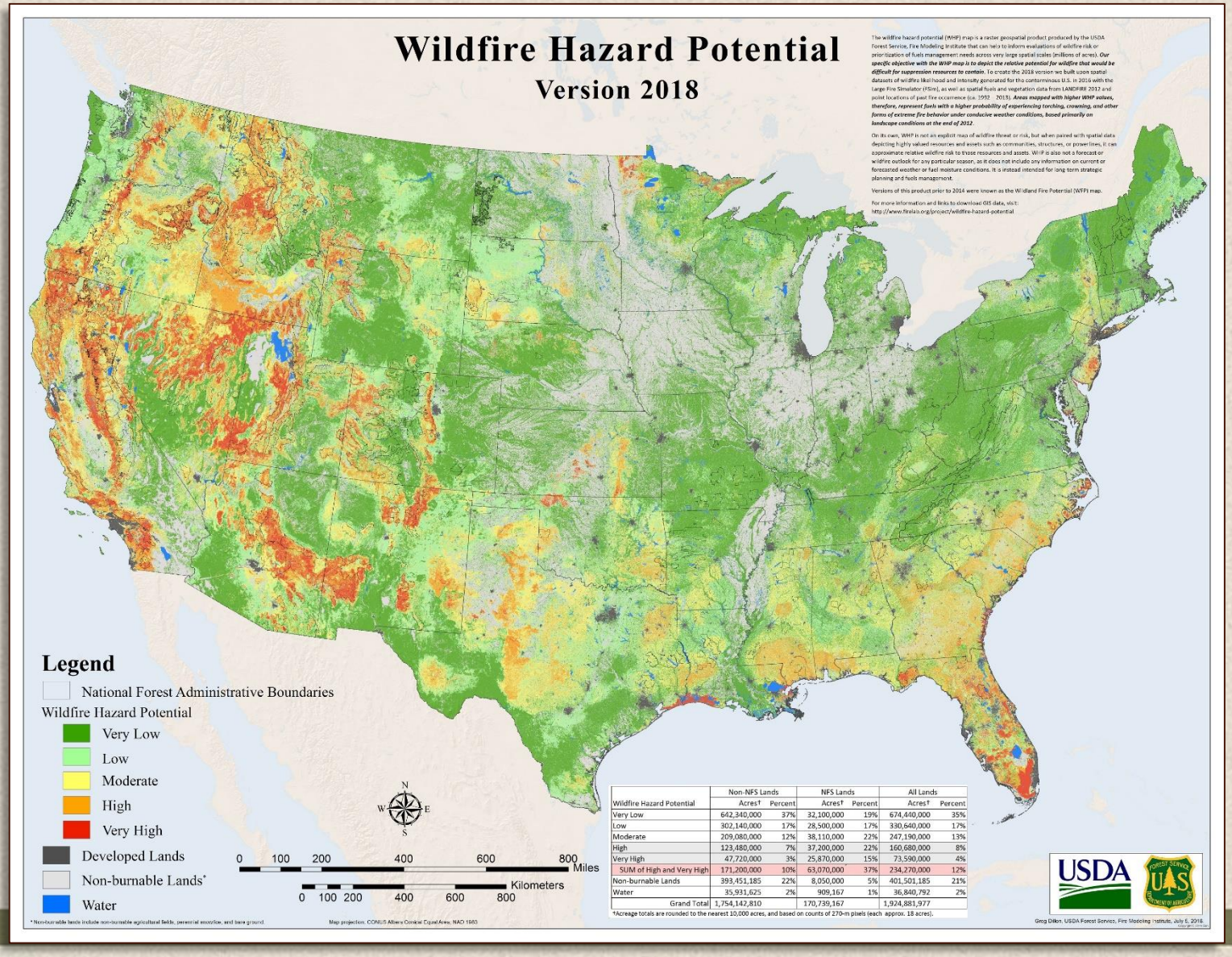
What is at Risk?

- Example – Communities





National Products



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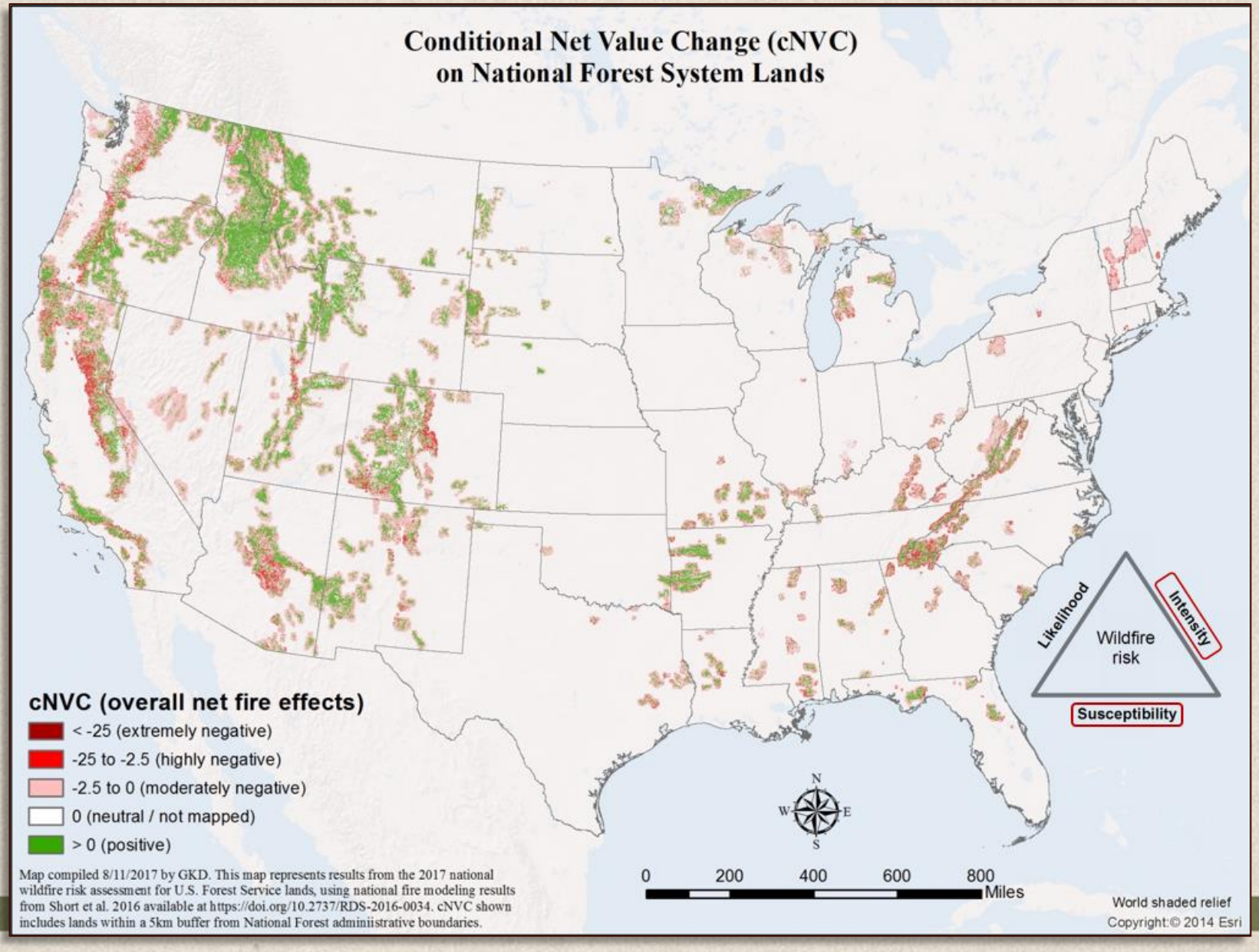

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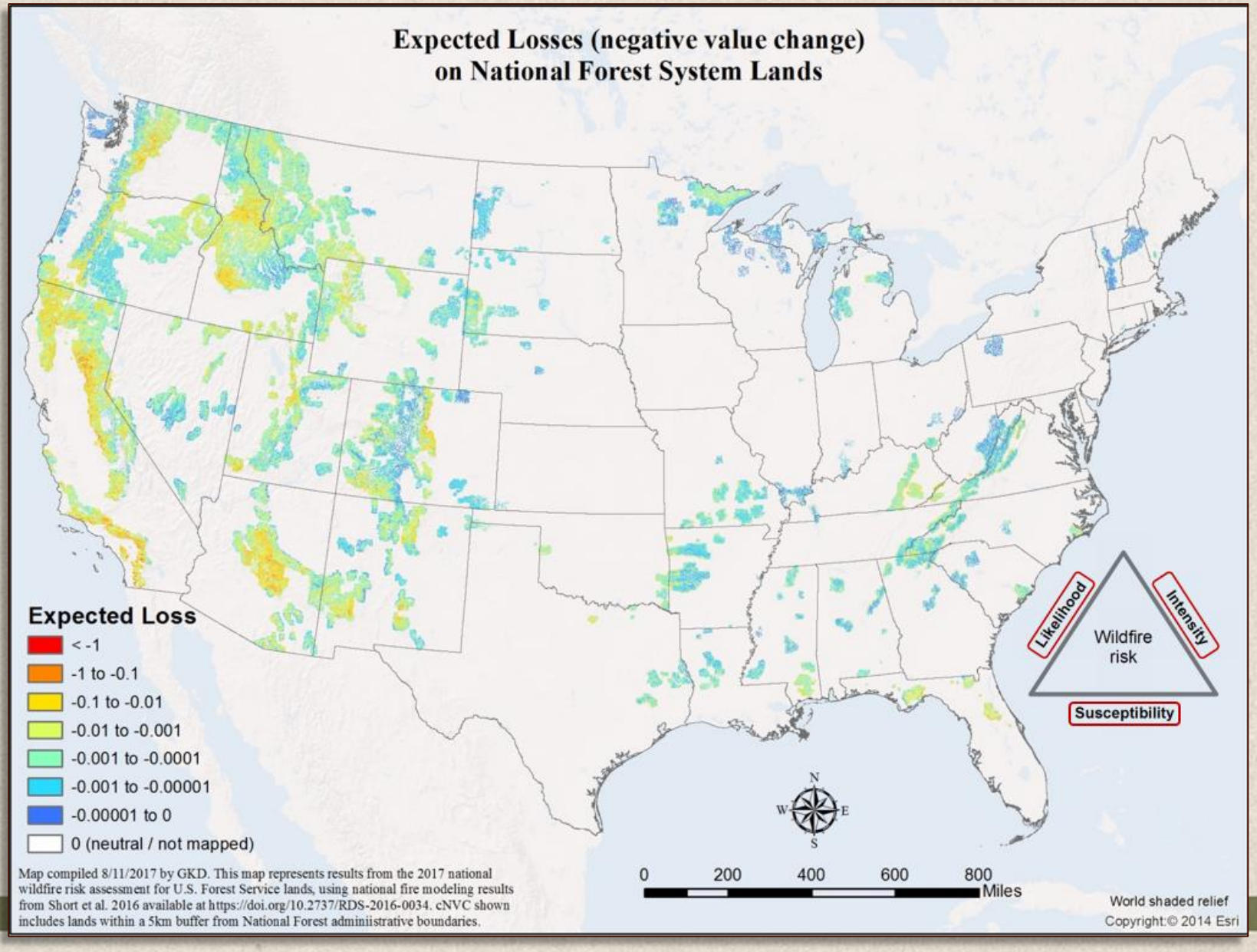

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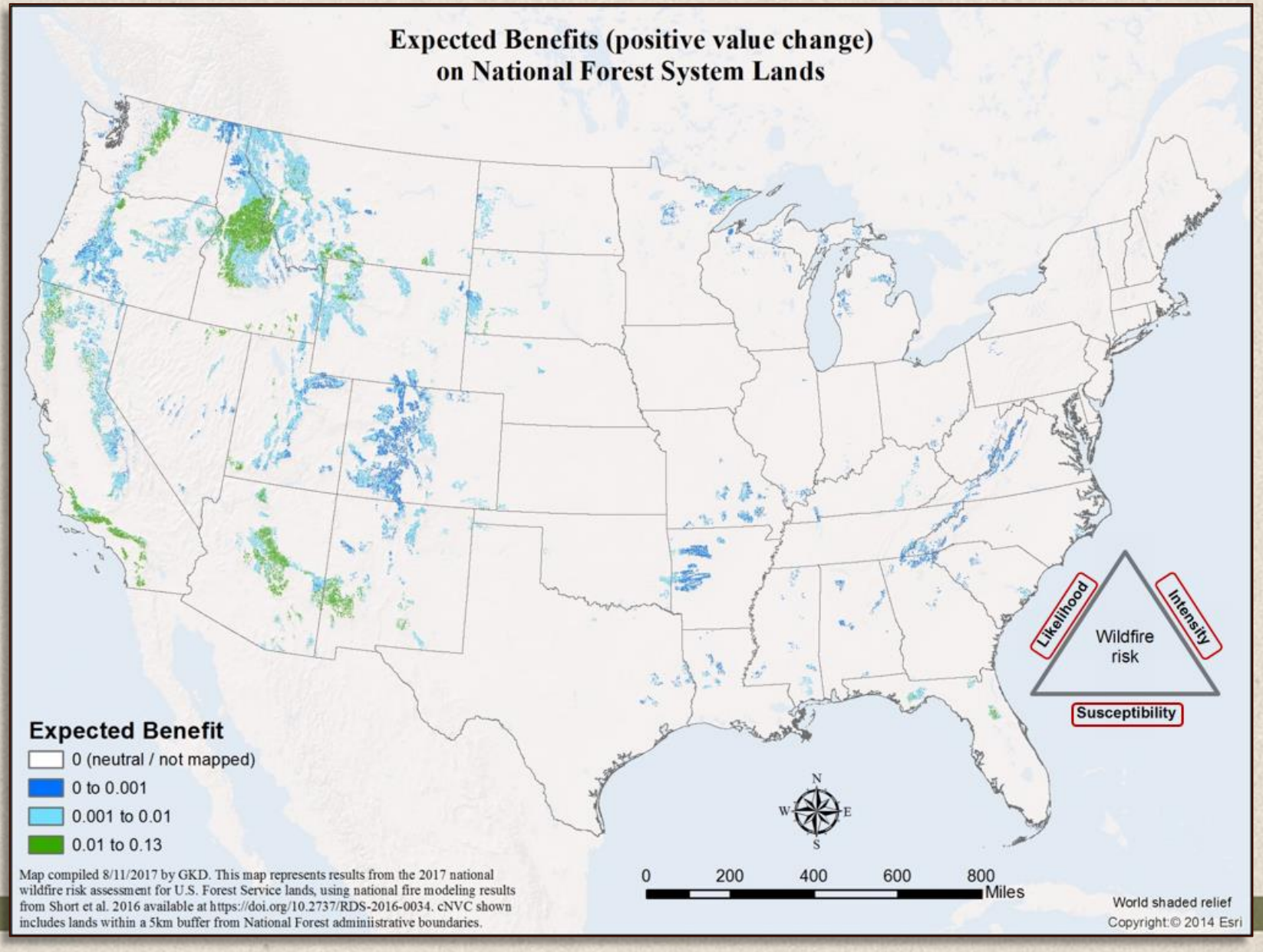


Community Planning Assistance for Wildfire (CPAW)


Subdivision Code, Zoning Code, Building Code, Fire Code,
WUI Code, General Plan, Hazard Mitigation Plan,
Community Wildfire Protection Plan, Design Guidelines etc.

US National Wildfire Hazard Data for Communities

Burn Probability

Conditional Flame Length

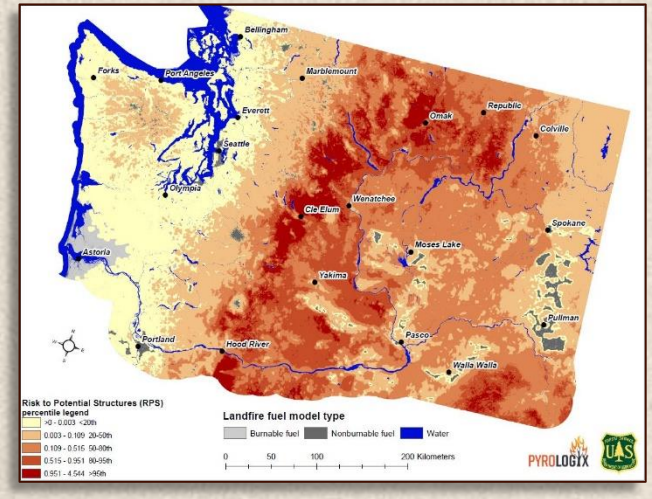
Risk to Potential Structures

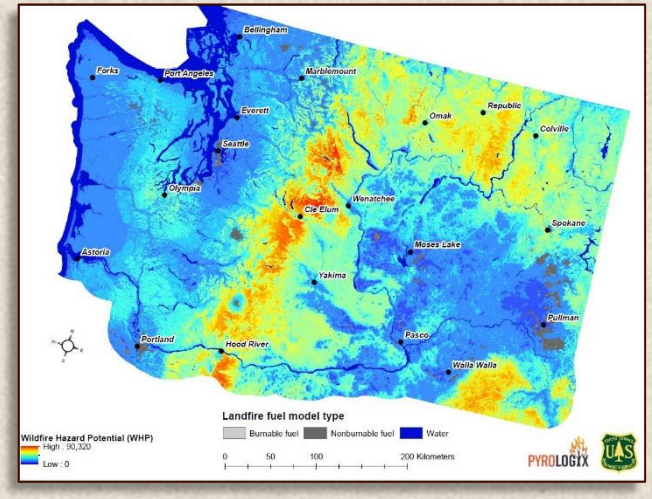
Wildfire Hazard Potential

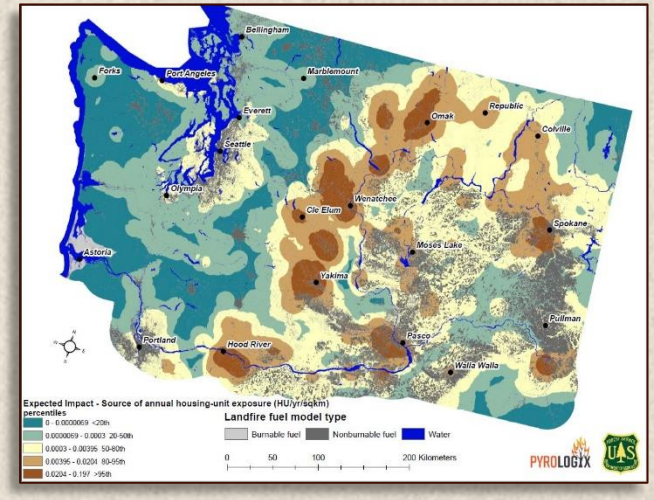
Housing Unit Density

Housing Units Exposed to Wildfire

Source Areas for Expected Impacts to Housing Units







More Information

- **Risk assessment information**
  - Scott and others. 2013. A wildfire risk assessment framework for land and resource management. RMRS-GTR-315. https://www.fs.usda.gov/treesearch/pubs/44723
  - Scott and Thompson. 2015. Emerging concepts in wildfire risk assessment and management. In RMRS-P-73. https://www.fs.usda.gov/treesearch/pubs/49444
- **National FSim modeling data**
  - Short and others. 2016. Spatial dataset of probabilistic wildfire risk components for the conterminous United States. https://doi.org/10.2737/RDS-2016-0034
- **National Wildfire Hazard Potential**
  - https://www.firelab.org/project/wildfire-hazard-potential
- **Community Planning Assistance for Wildfire (CPAW)**
  - https://planningforwildfire.org/
- **Wildfire Risk Management Science Team**
  - https://www.fs.fed.us/rmrs/groups/wildfire-risk-management-science-team

Questions?

Greg Dillon
USDA Forest Service, RMRS, Fire Modeling Institute
Missoula, Montana, USA
greg.dillon@usda.gov | +1 (406) 829-6783

United States Department of Agriculture
Forest Service