



Photo: Greg Dillon

# How maps of wildfire hazard and risk can inform mitigation strategies

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Malden, WA. Photo: Spokesman-Review



Glass Fire, CA. Photo: Sacramento Bee



Talent, OR. Photo: KTVL





**Treated Area | Small Diameter Tree Thinning & Understory Burning**  
**East Flank | Rosland Road Fire**

# Outline

- Background
  - Foundations of wildfire risk
- Example tools and applications
  - Different tools for different times in the continuum of wildfire mitigation and management
- Wildfire Risk to Communities
  - Closer look at this online resource
- Parting thoughts and resources for more information

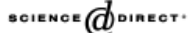


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# Wildfire Hazard and Risk



Available online at [www.sciencedirect.com](http://www.sciencedirect.com)



Forest Ecology  
and  
Management

Forest Ecology and Management 211 (2005) 97–108

[www.elsevier.com/locate/foreco](http://www.elsevier.com/locate/foreco)

## The challenge of quantitative risk analysis for wildland fire

Mark A. Finney\*

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### Abstract

Quantitative fire risk analysis depends on characterizing and combining fire behavior probabilities and effects. Fire behavior probabilities are different from fire occurrence statistics (historic numbers or probabilities of discovered ignitions) because they depend on spatial and temporal factors controlling fire growth. That is, the likelihood of fire burning a specific area is dependent on ignitions occurring off-site and the fuels, topography, weather, and relative fire direction allowing each fire to reach that location. Research is required to compare computational short-cuts that have been proposed for approximating these fire behavior distributions. Fire effects in a risk analysis must also be evaluated on a common scale for the variety of values susceptible to wildland fire. This means that appraisals of fire impacts to human infrastructure and ecological values must be measured by the same currency so that the risk assessment yields a single expectation of fire effects. Ultimately, this will help guide planning and investment into management activities that can alter either the probabilities of damaging fire or the susceptibility to those fire behaviors.

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**Keywords:** Wildland fires; Quantitative risk analysis; Net value change

### 1. Introduction

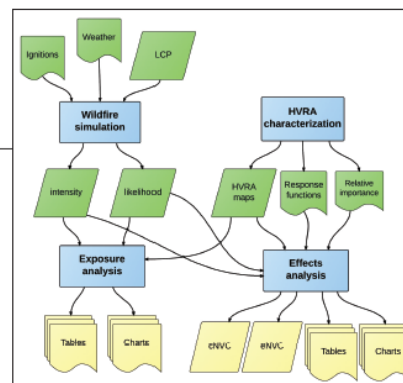
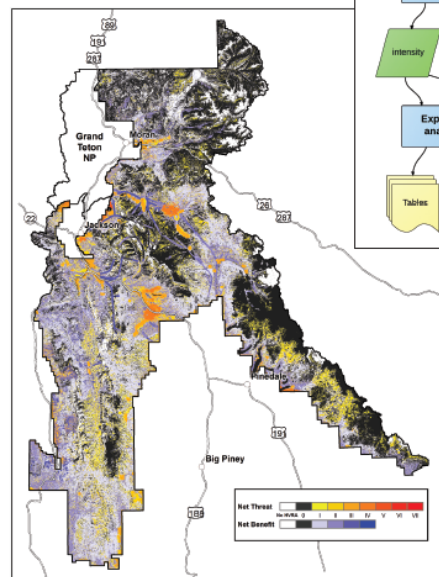
Fire planning and risk assessment are concerned with how often fires burn, what effects they have on wildland and urban values, and what opportunities exist to improve the situation through management actions. In the United States, most wildland fires are suppressed. Fires are detected, reported, and initial attack resources dispatched. Fire statistics for federally managed public lands reveal that 99% of all reported fires are suppressed by initial attack forces (NIFC, 2002). Other measures from around the United

States similarly suggest about 98% of fires in 2002 are less than 100 ha (250 acres; Neuenschwander et al., 2000; Cardille and Ventura, 2001). The remaining percentage escapes initial attack for many reasons, mostly involving extreme weather, overwhelming of suppression resources by multiple ignitions, and fuel types producing fire behavior that exceeds fire-fighting capabilities. Where management policies explicitly disallow free-burning fires, the rare escaped fires burn under weather scenarios among the most extreme and in fuel conditions that have often been exacerbated by the overall success of fire exclusion under more moderate conditions. Even if fuels remain unchanged during the long fire-free intervals, these policies shift the distribution of fire behaviors toward

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## A Wildfire Risk Assessment Framework for Land and Resource Management

Joe H. Scott  
Matthew P. Thompson  
David E. Calkin



USDA United States Department of Agriculture / Forest Service  
Rocky Mountain Research Station  
General Technical Report RMRS-GTR-315  
October 2013



## Emerging Concepts in Wildfire Risk Assessment and Management

Joe H. Scott, Pyrologix LLC, Missoula, MT, and Matthew P. Thompson, Human Dimensions Program, Rocky Mountain Research Station, U.S. Forest Service, Missoula, MT

**Abstract**—A quantitative measure of wildfire risk across a landscape—expected net change in value of resources and assets exposed to wildfire—was established nearly a decade ago. Assessments made using that measure have been completed at spatial extents ranging from an individual county to the continental United States. The science of wildfire risk assessment and management continues to build on the basic framework to develop new analysis techniques that address specific fire management problems. This paper reviews central concepts of the basic risk assessment framework and describes several emerging terms and concepts now under development. These new concepts include: 1) describing certain results of stochastic simulation systems as a wildfire event set, 2) defining a biophysical freshed as the land area where fires can originate and eventually reach a designated point, line or area in a designated period of time, 3) defining a fireplain as the land area where fire originating from a designated point, line or polygon (or set thereof) can reach during a designated period of time, 4) an exceedance probability curve, which plots the magnitude of an event (or its effects) against the likelihood that magnitude will be exceeded during a designated period of time, and 5) an analysis of wildfire Risk Associated with an Ignition Location (RAIL analysis), which characterizes the wildfire risk where the risk originates rather than where it occurs.

**Keywords:** event set, exceedance probability, fireplain, freshed, RAIL analysis

### Background

A quantitative measure of wildfire risk across a landscape—expected net change in value of highly valued resources and assets (HVRAs) exposed to wildfire—was established nearly a decade ago (Finney 2005). Continued development of that framework has produced a few general wildfire risk assessment concepts, primarily the conceptualization of wildfire risk as the wildfire risk triangle (Figure 1). Wildfire risk at a given location on the landscape is a function of the likelihood of wildfire burning the location, the fire intensity when it does burn, and the susceptibility of all exposed HVRAs that exist there.

Stochastic simulation of wildfire occurrence, growth, and behavior is the foundation of quantitative wildfire risk assessment. A stochastic simulation incorporates random variation in one or more simulation inputs. For stochastic wildfire simulations, the variable inputs fall into two categories: fire occurrence and weather. These inputs are accommodated in different ways in fire simulation software (Table 1). FlamMap5 (Finney 2006) has a stochastic fire simulation feature that allows simulation of many fires for one weather scenario, often the so-called “problem-fire” scenario. The problem-fire scenario is a weather scenario (wind speed and direction, fuel moistures, and fire spread duration) that leads to damaging short-duration wildfires (Bahro and others 2007; Moghaddas and others 2010). Fsim (Finney and others 2011b) also simulates many fires (focusing on fires

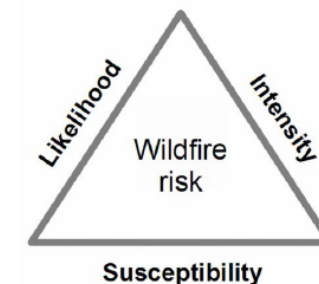


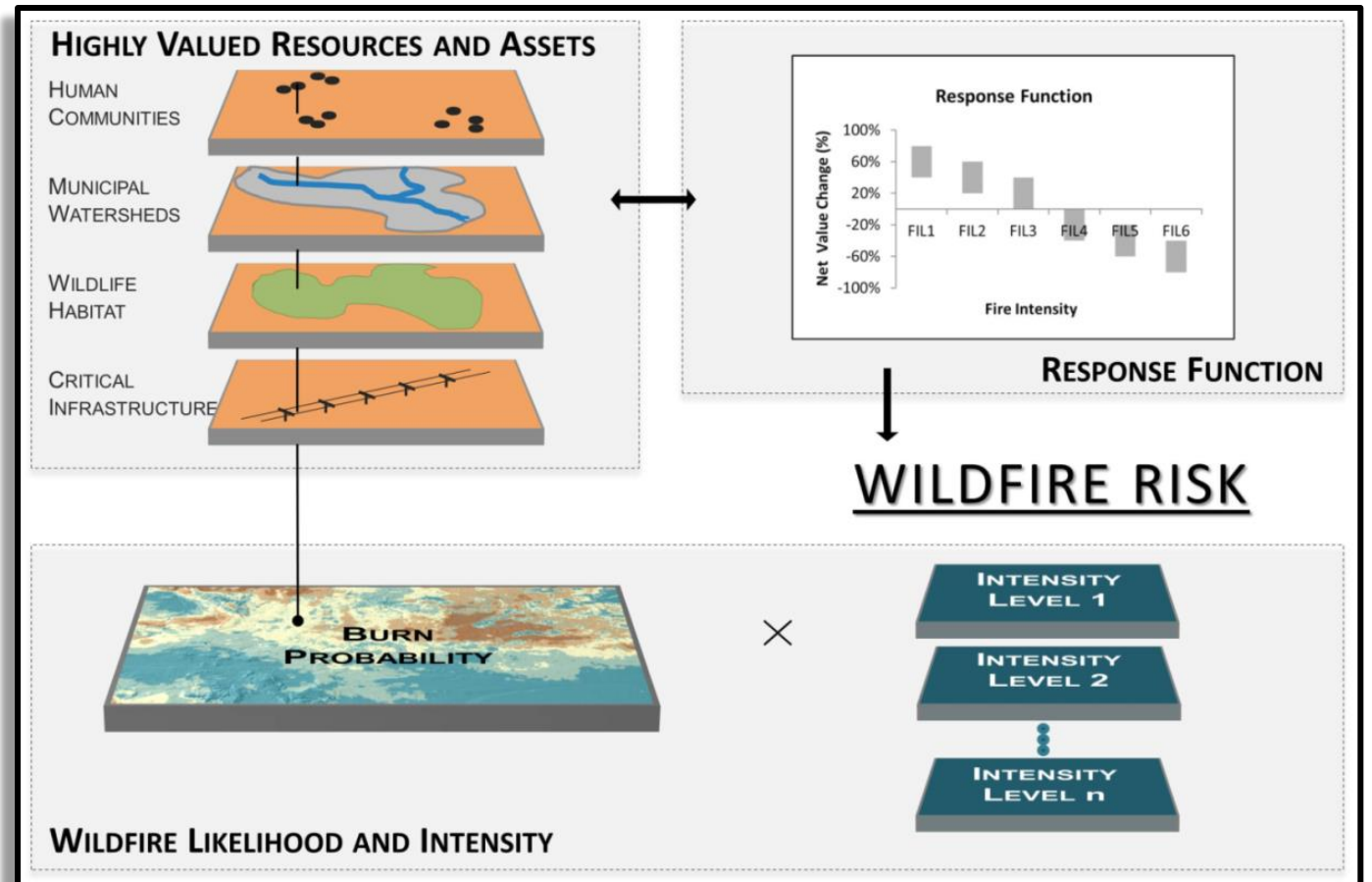
Figure 1—Wildfire risk triangle illustrates the major building blocks of quantitative wildfire risk assessment—the likelihood and intensity of wildfire and the susceptibility of resources and assets exposed to it (from Scott and others 2013).

that escape initial attack and become large), but also simulates many weather scenarios. Fsim is a valuable simulation system because its results represent a designated period of time—one complete fire season—and because it attempts to simulate the full range of escaped-fire sizes that can occur on the landscape rather than focus on a problem-fire scenario. FSPro (Andrews and others 2007; Finney and others 2011a; U.S. Forest Service 2009) is a stochastic simulation system used for incident management planning and decision-making (Calkin and others 2011). FSPro is used only after a wildfire

In: Keane, Robert E., Jolly, Matt, Parsons, Russell, Riley, Karin. 2015. Proceedings of the large wildland fire conference, May 19-23, 2014, Missoula, MT. Proc. RMRS-P-73, Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 345 p.

# Wildfire Hazard and Risk Assessment

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





Getting out ahead of the issue with mitigation work

Long-term strategic planning

Positioning resources, preparing before the fire starts

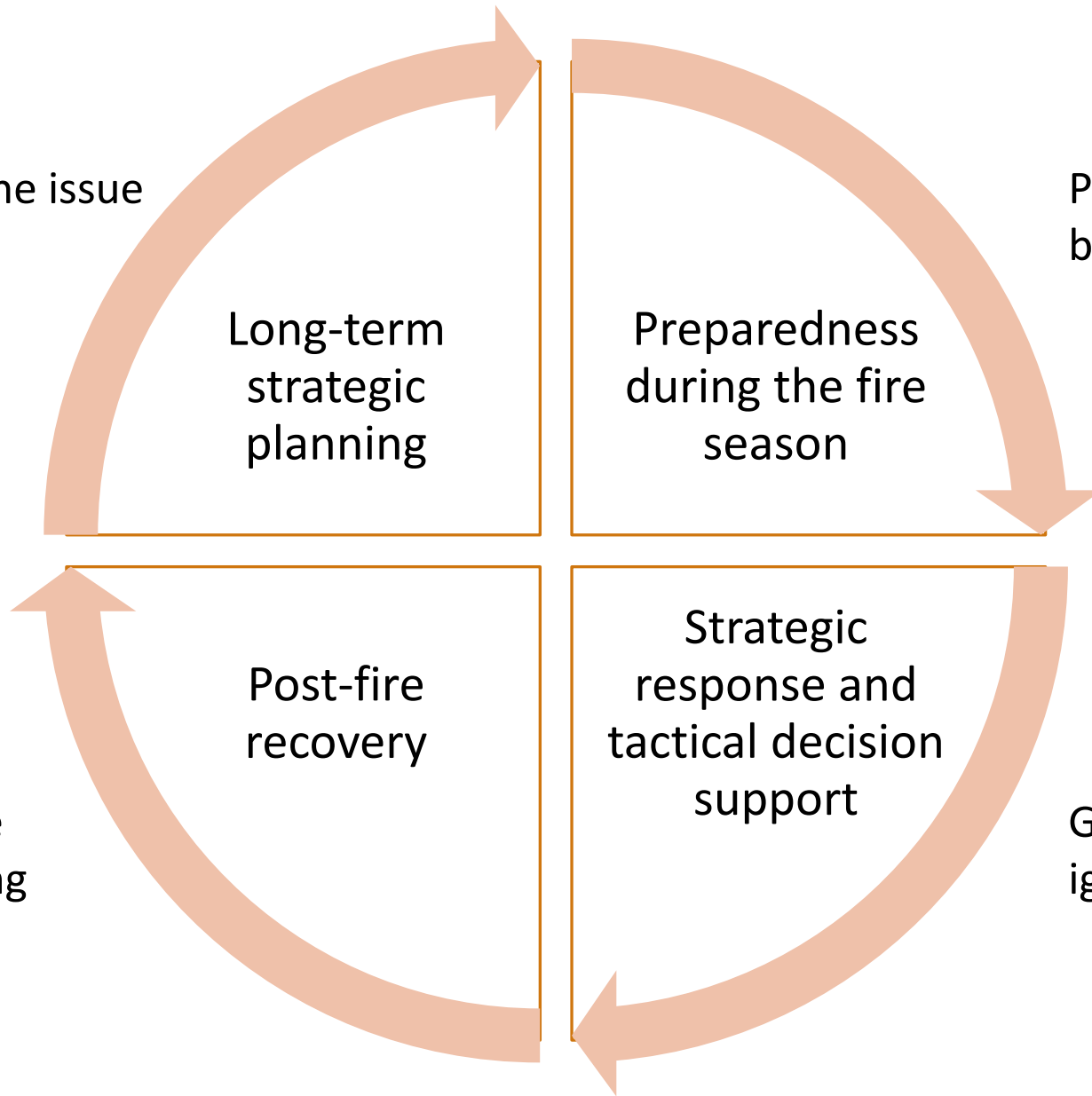
Preparedness during the fire season

Managing the post-fire environment, rebuilding

Post-fire recovery

Guiding decision making once ignitions happen

Strategic response and tactical decision support



# Strategic Response and Tactical Decision Support



Wildland Fire  
Decision Support System

- Modeling wildfire spread under current and forecasted weather conditions
- Understanding the probability of fire reaching specific locations
- Understanding the expected type of fire behavior
- Guiding tactical decisions to limit spread and/or reduce intensity

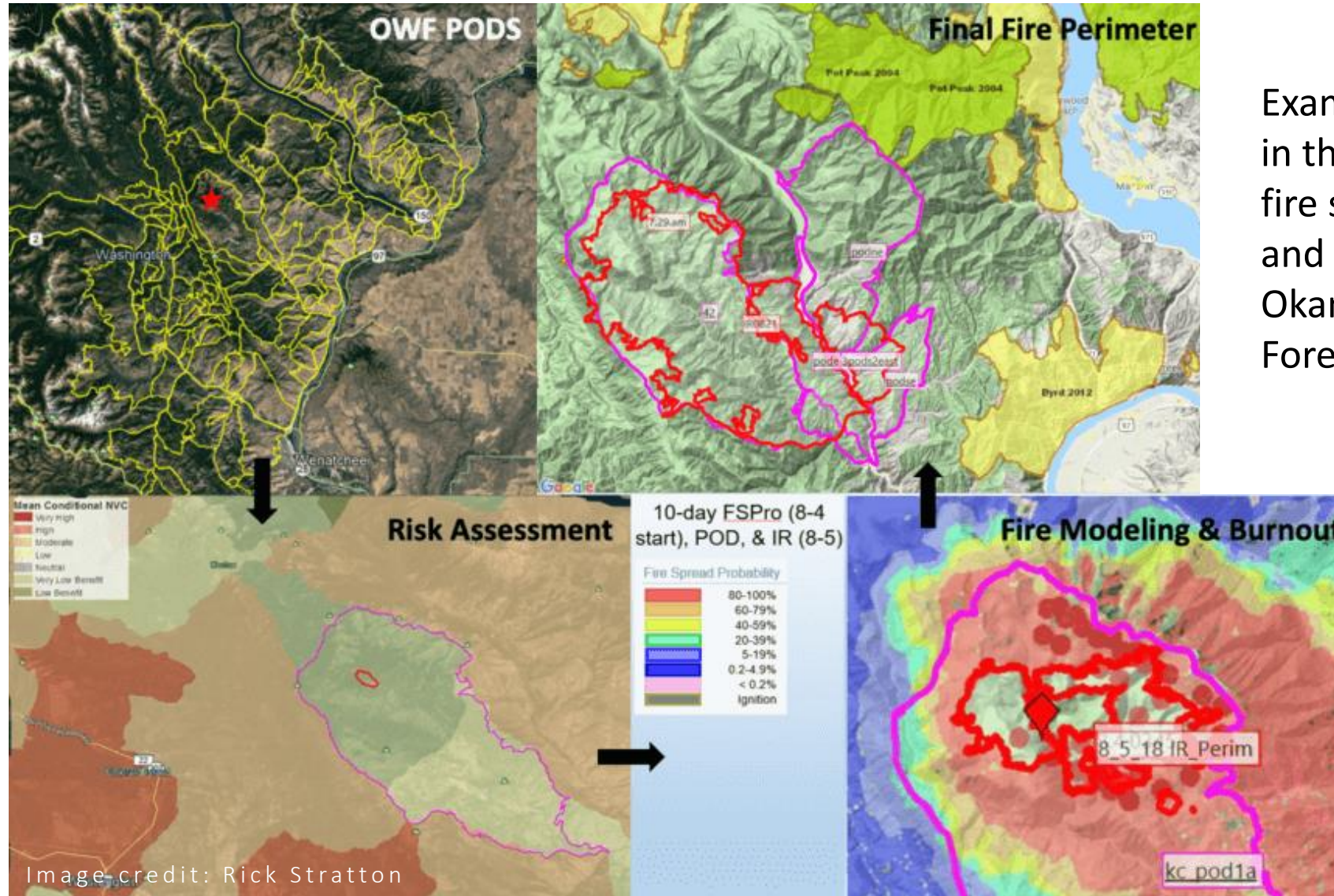


- Provides access to data products that can support risk-informed decisions to achieve safer and improved outcomes on active fires
- Unique analytical products to support Strategic Risk Assessment and Strategic Operational Planning on active fires
- <https://experience.arcgis.com/experience/f9d7f7f920494c3db43a23a8dffe4664>



- Potential Operational Delineations
- <https://www.fs.usda.gov/research/rmrs/projects/pods>

# Strategic Response and Tactical Decision Support

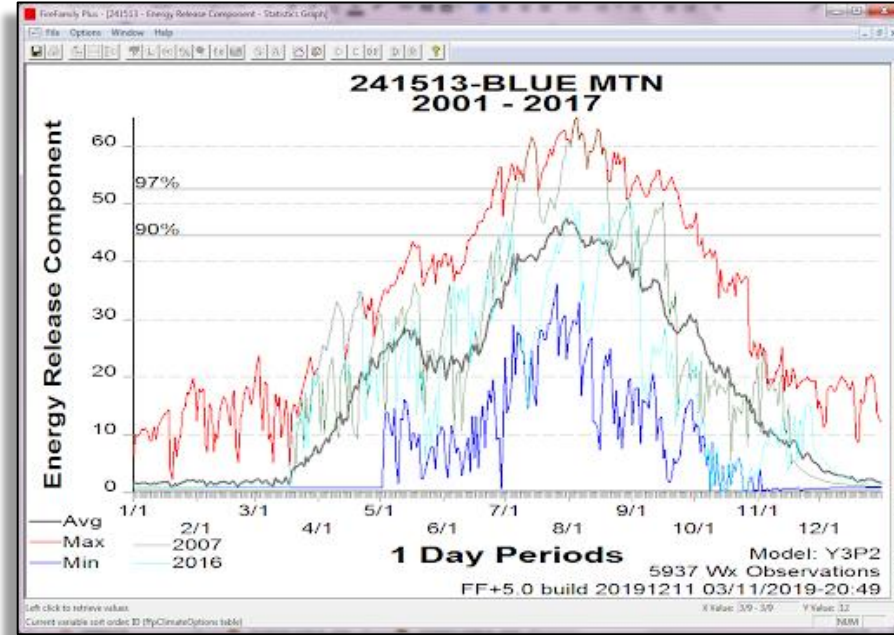


Example of risk assessment data in the RMA Dashboard, WFDSS fire spread probability modeling, and PODs. Cougar Creek Fire, Okanogan-Wenatchee National Forest, 2018.



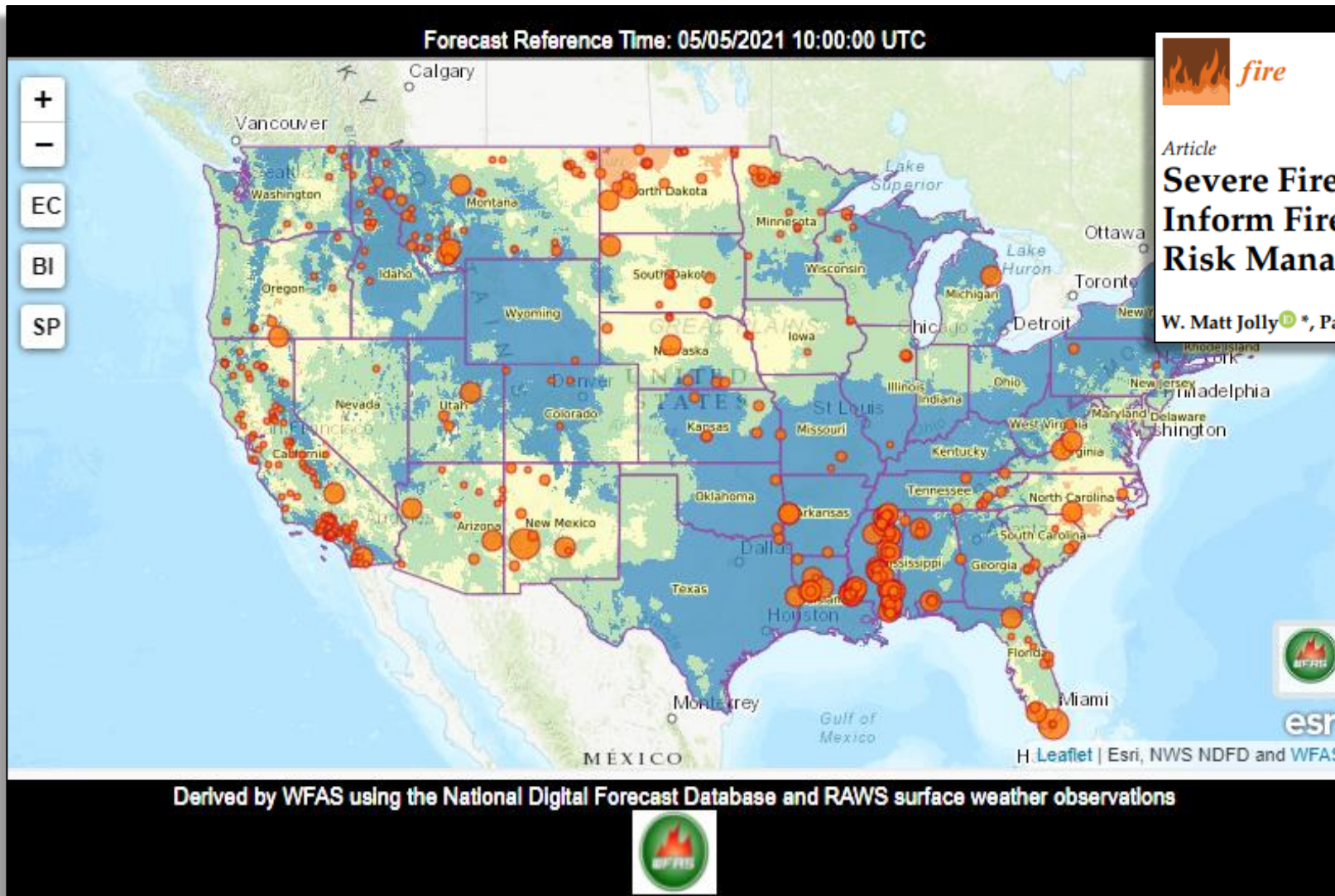
# Seasonal Preparedness

## National Fire Danger Rating System (NFDRS)

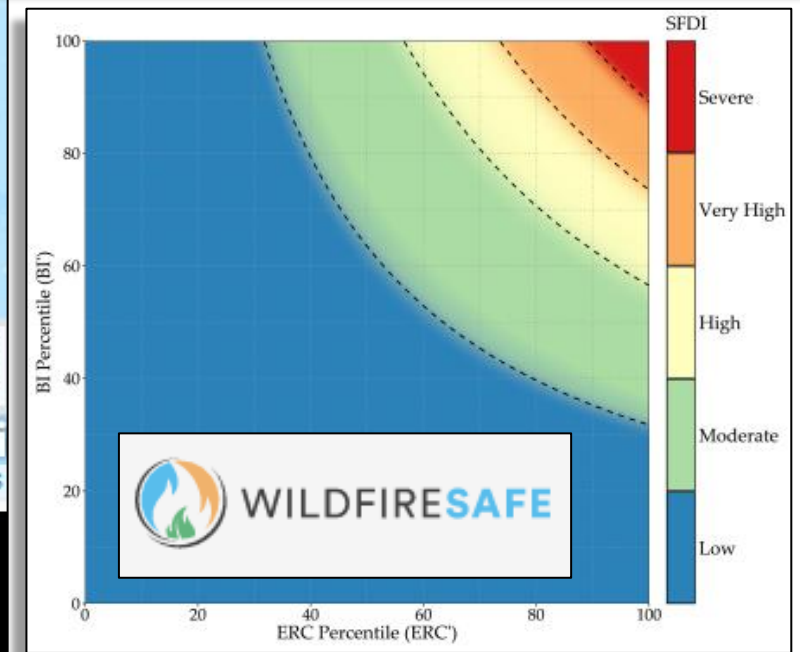


- Major updates to the NFDRS in recent years to automate and incorporate weather forecast data
- Fire Danger = Dynamic Wildfire Hazard

# Seasonal Preparedness

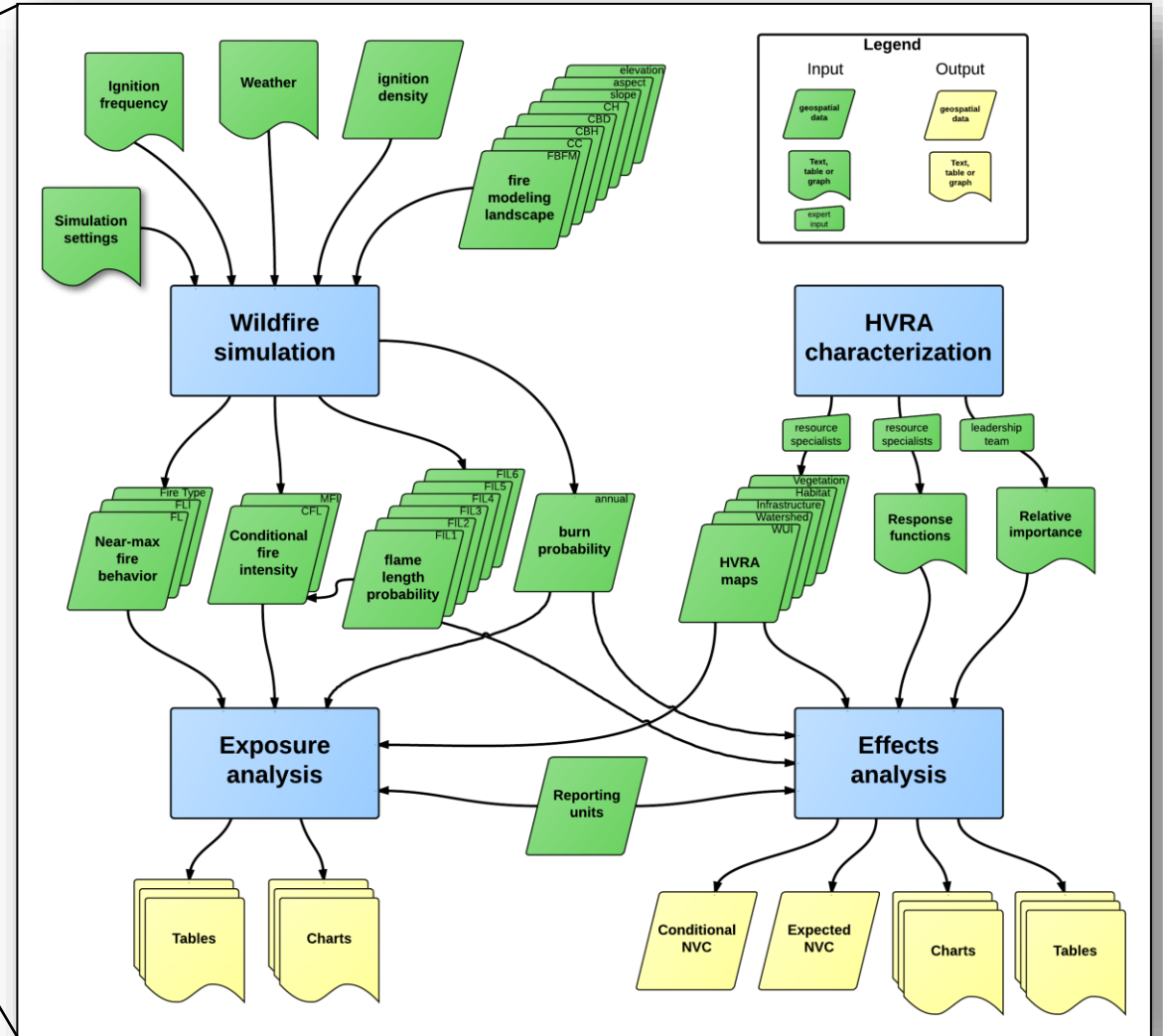
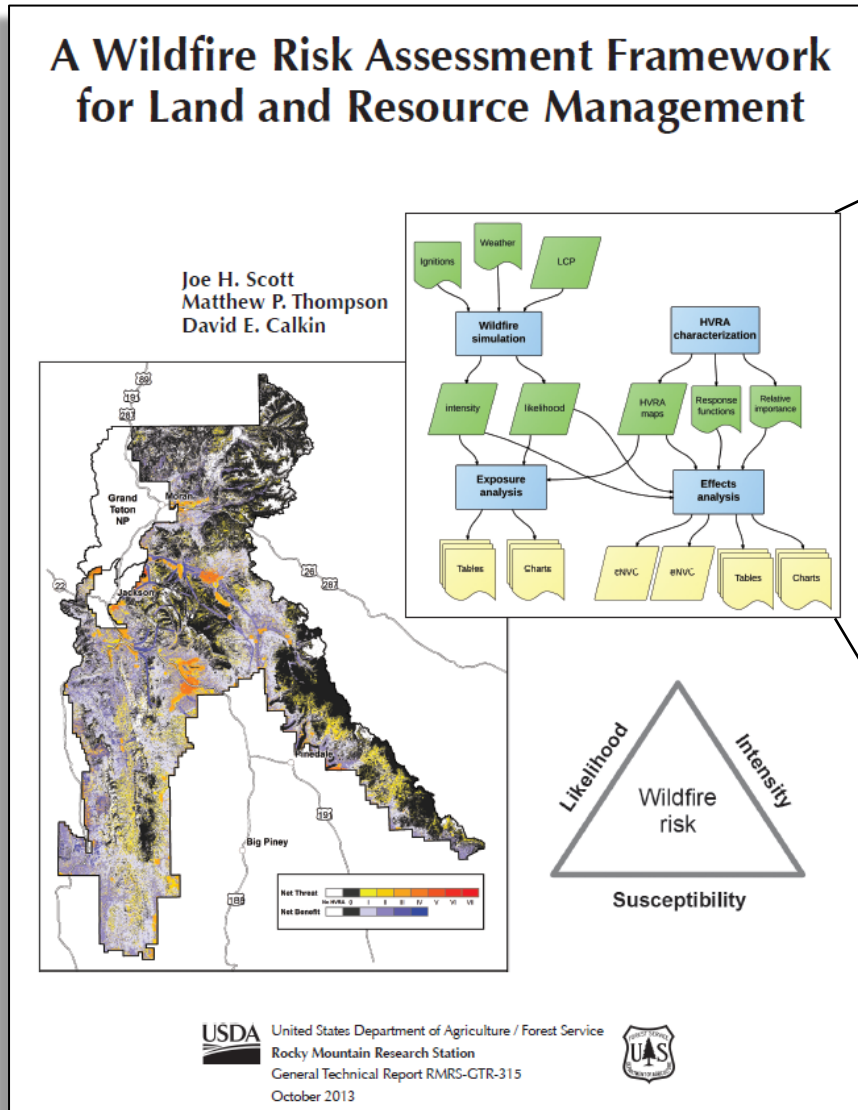


Article  
**Severe Fire Danger Index: A Forecastable Metric to Inform Firefighter and Community Wildfire Risk Management**  
W. Matt Jolly\*, Patrick H. Freeborn, Wesley G. Page and Bret W. Butler

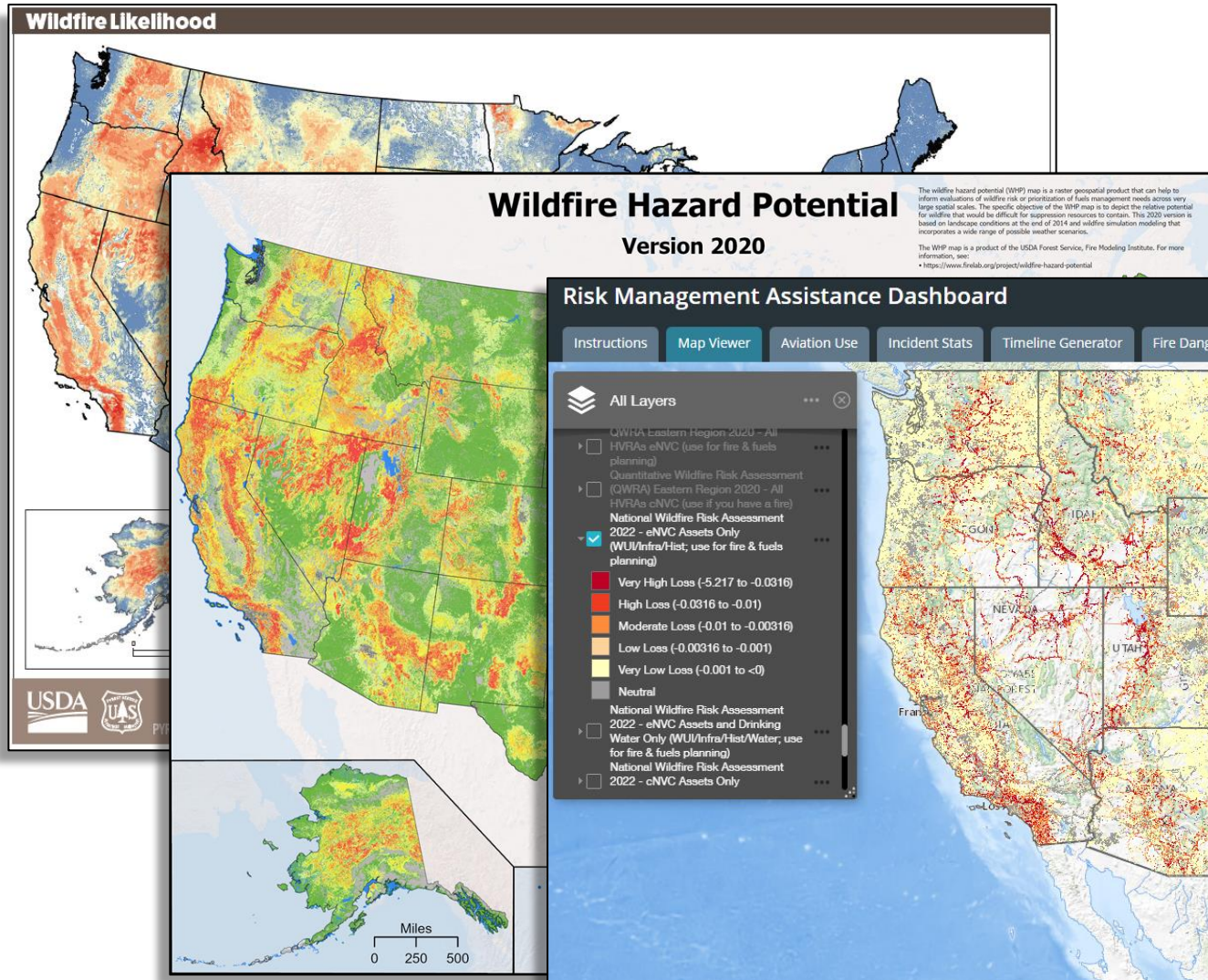


# Long-term Strategic Planning and Mitigation

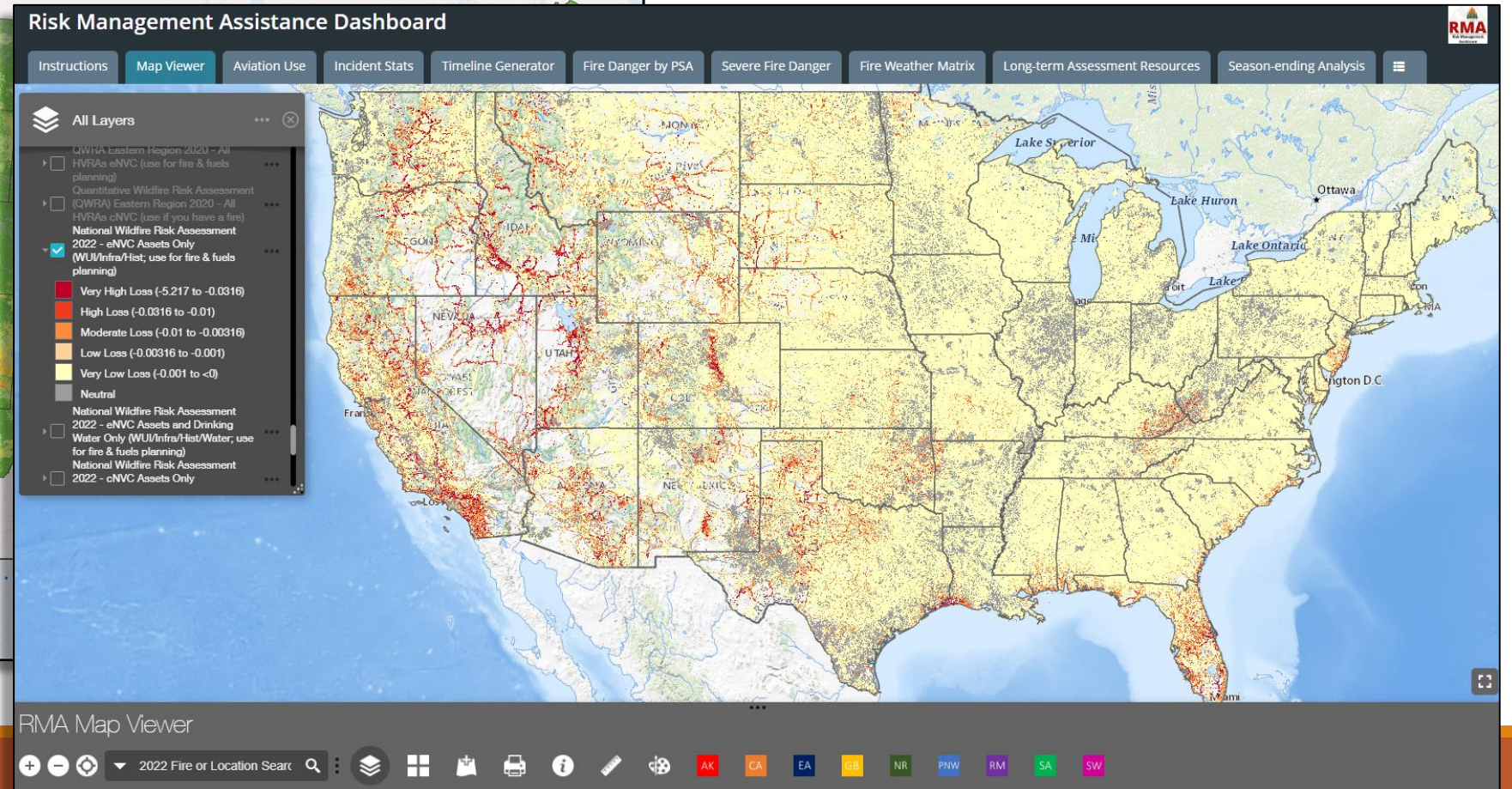
## Quantitative Wildfire Risk Assessment (QWRA)



# Long-term Strategic Planning and Mitigation



- Static maps that depict one or more component of risk
- Help to prioritize and guide work to mitigate future hazard and risk



# Long-term Strategic Planning and Mitigation



- Anyone can create a login and access tools
- Includes a module to run risk assessments
- Great online training resources and help documentation
- <https://iftdss.firenet.gov/>



- Free, easy to use website with interactive maps, charts, and resources
- <https://wildfirerisk.org>





# WILDFIRE RISK TO COMMUNITIES



UNDERSTAND



EXPLORE

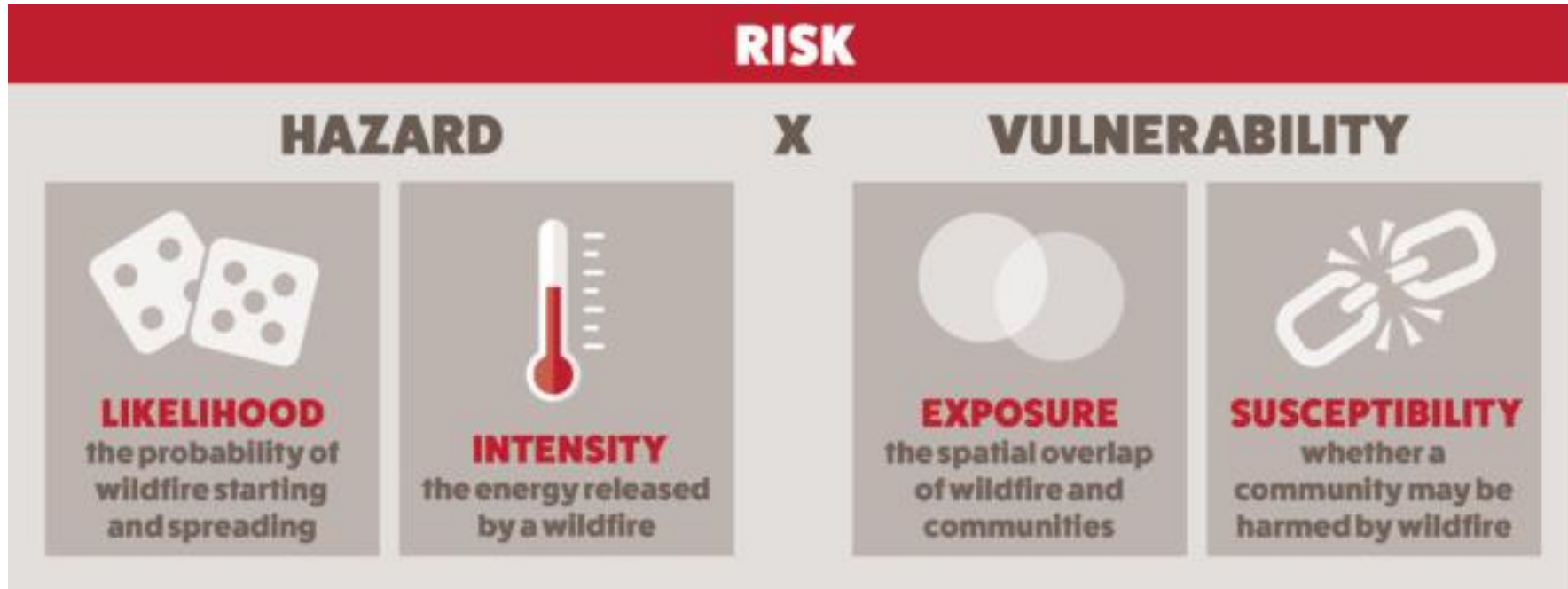


REDUCE

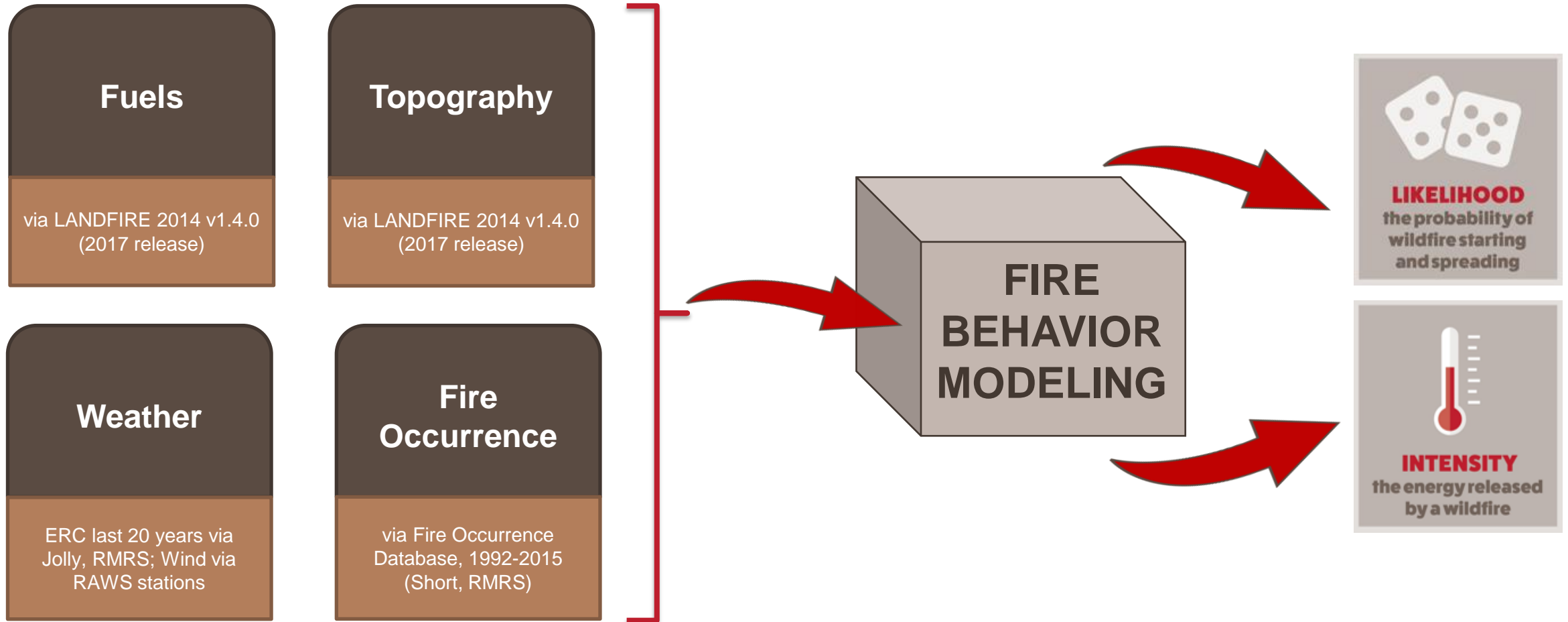
- Directed by Congress in 2018 Consolidated Appropriations Act
- Nationwide maps & data with consistent methods
- Searchable by community, tribal areas, county, state
- Published April 2020 at [www.wildfirerisk.org](http://www.wildfirerisk.org)
- Target audience: Elected officials, land use planners, fire managers, collaboratives



# UNDERSTANDING RISK



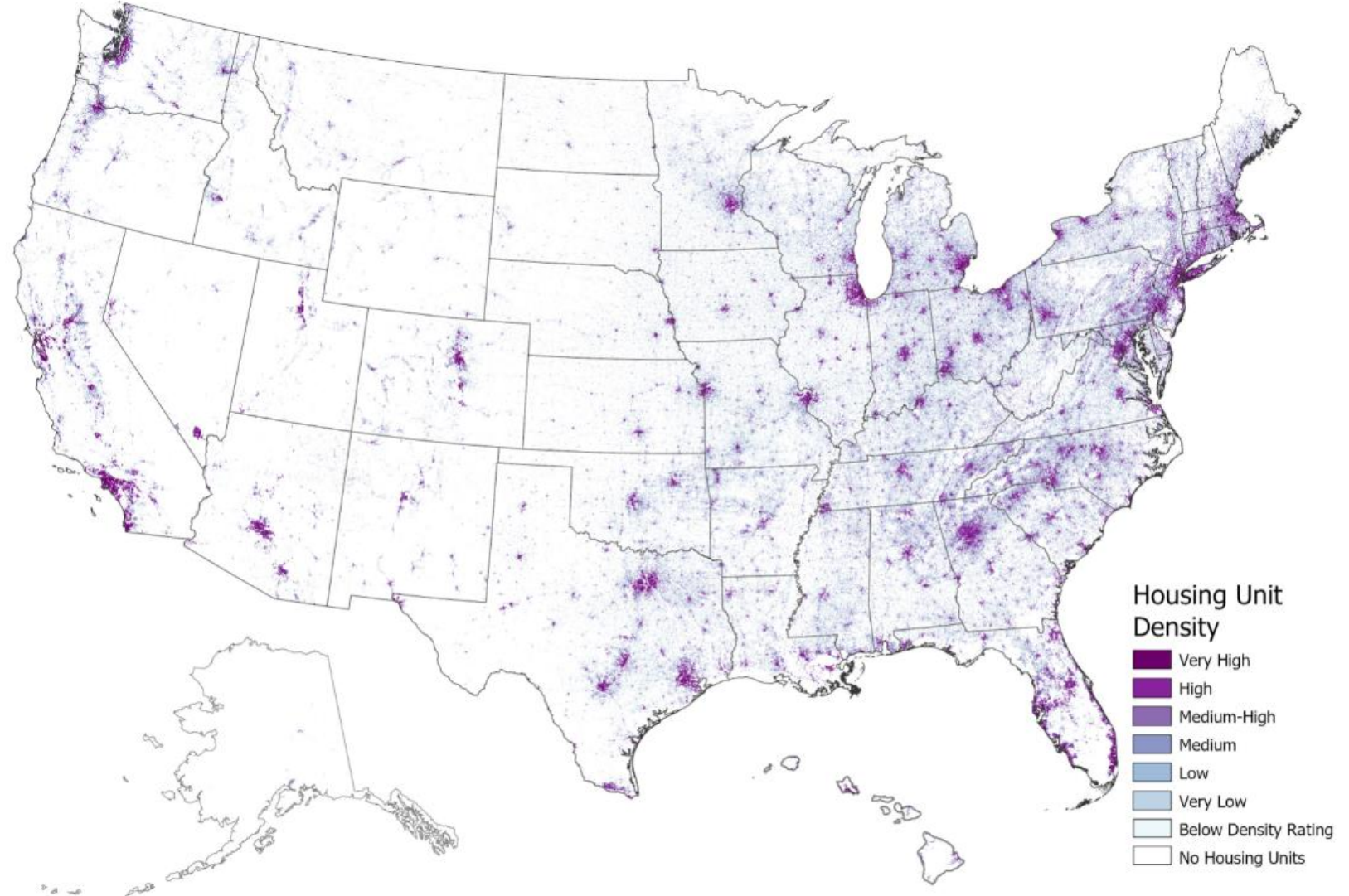
# MAPPING WILDFIRE HAZARD



# HOUSING UNIT DENSITY

## Sources:

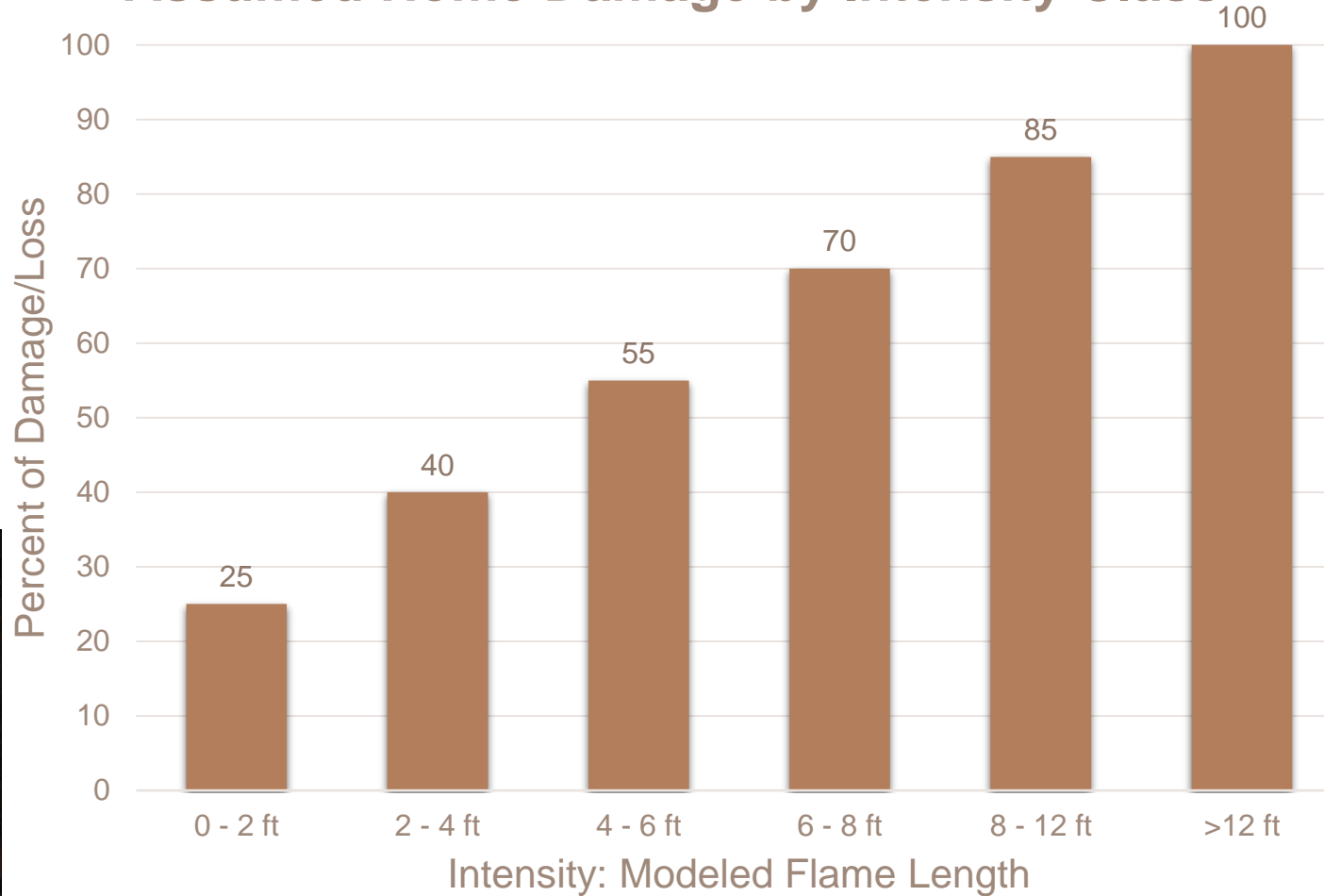
- US Census Bureau
  - 2018 5-year American Community Survey
  - 2018 Population Estimates Program
- Microsoft Building Footprints
- LANDFIRE land cover data



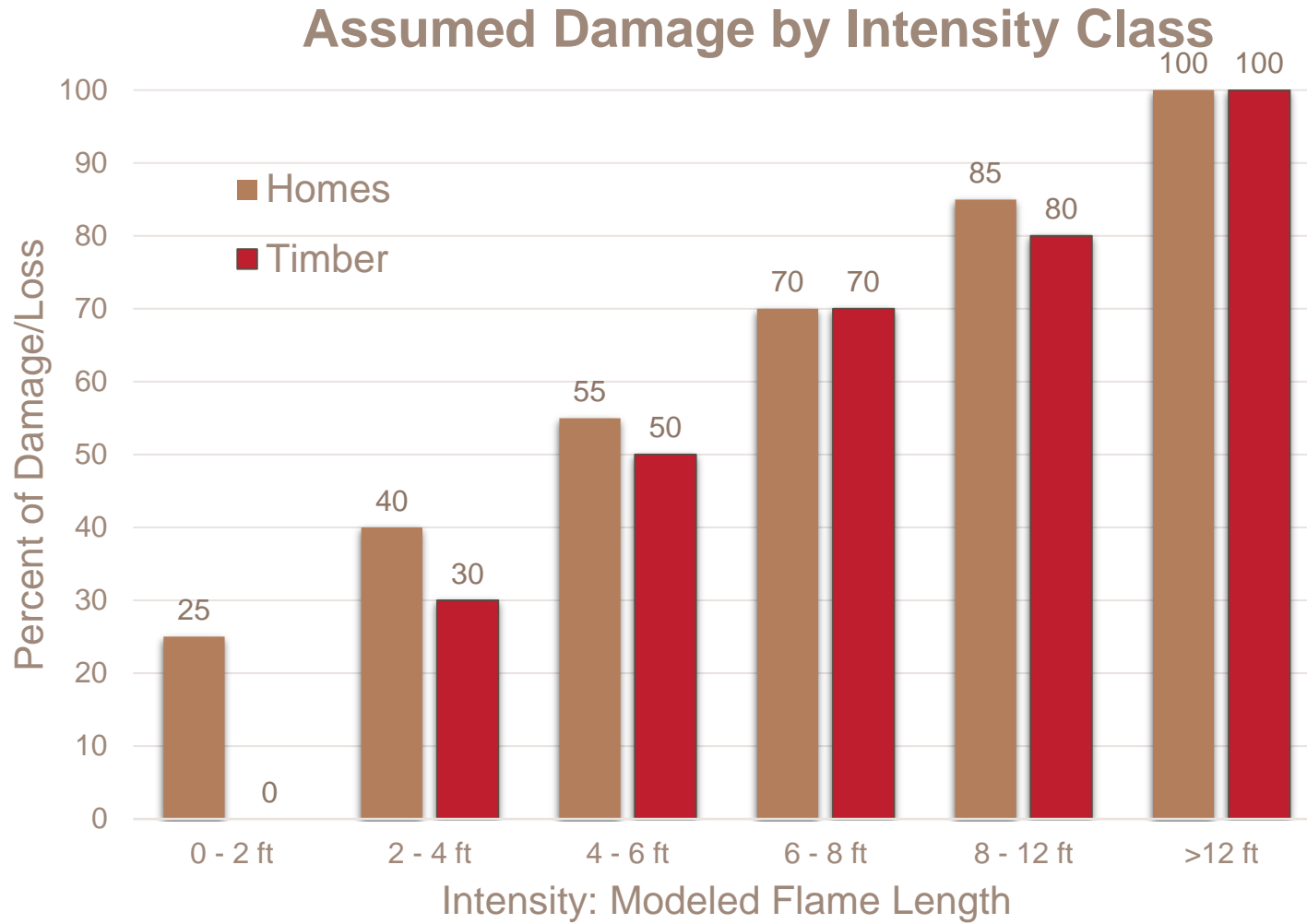
# WHAT ABOUT SUSCEPTIBILITY?



## Assumed Home Damage by Intensity Class

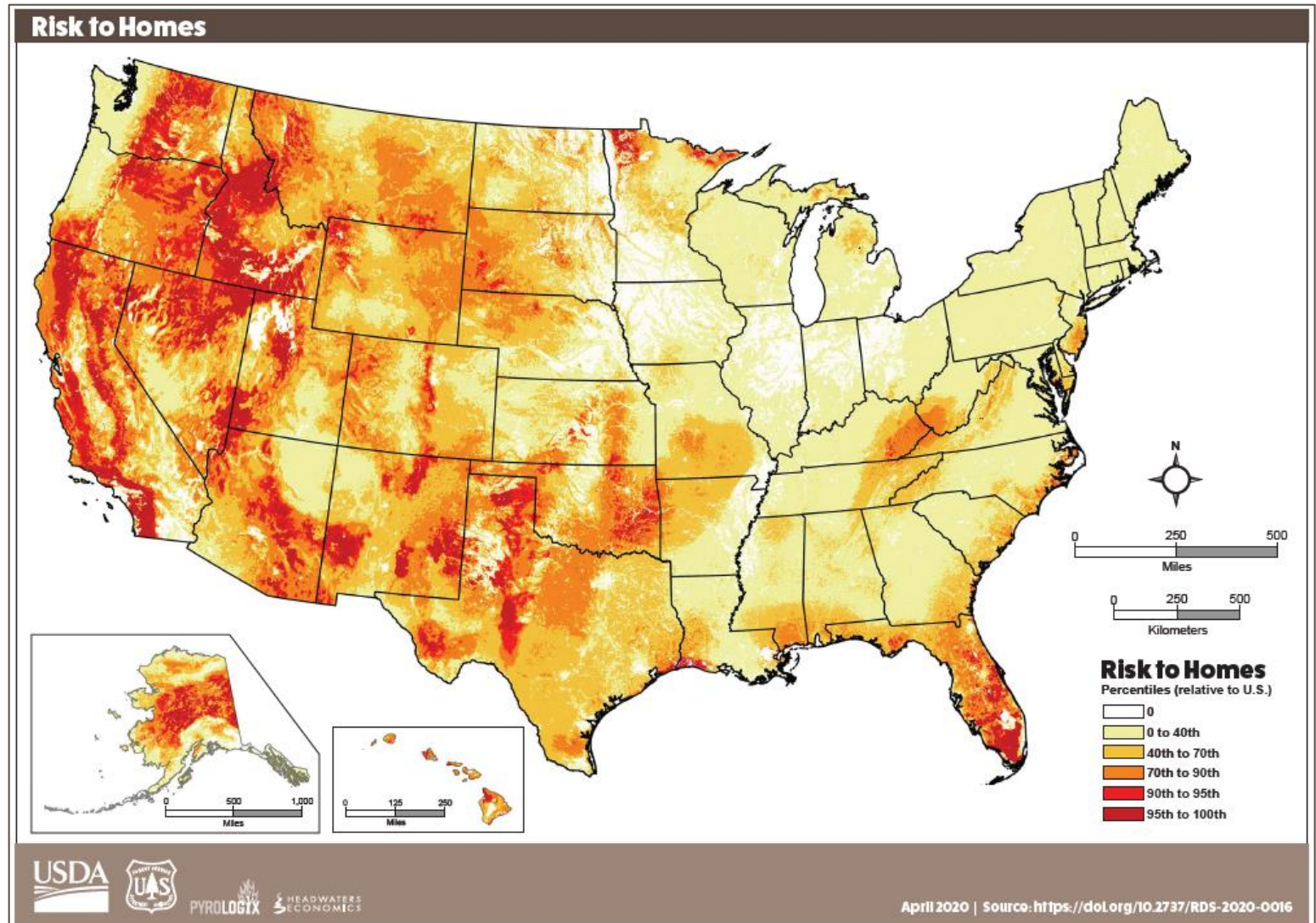


# WHAT ABOUT SUSCEPTIBILITY?



# EXPLORE RISK

- For every pixel: "What would be the relative risk to a house if one existed here?"
- The map could also be interpreted as relative risk to timber resources if present
- Searchable by community, tribal area, county, or state



# REDUCE RISK



**IGNITION-  
RESISTANT  
HOMES**



**LAND USE  
PLANNING**



**EVACUATION &  
READINESS**



**SMOKE READY**



**PREVENT  
IGNITIONS**



**RESPONSE**



**EQUITABLE  
RISK  
REDUCTION**



**HAZARDOUS  
FUELS  
MANAGEMENT**



**RECOVERY &  
REBUILDING**



# REDUCE RISK

## Identify your most relevant actions

Everyone has a part to play in reducing wildfire risk. Select a role to highlight tools, tips, and programs that can help.

FILTER BY ROLE

Land Managers



### Ignition-Resistant Homes

Use wildfire-resistant building materials and landscaping.



### Land Use Planning

Direct how communities develop in wildfire-prone areas using plans and regulations.



### Evacuation & Readiness

Be ready for wildfires with community alerts, evacuation routes, and family plans.



### Equitable Risk Reduction

Address the social and economic vulnerabilities of people in the community.



### Smoke Ready

Prepare for the health impacts of wildfire smoke in the community.



### Prevent Ignitions

Reduce ignitions from campfires, debris burning, vehicles, and other sources.



### Response

Manage and fight wildfires to protect lives, communities, and resources.



### Hazardous Fuels Management

Cut, thin, burn, or otherwise reduce flammable vegetation on the landscape.



### Recovery & Rebuilding

Restore the landscape and community following a wildfire.

# REDUCE RISK

## Identify your most relevant actions

Everyone has a part to play in reducing wildfire risk. Select a role to highlight tools, tips, and programs that can help.

FILTER BY ROLE

Homeowners



### Ignition-Resistant Homes

Use wildfire-resistant building materials and landscaping.



### Land Use Planning

Direct how communities develop in wildfire-prone areas using plans and regulations.



### Evacuation & Readiness

Be ready for wildfires with community alerts, evacuation routes, and family plans.



### Equitable Risk Reduction

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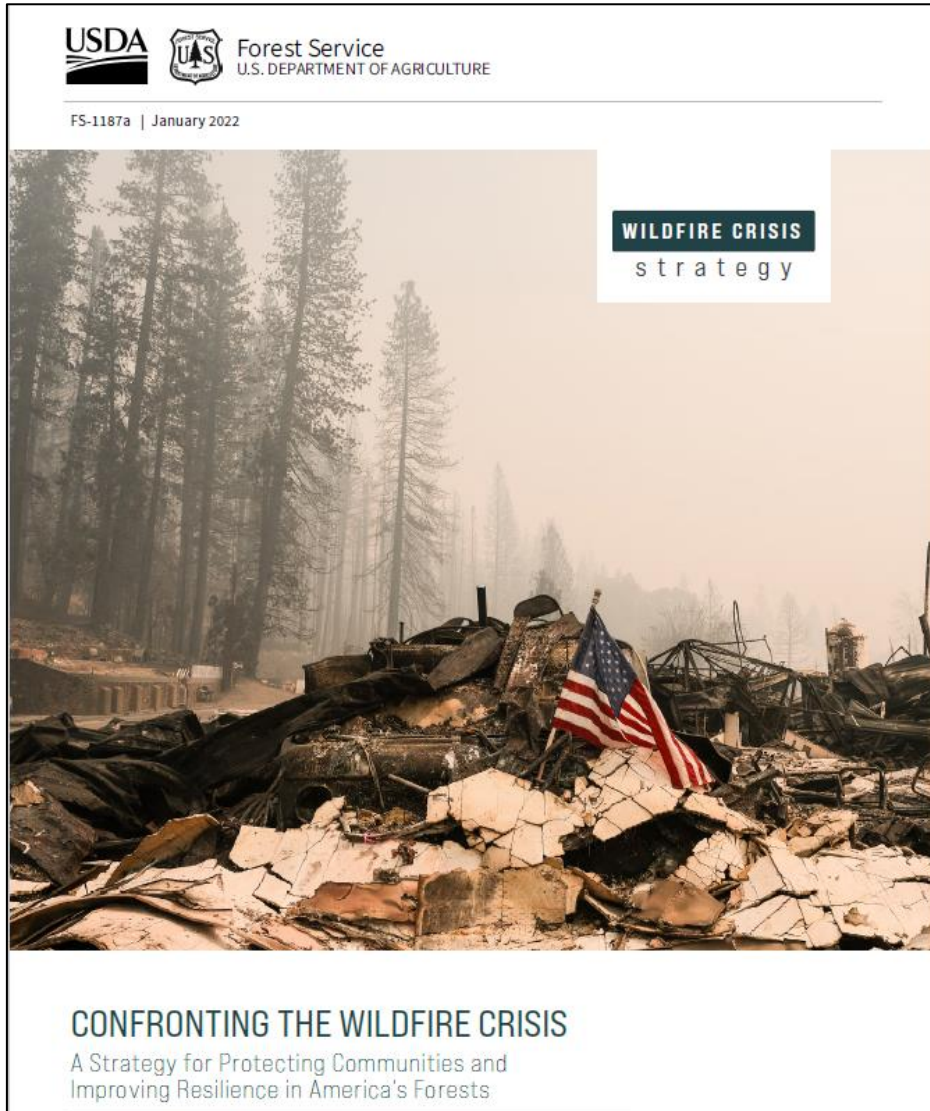
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Photo: Greg Dillon

# The Wildfire Crisis Strategy



“...The risk has reached crisis proportions in the West, calling for decisive action to **protect people and communities and improve forest health and resilience**. It will take a **paradigm shift in land management** across jurisdictional boundaries to **reduce risk and restore fire-adapted landscapes**. In response, the U.S. Department of Agriculture, Forest Service is establishing a strategy for working with partners to **dramatically increase fuels and forest health treatments by up to four times current treatment levels in the West.**”

It is essential to leverage agency capacity for **coordinating** treatments on other federal, state, Tribal, and private lands in the West.

It is also essential to leverage agency capacity to help **gather and share local lessons** while monitoring the effectiveness of local initiatives in reducing community and homeowner risk, with a focus on continual learning.

But ultimately these steps rely on the actions of other agencies, communities, collaboratives, and homeowners.

In other words, the highest leverage actions are **outside the agency's scope of control**.

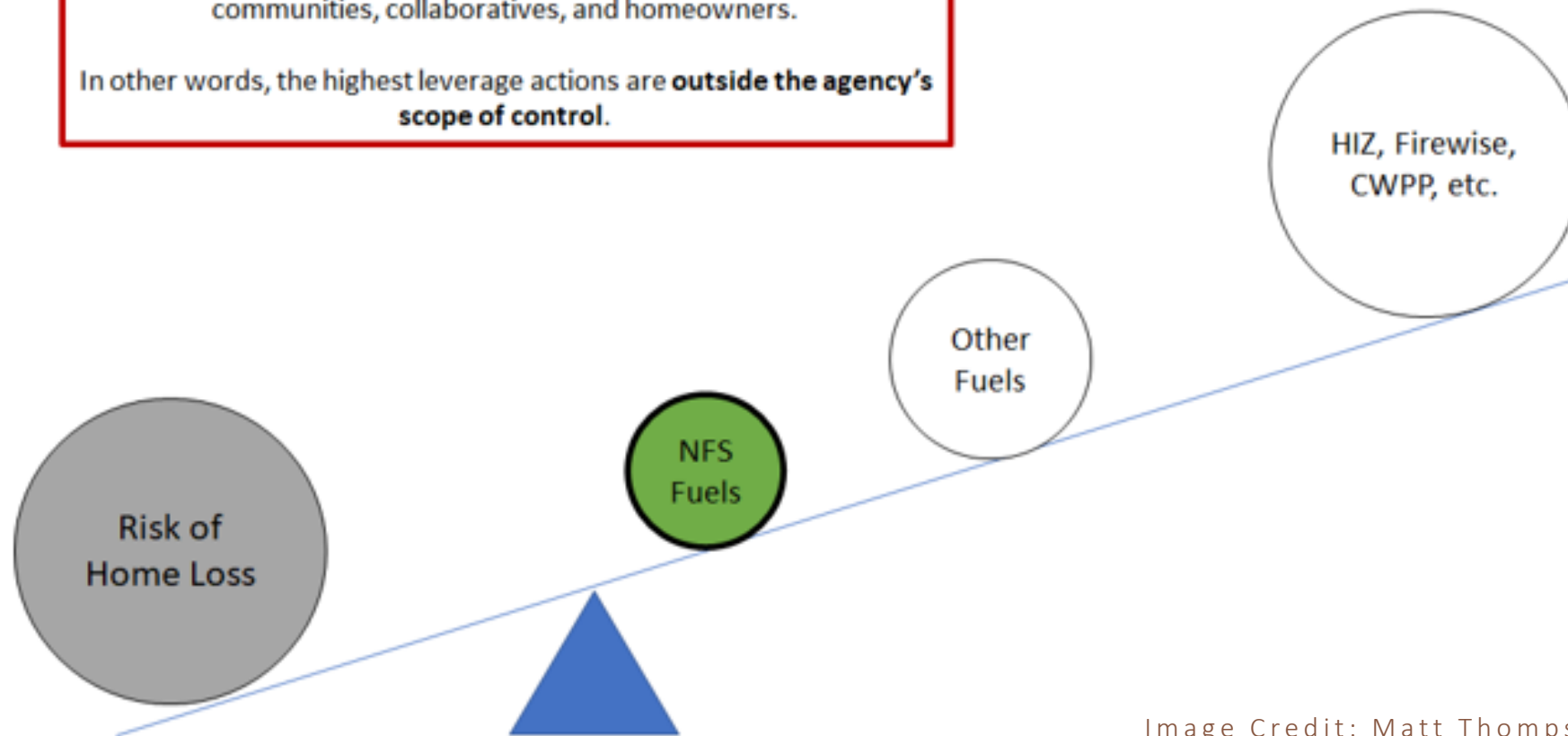


Image Credit: Matt Thompson

# Resources for More Information

- **Missoula Fire Lab Seminar Series – Special Series on the Wildfire Crisis Strategy**
  - The Wildfire Crisis Strategy: How it started, how it's going, and how RMRS science contributes
  - Contribution of Risk Science and Scenario Planning to Build the 2022 US Wildfire Crisis Strategy
  - Research Foundations of Analytics Supporting the Wildfire Crisis Strategy
  - A Road Map for Supporting Strategic Risk Reduction Investments with Land and Fire Management Operations
  - A Strategic Framework for Planning, Mitigation, and Response
  - Minding the Science-Practice Gap in the Wildfire Crisis Strategy: Building Capacity for the Co-Management of Wildfire Risk Transmission (CoMFRT)
  - Transforming Data into Useful Information for Wildfire Decision-Making: Improving the Utility of Remote Sensing Products at Tactical and Planning Scales
  - Community-Focused Programs, Datasets, and Planning Resources for Wildfire Risk Mitigation
  - How an Evidence-Based Approach to Community-Focused Wildfire Education Programs Can Put People at the Center of Wildfire Solutions
  - Slack & Scarcity in Wildfire Management

# Resources for More Information

- Forest Service Research & Development SCIENCEx Fire Webinar Series
  - Fire History and Fire Ecology
    - <https://www.fs.usda.gov/research/products/multimedia/webinars/science-x-fire-fire-history-and-fire-ecology>
  - Fire Weather and Smoke
    - <https://www.fs.usda.gov/research/products/multimedia/webinars/science-x-fire-fire-weather-and-smoke>
  - Fire Behavior
    - <https://www.fs.usda.gov/research/products/multimedia/webinars/science-x-fire-fire-behavior>
  - Modeling Risk and Trade-Offs
    - <https://www.fs.usda.gov/research/products/multimedia/webinars/science-x-fire-modeling-risk-and-trade-offs>
  - Looking Toward the Future
    - <https://www.fs.usda.gov/research/products/multimedia/webinars/science-x-fire-looking-toward-future>

Thank you

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