

# Progress on closing gaps in postfire debris-flow hazard assessment



**Jason Kean**

Katy Barnhart, Andrew Graber, Olivia Hoch, Eric Jones, Jonathan King, Jaime Kostelnik, Nick Mathews, Francis Rengers, Dennis Staley, Robert Schmitt, Brittany Selander, Matthew Thomas, and students





2021 Hermits Peak / Calf  
Canyon Fire, New Mexico  
Tributary to Gallinas Creek  
June 2021

Monitoring Station  
with video camera





June 27, 2022

$I_{15\text{peak}} = 20 \text{ mm/hr}$





August 3, 2022

$I_{15\text{peak}} = 104 \text{ mm/hr}$





2021 Hermits Peak / Calf Canyon Fire, NM  
Tributary to Gallinas Creek  
August 2021





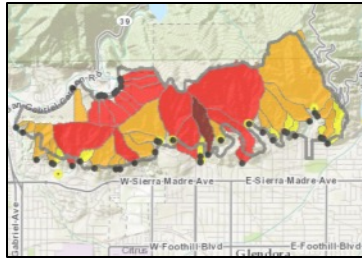
Debris flows are different animals than floods.



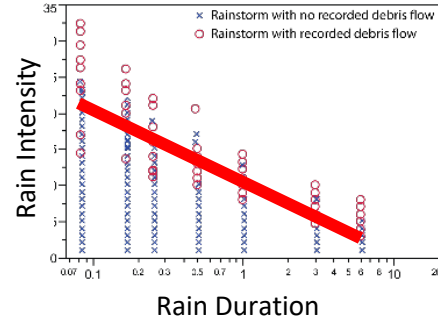


# Postfire debris flow: *Key questions.....*

**Where?**



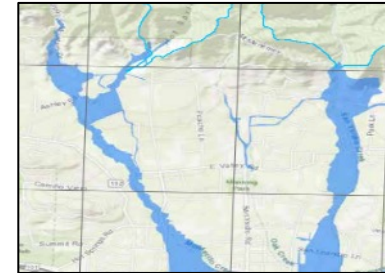
**When?**



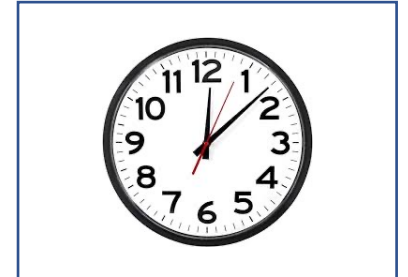
**How big?**



**How fast and far?**



**How long?**



Operational products

Under development

The answers vary on the **local geology**, **climate**, **burn severity**, and **topography**.

The USGS and partners collect **data** from burn areas across the country to answer these questions.



## Progress on closing gaps in postfire hazard assessment:

- 1** New **dashboard** to improve delivery of results
- 2** **Open-source code** with faster computing and increased flexibility
- 3** Account for **regional climatology** in hazard assessment
- 4** Predict **how fast and far** flows will travel
- 5** Estimate **how long** burn areas will remain a hazard





# New dashboard to improve delivery of results



USGS Post Wildfire Debris Flow Hazard Assessment Viewer

Select Fire Year  
View All Fire Years

Select by Fire  
View All

[Scientific Background](#) | [Frequently Asked Questions](#) | [Assessment Requirements](#) | [Disclaimer](#) | [Feedback](#)

## Fires Within Map Extent

(Select to View Details)

### 204 Cow Fire

Malheur National Forest, OR  
Start Date: August 8, 2019

### 242 Fire

Fremont-Winema National Forest,  
OR  
Start Date: September 6, 2020

### 416 Fire

San Juan National Forest, CO  
Start Date: May 31, 2018

### Airplane Lake Fire

Alphabetical | Most Recent

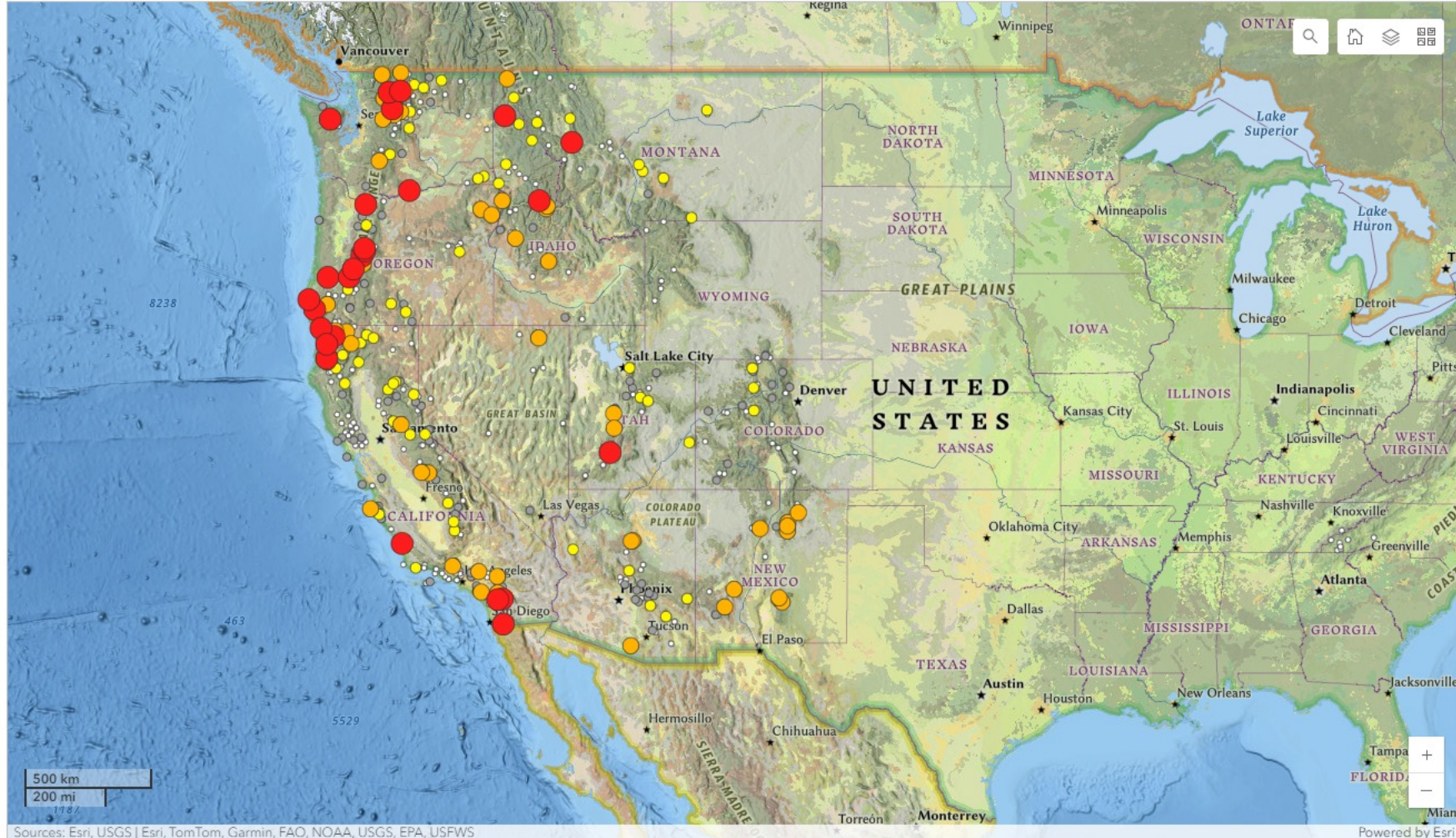
◀ 1 of 482 ▶

## Download Hazard Assessment Results

Marten Creek

### Hazard Assessment Data

Geodatabase Download Link	View
Shapefile Download Link	View
Hazard Assessment PDF	View
Unique URL	<a href="https://usgs.maps.arcgis.com/apps/dashboard">https://usgs.maps.arcgis.com/apps/dashboard</a>



Sources: Esri, USGS | Esri, TomTom, Garmin, FAO, NOAA, USGS, EPA, USFWS

2D | 3D

## EXPLANATION

Response to a design storm with a peak 15-minute intensity of 24 mm/h

### Fire Location

#### Fire Year

- 2023
- 2022
- 2021
- 2020 and older

#### Fire Perimeter



#### Likelihood

- 0-20%
- 20-40%
- 40-60%
- 60-80%
- 80-100%

#### Volume (m<sup>3</sup>)

- <1,000
- 1,000-10,000
- 10,000-100,000
- >100,000

#### Combined Hazard

- Low
- Moderate
- High





# New dashboard to improve delivery of results



## USGS Post Wildfire Debris Flow Hazard Assessment Viewer

Select Fire Year  
View All Fire Years

Select by Fire  
View All

St  
Vi

[Scientific Background](#) | [Frequently Asked Questions](#) | [Assessment Requirements](#) | [Disclaimer](#) | [Feedback](#)

### Fires Within Map Extent

(Select to View Details)

#### Hermit's Peak-Calf Canyon, Phase I Fire

Santa Fe National Forest, NM  
Start Date: April 5, 2022

Alphabetical

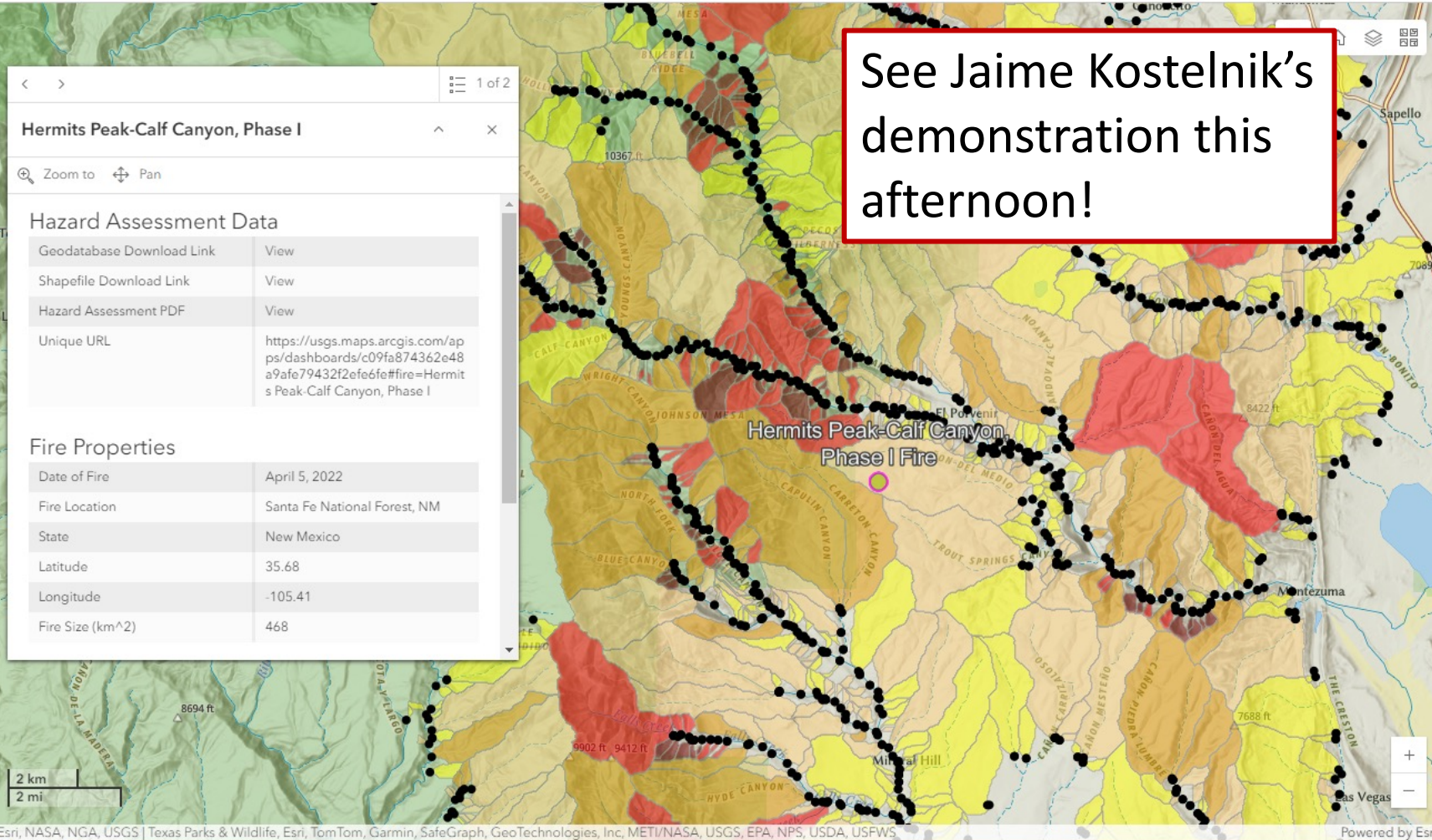
Most Recent

### Download Hazard Assessment Results

#### Hermit's Peak-Calf Canyon, Phase I

##### Hazard Assessment Data

Geodatabase Download Link	View
Shapefile Download Link	View
Hazard Assessment PDF	View
Unique URL	<a href="https://usgs.maps.arcgis.com/apps/dashboards/c09fa874362e48a9afe79432f2efe6fe#fire=Hermit's%20Peak-Calf%20Canyon,%20Phase%20I">https://usgs.maps.arcgis.com/apps/dashboards/c09fa874362e48a9afe79432f2efe6fe#fire=Hermit's Peak-Calf Canyon, Phase I</a>



Hermit's Peak-Calf Canyon, Phase I

Hazard Assessment Data

Geodatabase Download Link	View
Shapefile Download Link	View
Hazard Assessment PDF	View
Unique URL	<a href="https://usgs.maps.arcgis.com/apps/dashboards/c09fa874362e48a9afe79432f2efe6fe#fire=Hermit's Peak-Calf Canyon, Phase I">https://usgs.maps.arcgis.com/apps/dashboards/c09fa874362e48a9afe79432f2efe6fe#fire=Hermit's Peak-Calf Canyon, Phase I</a>

Fire Properties

Date of Fire	April 5, 2022
Fire Location	Santa Fe National Forest, NM
State	New Mexico
Latitude	35.68
Longitude	-105.41
Fire Size (km^2)	468

### EXPLANATION

Response to a design storm with a peak 15-minute intensity of 24 mm/h

**Fire Location**

**Fire Year**

- 2023
- 2022
- 2021
- 2020 and older

**Fire Perimeter**

**Likelihood**

- 0-20%
- 20-40%
- 40-60%
- 60-80%
- 80-100%

**Volume (m<sup>3</sup>)**

- <1,000
- 1,000-10,000
- 10,000-100,000
- >100,000

**Combined Hazard**

- Low
- Moderate
- High



2

## Open-source code with faster computing and increased flexibility



[SCIENCE](#) [PRODUCTS](#) [NEWS](#) [CONNECT](#) [ABOUT](#)

Latest Earthquakes |



[SOFTWARE](#) | [SOFTWARE RELEASES](#)

### pdfdf 1.0.0

January 5, 2024

[View Software Release](#)

A python library to facilitate postfire debris-flow hazard assessment and research

- Core code (*pdfdf*) and user guide available now
- Expanded version (*wildcat*) coming soon
- Cloud computing (*ocelot*) to follow

See Jonathan King's talk on Wednesday!

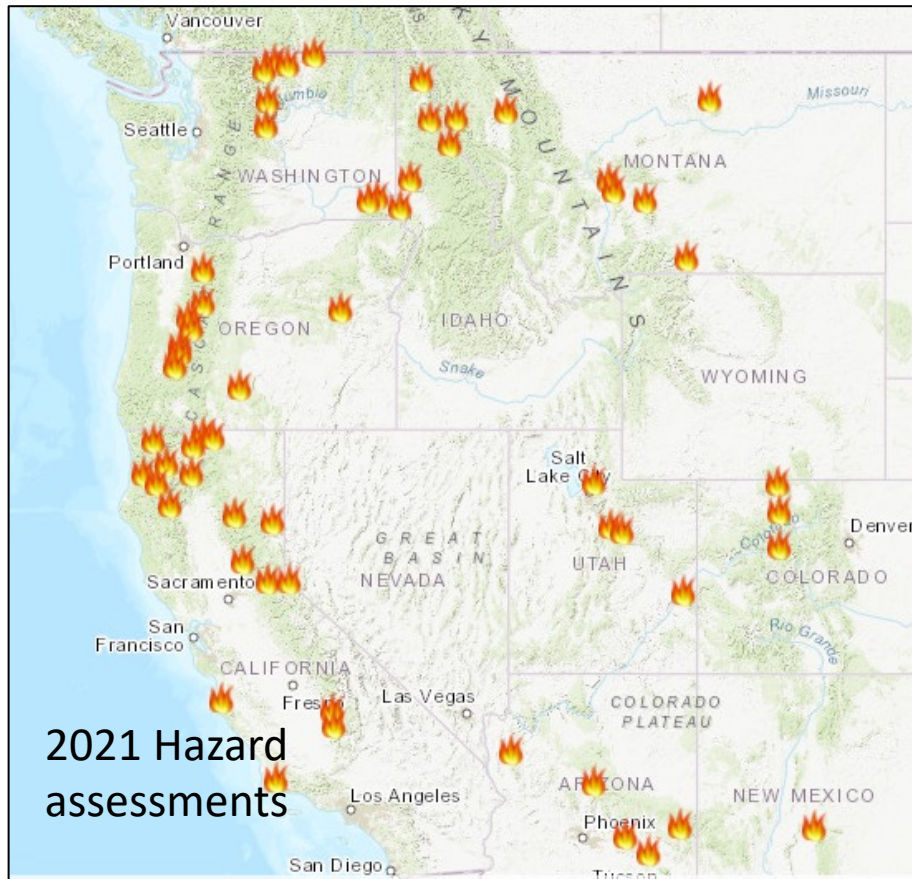


3

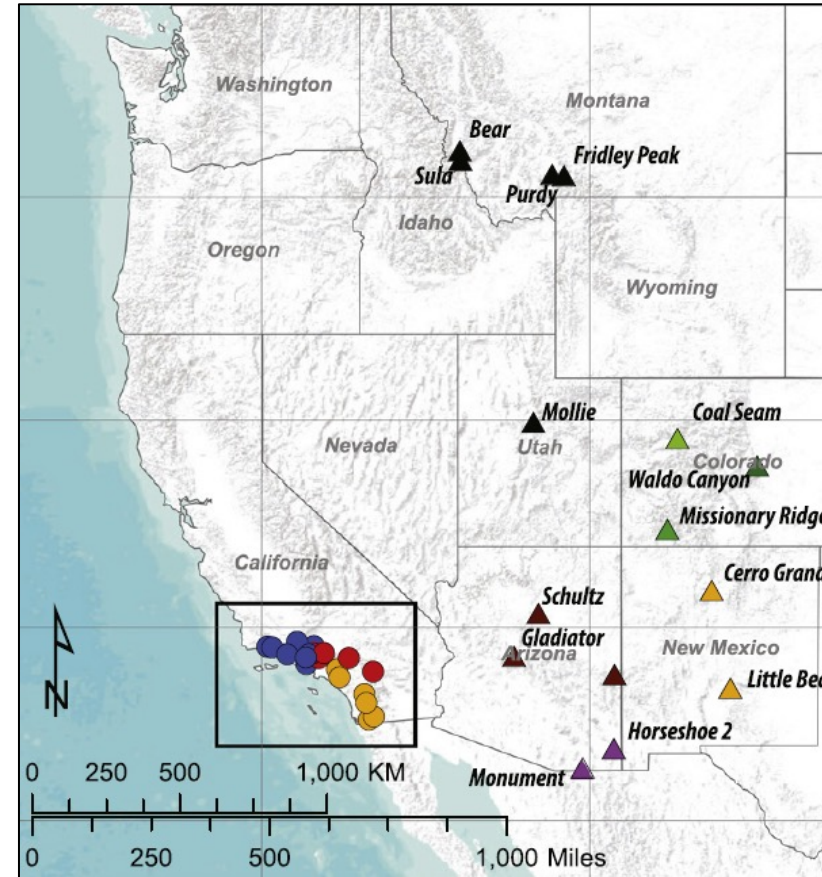
# Account for regional climatology in hazard assessment



Where we are asked to work



Where we have data



Models trained with data from southern CA

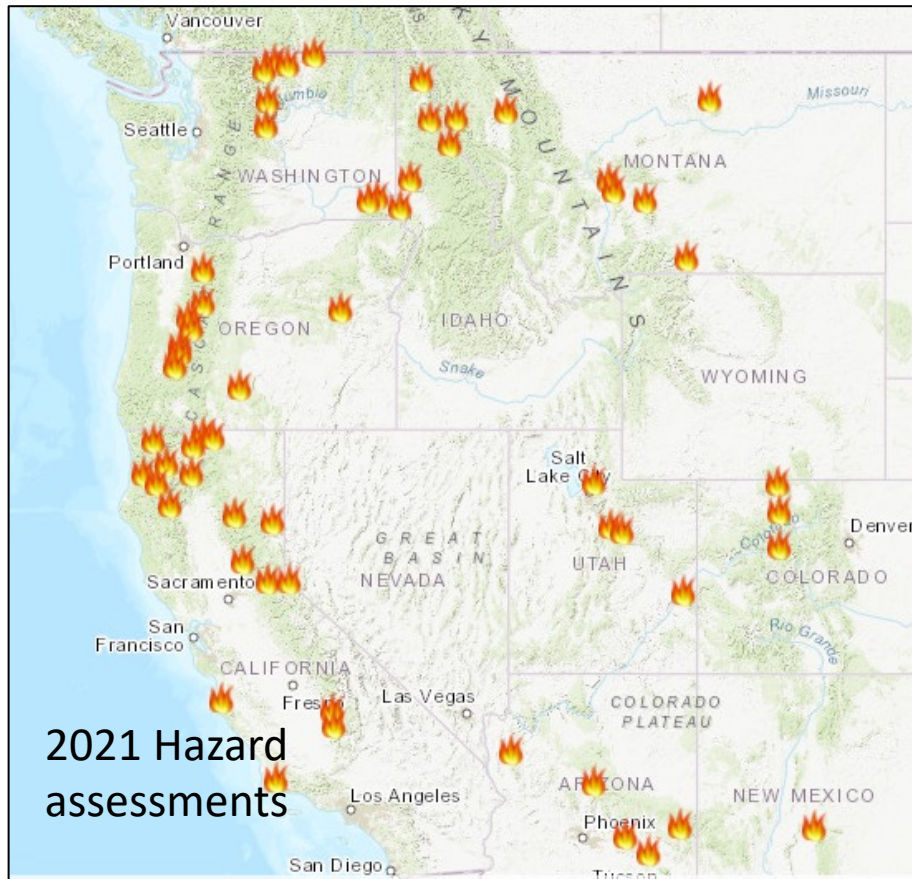
Models tested in primarily semi-arid areas of western US



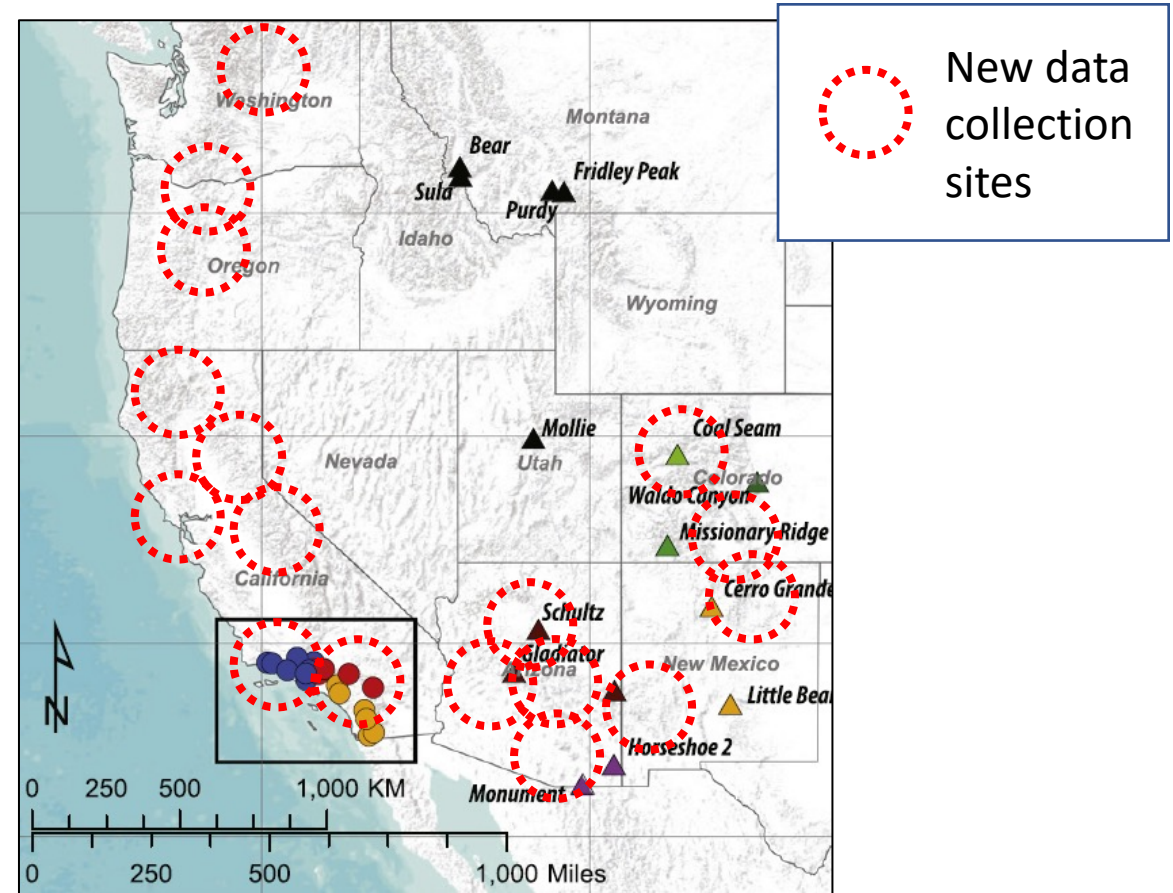
3

# Account for regional climatology in hazard assessment

Where we are asked to work



Where we have data





3

# New data collection for model recalibration

Oregon



Washington



DOGAMI

2021 Columbia River Gorge, OR - Eagle Creek Fire

Graber, 2023, USGS data release

Burns et al., in prep.

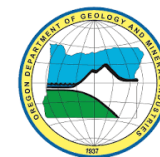
Selander et al., in prep.

WGS, online database



Washington Geological Survey

2022 Okanogan County, WA - Muckamuck Fire





3

# New data collection for model recalibration

# Northern California



2021 Big Sur, CA - Dolan Fire

Thomas et al., 2023a, Landslides



2021 Coffee Creek, CA - River Complex

Cavagnaro et al., in prep.



2022 Feather River Canyon, CA - Dixie Fire





3

# New data collection for model recalibration

# Southern California



USGS

2018 Montecito, CA - Thomas Fire



SB County

2022 Oak Glen, CA - Apple/El Dorado Fire



CGS

2021 Silverado, CA - Bond Fire





3

# New data collection for model recalibration

# Colorado



Denver Channel

2021 East Troublesome Fire, CO

Graber, 2023,  
USGS data release



USGS

2021 Poudre Canyon, CO - Cameron Peak Fire

Rengers et al., 2023,  
NHES



CDOT

2021 Glenwood Canyon, CO - Grizzly Creek Fire





3

# New data collection for model recalibration

Arizona



New Mexico



2022 near Flagstaff, AZ - Pipeline Fire



2020 near Silver City, NM - Tadpole Fire



2022 near Las Vegas, NM - HPCC Fire

Graber, 2023, USGS data release

Rengers et al., 2023, NHSS

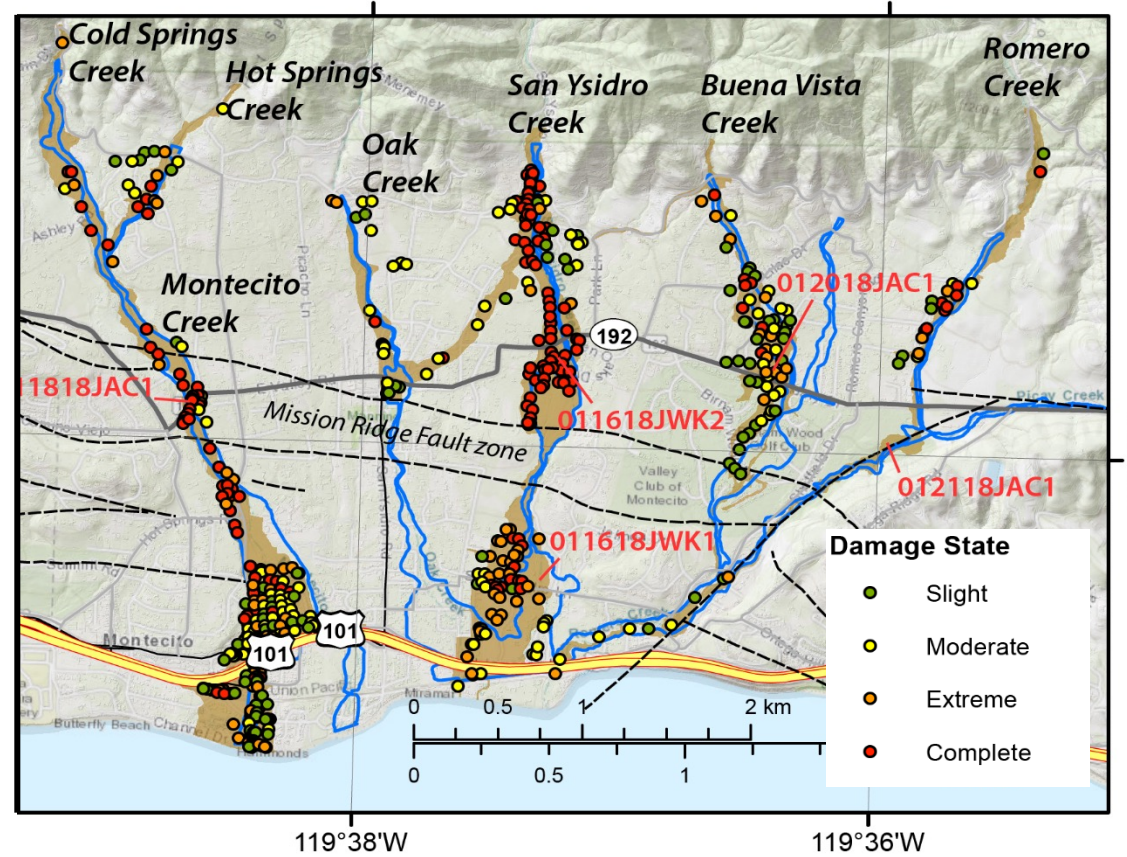
McGuire et al., 2021, JGR-ES





3

Predictions of how fast and far flows will travel



Detailed mapping of Montecito debris-flow event provides rare data to test runout models

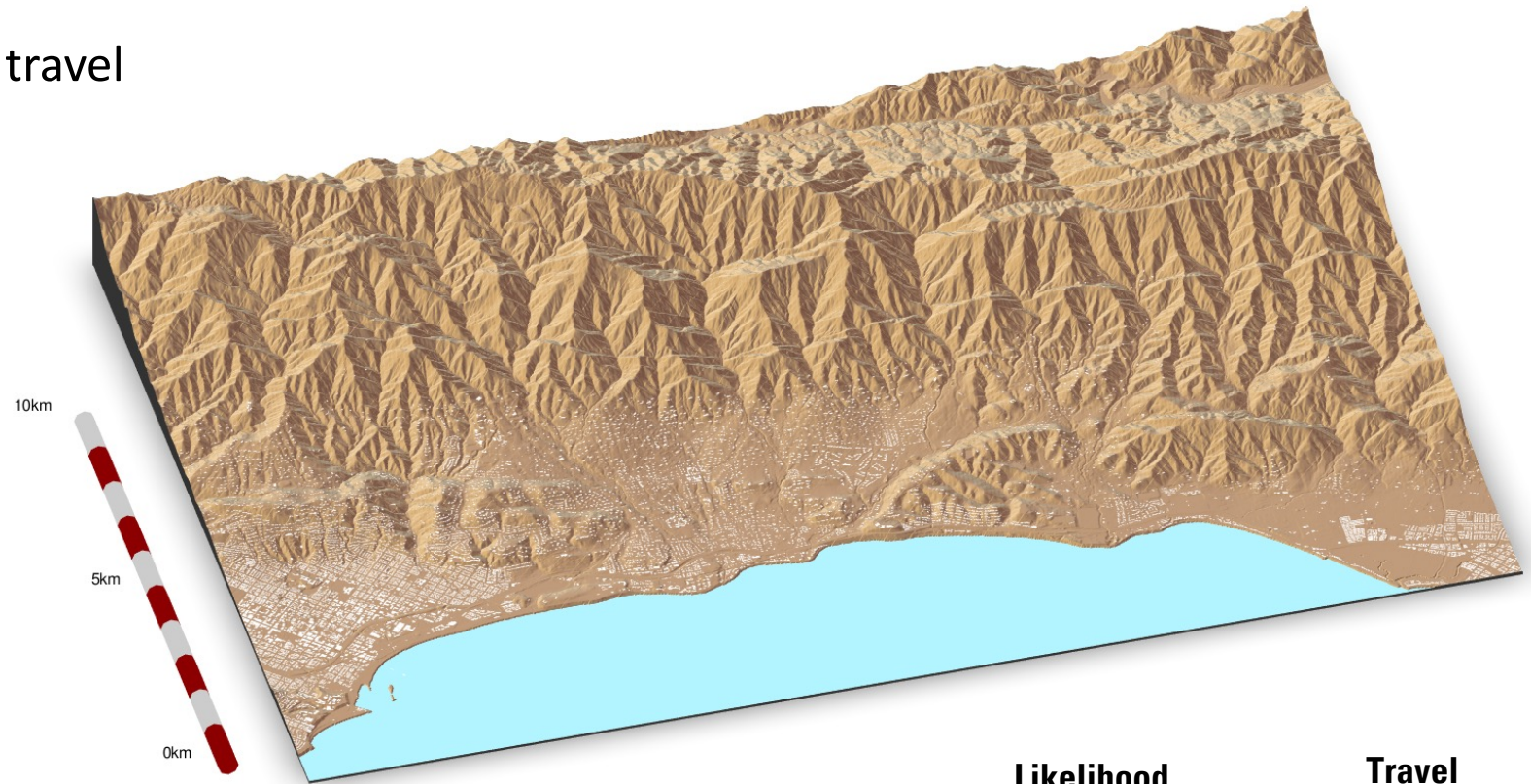
Kean et al., 2019, Geosphere.





## 4 Predict **how fast and far** flows will travel

- Get **stakeholder input** on design of new debris-flow inundation maps
- Several models can predict runout area if properly calibrated, **BUT**
- **Size matters!** Predicting how far flows travel requires good estimates of size.
- **Good physics** are needed to predict how fast flows move and estimate damage.



### Explanation

- Building footprints
- Area burned by the Thomas Fire
- Area impacted by debris flows
- Damaged buildings

### Likelihood

design storm with 15-minute rainfall intensity of 24mm/hr

- 0 to 20 percent
- 20 to 40 percent
- 40 to 60 percent
- 60 to 80 percent
- 80 to 100 percent

### Travel distance

with different design storms

- 25 mm/hr
- 50 mm/hr
- 75 mm/hr
- 100 mm/hr

Barnhart et al.,  
2023, JGR-ES.

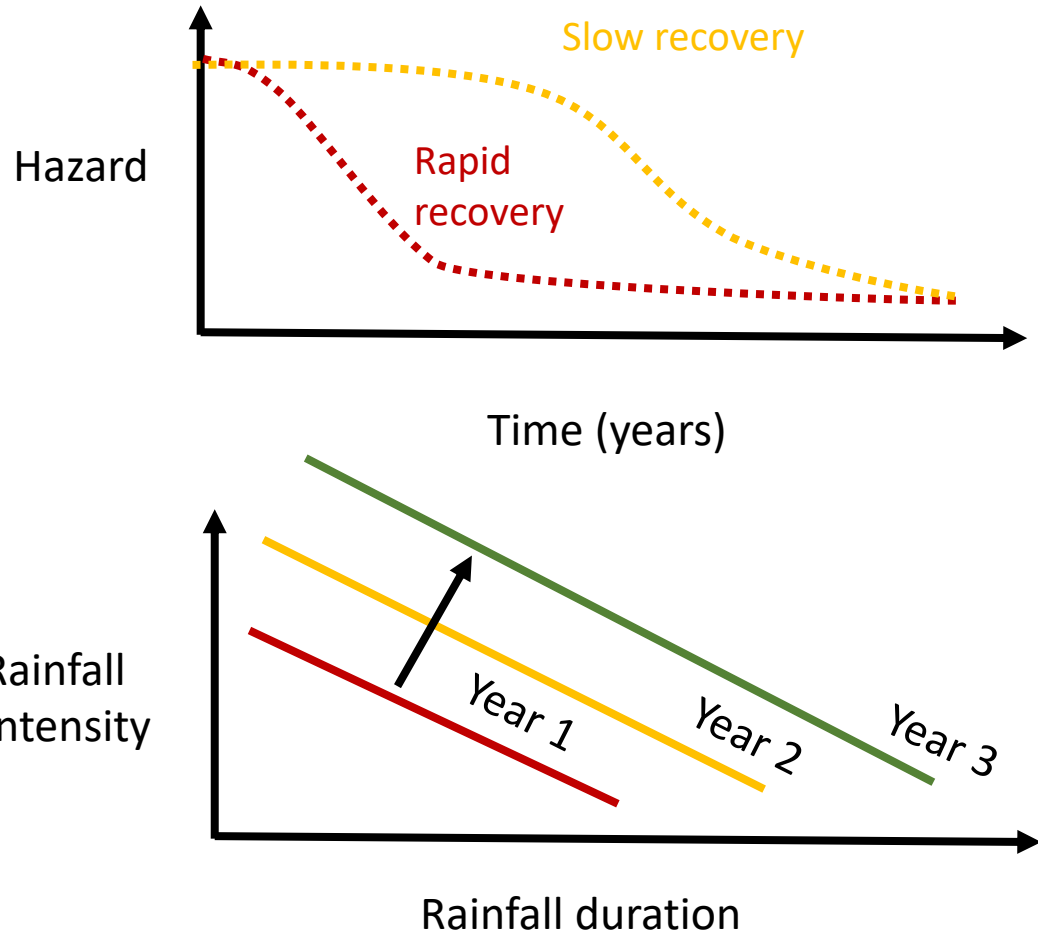
Barnhart et al.,  
2023, USGS-  
OFR.

Barnhart et al.,  
2024, NHES.



5

Estimate **how long** burn areas will remain a hazard



Interstate 70 through Glenwood Canyon, Colorado has been under threat to debris flows for several years since the 2020 Grizzly Creek Fire



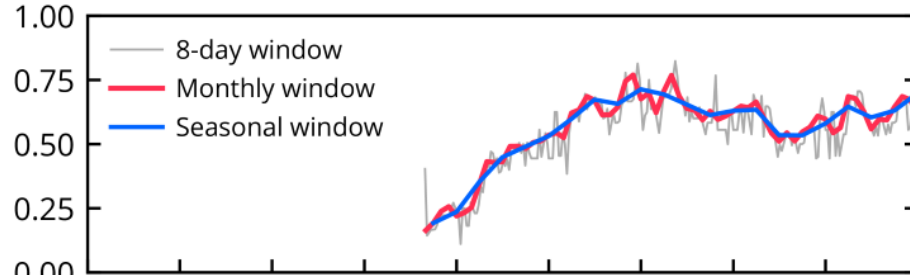
5

Estimate **how long** burn areas will remain a hazard

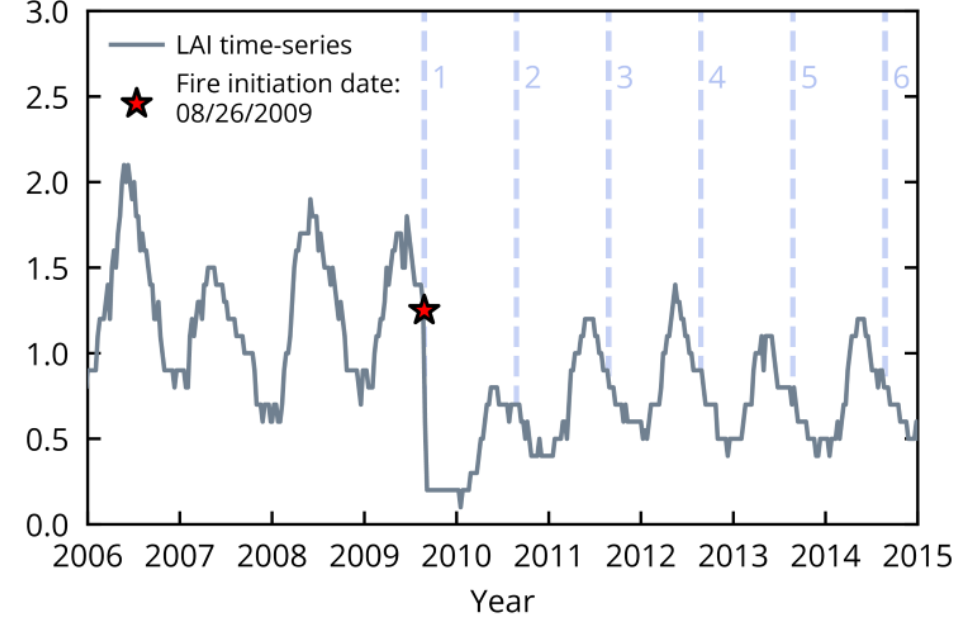


2009 Station Fire

Recovery Ratio



Leaf-Area Index



Use remote sensing data to track vegetation recovery

$$Recovery\ Ratio = \frac{LAI_{postfire}}{LAI_{prefire}}$$

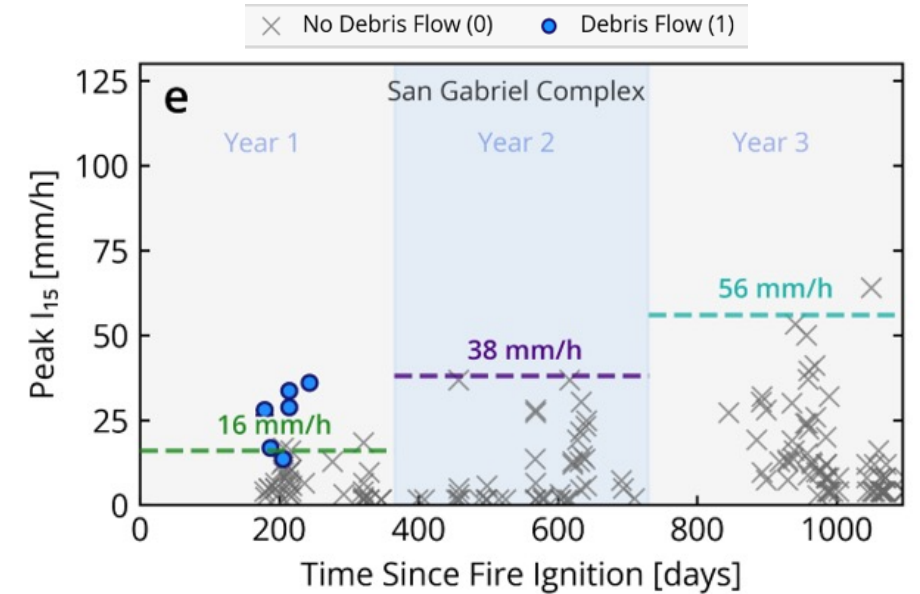
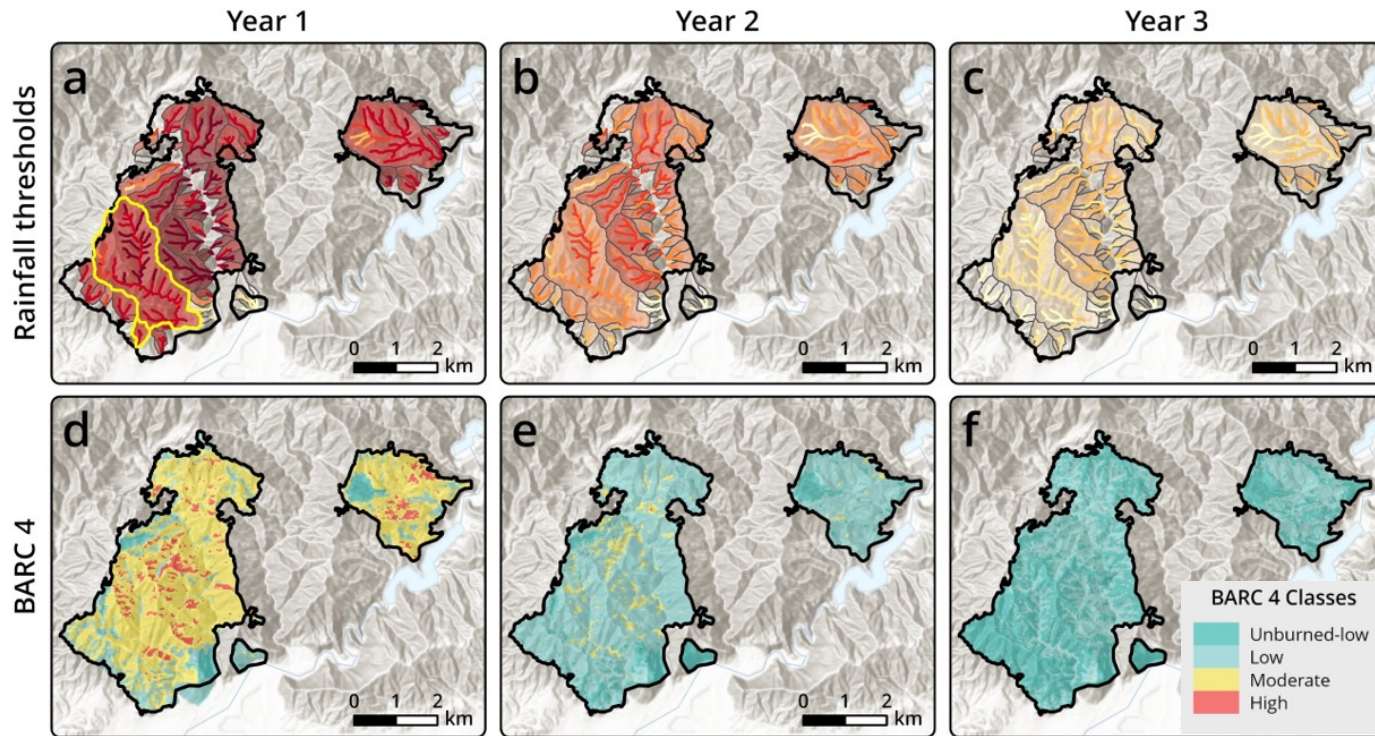
Runoff-generated debris flows are rare when Recovery Ratio > 2/3



5

# Estimate how long burn areas will remain a hazard

Use repeat dNBR and BARC4 imagery to **update hazard maps and rainfall thresholds** with time  
*Example: San Gabriel Complex, CA*

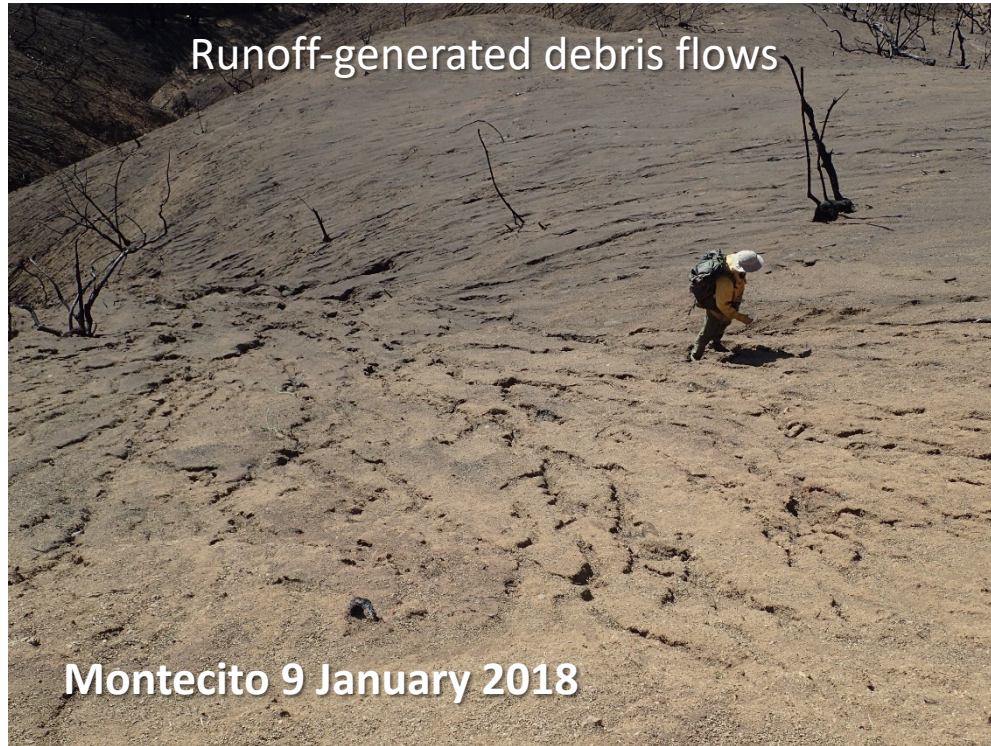


Hazard decreases as rainfall thresholds go up



5 Estimate **how long** burn areas will remain a hazard

- After 2/3 recovery, postfire shallow landslides can be a hazard
- We need to develop appropriate tools predict postfire shallow landslides





## Progress on closing gaps in postfire hazard assessment:

## Delivery Timeline

- 1** New **dashboard** to improve delivery of results Available now
- 2** **Open-source code** Available now with additions in 2024-2025
- 3** Account for **regional climatology** Operational by 2026
- 4** Predict **how fast and far** flows will travel Operational by 2027
- 5** Estimate **how long** burn areas will remain a hazard Operational by 2027