

Co-production of Earthquake Risk Mitigation Knowledge and Practice: ShakeOut and HayWired

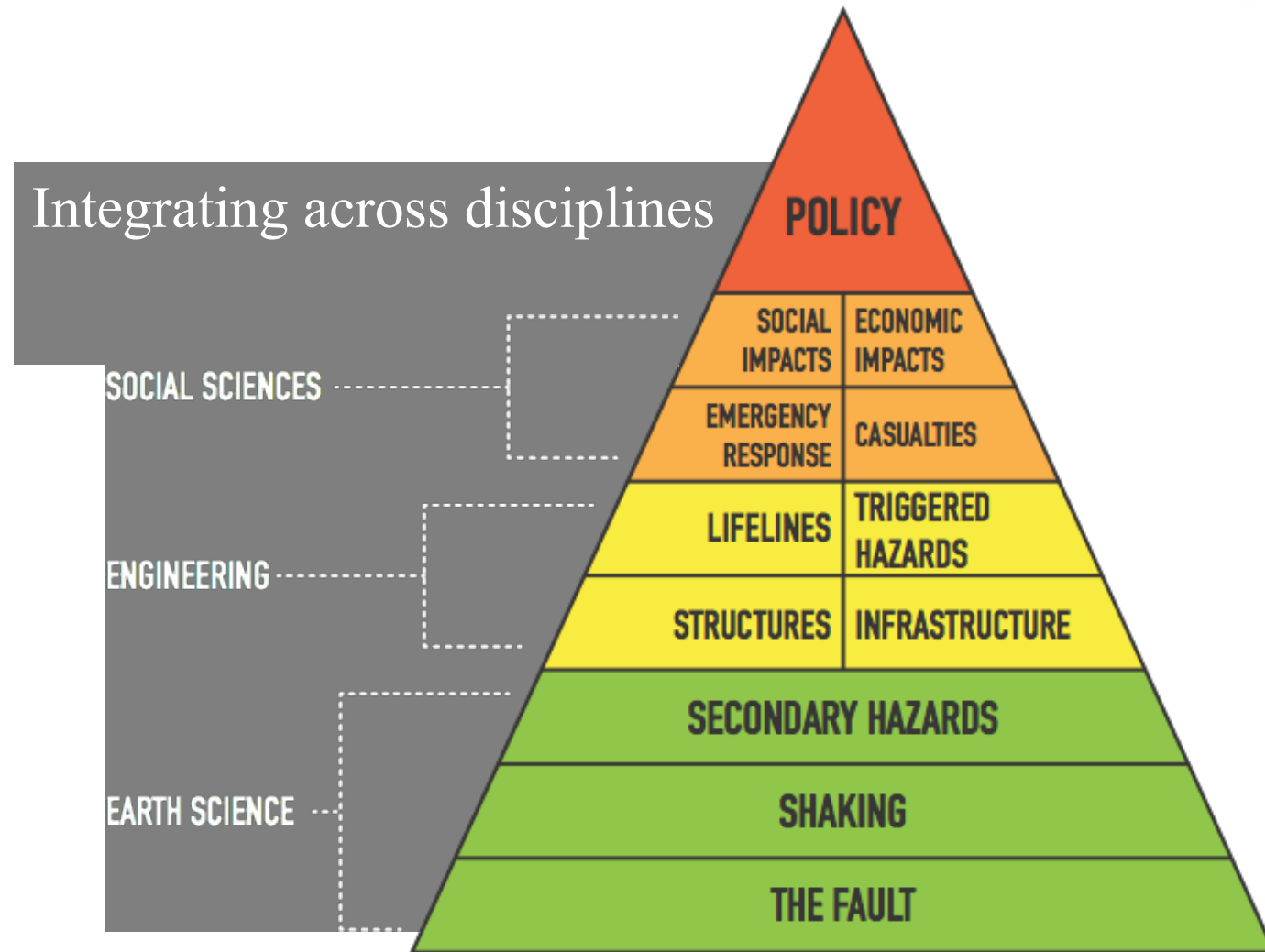
Anne Wein, U.S. Geological Survey

Speaking the same language!



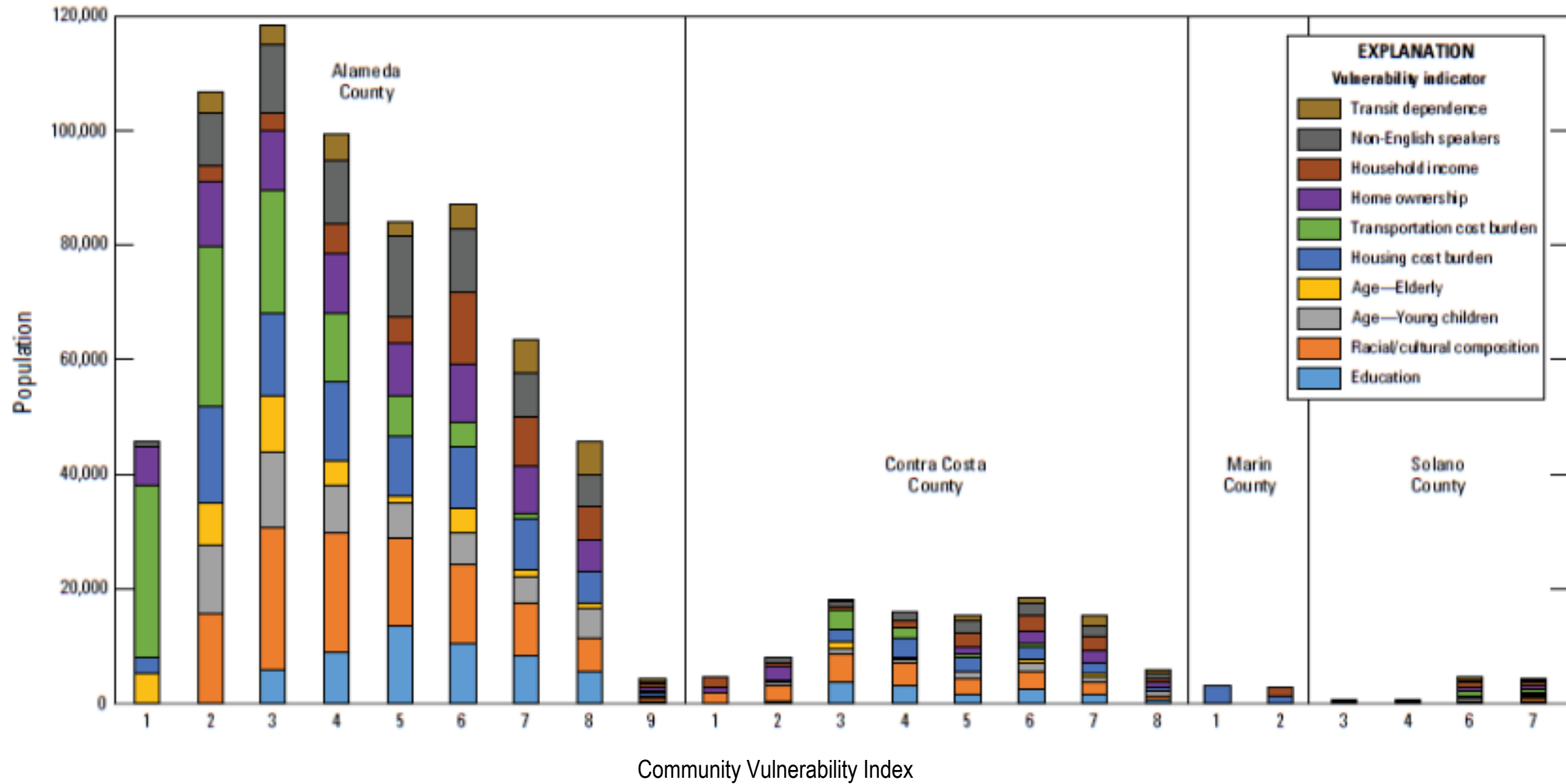
- ▶ Inter- and trans-disciplinary
- ▶ Fault lines
- ▶ Displacement
- ▶ Stress and strain

Inter- and trans-disciplinary



BUILDING THE SHAKEOUT SCENARIO

Fault Lines



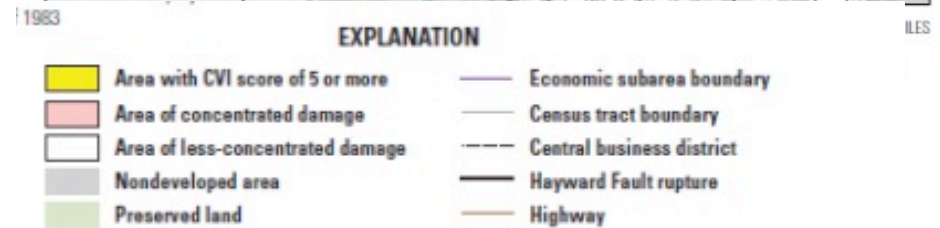
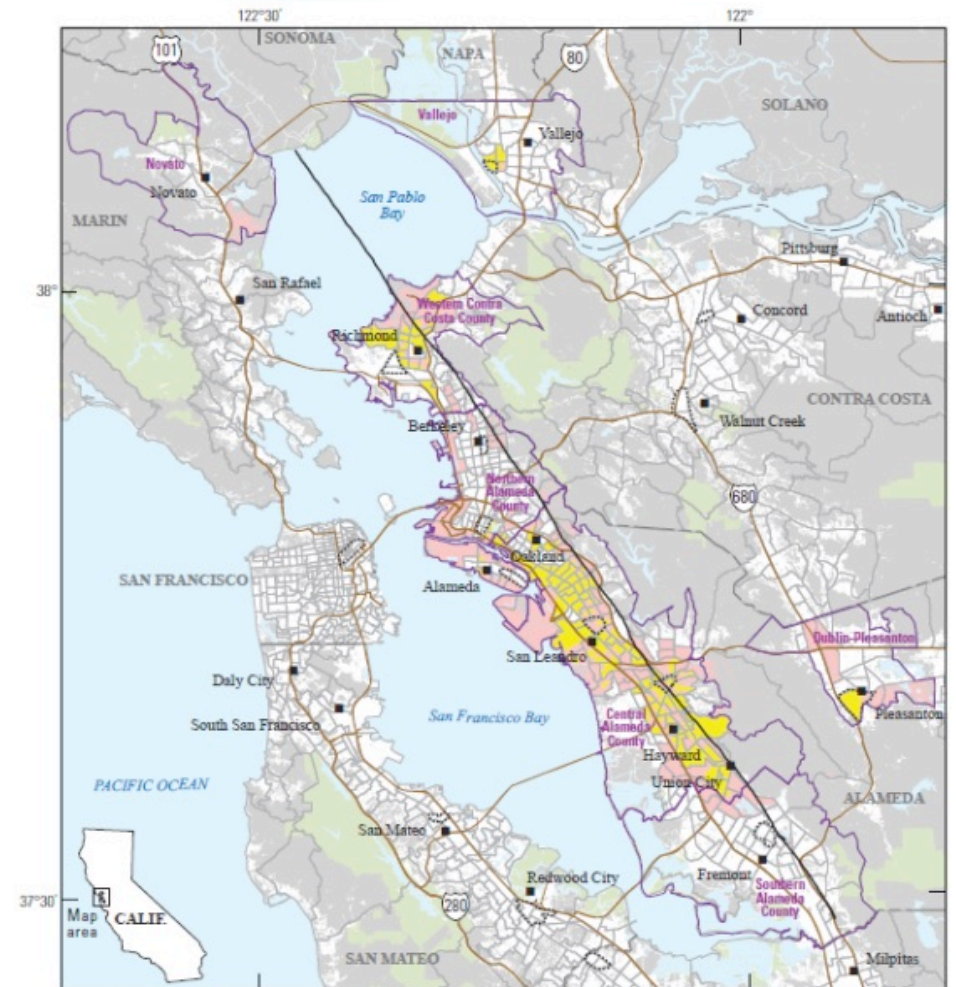
Social fault lines are considered using the Community Vulnerability Index (Bay Conservation & Development Commission/Association of Bay Area Governments) in the HayWired Scenario Volume 3, [Chapter U](#). HayWired highlighted neighborhoods with CVI 5+ as vulnerable.

Displacement



Population displacement after the Great 1906 San Francisco Earthquake.
Source: U.S. National Archives and Records Administration, and M. Reiger, Federal Emergency Management Agency

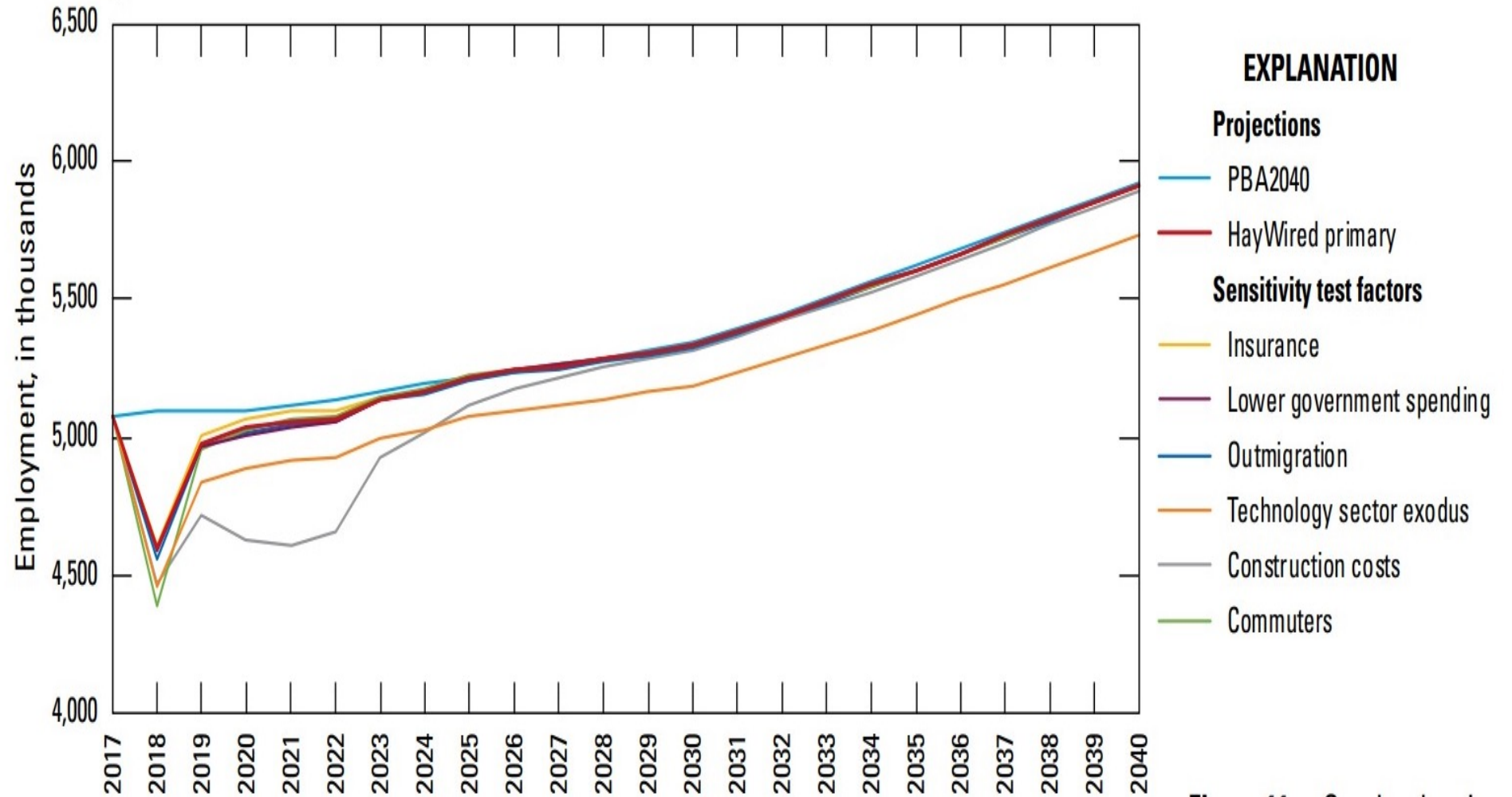
Vulnerable Communities in areas of Concentrated Damaged (yellow) in the HayWired Scenario (Volume 3, [Chapter U](#)).



Stress and Strain



HayWired economic recovery compared to the Plan Bay Area 2040 economic forecast, HayWired Volume 3, [Chapter V3](#)

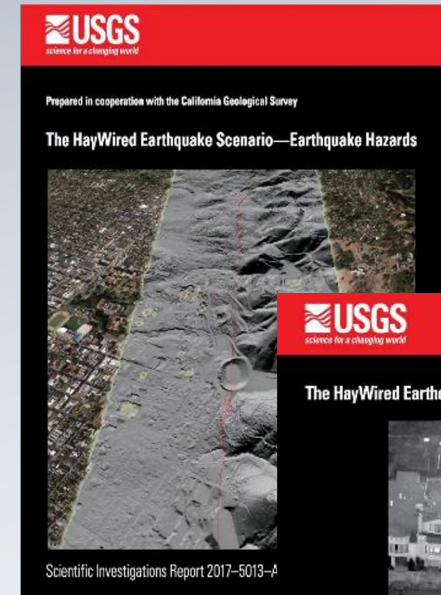
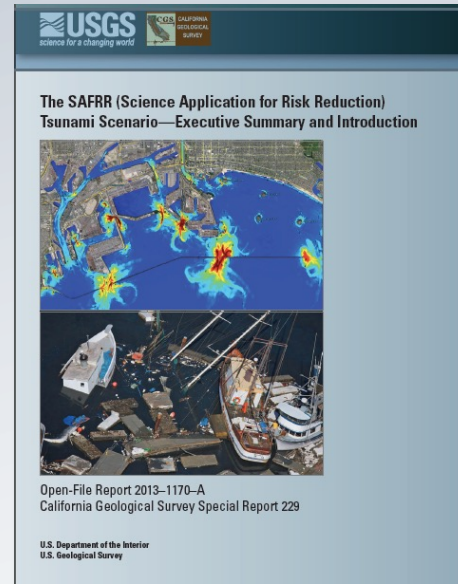
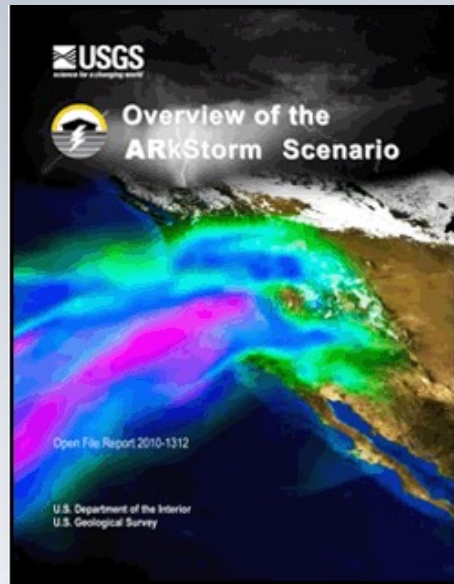
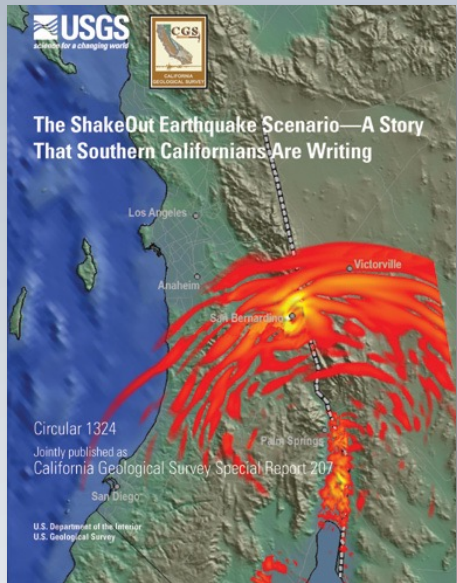


State-wide, we can integrate science above ground as well as beneath us!

Overview

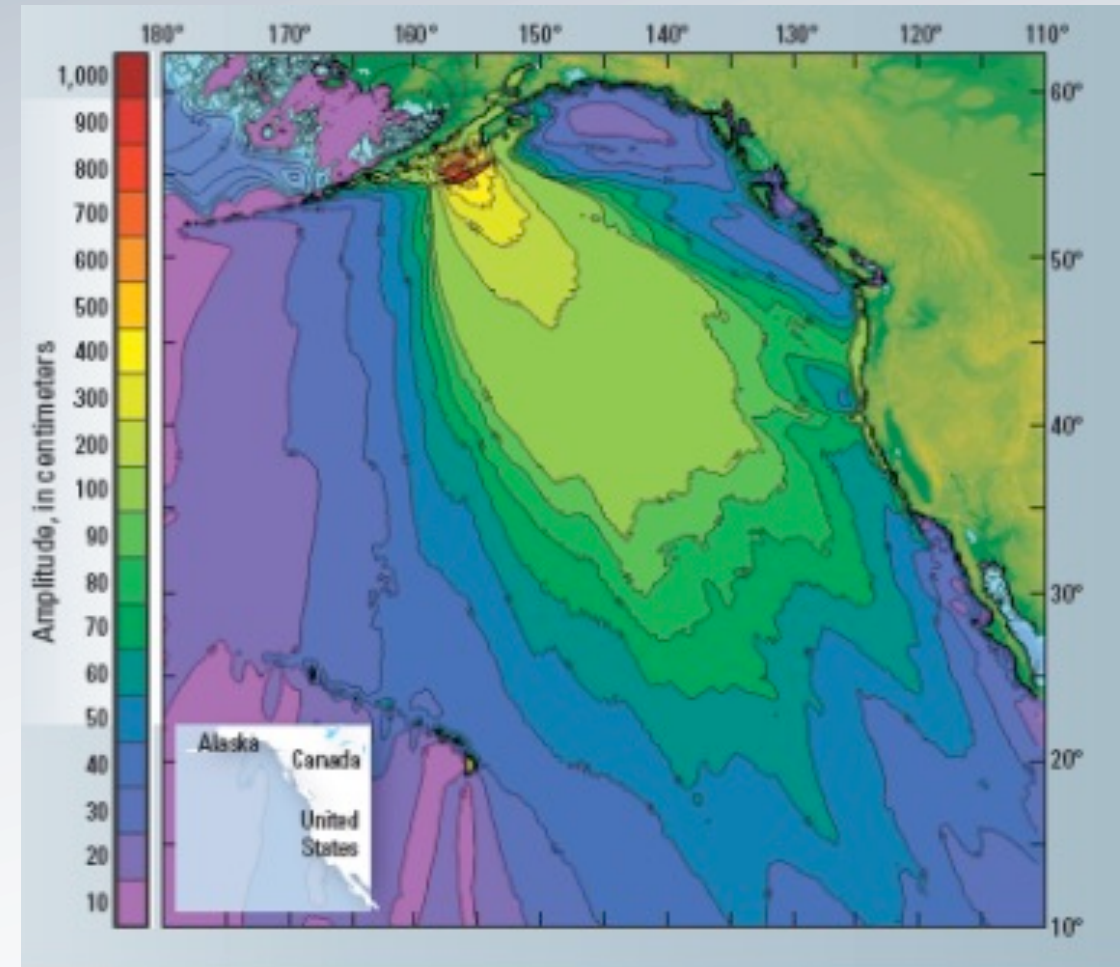
1. Principles of USGS multi-hazard scenarios
2. Scenario goals and evaluations
3. Key opportunities state-wide

SAFRR Scenarios



Principles of a SAFRR Scenario

1. A single, large but plausible event
2. An event we need to be ready for
3. Integrate across many disciplines
4. Use best hazard science
5. Consensus among leading experts
6. Create study with community partners
7. Results presented in products that fit the user, not only the scientist



The Tohoku-Oki tsunami influenced the source of [SAFRR Tsunami](#) in the Aleutian Islands affecting all of California.

Principles of a SAFRR Scenario

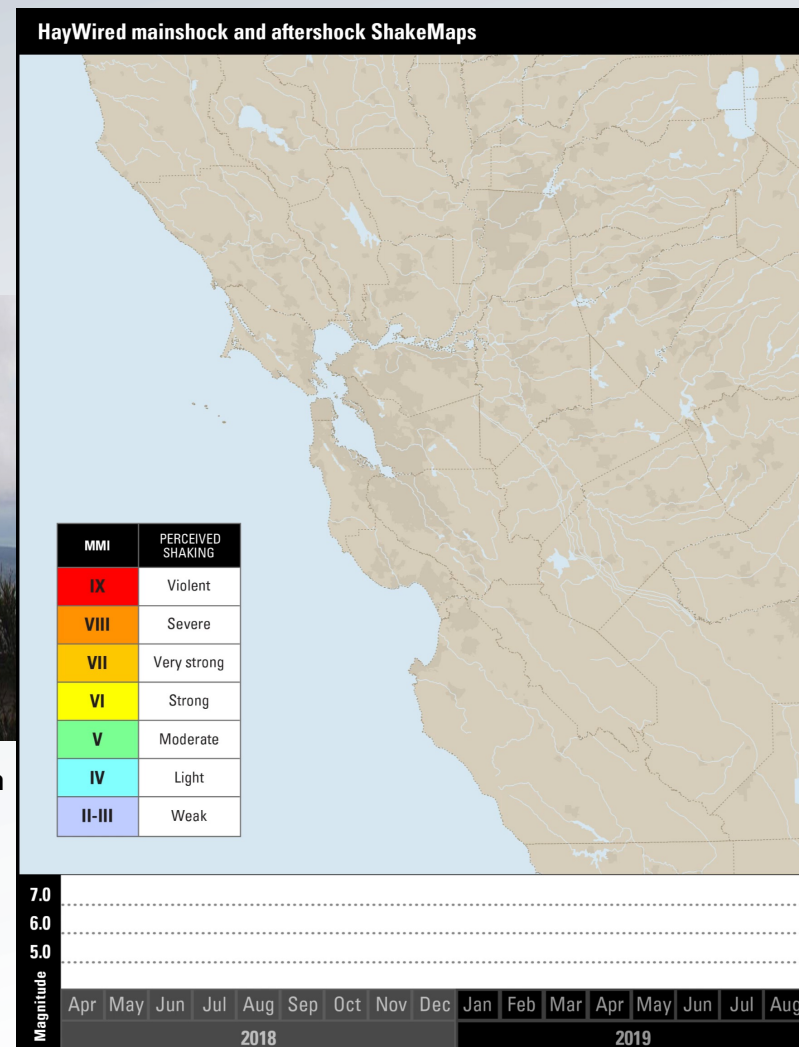
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The 2011 Christchurch aftershock. Credit Gillian Needham

The 2010- present Canterbury (Aotearoa, New Zealand) earthquake sequence motivated the development of the HayWired earthquake sequence and aftershock forecasts (Wein, Felzer, Jones, Porter, 2018, [Volume 1](#), Chapter G).

Animation credit: Jennifer Bruce. In https://geonarrative.usgs.gov/haywired_vol1/

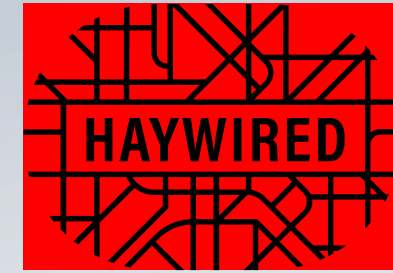


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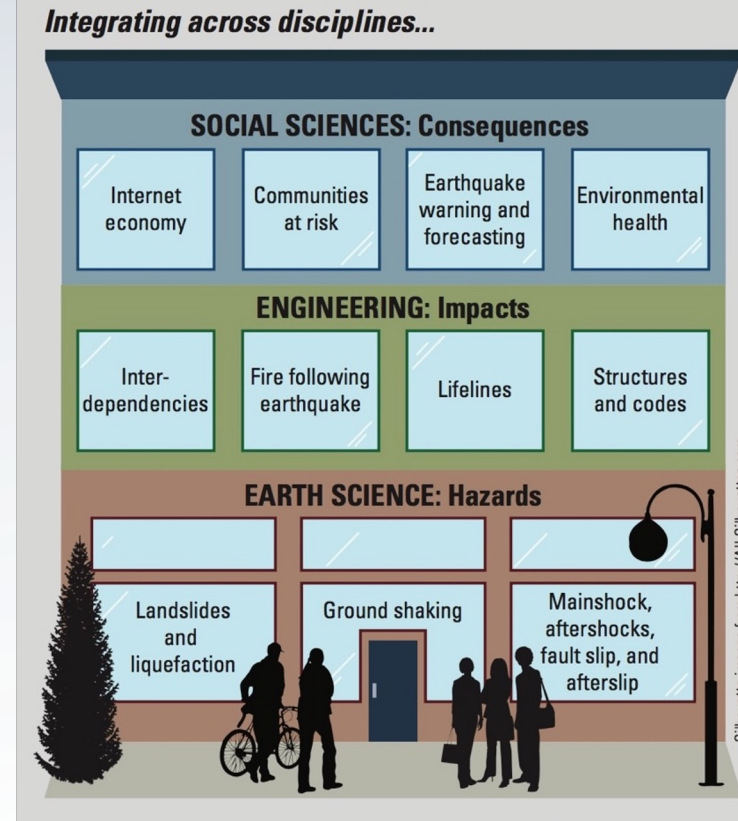
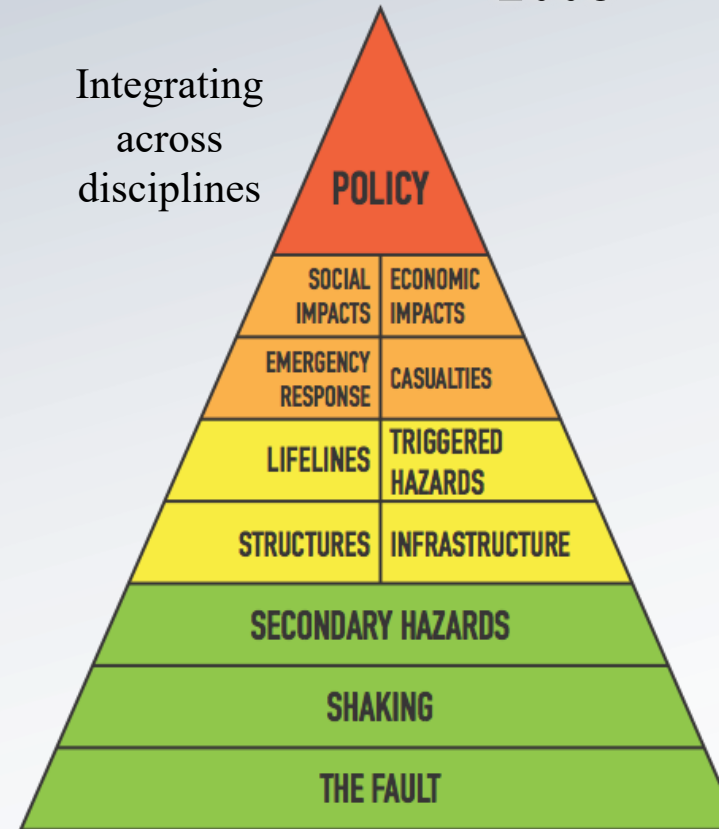


2008



2018-21

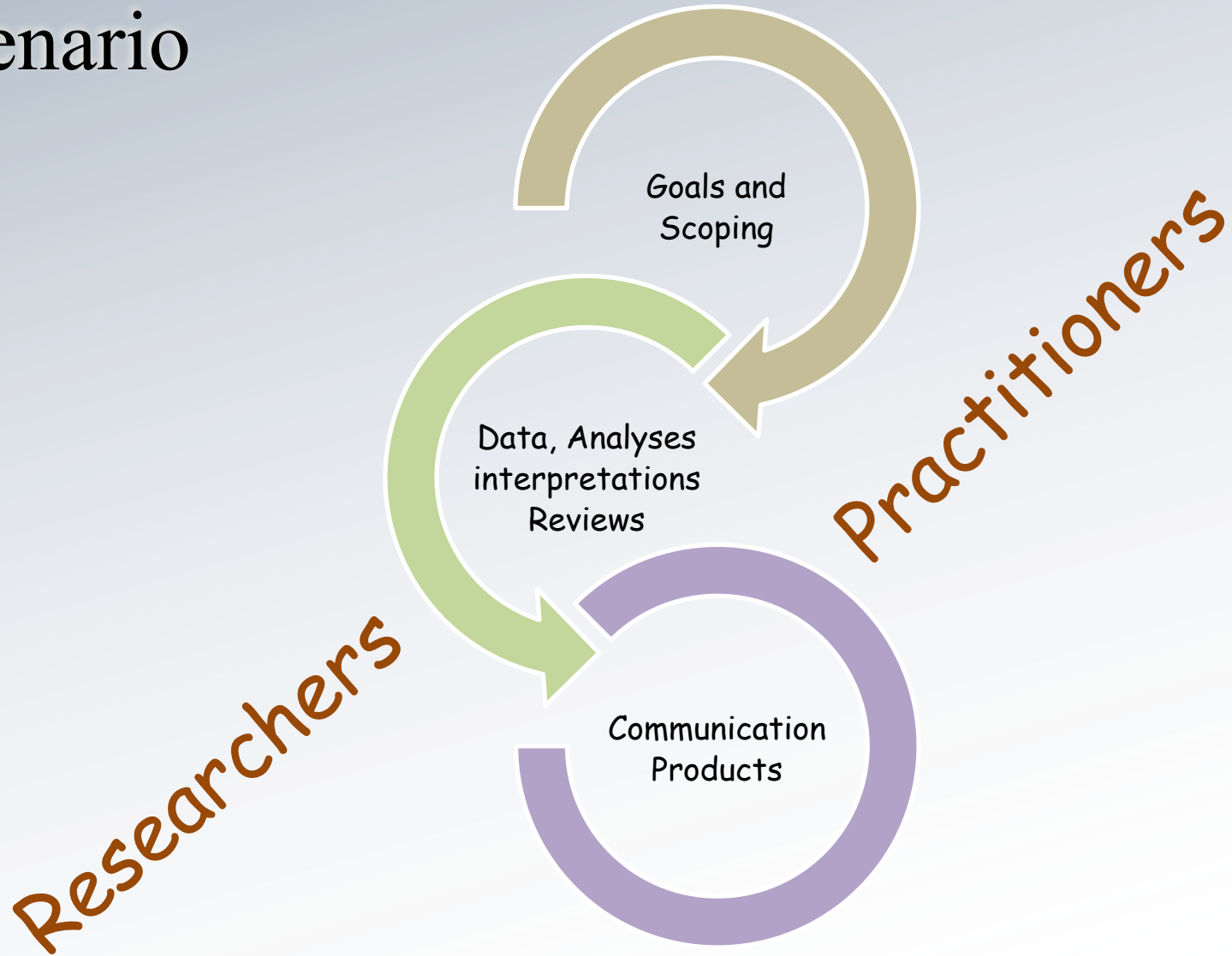
Integrating
across
disciplines



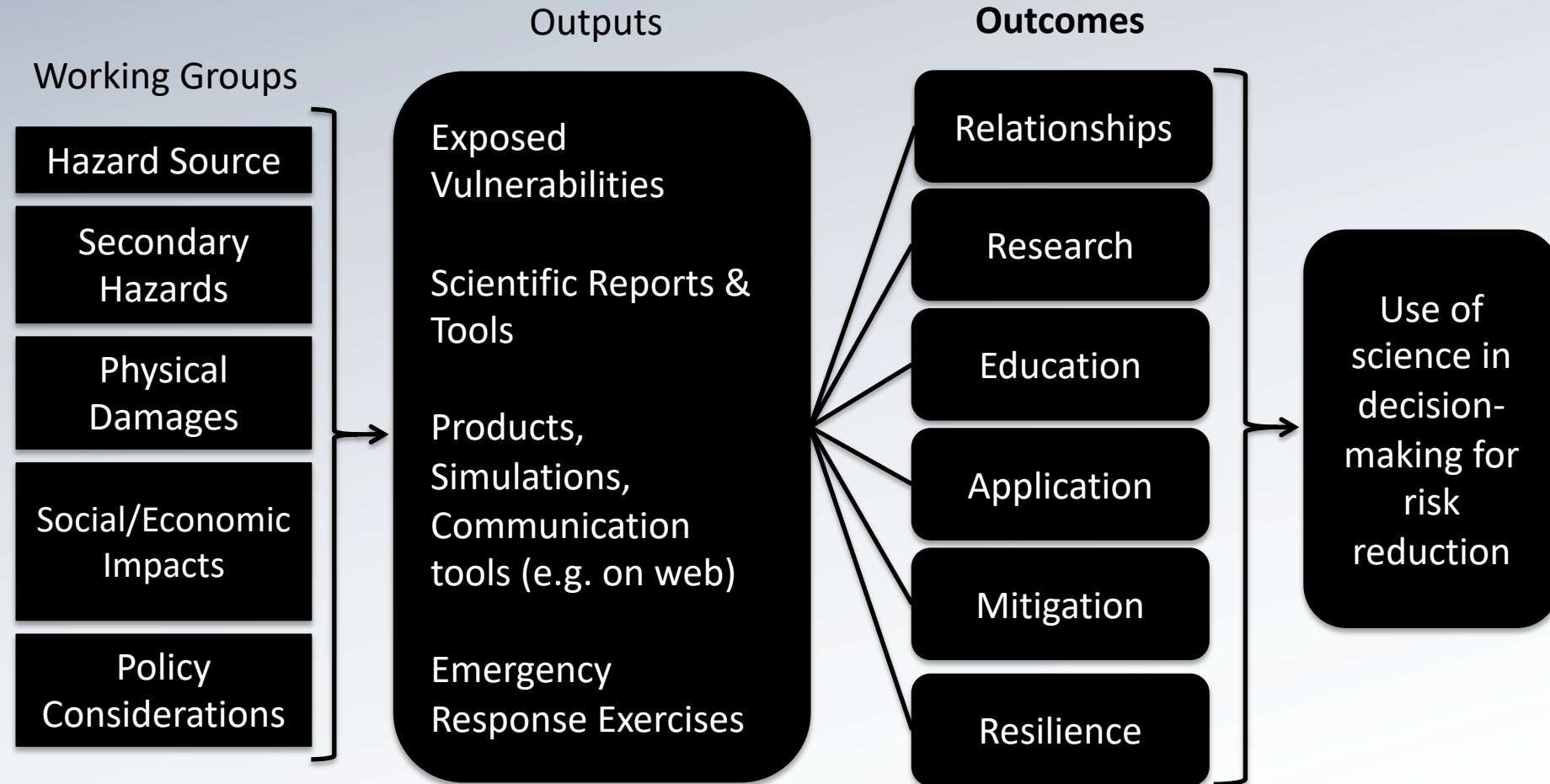
Silhouette images from <http://All-Silhouettes.com>

Principles of a SAFRR Scenario

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Components of a Scenario



HayWired Goals

Improve hazard
communication

Understand risk &
inform actions

Build capacity to
respond & recover



Business, Consumer Services and Housing Agency
Alfred E. Alquist Seismic Safety Commission
U.S. Geological Survey

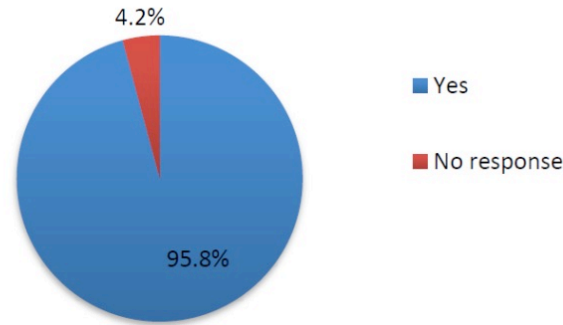
**OUTSMART
DISASTER
.COM**

Evaluation

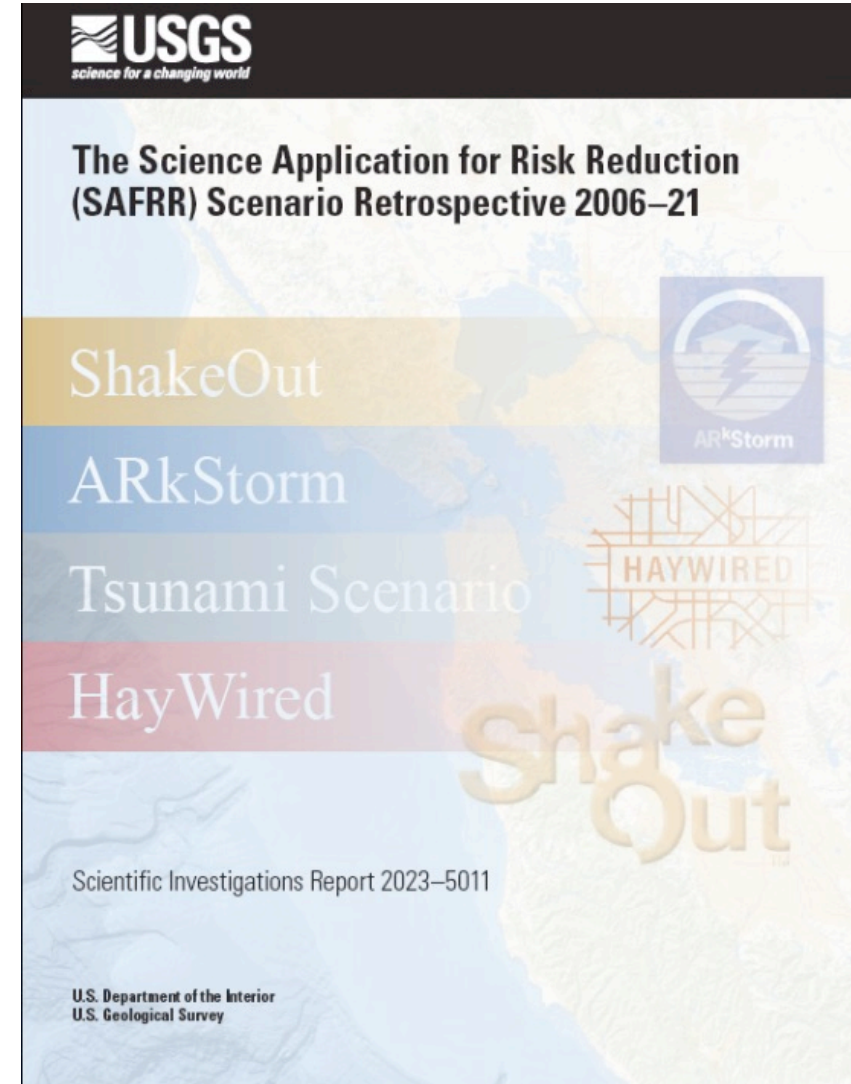
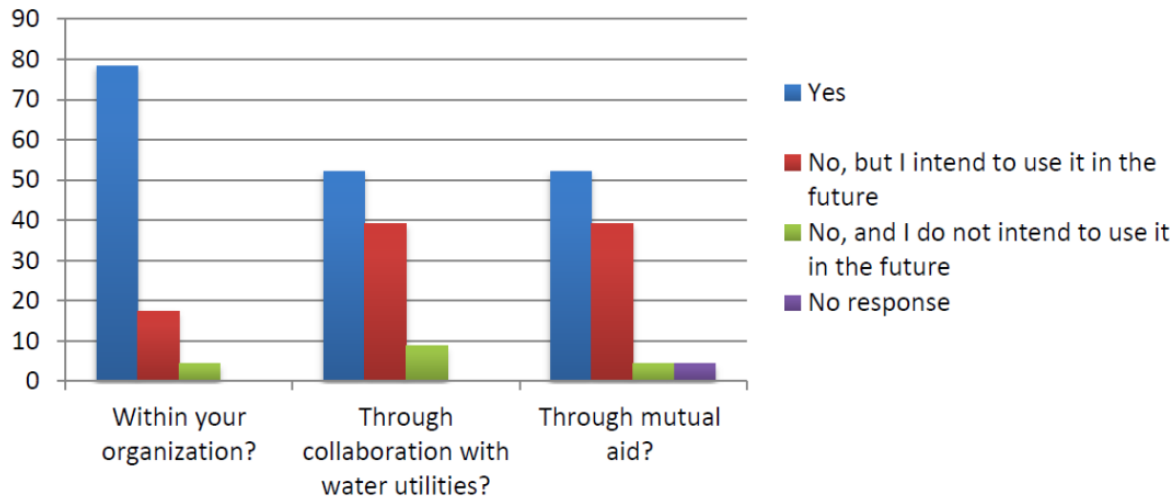


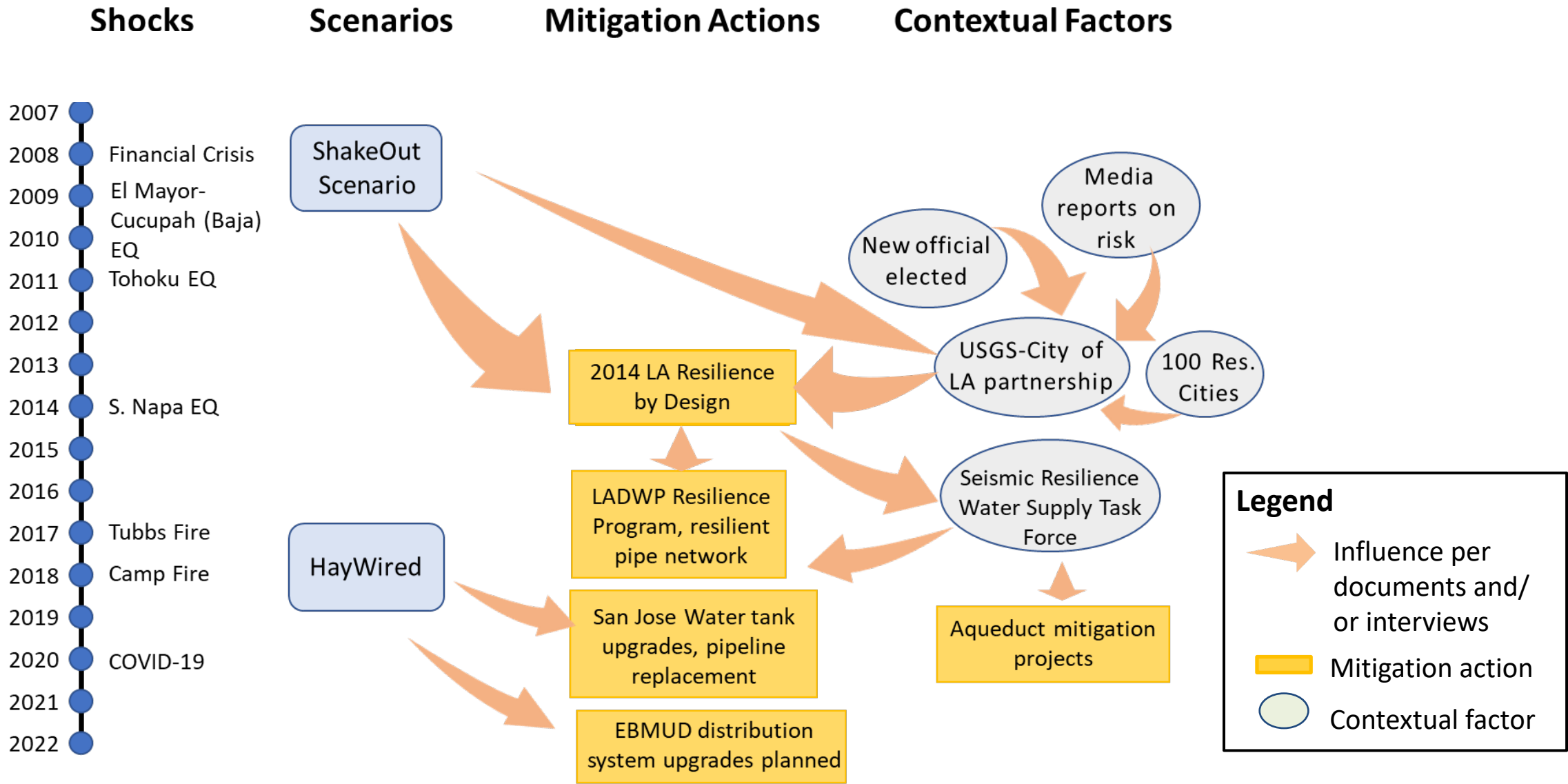
HayWired Scenario Fire Following Earthquake in [Volume 2](#), Chapter P, presented by Charles Scawthorn in a Workshop with Bay Area Fire Department and emergency managers, . Evaluation led by Liesel Richie.

Responses to:
 "Were the estimates of post-earthquake fires in the Haywired scenario for the Hayward Fault presented in this Workshop representative of a realistic 'fire following earthquake' event that could affect the East Bay?"
 (n=24)



Responses to: "Have you used the information provided during the workshop to improve prevention..."
 (n=23)





Used with permission from Rodgers et al., Effectiveness of Past California Earthquake Scenarios in Motivating Mitigation, Northern California Earthquake Hazards Workshop, February 2023. This material is based upon work supported by the U.S. Geological Survey under Grant No. G21AP10023-00 and also made possible by the generous support of the American people through USAID Award No. 720FDA20CA00032.

Diversify HayWired



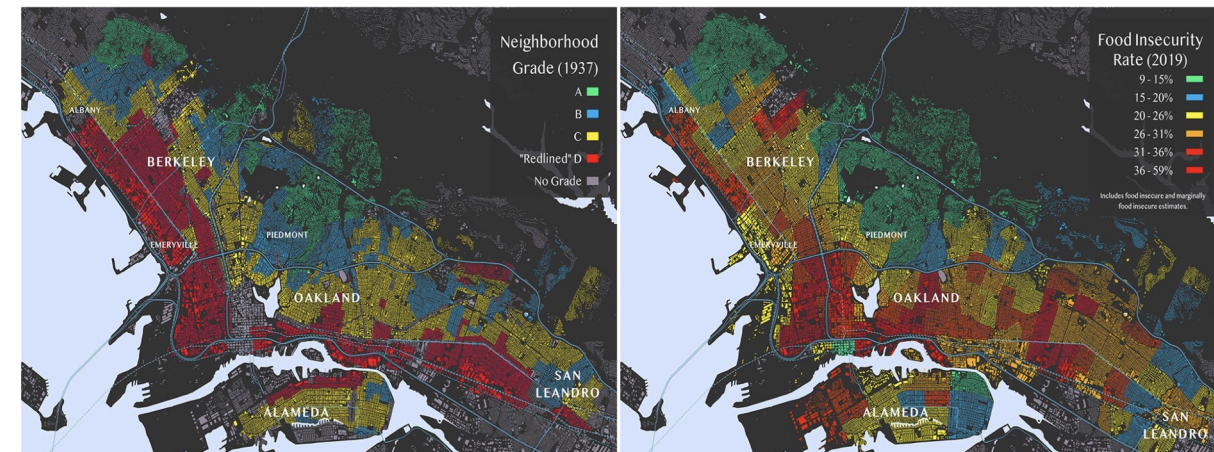
- ▶ Community Science with Professor Faas and student, San Jose State University, Anthropology Department
 - ▶ Japantown and LGBTQ+ Center

- ▶ [Diversifying HayWired Communications](#) with Bill Anderson Fund Executive Director, Nnenia Campbell and fellows
 - ▶ Food security organizations and minority-owned business



HayWired Volume 3 Rollout [Video 5](#) at 30:12

Images comparing HOLC Redlined neighborhoods and Food Insecurity Rates, 2019



Source: [Roots Of Hunger: A Look At Current Food Insecurity In Historically Redlined Neighborhoods](#)

Key Opportunities

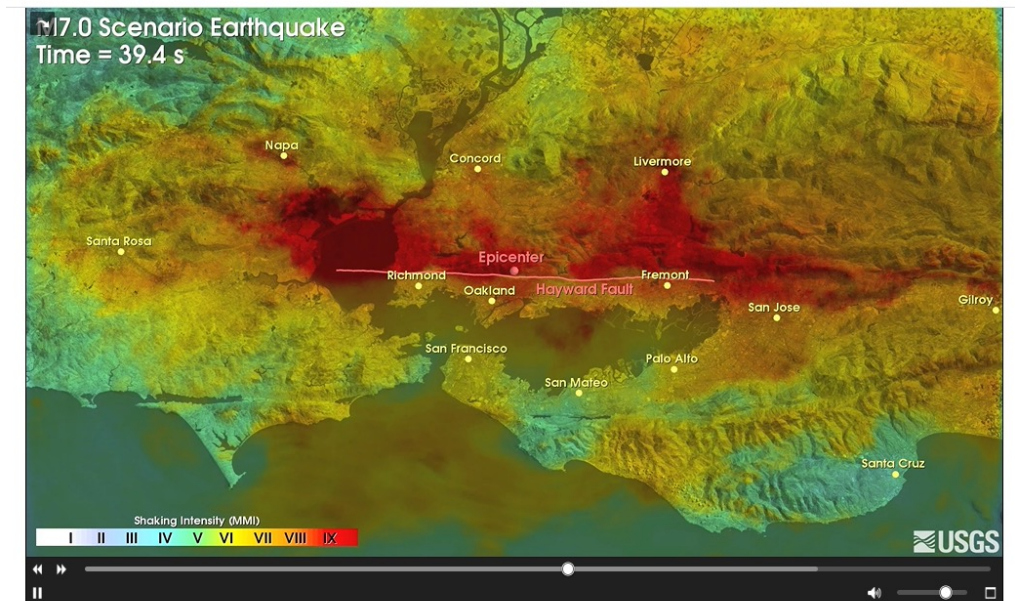
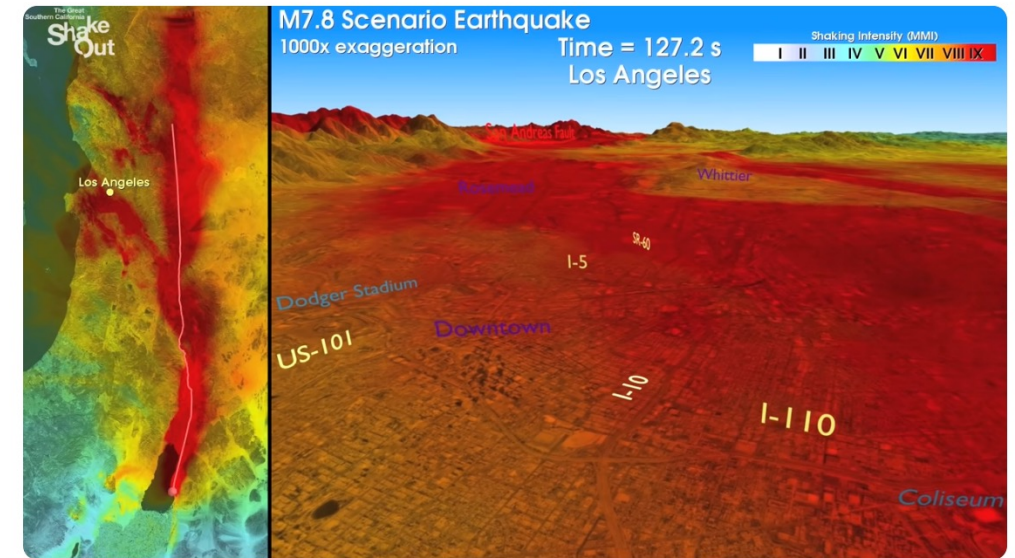


1. Emphasizing SCEC's integrated earthquake science provides best available and credible foundation
2. Understanding the societal ripple effects that transcend southern California and the San Andreas fault system
3. Fostering research and practice collaborations that build diverse relationships and expand networks of Influence
4. Making our science actionable with Earthquake County Alliance partnerships

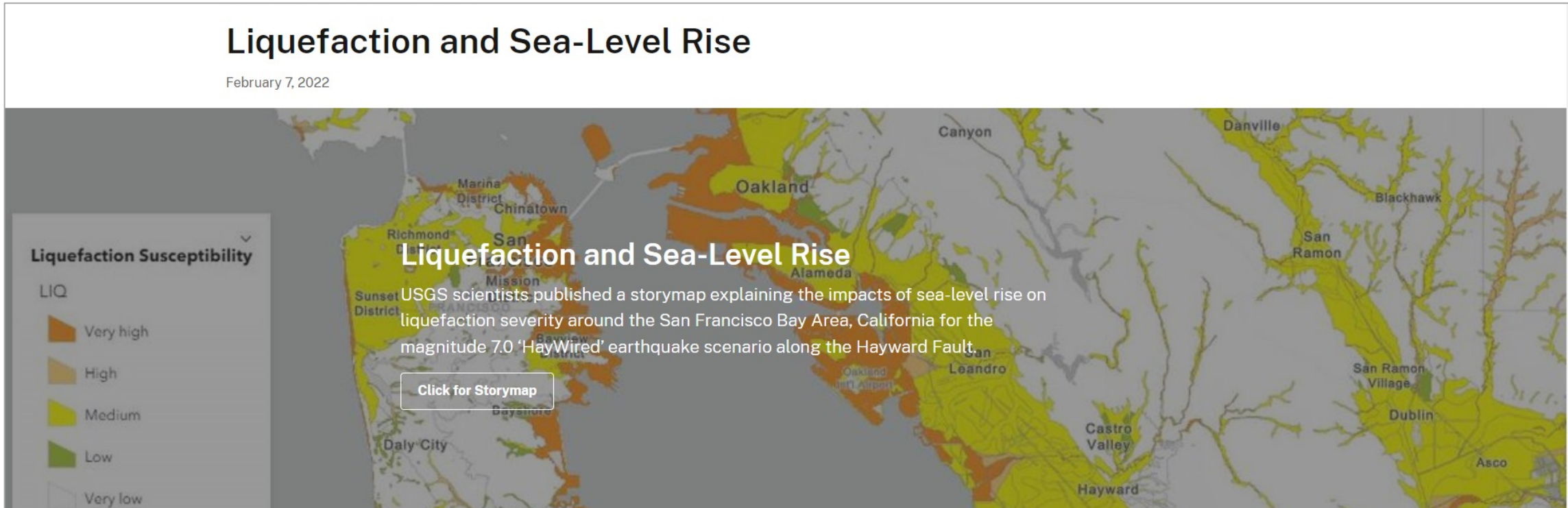
1. Best Available Integrated Science



- ▶ SCEC contributed 3-D physics based ground motions including 3 validation runs for ShakeOut and 3 rupture sources on the Hayward fault
- ▶ Benefits
 - ▶ Credible
 - ▶ Educational
 - ▶ inputs for ground failure and structural damage
 - ▶ time histories for tall building functional recovery estimation
- ▶ Epidemic type aftershock sequence (ETAS) model used to produce sequences for HayWired, cross-checked with UCERF-3 ETAS
 - ▶ 1 in 20 sequences moved into the south bay



- ▶ Interactions with climate change



Authors. Travis Poitras, Alex Grant, Anne Wein, Keith Knudsen, Kevin Befus, Monica Erdman, Kimber Petersen.

<https://geonarrative.usgs.gov/liquefactionandsealevelrise/>

- ▶ Integrated transdisciplinary science to communicate for reducing risk and improving community resilience

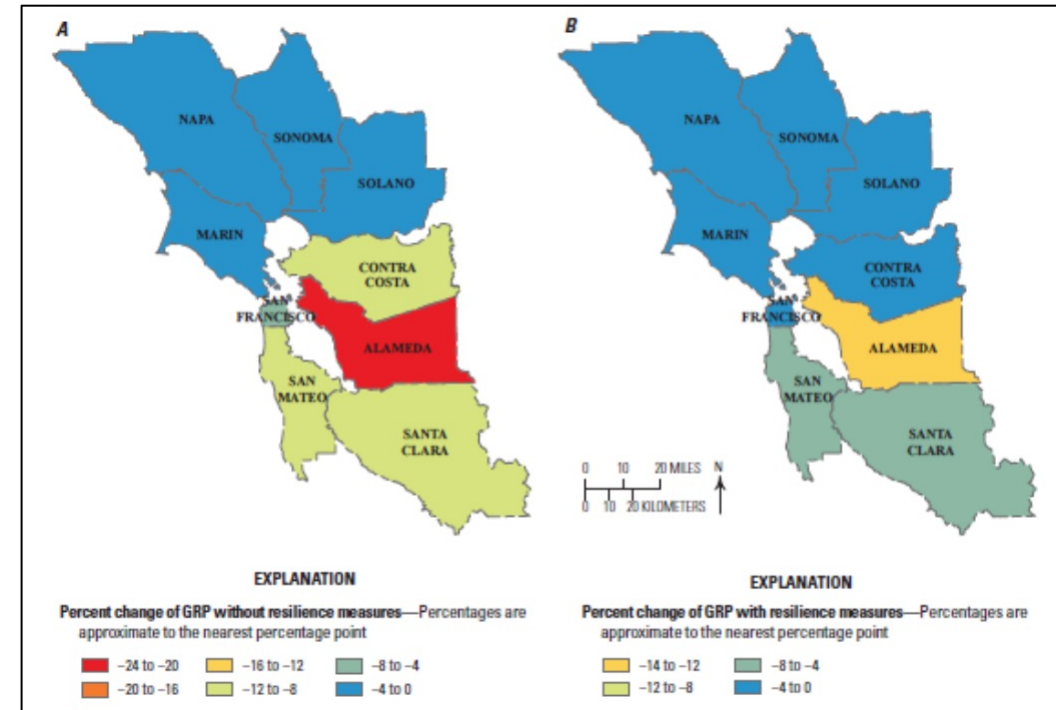
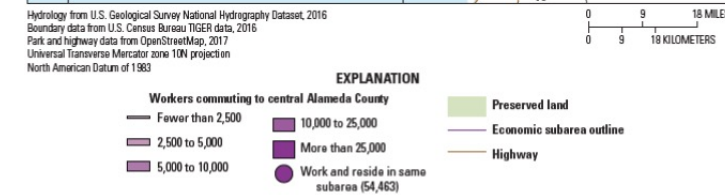
2. Societal Ripple Effects



- ▶ Risk reduction and improved community resilience occurs above and beyond the transform boundary
- ▶ Effects spread via
 - ▶ Transportation re-routing
 - ▶ Economic impact ripple effects
 - ▶ Population displacement

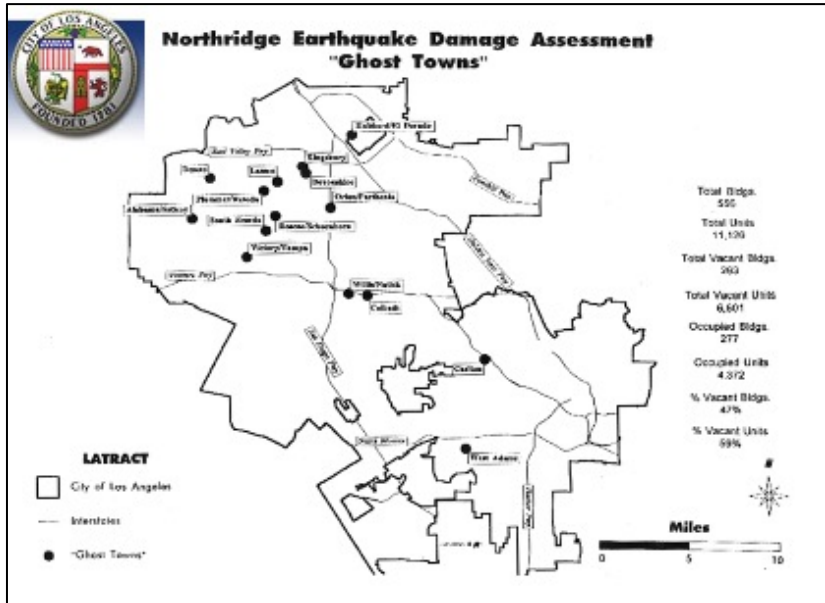
Home-Workplace relation: Where employees live relative to their workplace in the heavily impacted central Alameda subarea (Wein, Belzer, Kroll, Au et al., 2021, HayWired Scenario Volume 3,

[Chapter V5](#)



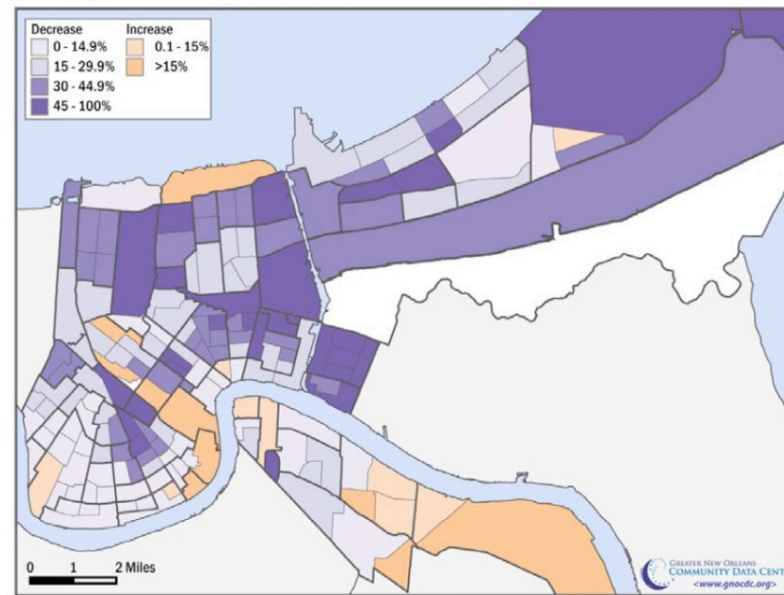
HayWired Scenario Business Interruption Losses in the first six months without and with economic resilience. (Sue Wing, Wei, Rose, Wein, 2021, HayWired Scenario Volume 3, [Chapter V2](#))

Concentrated Damage & Population Displacement



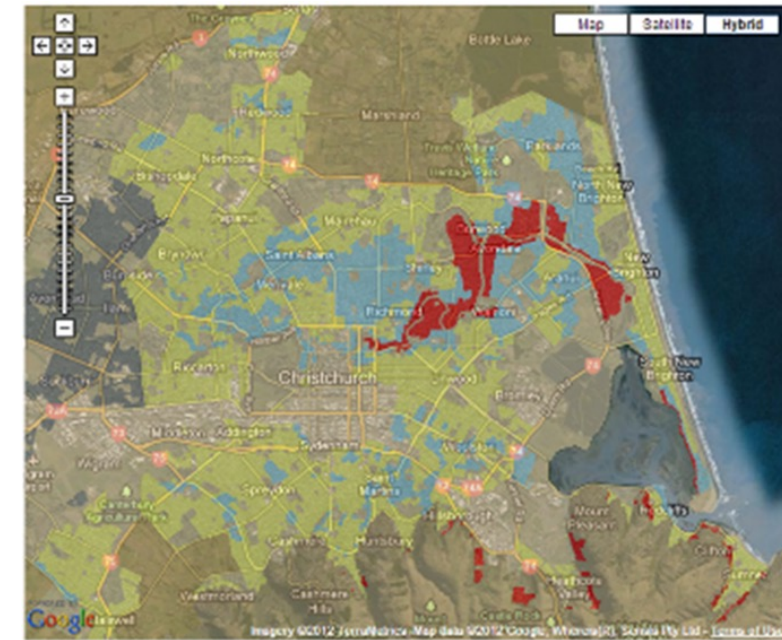
Multi-family building damage led to "ghost town" neighborhoods across Los Angeles following the 1994 Northridge earthquake

Percent change in occupied housing units by census tract, 2000-2010
New Orleans



Source: GNOCDC analysis of data from the U.S. Census Bureau.¹⁷

Flooding displaced nearly 90% of New Orleans population after 2005 Hurricane Katrina. Source: GNOCDC analysis of data from the U.S. Census Bureau.

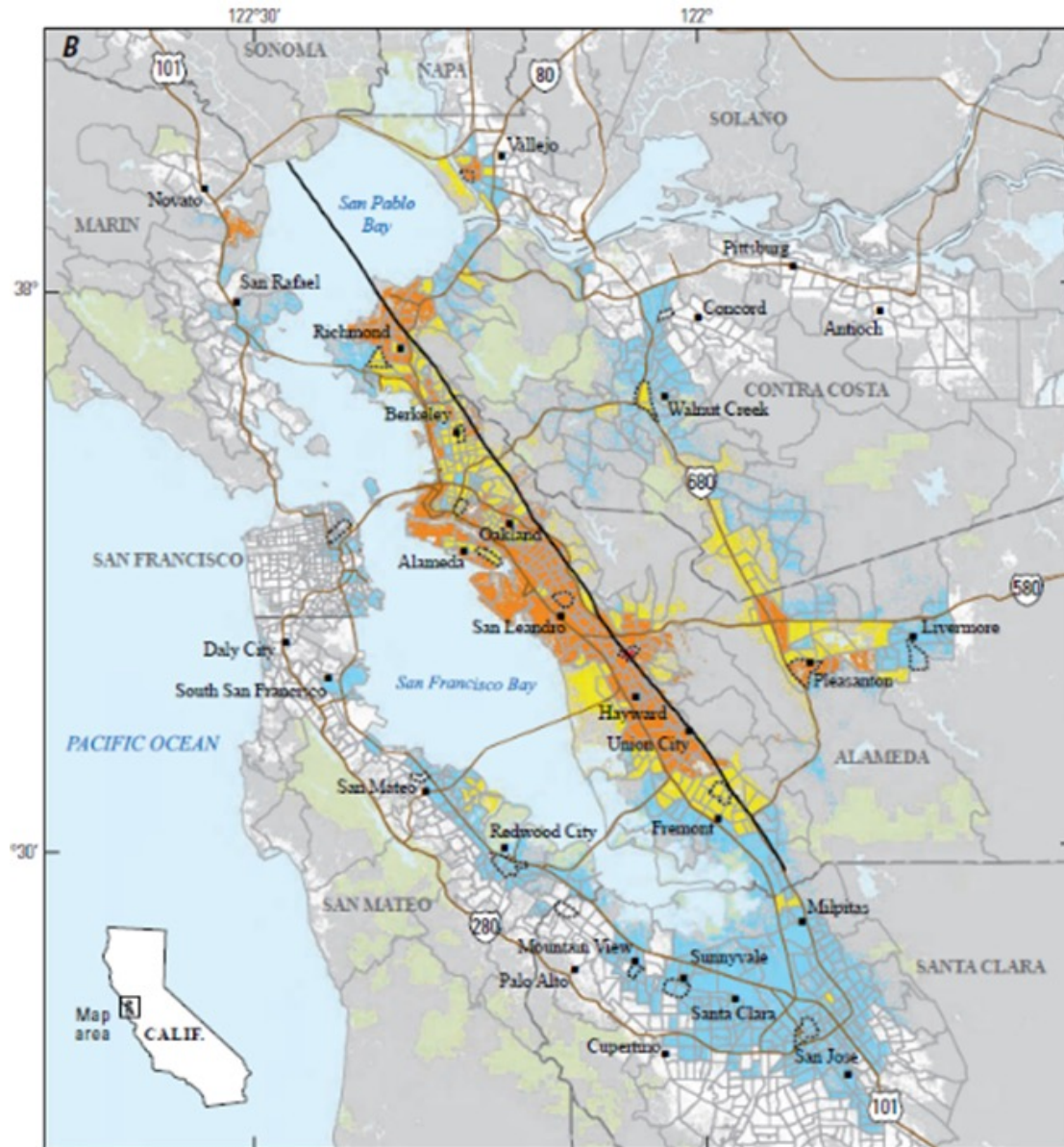


Ground failure led to a government buyout of >7,000 residences in "red zones" in the Canterbury region following the 2010-2011 earthquakes. (Canterbury Earthquake Recovery Authority, 2016)

Concentrated Damage & Population Displacement



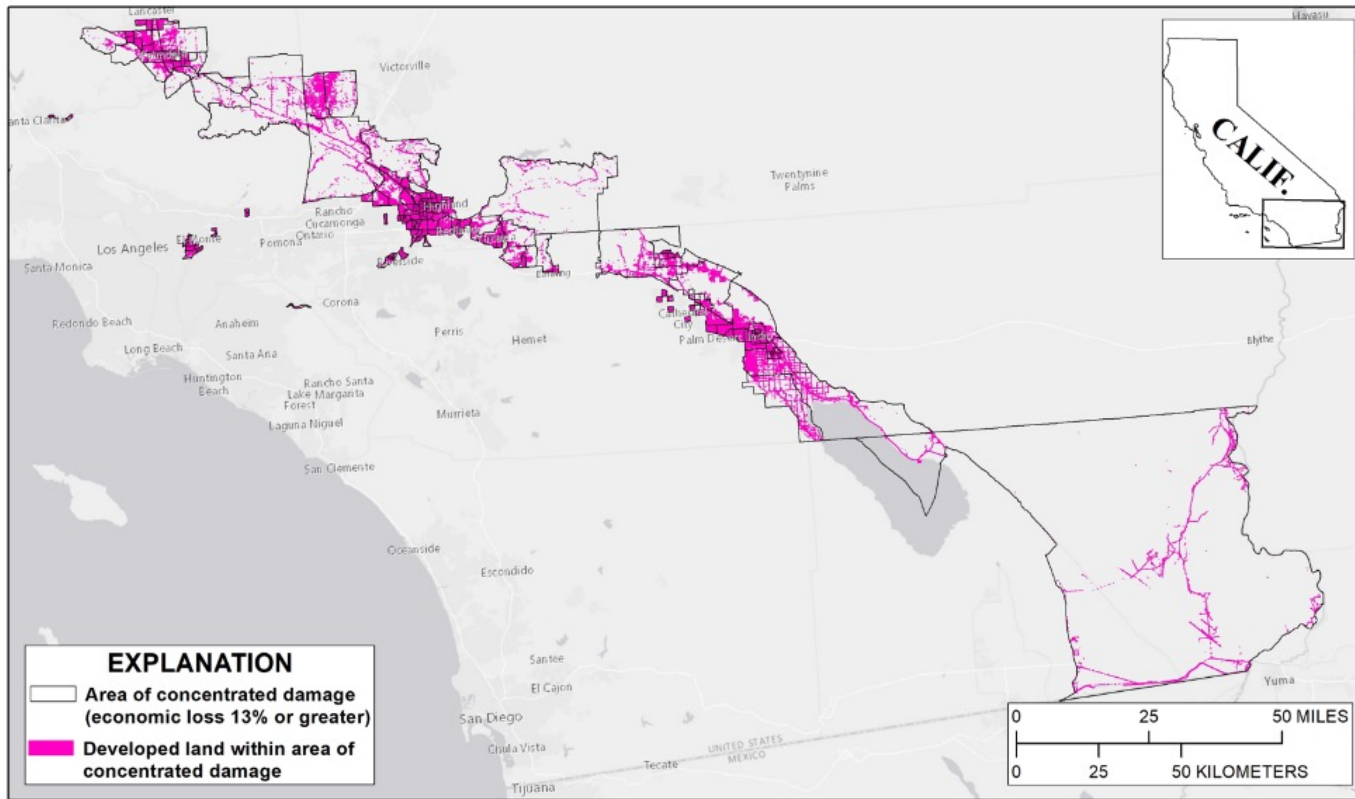
- ▶ 500,000 people residing in areas of 20+% extensive or complete building damage



EXPLANATION	
60 percent and greater	Nondeveloped area
20 to 60 percent	Preserved land
10 to 20 percent	Census tract boundary
2 to 10 percent	Central business district
Less than 2 percent	Hayward Fault rupture
	Highway

Concentration building damage for all occupancies (Johnson, Jones, Wein, Peters, 2021, HayWired Scenario Volume 3, [Chapter U.](#))

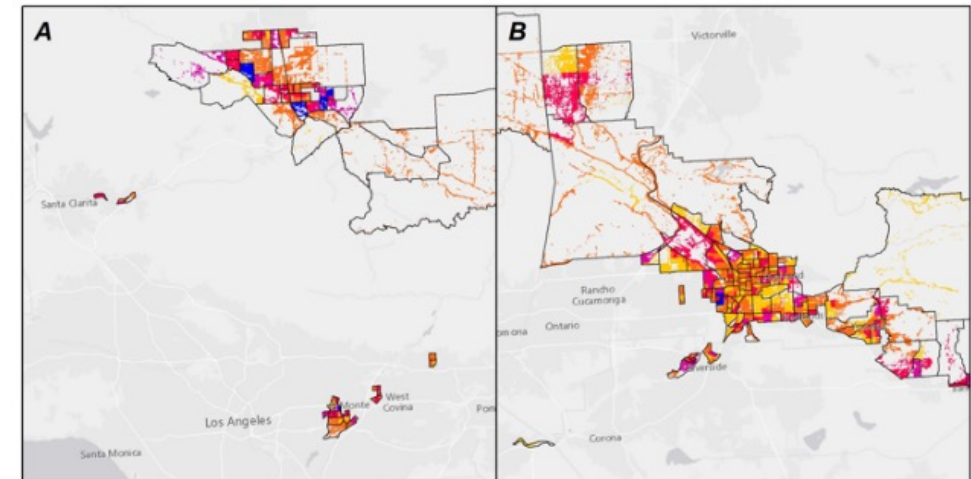
Populations in ShakeOut Areas of Concentrated Damage (Ground shaking, Landslide and Liquefaction only)



- ▶ 100,000 households displaced (Hazus)
- ▶ 900,000 people and 283,000 housing units in areas of concentrated damage

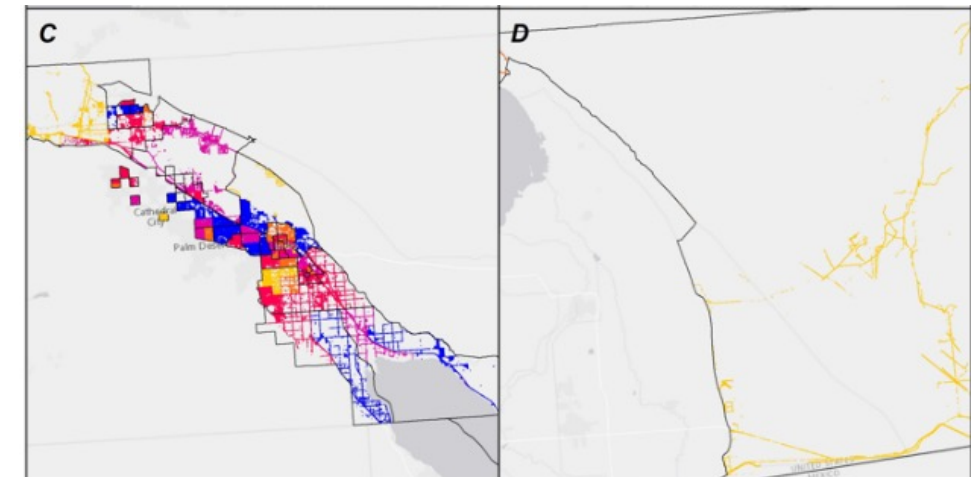


Courtesy of Laurie Johnson and Jamie Jones, 2022



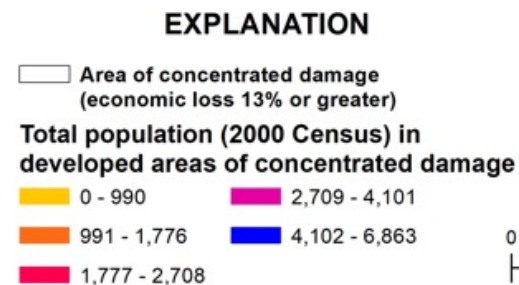
Los Angeles County
(Lancaster, Palmdale, Santa Clarita, El Monte, West Covina, Glendora)

San Bernardino and Riverside Counties
(Pinon Hills, Phelan, San Bernardino, Redlands, Riverside, Yucaipa, Banning)



Riverside County
(Desert Hot Springs, Palm Springs, Palm Desert, Indio, La Quinta)

Imperial County



3. Networks of Influence



- ▶ New Practice
 - ▶ MTC/ABAG chief economist participation => an earthquake in horizon planning
 - ▶ Regional economist advisory role in ShakeOut => summary of HayWired economic analyses
 - ▶ HayWired Communities at Risk panel => 1st housing recovery session in California Housing conference
- ▶ New Research
 - ▶ Platform for further research complements and extensions



- Bay Area Metro Award
 - HayWired in Horizon Futures planning



- REMI George I. Treyz Silver Award
 - Excellence in economic & demographic analysis

4. SCEC/ECA Partnership





HayWired Scenario EXERCISE TOOLKIT

A **guide** for creating
discussion-based exercises
using the HayWired
Earthquake Scenario



Themes and Issues Overview

- Topics addressed in the scenario, with ideas for how to exercise each, are organized within emergency management phases:

- Planning & Preparedness
- Response
- Recovery
- Mitigation

- Document symbols indicate a Facilitator Guide and imagery slide deck for the topic



	Planning and Preparedness	Response	Recovery	Mitigation
Access to Data & Information		29		39
Accounting for Employees		29		
Aftershocks & Fault Afterslips			35	
Alternate Locations	23		36	
Building Content				39
Clean-up				39
Communications & Internet	23 & 24	29 & 30		
Customer Base			36	
Economic Impact			36	
Elevators		31		
Employee Commutes and Residences	24			
Employee Retention & Staffing Shortage		31	37	
Fires After the Earthquake				40
Fuel (Gasoline and Diesel)	24	31		
Generators	25			
Insurance			37	
Lifeline Infrastructure in Fault Zones				40
Mail Package Delivery		32		
Mental Wellbeing			37	
Natural Gas	25	32		
Payroll	26			
Power (Electricity)	26	33	38	
ShakeAlert®	26			40
Shutting Off Utilities				41
Slow Return to Normal			38	
Structural & Non-Structural Building Damages				41
Supply Chain Movement of Goods	27			41
Water	27	33 & 34		
Wastewater Sewer	27	34		
Working Remotely	28			

Key Opportunities



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2. Understanding the **societal ripple effects** that transcend southern California and the San Andreas fault system
3. Fostering research and practice collaborations that build **relationships** and expand networks of Influence
4. Making our science **actionable** with Earthquake County Alliance partnerships

Thank You



To all our SAFRR scenario contributors and partners

And you for your attention

<https://www.usgs.gov/programs/science-application-for-risk-reduction/science/haywired-scenario>

Anne Wein
awein@usgs.gov