Institute for Catastrophic Loss Reduction
Building resilient communities

Institut de prévention des sinistres catastrophiques
Bâtir des communautés résilientes

Overview of the business case for better infrastructure

Dr. Keith Porter and Ishmael Legaspi

October 6, 2026

2008: Engineering information
2026: Persuasion using eng. econ

Keith Porter, Institute for Catastrophic Loss Reduction chief engineer

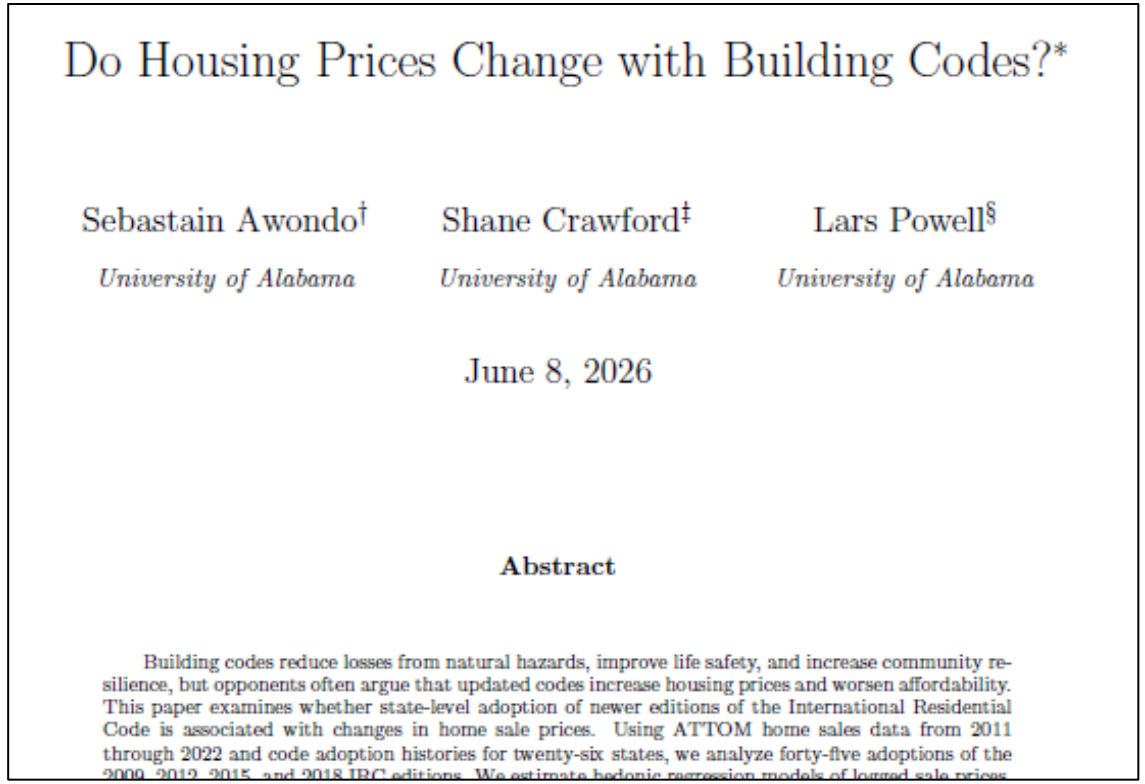
There can be more than one big problem
We can solve more than one problem at a time

New buildings & lifelines

Existing buildings & lifelines

Resilience doesn't cost more. It can pay off big at resale.

Code changes don't affect price (one of several studies)



Do Housing Prices Change with Building Codes?*

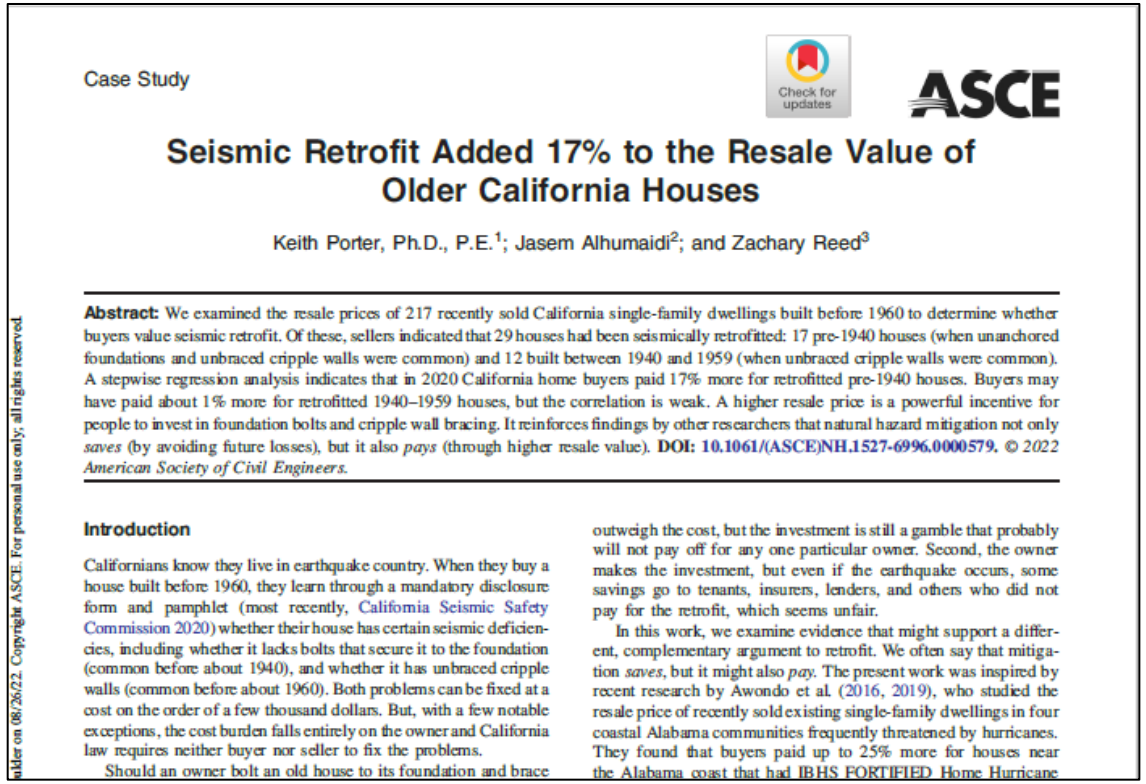
Sebastain Awondo† — *University of Alabama*
Shane Crawford‡ — *University of Alabama*
Lars Powell§ — *University of Alabama*

June 8, 2026

Abstract

Building codes reduce losses from natural hazards, improve life safety, and increase community resilience, but opponents often argue that updated codes increase housing prices and worsen affordability. This paper examines whether state-level adoption of newer editions of the International Residential Code is associated with changes in home sale prices. Using ATTOM home sales data from 2011 through 2022 and code adoption histories for twenty-six states, we analyze forty-five adoptions of the 2009, 2012, 2015, and 2018 IRC editions. We estimate hedonic regression models of logged sale prices

Retrofits increase resale value (one of several studies)



Case Study

Check for updates

ASCE

Seismic Retrofit Added 17% to the Resale Value of Older California Houses

Keith Porter, Ph.D., P.E.[1]; Jasem Alhumaidi[2]; and Zachary Reed[3]

Abstract: We examined the resale prices of 217 recently sold California single-family dwellings built before 1960 to determine whether buyers value seismic retrofit. Of these, sellers indicated that 29 houses had been seismically retrofitted: 17 pre-1940 houses (when unanchored foundations and unbraced cripple walls were common) and 12 built between 1940 and 1959 (when unbraced cripple walls were common). A stepwise regression analysis indicates that in 2020 California home buyers paid 17% more for retrofitted pre-1940 houses. Buyers may have paid about 1% more for retrofitted 1940–1959 houses, but the correlation is weak. A higher resale price is a powerful incentive for people to invest in foundation bolts and cripple wall bracing. It reinforces findings by other researchers that natural hazard mitigation not only *saves* (by avoiding future losses), but it also *pays* (through higher resale value). **DOI: 10.1061/(ASCE)NH.1527-6996.0000579.** © *2022 American Society of Civil Engineers.*

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Introduction

Californians know they live in earthquake country. When they buy a house built before 1960, they learn through a mandatory disclosure form and pamphlet (most recently, California Seismic Safety Commission 2020) whether their house has certain seismic deficiencies, including whether it lacks bolts that secure it to the foundation (common before about 1940), and whether it has unbraced cripple walls (common before about 1960). Both problems can be fixed at a cost on the order of a few thousand dollars. But, with a few notable exceptions, the cost burden falls entirely on the owner and California law requires neither buyer nor seller to fix the problems.

Should an owner bolt an old house to its foundation and brace outweigh the cost, but the investment is still a gamble that probably will not pay off for any one particular owner. Second, the owner makes the investment, but even if the earthquake occurs, some savings go to tenants, insurers, lenders, and others who did not pay for the retrofit, which seems unfair.

In this work, we examine evidence that might support a different, complementary argument to retrofit. We often say that mitigation *saves*, but it might also *pay*. The present work was inspired by recent research by Awondo et al. (2016, 2019), who studied the resale price of recently sold existing single-family dwellings in four coastal Alabama communities frequently threatened by hurricanes. They found that buyers paid up to 25% more for houses near the Alabama coast that had IBHS FORTIFIED Home Hurricane

Some cities fixed their biggest existing-building problems

Sole successful voluntary program

CITY OF BERKELEY

City Services | Community & Recreation | Safety & Health

Construction & Development › Seismic Safety › Funding For Seismic Retrofits › Transfer Tax Rebates for Seismic Wo

Transfer Tax Rebates for Seismic Work

Current or former owners of buildings used exclusively for residential purposes, or mixed-use buildings with at least two residential units can receive a rebate of their real estate transfer tax for voluntary seismic upgrades completed prior to or within a year of sale.

Many successful mandates

hquake Safety Implementation Program

Soft Story | Retrofund | Private Schools | Facade Maintenance | EPIC

1906 San Francisco Earthquake, Mayor Ed Lee signed oft Story Retrofit Ordinance. This legislation requires the co "multi-unit soft-story buildings," defined as: wood- ing five or more residential units, having two or more eak" story, and permitted for construction prior to gram is currently active.

softstory

nt Chiu, Supervisors Breed and Wiener with Director of ick Otellini at the 1906 Earthquake commemoration and gning of the Soft Story Ordinance.

y Wood Frame Retrofit

This site is a guide for San Franciscans to get up to date information about the Mandatory Soft Story Retrofit Ordinance and its requirements. Also, please note

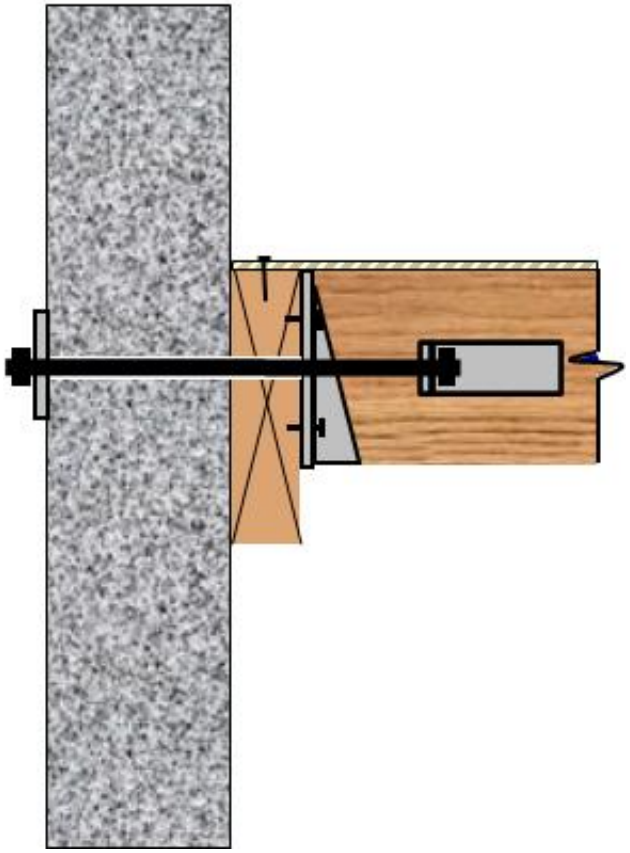
The Soft Story Legislation

Mandatory Seismic Retrofit Program Wood Frame Buildings, Ordinance, Signed Copy, April 18, 2013

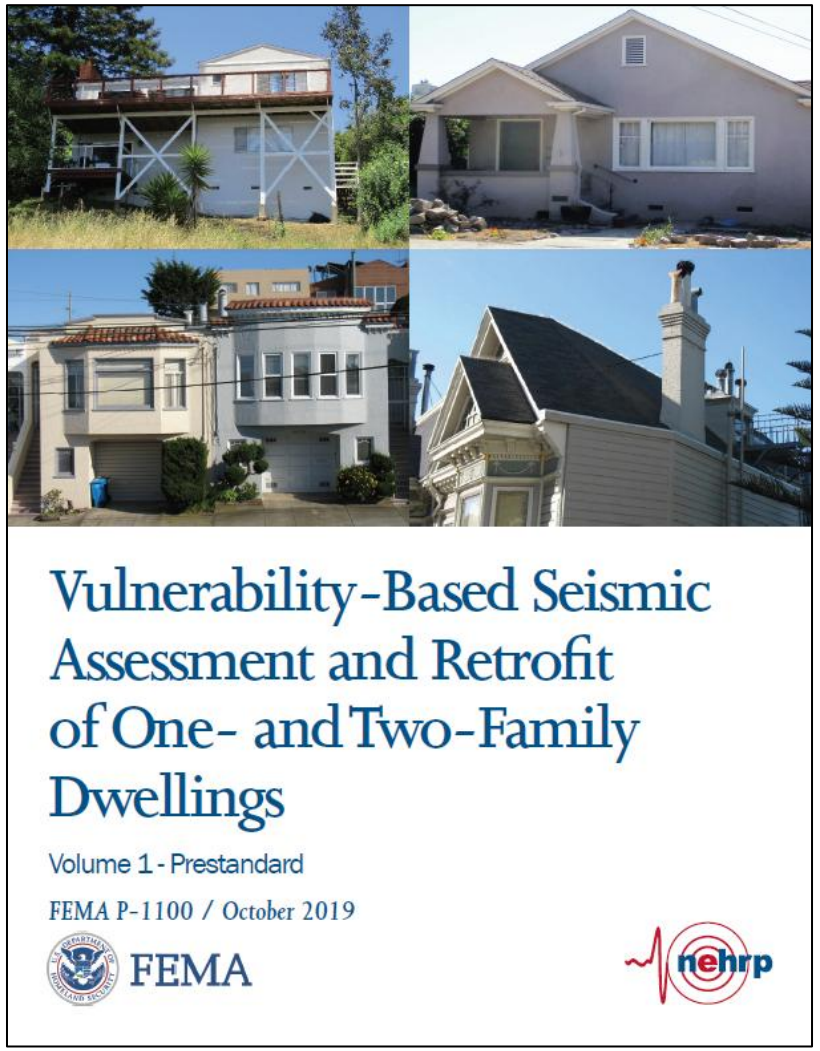
Signing of the Mandatory Seismic R Program and 1906 Earthquake Anniversary, Press Release

The Department of Building Inspecti promoted Robert Chun to Program Manager for the Mandatory Seismic

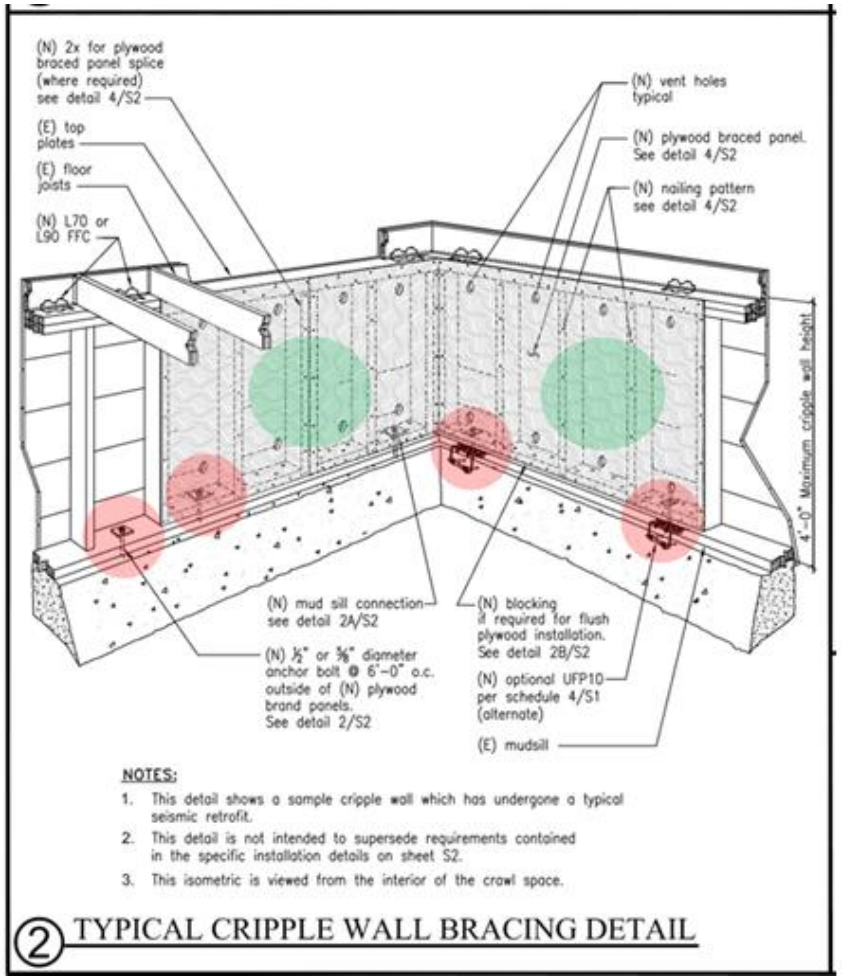
Some water & electric lifelines are solving their problems too



Unbraced cripple walls & lack of foundation bolts



EBB: 32,500 fixed since 2011 ($100 million), 4 million to go ($12B)



Older soft-story woodframe apartment buildings

ATC 52-3

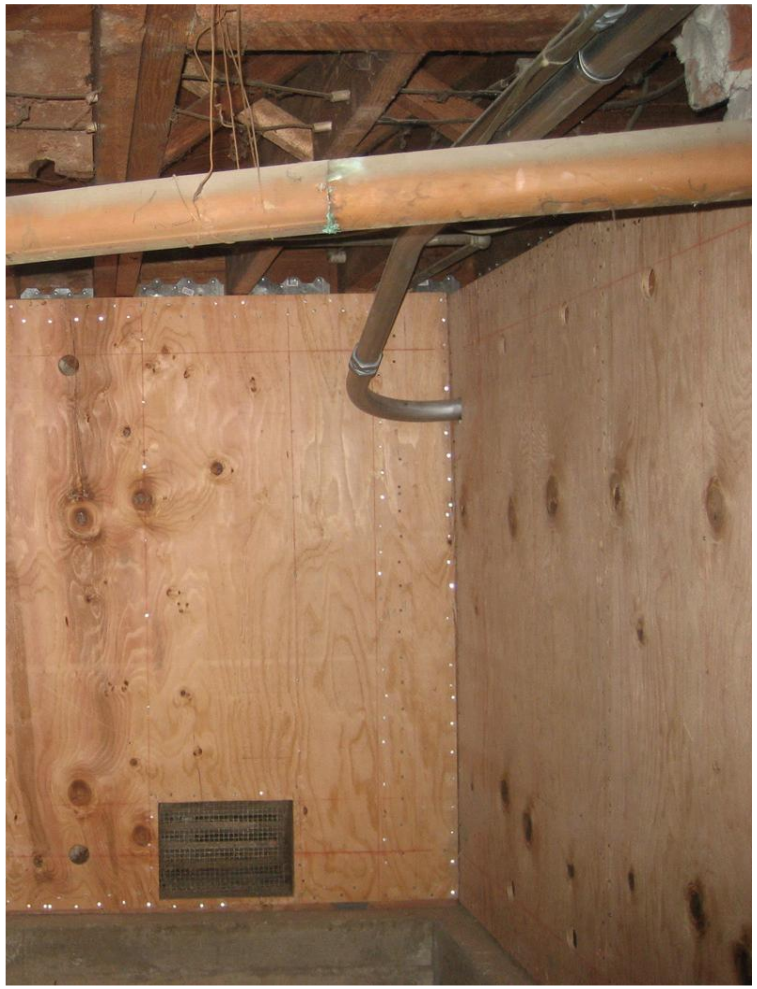
Here Today—Here Tomorrow: The Road to Earthquake Resilience in San Francisco

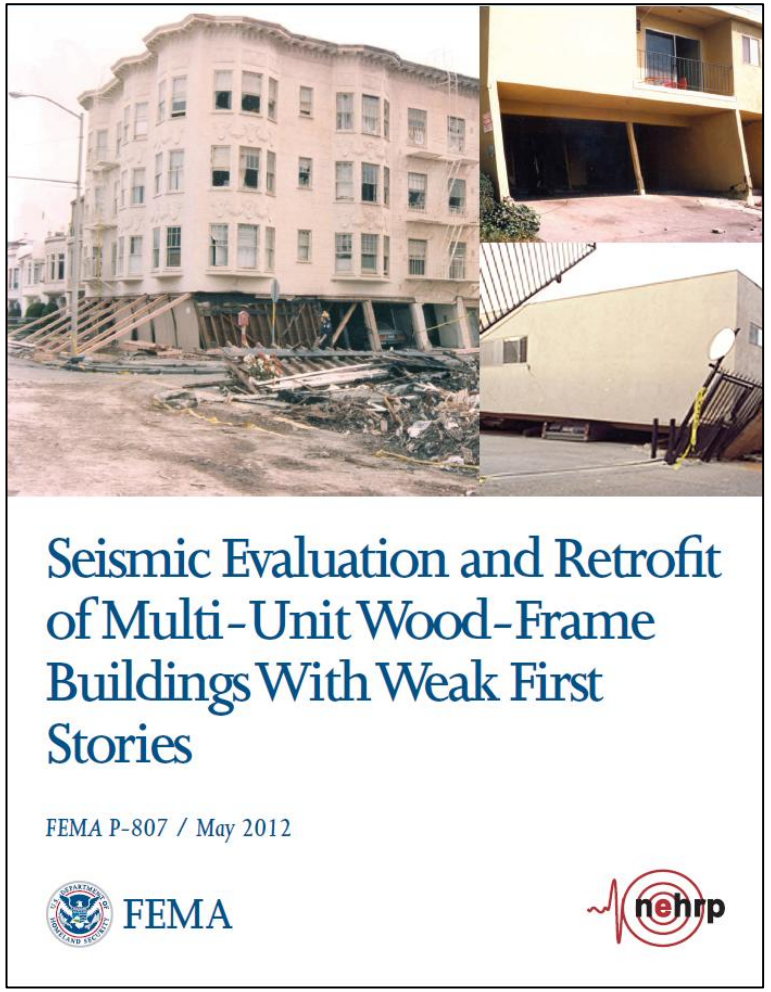
Earthquake Safety for Soft-Story Buildings

ATC Applied Technology Council

Prepared for
San Francisco Department of Building Inspection
under the Community Action Plan for Seismic Safety (CAPSS) Project

Up to 700,000 buildings, 2 million housing units, $30 billion





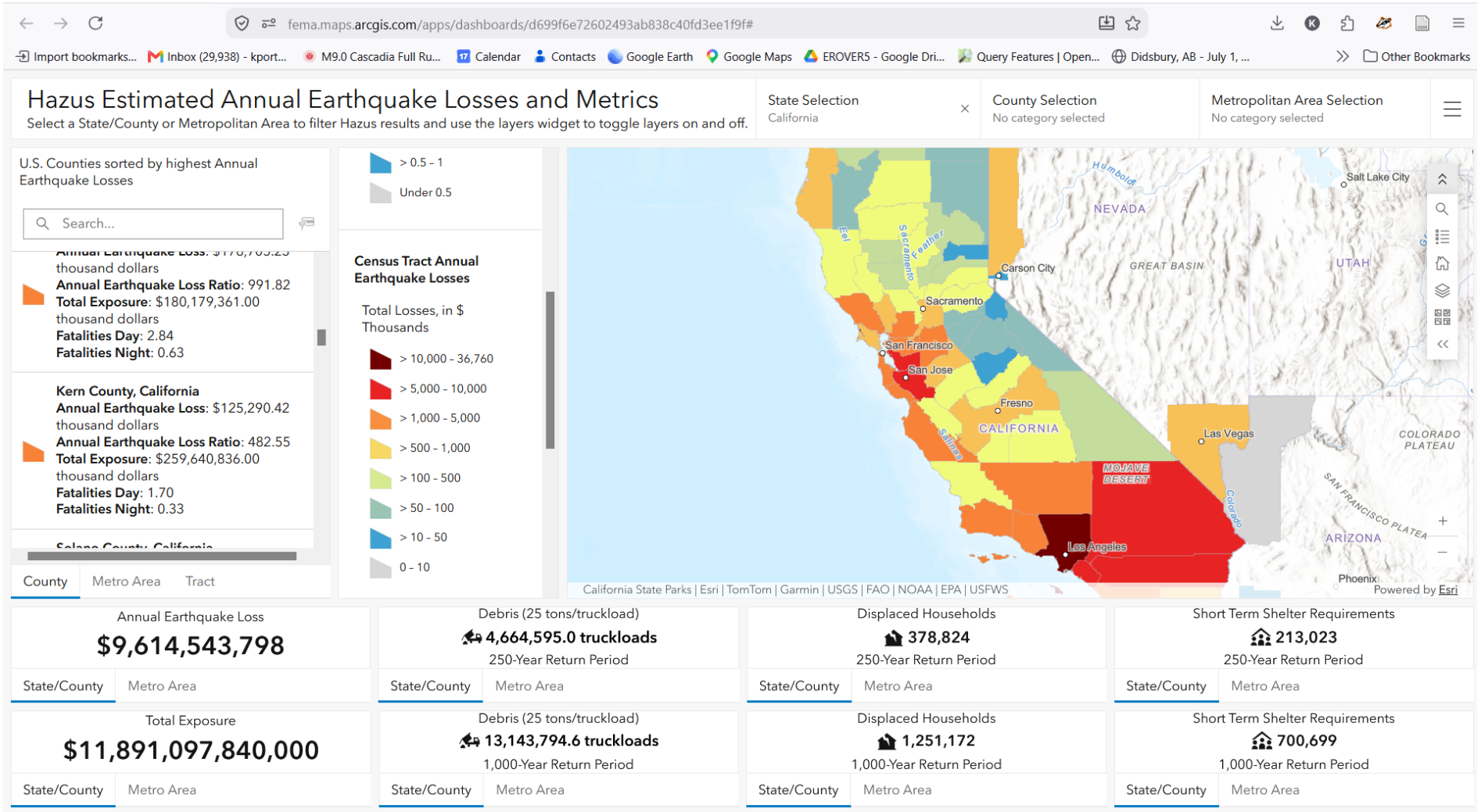
Cost to big, familiar earthquake problems

Problem	Solution	Cost
4,000,000 older wood houses	Earthquake bolt+brace; FEMA P-1100	$12 B
2,000,000 apartments in soft-story buildings	Soft-story retrofit; FEMA P-807	$30 B
350,000 unbraced manufactured homes	Engineered tie-down systems	$5 B
130 tall steel buildings	Dogbone, etc., ANSI/AISC 342	$12 B
Fire following earthquake	High-pressure water & PWSS	$0.6 B
10,000s trapped in elevators for days or weeks	Battery rescue devices, 100k elevators	$0.5B
People don't drop, cover, and hold on	Teach them	$0.01
Water & electric grid resilience	Resilient backbone, IEEE 693…	$40 B?
7 big earthquake problems		$100 B

$100 B ≈ 0.6% of CA budget, 0.05% of CA GDP annually for 50 years

The problem is not the money.

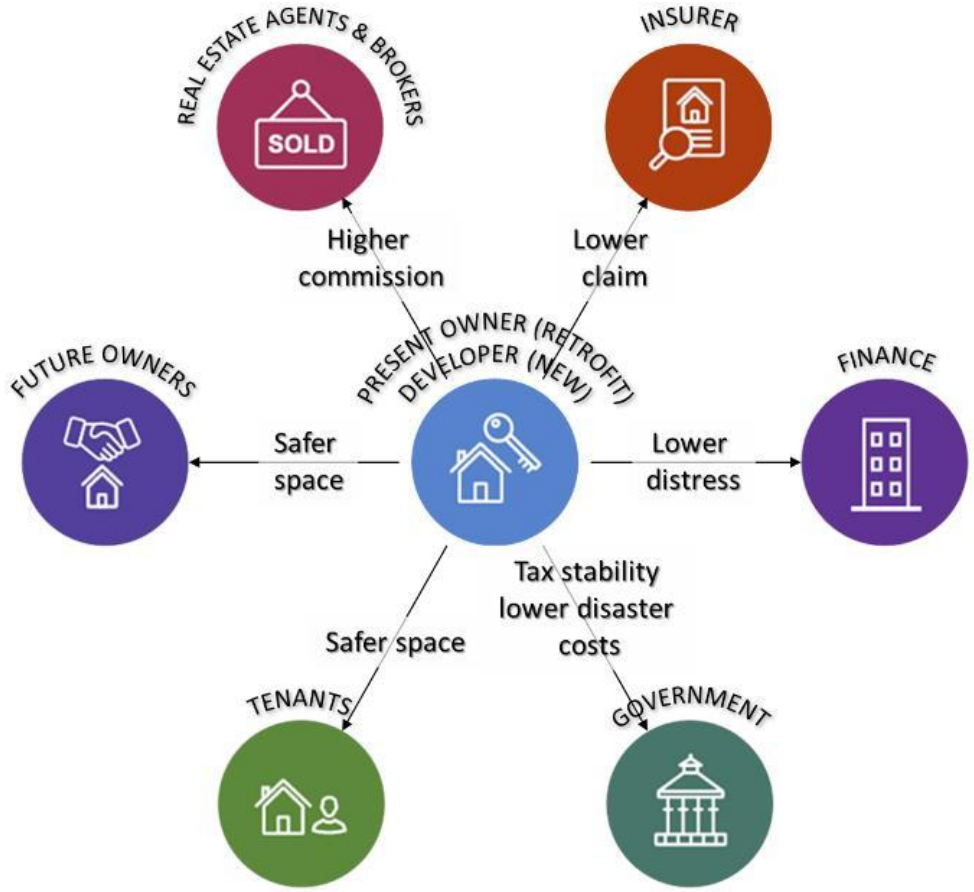
FEMA P-366: Delay costs $10 billion per year



Problem is not earthquakes, buildings, or cost. It's dithering.

60 years' delay in Venezuela: 25,000+ lives, $40B+ in economic harm.
Prevention might have cost 0.3% of the revenue from 60 years of oil exports.

It’s costly to fix stuff. But everyone wins if do so. Let them help pay.



- Owner: avoided loss if earthquake hits during tenure; added resale value
- Future owners: ditto
- Insurers: avoided claims
- Finance: lower distress & default
- Government: lower disaster costs, stable tax revenues
- Community: stable & secure community
- Broader society: stable economy

This is not an engineering problem

- Known vulnerabilities in ~12 building classes
- We know the technical solutions
- Most are costly but dithering costs more. Our challenge:

1. Who are all the influential groups with something to lose?
2. Who among us reaches them & how?
3. What should our spokespeople say?

Some retrofit costs and avoidable losses

Ishmael Legaspi

California Geological Survey

Comparing Retrofit Costs and Avoided Losses

Research question: How do the costs of seismic retrofits compare with the losses they could prevent?

- Evaluated seven retrofit measures using the National Structures Inventory, ShakeOut Scenario shaking data, and estimated losses
- Combined datasets in ArcGIS Pro to compare outcomes by retrofit type

01 **Woodframe Bolt+Brace**

02 **Manufactured Home Tie-Downs**

03 **Soft-Story Apartments**

04 **URM Wall/Parapet Bracing**

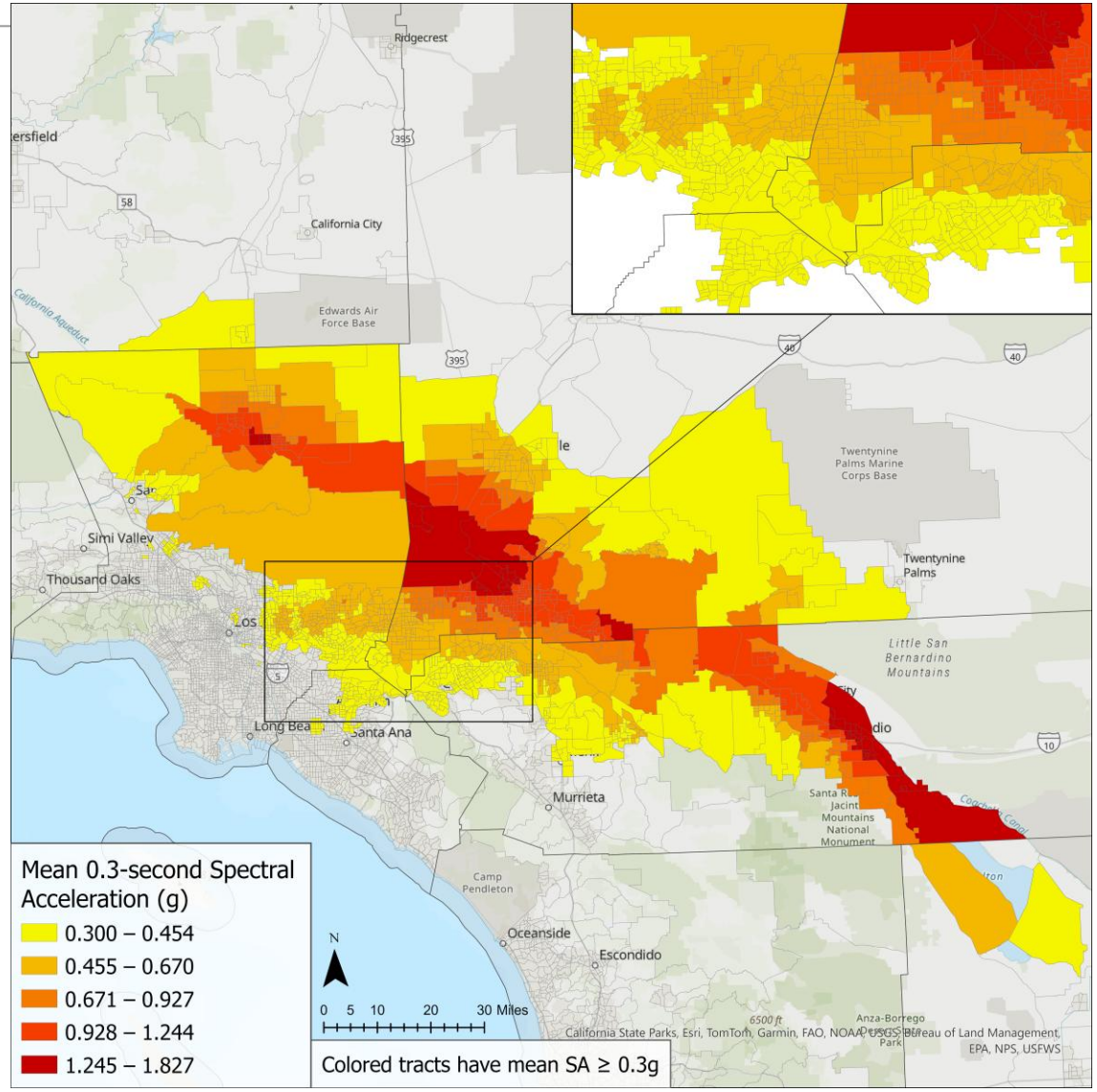
05 **Nonductile Concrete Shearwalls**

06 **Roof-to-Wall Connections for RM1/PC1**

07 **High-Rise Steel Dogbone**

Focusing on Buildings Exposed to Strong Shaking

- Used ground motions from the 2008 ShakeOut Scenario
- Summarized 0.3-second spectral acceleration by census tract.
- Study area: tracts with mean **SA03 ≥ 0.3g**
  - 1,426 tracts
- 0.3g deemed a significant threshold for damaging shaking.



Scenario Benefit-Cost Ratio

$$\text{Loss} = V \times y(SA03) \times m$$

$$B = \text{Loss (as-is)} - \text{Loss (retrofit)}$$

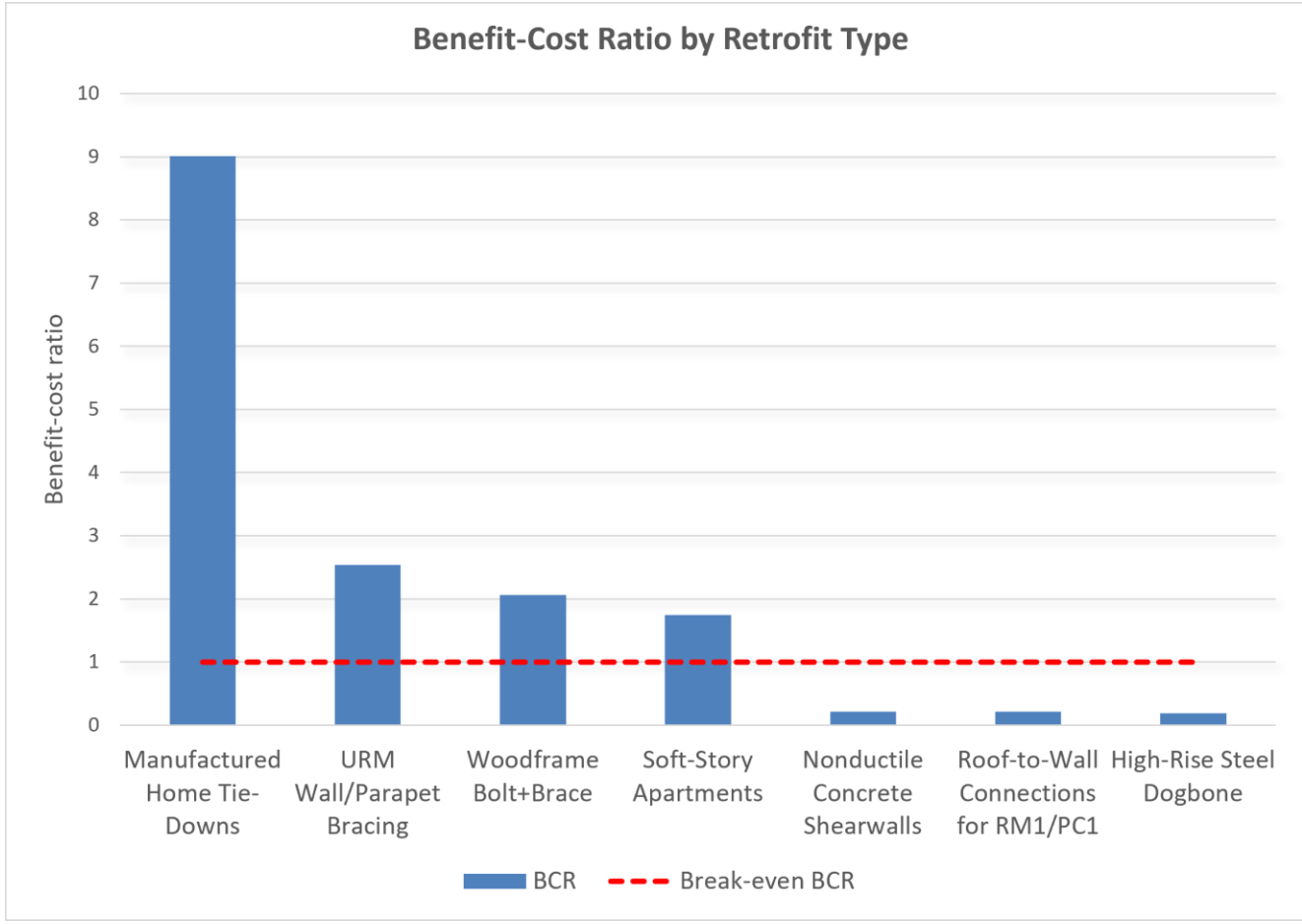
$$C = \text{Area} \times \text{unit cost}$$

$$\text{Scenario BCR} = B/C$$

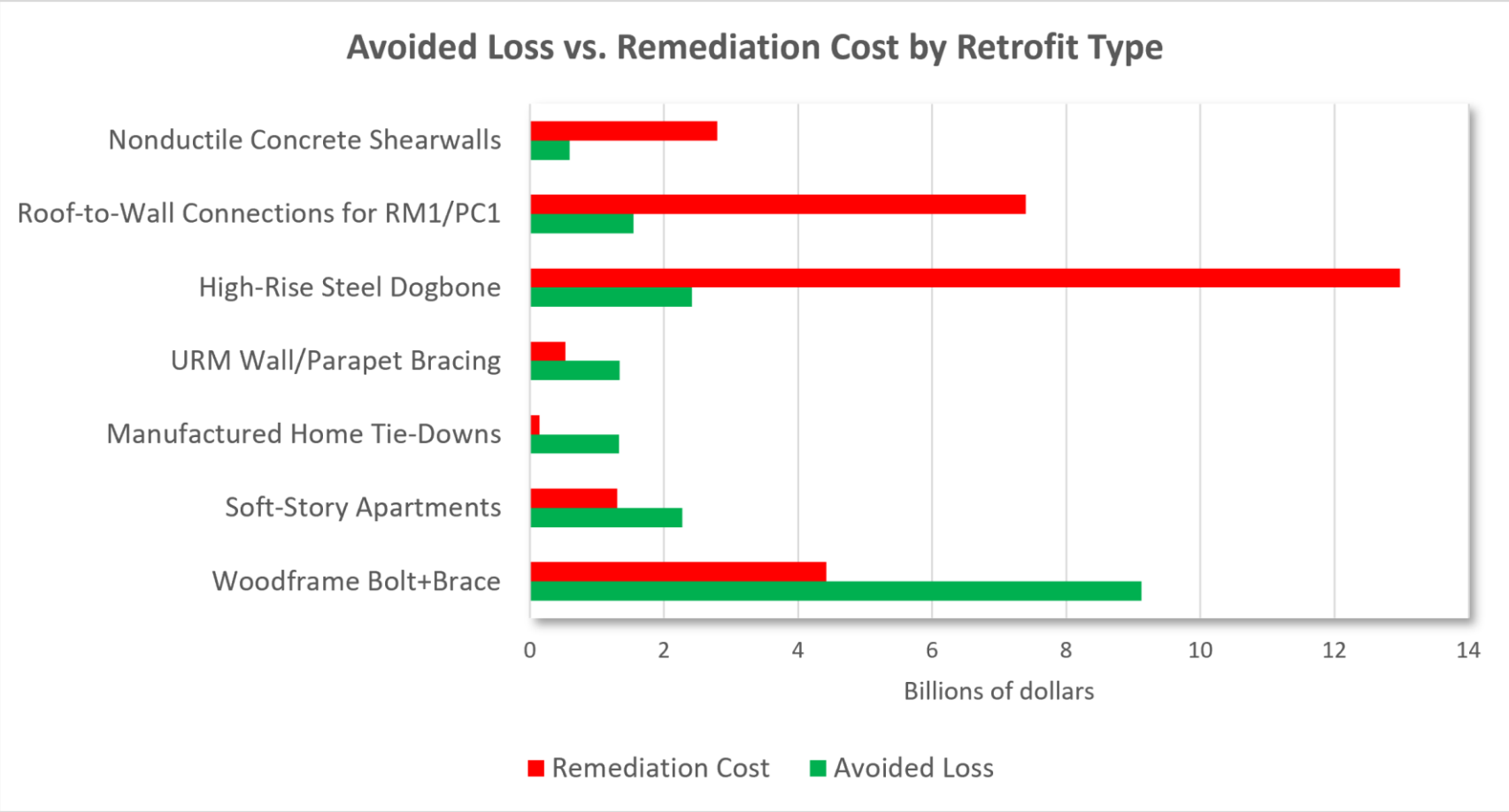
- V = replacement cost from National Structure Inventory (NSI) + Hazus
- SA03 from ShakeOut (e.g., Graves et al. 2008)
- y(SA03) = loss/unit value at SA03 (Porter 2009)
- m = multiplier for other loss categories
- B = scenario benefit
- C = retrofit cost
- Area = sf from National Structure Inventory + Hazus
- unit cost = $/sf from NIST (Fung 2020)

Four Retrofit Categories Exceeded Break-Even

- Manufactured home tie-downs: highest benefit per dollar – BCR approx. 9
- URM wall/parapet bracing, woodframe bolt + brace, soft-story retrofits – BCR > 1
- High BCR = large benefit relative to the amount invested

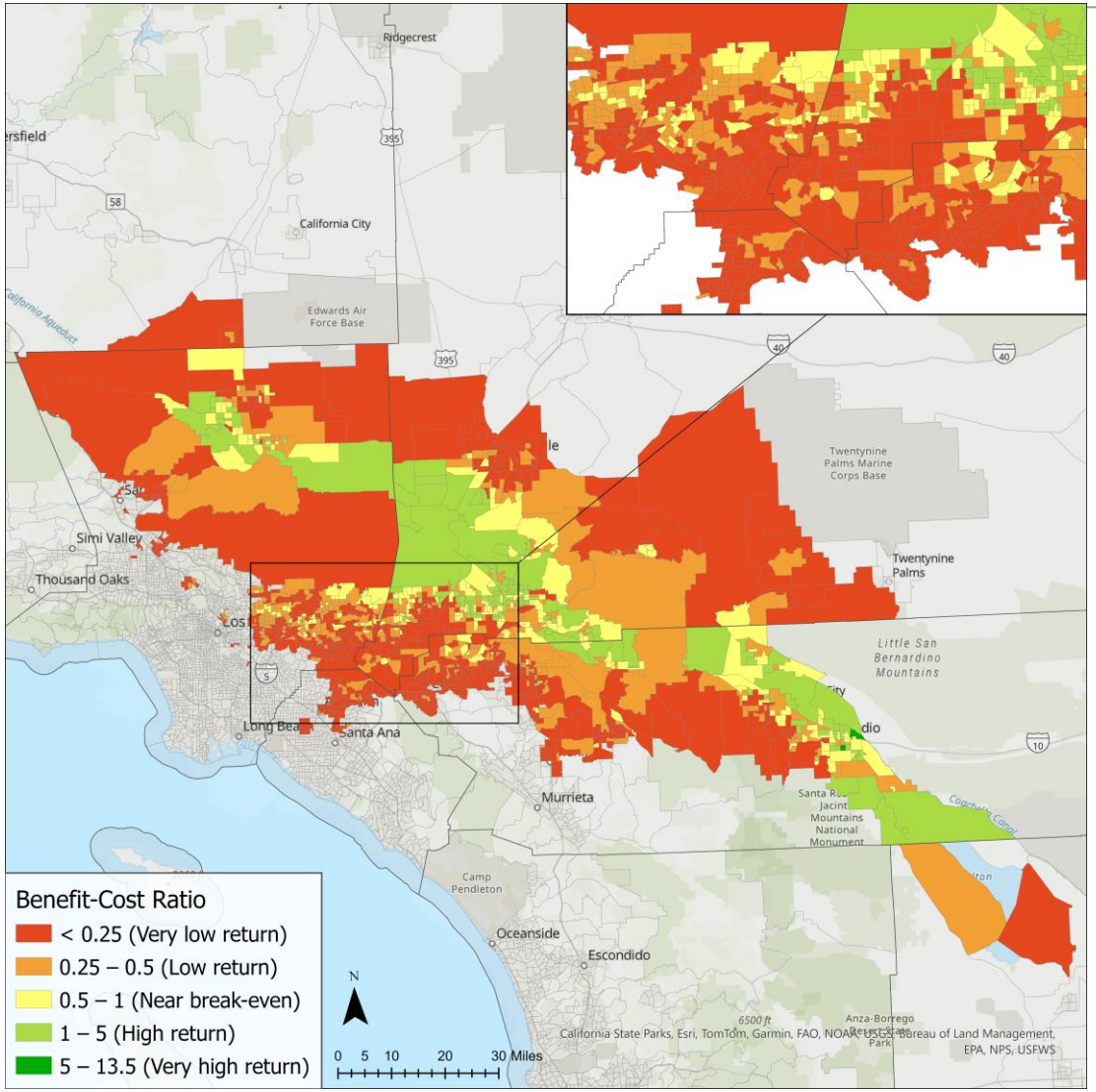


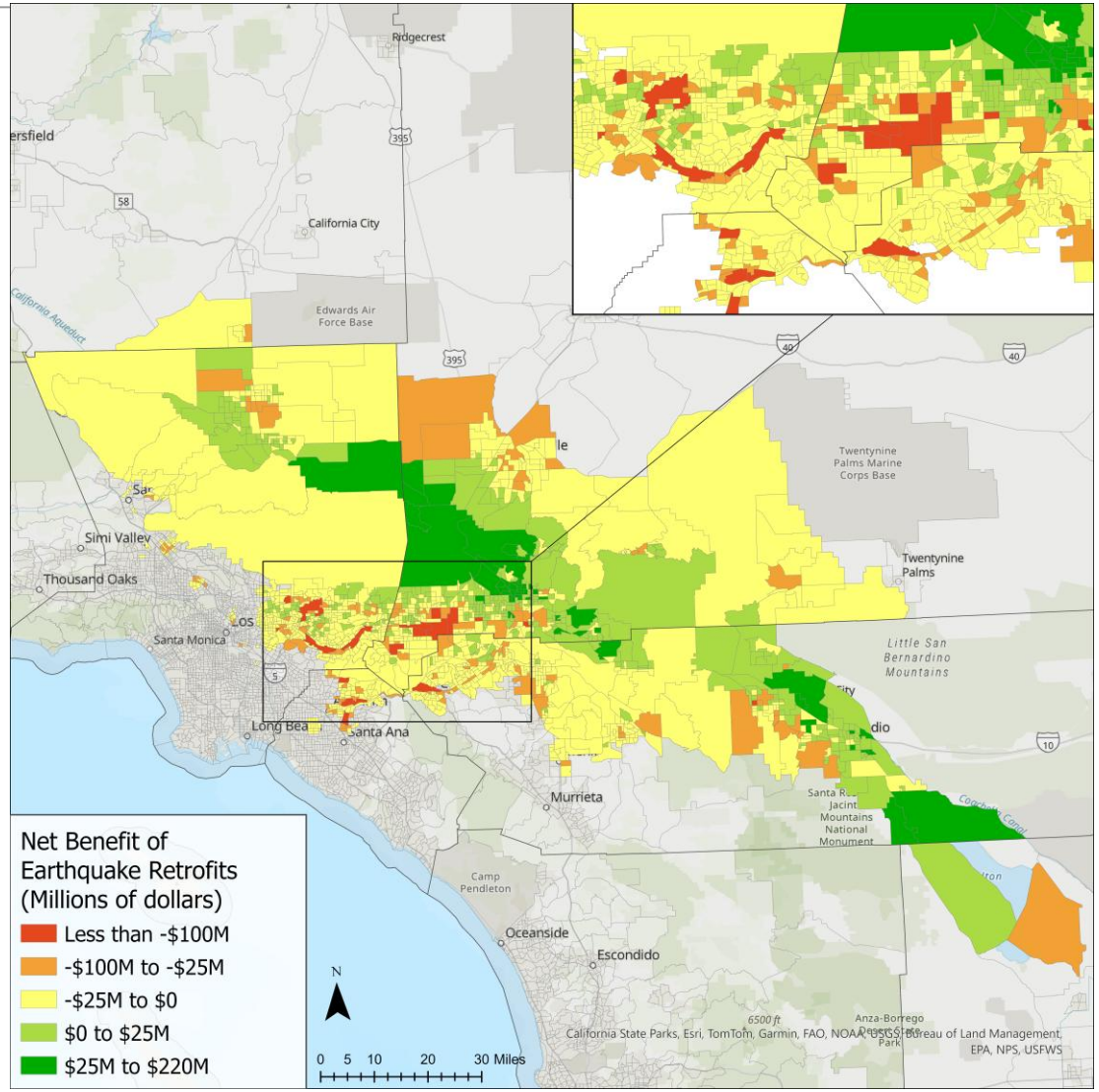
Total Benefits and Costs Differed by Retrofit Type



$18.6B avoided losses $29.6B retrofit costs 0.63 overall BCR

Retrofit Benefits Varied by Location





Gaps in the Benefit Estimates

- **Loss multipliers:** Multipliers only estimate broader consequences and cascading impacts
- **Inventory uncertainty:** Building inventory and classifications are imperfect and completed retrofits aren't calculated
- **Simplified assumptions:** Generalized retrofit costs and a uniform 90% loss reduction do not capture every building's conditions
- **Scenario scope:** Results reflect only one earthquake, without accounting for aftershocks or benefits over a building's lifetime

The Next Phase

- Several retrofit measures already showed substantial benefits in this study
- Next steps include:
  - Updated ShakeOut 2.0 ground motions
  - Improved inventory and retrofit-status data
  - More detailed estimates of human and economic consequences
- Continued research can help communities decide where and how to invest before the next major earthquake