Future Direction of Risk Analysis

in re PEER*…in re Natural Hazards…in re…*

C. Scawthorn, S.E.

Prof. (ret.) Kyoto University

Visiting Researcher, PEER

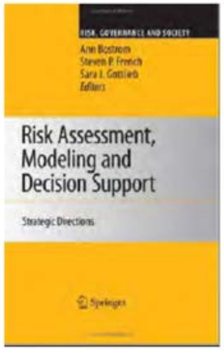
2020 PEER Annual Meeting

The Future of Performance-Based Natural Hazards Engineering

What's past is prologue

A Brief History of Seismic Risk Assessment

Citation:
Scawthorn, C. (2008) *A Brief History of Seismic Risk Assessment* (Chapter 1 in: *Risk Assessment, Modeling, and Decision Support: Strategic Directions*, edited by Ann Bostrom, Steven French and Sara Gottlieb), Springer



http://www.sparisk.com/pubs/Scawthorn-2008-History.pdf

Outline

- Risk Criteria
- Risk Equity
- Risk Governance

But First.....

EEW

EEW

Effective Warning consists of:

- ✓ Alert (*MyShake*)
  - ✓ Detection Analysis / decision
  - ✓ Transmission
  - ➢ Receipt (if you have a smartphone)
- Audience
  - Comprehension (the message)
  - ***Action (the pay-off)***

We need tailored messages and planned actions

EEW

Planned actions:

- What to do?
- Depends on:
  - Who you are (child, teacher, able-bodied…)
  - Where you are (home, school, gas-works…)
  - Building: wood frame, RC pancake, URM…)
  - Largely an engineering domain

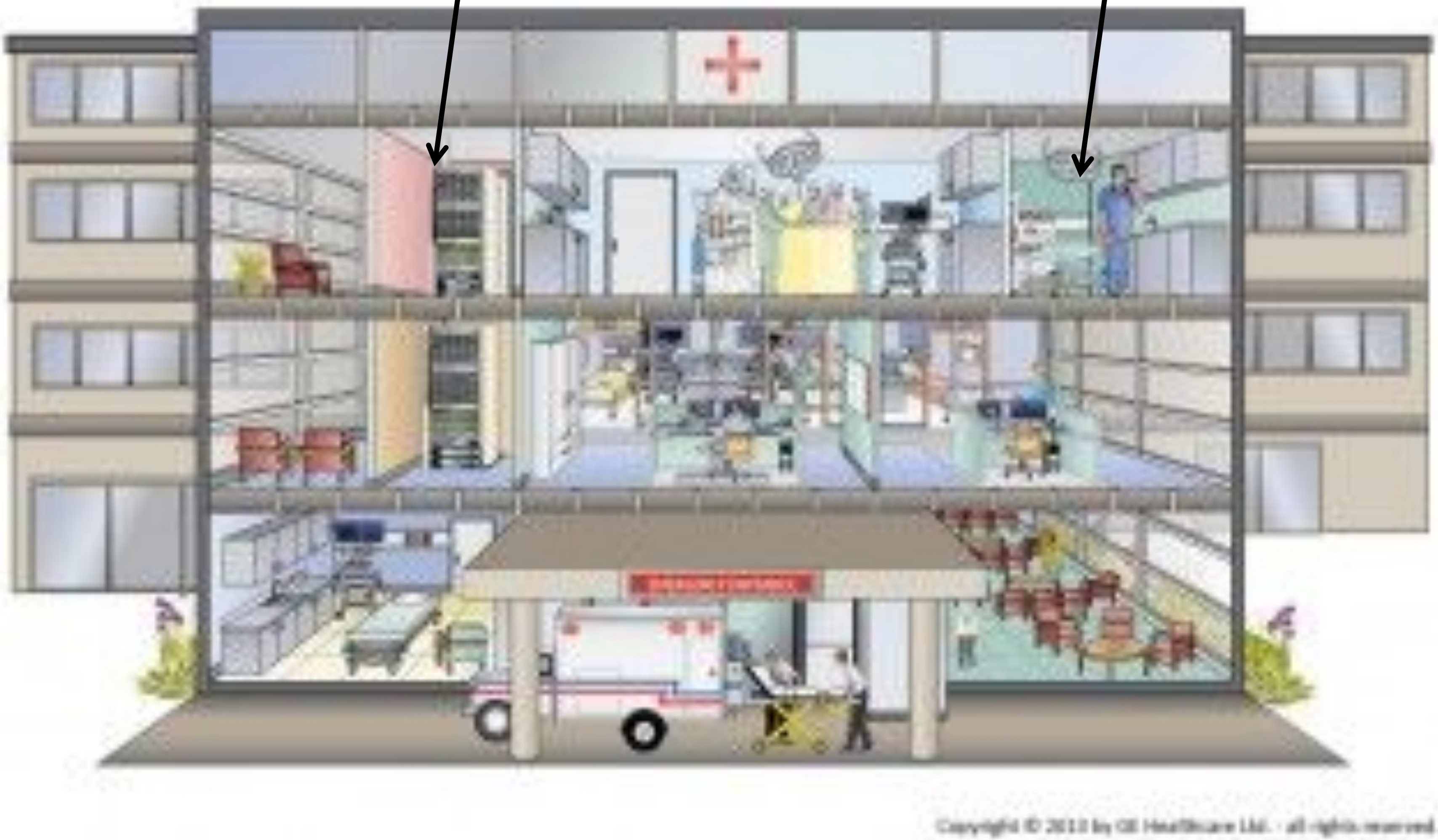
Tailored Messages:

- determined by planned actions
- Largely a social science domain

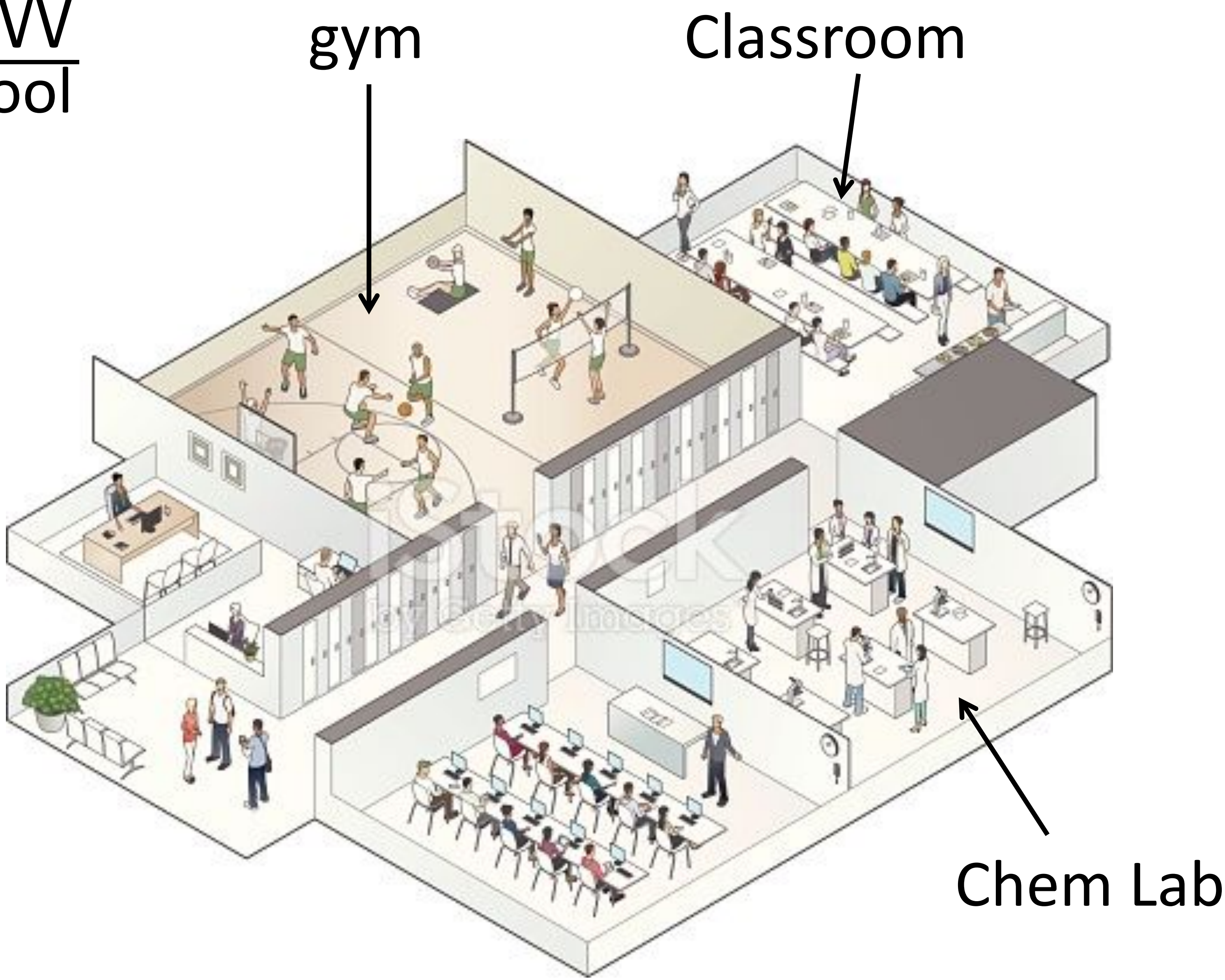
EEW
Hospital

Lounge

Operating room



EEW
School



EEW Needs

- For every building
  - Assessment of performance
  - Structural and non-structural
- Every room in every building
  - Assessment of performance
  - Ceilings, fixtures, furniture…
  - DCH, remain, flee…
- Messaging
  - Placards?
  - Annunciators?
  - Smartphone / location-sensed? (someday)

Risk Criteria

Table 1.3-1 Target Reliability (Annual Probability of Failure, P_F) and Associated Reliability Indices (β)[1] for Load Conditions That Do Not Include Earthquake, Tsunami, or Extraordinary Events[2]

Basis	Risk Category I	Risk Category II	Risk Category III	Risk Category IV
Failure that is not sudden and does not lead to widespread progression of damage	$P_F = 1.25 \times 10^{-4}$/yr $\beta = 2.5$	$P_F = 3.0 \times 10^{-5}$/yr $\beta = 3.0$	$P_F = 1.25 \times 10^{-5}$/yr $\beta = 3.25$	$P_F = 5.0 \times 10^{-6}$/yr $\beta = 3.5$
Failure that is either sudden or leads to widespread progression of damage	$P_F = 3.0 \times 10^{-5}$/yr $\beta = 3.0$	$P_F = 5.0 \times 10^{-6}$/yr $\beta = 3.5$	$P_F = 2.0 \times 10^{-6}$/yr $\beta = 3.75$	$P_F = 7.0 \times 10^{-7}$/yr $\beta = 4.0$
Failure that is sudden and results in widespread progression of damage	$P_F = 5.0 \times 10^{-6}$/yr $\beta = 3.5$	$P_F = 7.0 \times 10^{-7}$/yr $\beta = 4.0$	$P_F = 2.5 \times 10^{-7}$/yr $\beta = 4.25$	$P_F = 1.0 \times 10^{-7}$/yr $\beta = 4.5$

[1]The target reliability indices are provided for a 50-year reference period, and the probabilities of failure have been annualized. The equations presented in Section 2.3.6 are based on reliability indices for 50 years because the load combination requirements in Section 2.3.2 are based on the maximum loads for the 50-year reference period.
[2]Commentary to Section 2.5 includes references to publications that describe the historic development of these target reliabilities.

$$P_f = 2*10^{-6} * 50 = 10^{-4}$$

One big building = 10,000 components

→ 1 failure during its life (?)

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Risk Criteria

2.3.1 Basic Combinati
foundations shall be desi
equals
followi
acting
combin
seismic
to Secti
of the e
shall be

1. 1.
2. 1.
3. 1.
4. 1.
5. 0.

2.3.2 Load Co
structure is lo
following load
the basic combi

1. In V-Zone
and 5 shal
2. In noncoas
be replace

2.3.3 Load C
Loads. When a
wind-on-ice loa
considered:

1. $0.5(L_r$ or
$0.2D_i + 0.$
2. $1.0W + 0.$
by $D_i + W$
3. $1.0W$ in combination 5 shall be replaced by $D_i + W_i$.
4. $1.0W + L + 0.5(L_r$ or S or $R)$ in combination 4 shall be replaced by D_i.

2.3.6 Basic Combinations with Seismic Load Effects. When a structure is subject to seismic load effects, the following load combinations shall be considered in addition to the basic combinations in Section 2.3.1. The most unfavorable effects from seismic loads shall be investigated, where appropriate, but they need not be considered to act simultaneously with wind loads.

Where the prescribed seismic load effect, $E = f(E_v, E_h)$ (defined in Section 12.4.2 or 12.14.3.1) is combined with the effects of other loads, the following seismic load combinations shall be used:

6. $1.2D + E_v + E_h + L + 0.2S$
7. $0.9D - E_v + E_h$

Where the seismic load effect with overstrength, $E_m = f(E_v, E_{mh})$, defined in Section 12.4.3, is combined with the effects of other loads, the following seismic load combination for structures shall be used:

6. $1.2D + E_v + E_{mh} + L + 0.2S$
7. $0.9D - E_v + E_{mh}$

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Risk Criteria

Table 1.3-2 Target Reliability (Conditional Probability of Failure) for Structural Stability Caused by Earthquake

Risk Category	Conditional Probability of Failure Caused by the MCE_R Shaking Hazard (%)
I & II	10
III	5
IV	2.5

Given an MCE, 5% of buildings will have failure?

San Francisco: 10,000 bldgs.?

New bldgs!

5% ??

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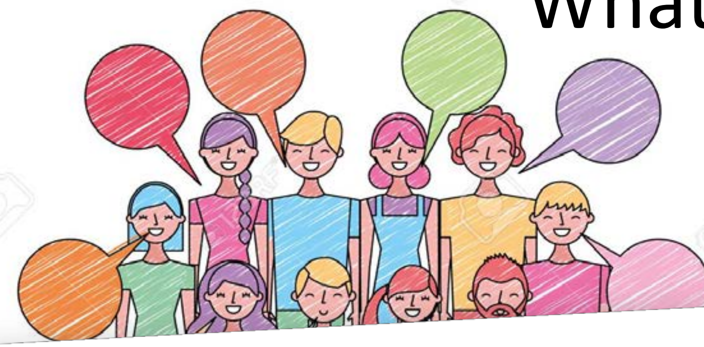
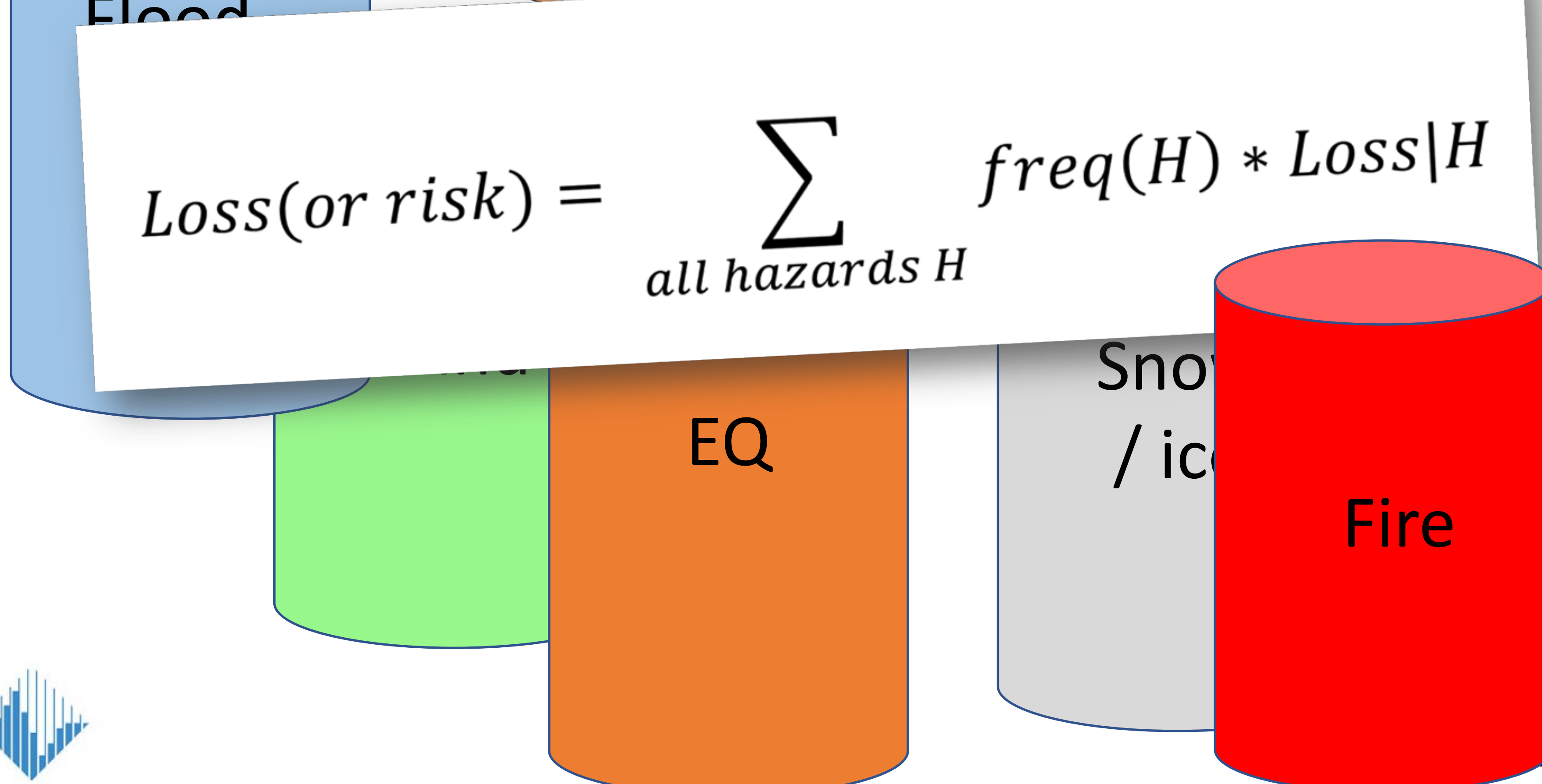
Risk Criteria

What's my risk?



$$Loss(or\ risk) = \sum_{all\ hazards\ H} freq(H) * Loss|H$$



Risk Criteria

Risk decision-making is hardly "democratic"

- Delegated to trusted professional... (engi...
- Modi... ...s, realto...
- Actual risk largely unknown
- Has not been deliberately chosen
- Heterogenously borne


The Public's Role in Seismic Design Provisions

Michael Davis,[a] S.M.EERI, and Keith Porter,[b] M.EERI

What is needed? More transparent, rational, open risk communication and decision-making process.

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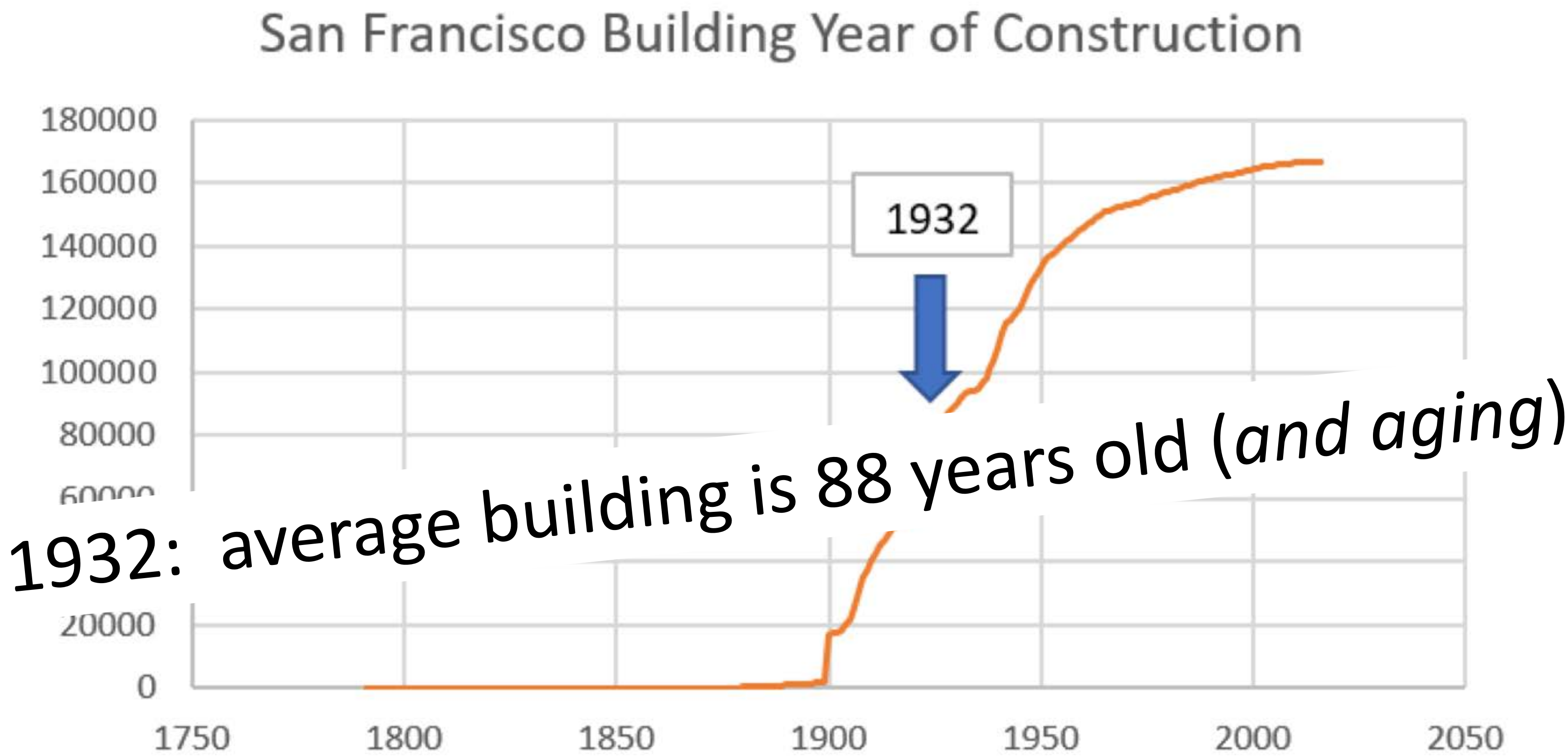
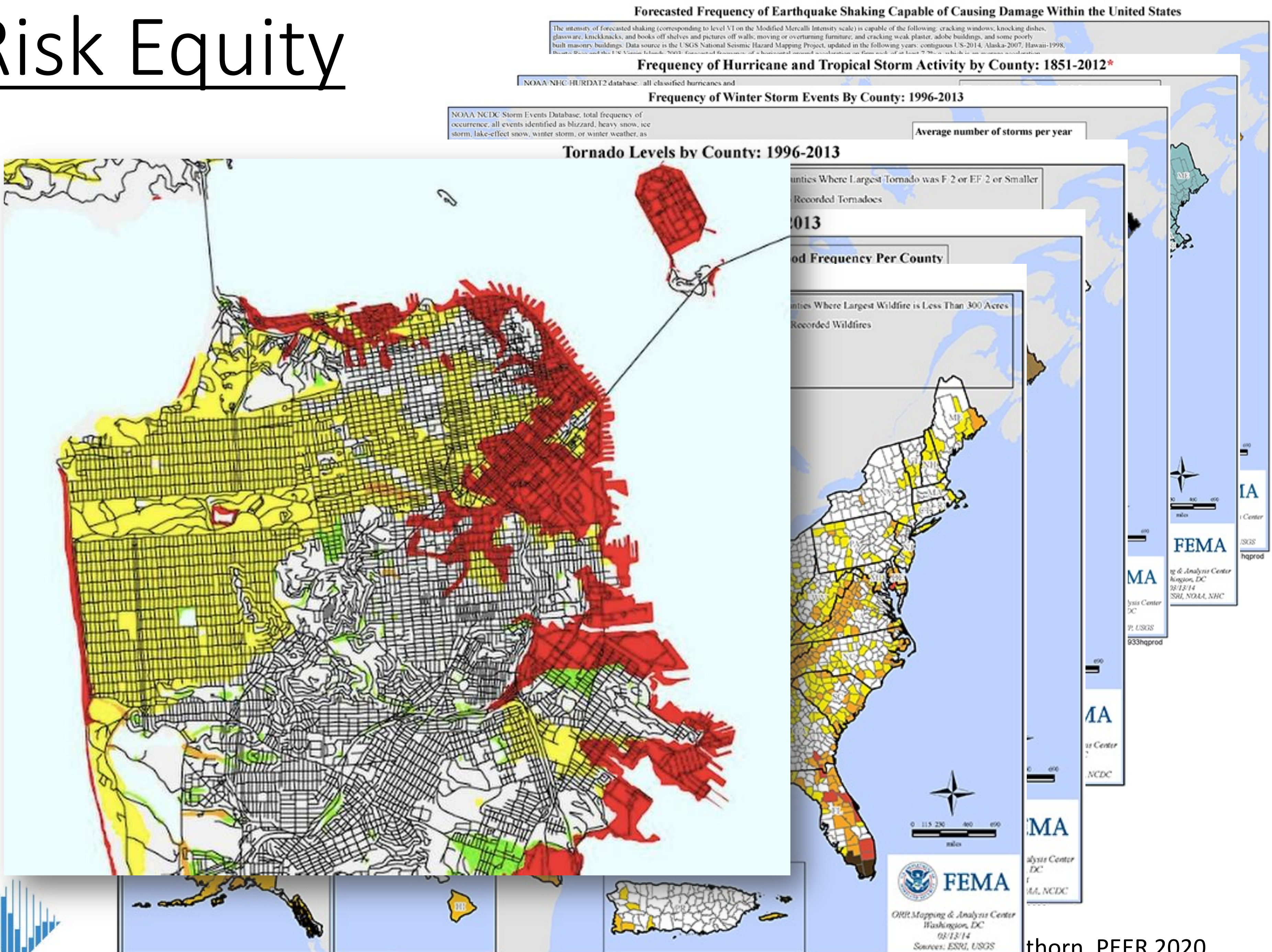
Risk Criteria



Based on actual building life,
Actual risk is greater (and will be greater)
than assumed (x 2~3)

Risk Equity



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Risk Equity

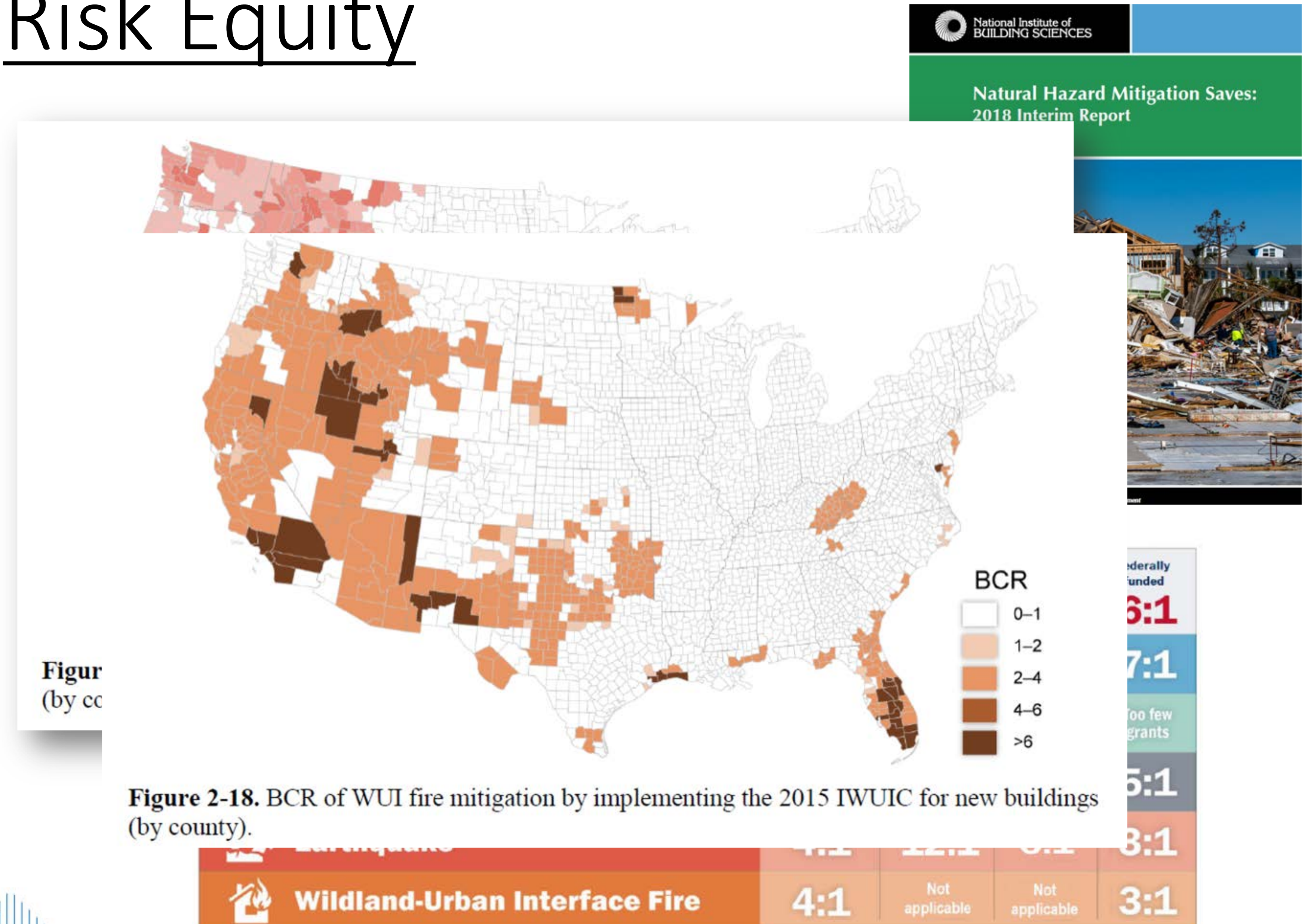
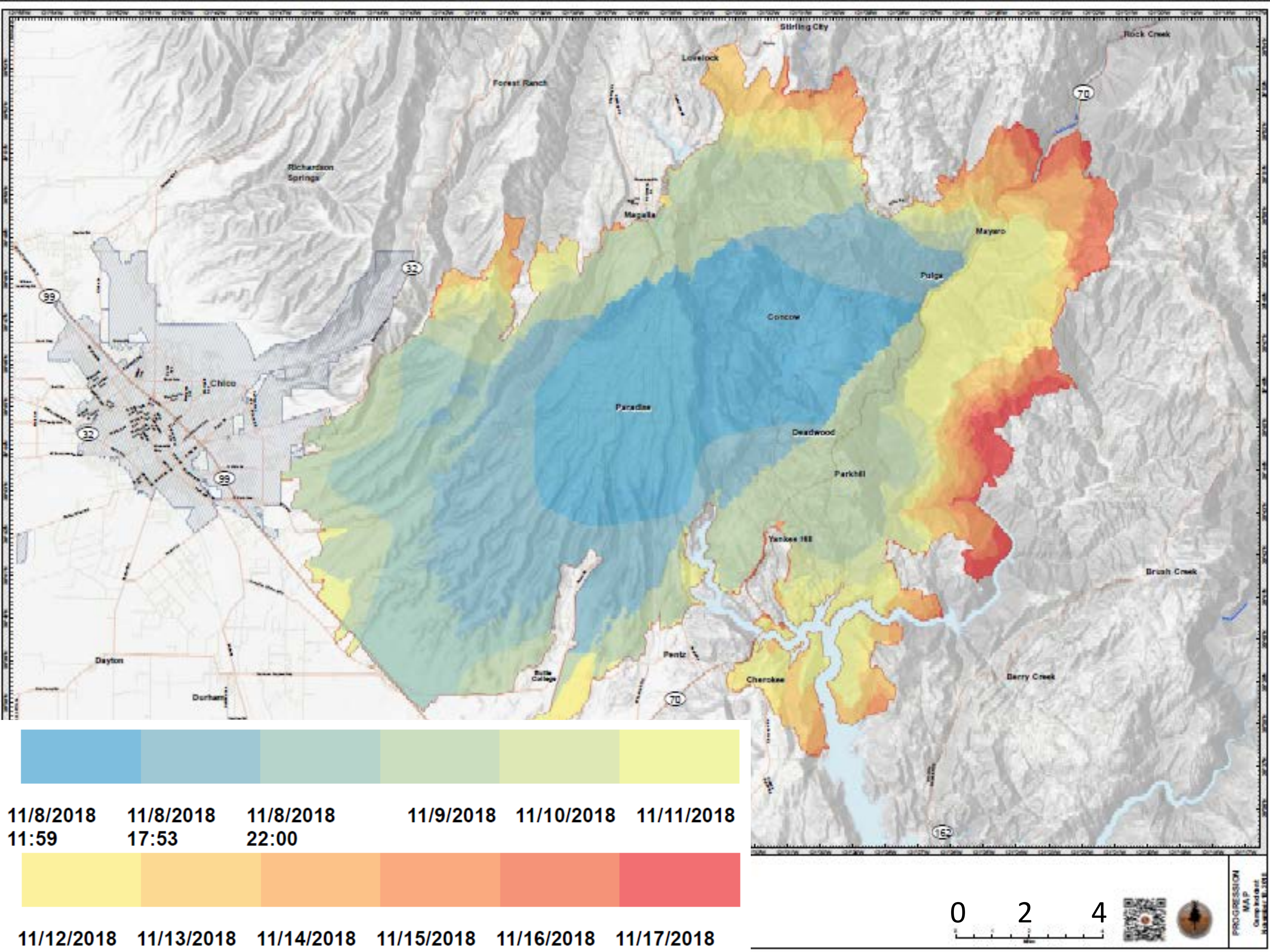


Figure 2-18. BCR of WUI fire mitigation by implementing the 2015 IWUIC for new buildings (by county).

Table 2-1. Benefit-cost ratio by hazard and mitigation measure.

October 2017 Northern / Dec 2017 Southern California wildfires

November 2018 Camp Fire, California)



Stirling City
Rock Creek
Lovelock
Forest Ranch
70
Richardson Springs
Magalia
Mayaro
32
Pulga
99
Concow
Chico
Paradise
32
Deadwood
99
Parkhill
Yankee Hill
Brush Creek
Pentz
Dayton
Butte College
Cherokee
Berry Creek
Durham
70
162
11/8/2018 11:59
11/8/2018 17:53
11/8/2018 22:00
11/9/2018
11/10/2018
11/11/2018
11/12/2018
11/13/2018
11/14/2018
11/15/2018
11/16/2018
11/17/2018
0
2
4
PROGRESSION MAP

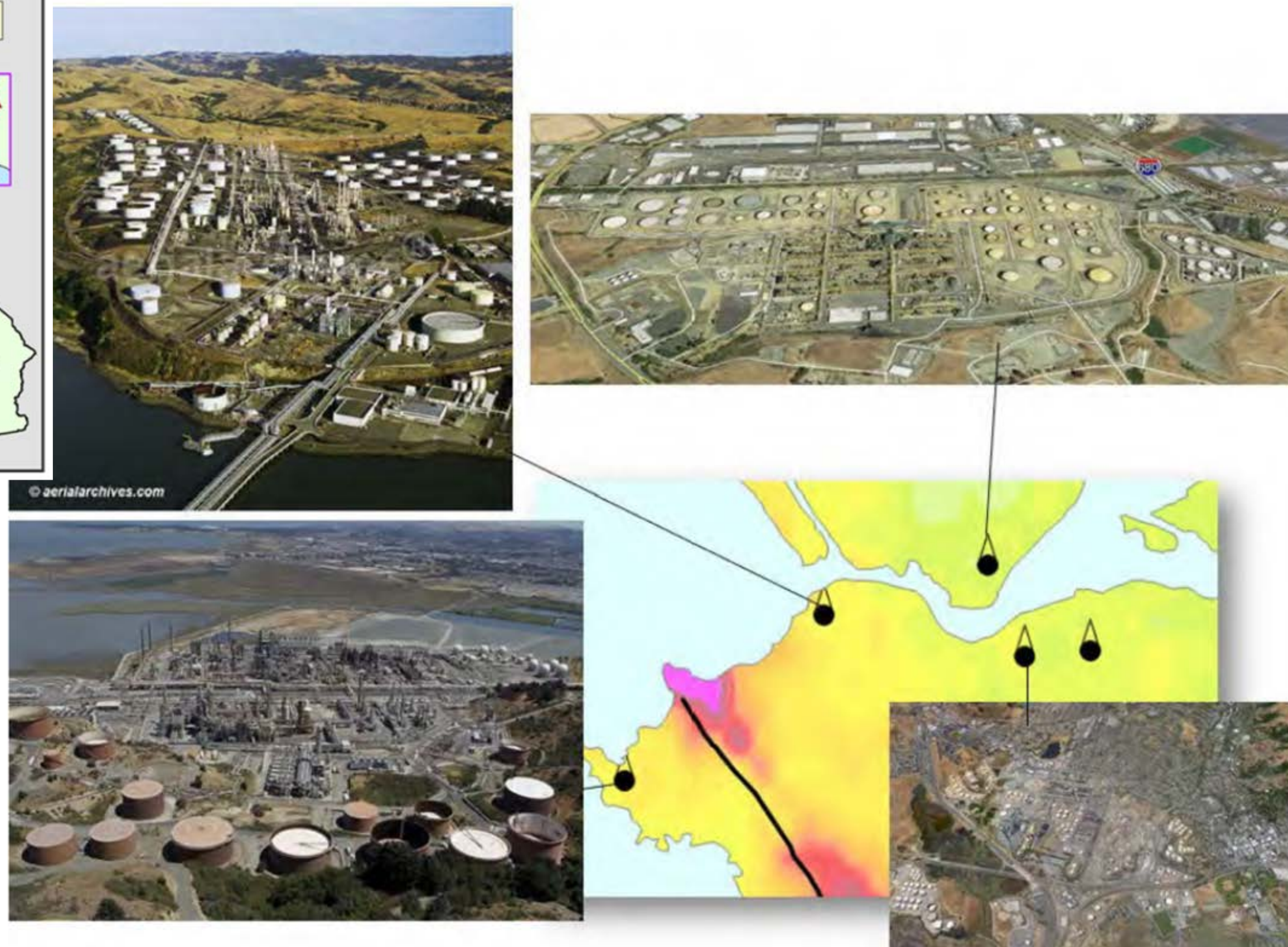
November 2018 Camp Fire, California) air quality impacts

Two years:

- 170 dead
- $115 billion in losses
- What are we doing about this?


Oroville dam spillway failure
188,000 people evacuated

Risk Equity



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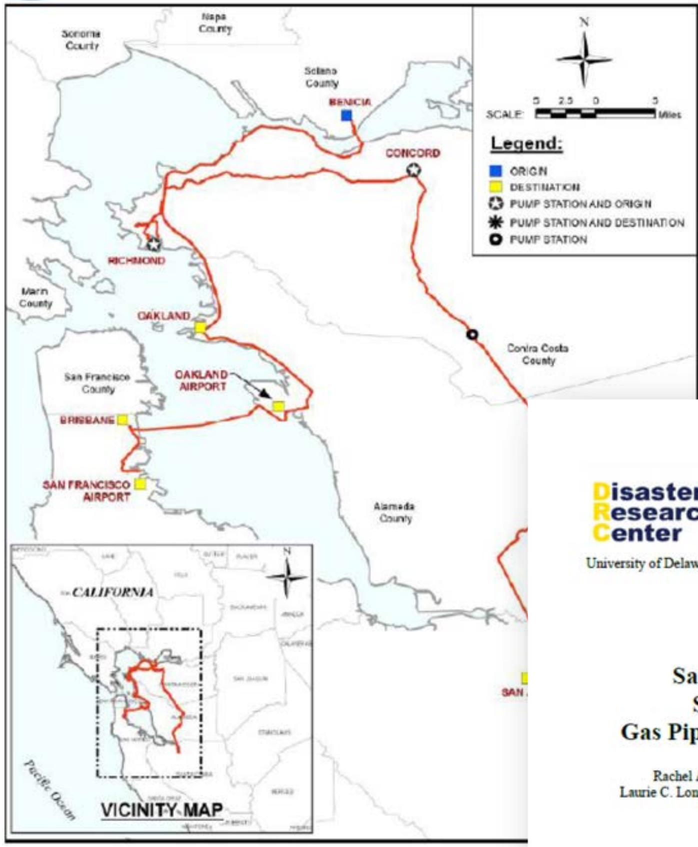
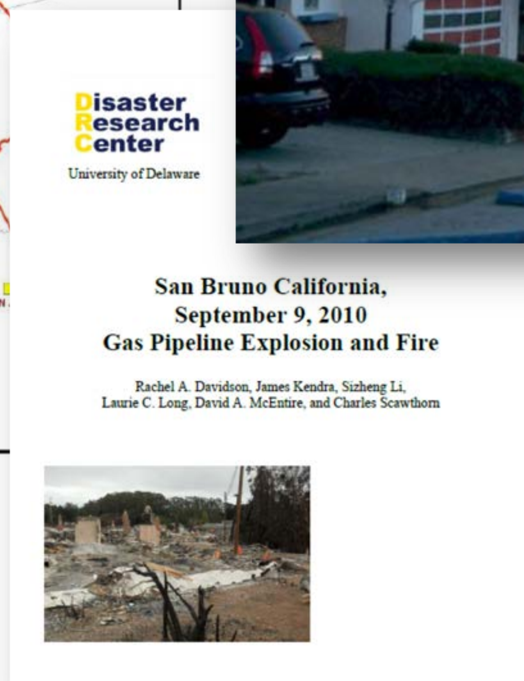
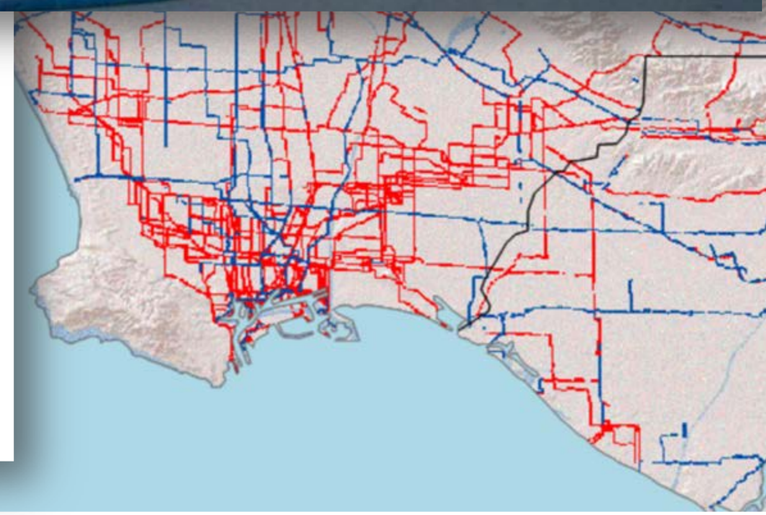
Risk Equity




Disaster Research Center
University of Delaware

San Bruno California,
September 9, 2010
Gas Pipeline Explosion and Fire

Rachel A. Davidson, James Kendra, Sizheng Li,
Laurie C. Long, David A. McEntire, and Charles Scawthorn



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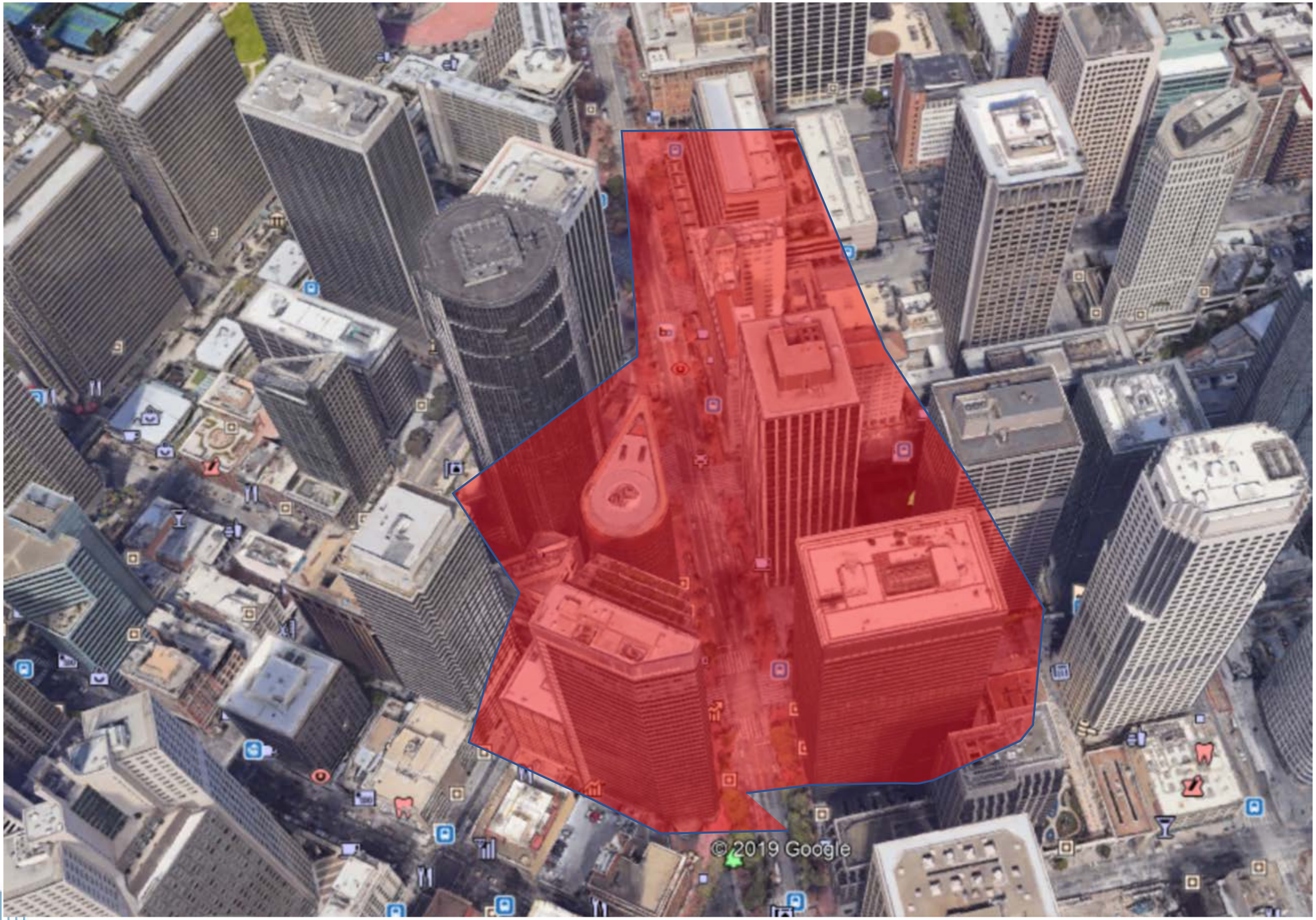
Risk Equity

Risk Equity



Risk Equity

Re risk, this is a target-rich environment

In which all the PEER skill sets ...hazard analysis, modeling, decision-making, communication.... Similarly apply **– only the hazard differs**

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Risk Equity

PEER

Earthquake Engineering

& Extreme Events

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Risk Equity

Risk is a by-product of most activities

- Why engage in these activities?
- Necessary, and profitable
- Who reaps the profit?
- Who bears the risk?
- Example:
  - Refineries:
    - Profit → Companies and investors
    - Risk → neighbors
  - Crude-by-rail:
    - Profit → companies and investors
    - Risk → those close to ROW (neighbors)

Risk Equity

What is needed?

- More equitable sharing of risk?
- Difficult: risk is location-specific
- Investors won't move to Richmond
- Anyway, should the risk be shared, or *reduced*?

Risk Governance

Fukushima Daiichi

Fundamental What: the price of risk should be included in the cost of goods and services

accident = $1 trillion*

40 years * 6 * 1000 MW * 70% availability = 1.47e12 kW-hrs

$1e12 / 1.47e12 kW-hrs = $0.68 / kW-hr
= cost of risk

Versus $0.22 per kW-hr if externality (risk) is ignored

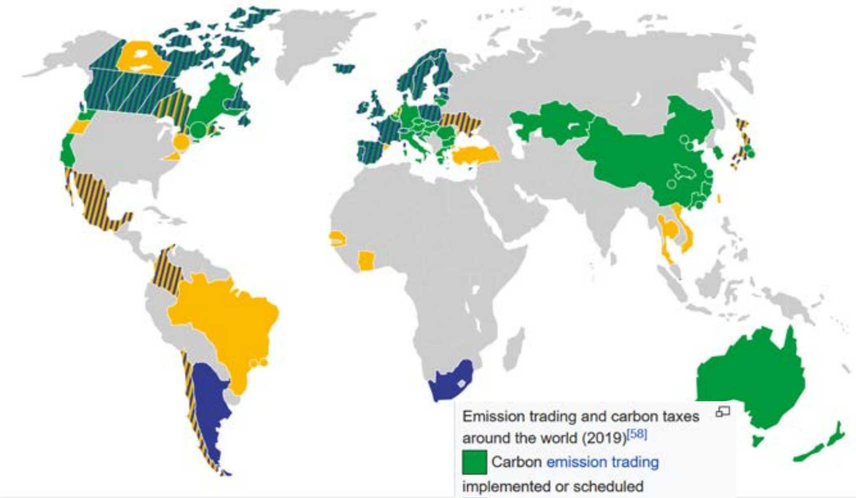
* Ref: Suzuki, T. (2019) An update from Fukushima, and the challenges that remain there, Bull. Atomic Scientists

Risk Governance

“cash is king” → price Risk

Analog: Climate change and carbon tax

Research shows that carbon taxes effectively reduce greenhouse gas emissions.[3][47][48] There is overwhelming agreement among economists that carbon taxes are the most efficient and effective way to curb climate change, with the least adverse effects on the economy.[4][5][6][7][49][50] (Wikipedia)



→ Risk tax

- Promotes risk reduction by producers
- Provides funds for risk reduction

Risk Governance

Analog:
LEED Building Certification

CERTIFIED
40 - 49 POINTS

SILVER
50 - 59 POINTS

GOLD
60 - 79 POINTS

PLATINIUM
80+ POINTS

U.S. RESILIENCY COUNCIL
Rating Building Performance in Natural Disasters

The USRC Platinum Rating represents a the highest level of building performance and is intended to exceed modern code standards in terms of safety, by protecting occupants against major injury and egress restrictions. Platinum rated buildings are expected to suffer negligible damage - less than 5% of replacement cost, and allow functional recovery within a few days of a major seismic event. **The USRC Platinum Rating is sought by owners who demand the highest level of asset protection and virtually uninterrupted functionality of their operations.**

The USRC Gold Rating represents a very high level of performance that is intended to exceed modern code standards in terms of safety, by protecting occupants against major injury. Gold rated buildings are expected to suffer only minor damage - less than 10% of replacement cost, and allow functional recovery within several weeks of a major seismic event. **The USRC Gold Rating is sought by owners who demand high levels of asset protection and minimal disruption to their operations.**

Building SAFE

Building Life-Safe

Building NOT RATED for Disaster Safety

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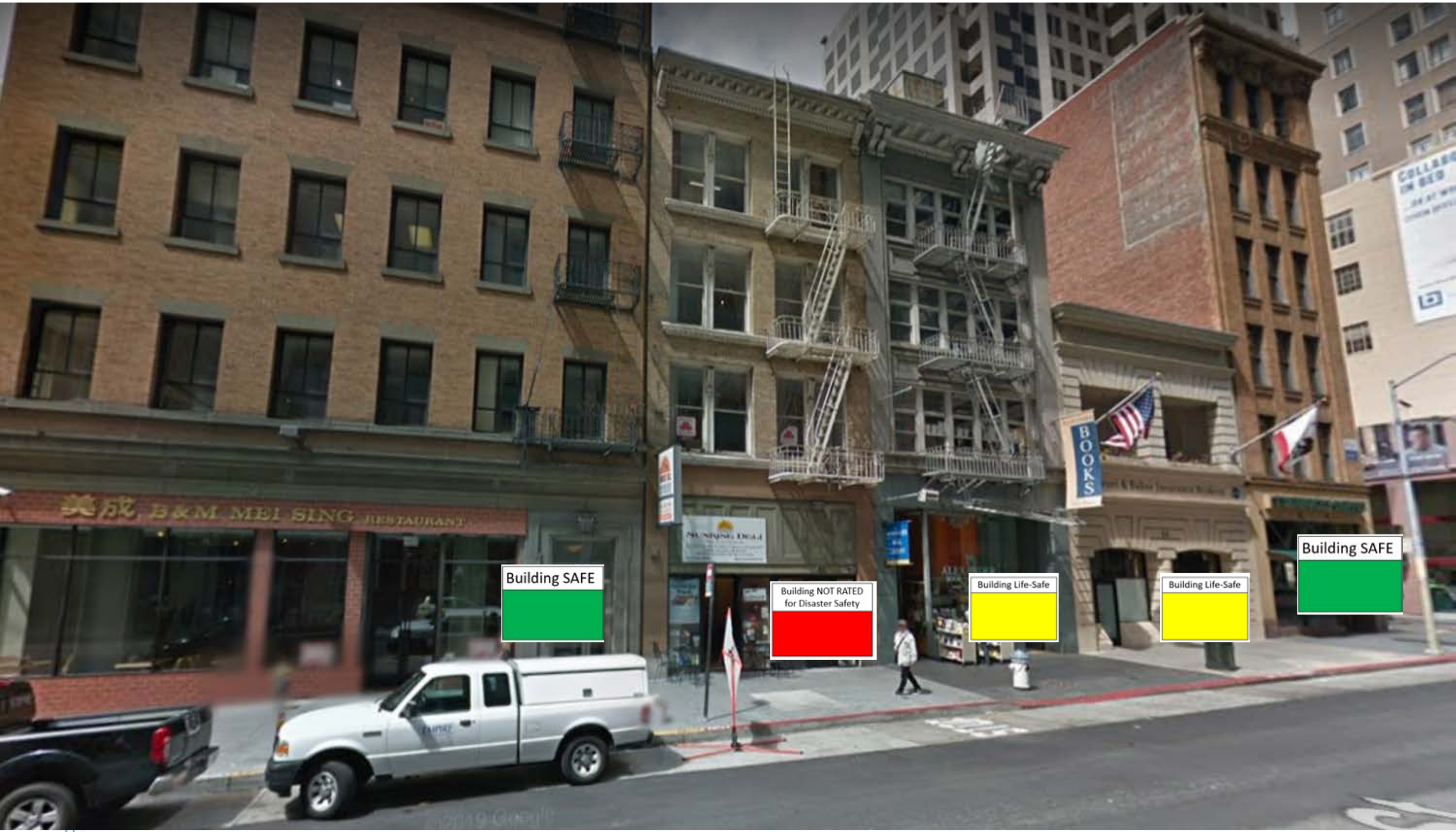
Risk Governance



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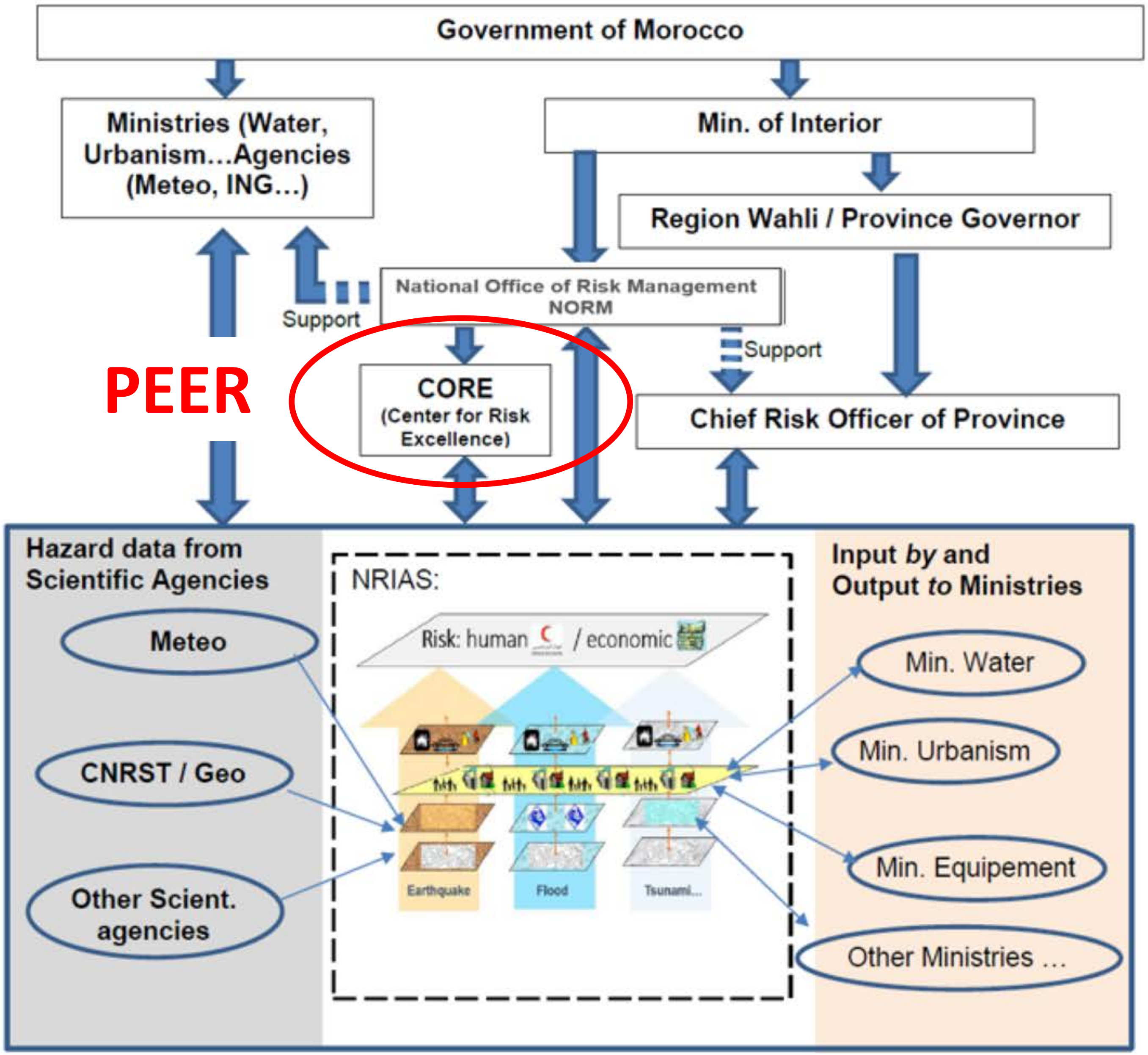
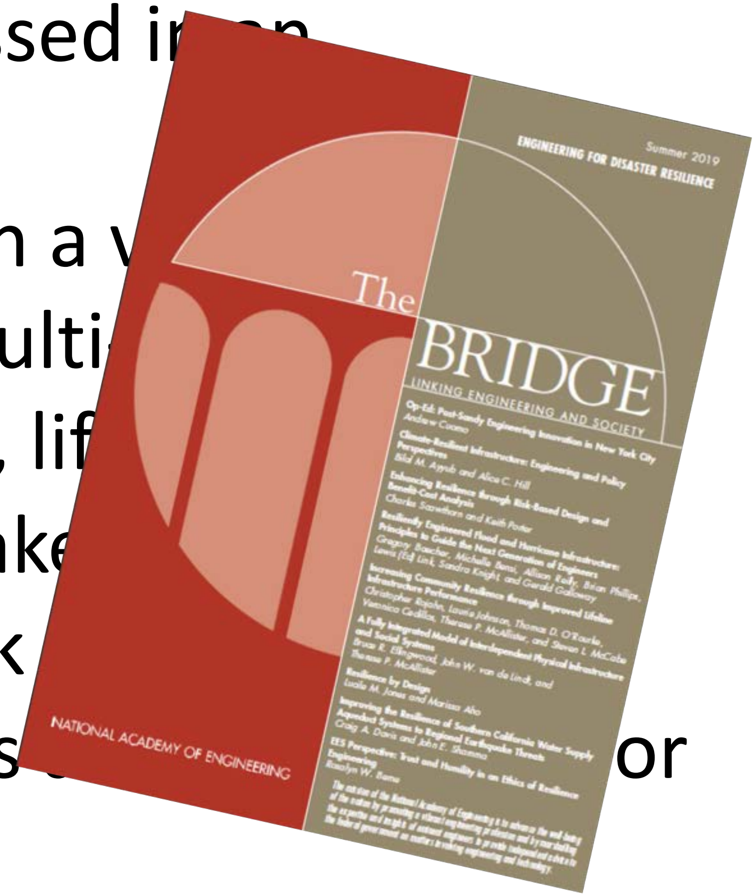
Cadre pour un système national d'analyse et d'information sur les risques



Future of Risk Analysis

- EEW creates a need for ubiquitous structural and non-structural seismic assessment
- This will have to be addressed in an automated manner
- Seismic risk doesn't exist in a v
  → PEER should address multi-
- Risk is unfairly borne – OK, lif
  but we should strive to make
- Risk reduction requires risk
  money talks, so a risk tax is … or risk reduction



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How?

Thank you

C. Scawthorn

www.sparisk.com

cscawthorn@berkeley.edu