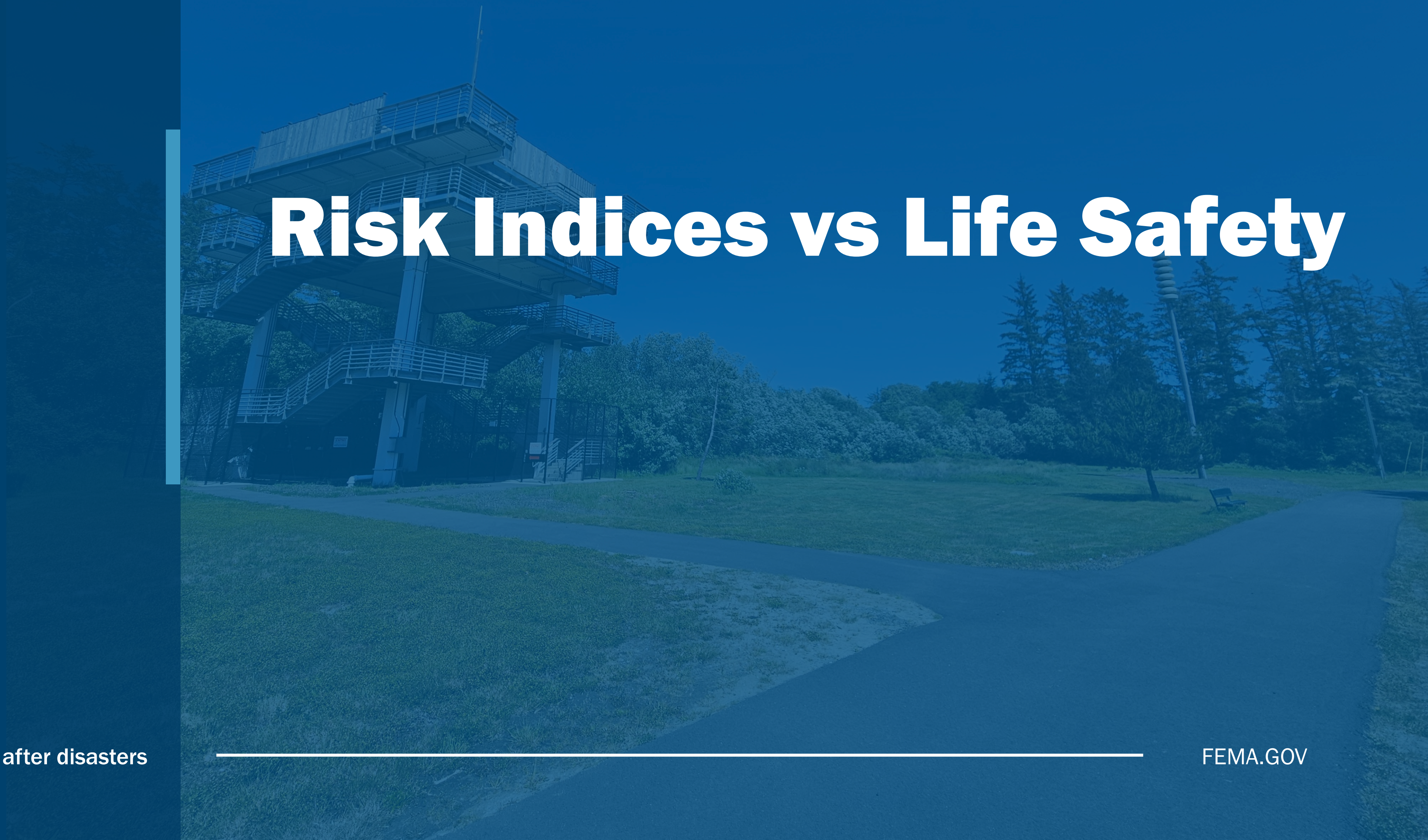
08 November 2024

FEMA’s conceptualization of tsunami risk

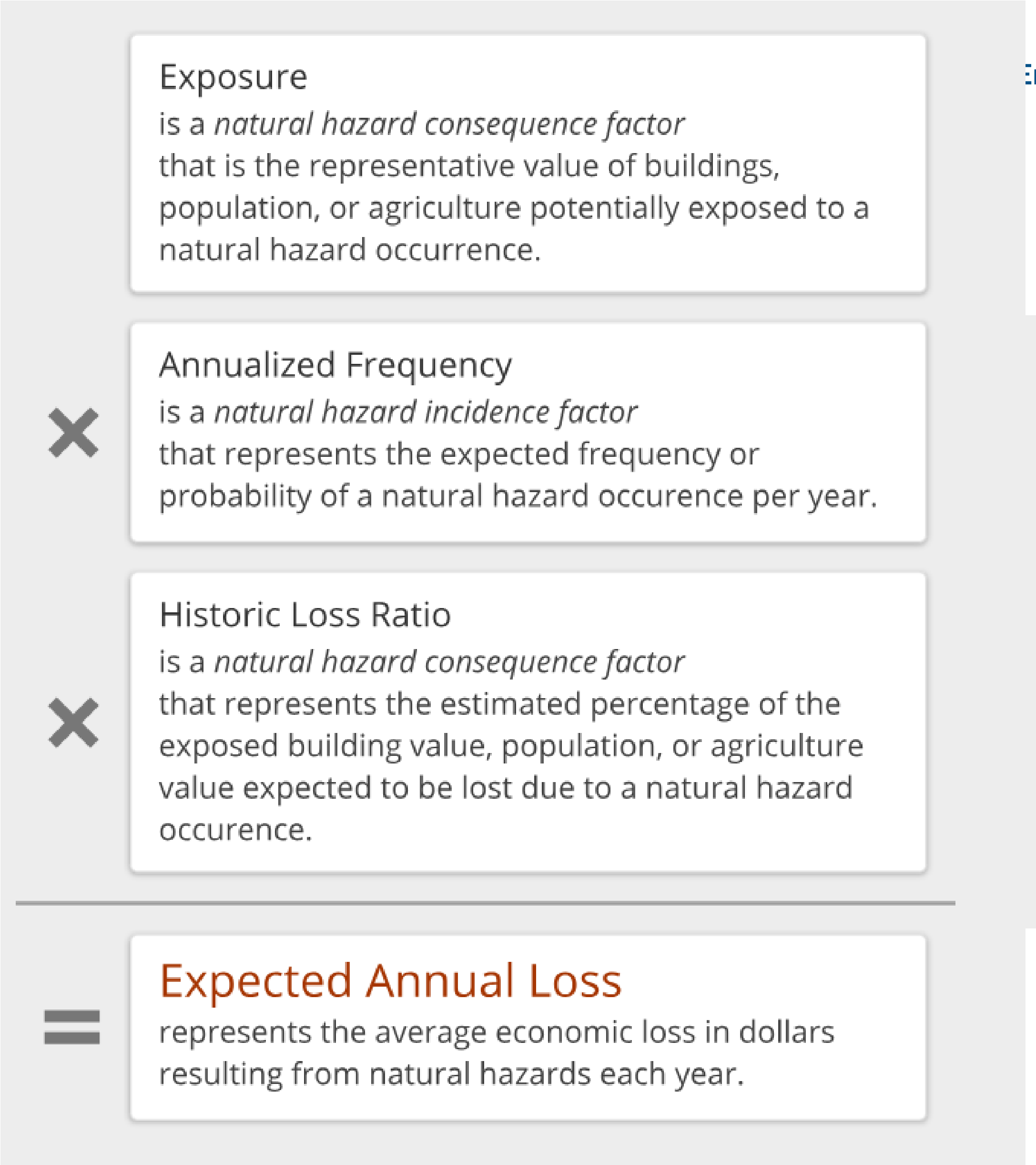
Kara Jacobacci

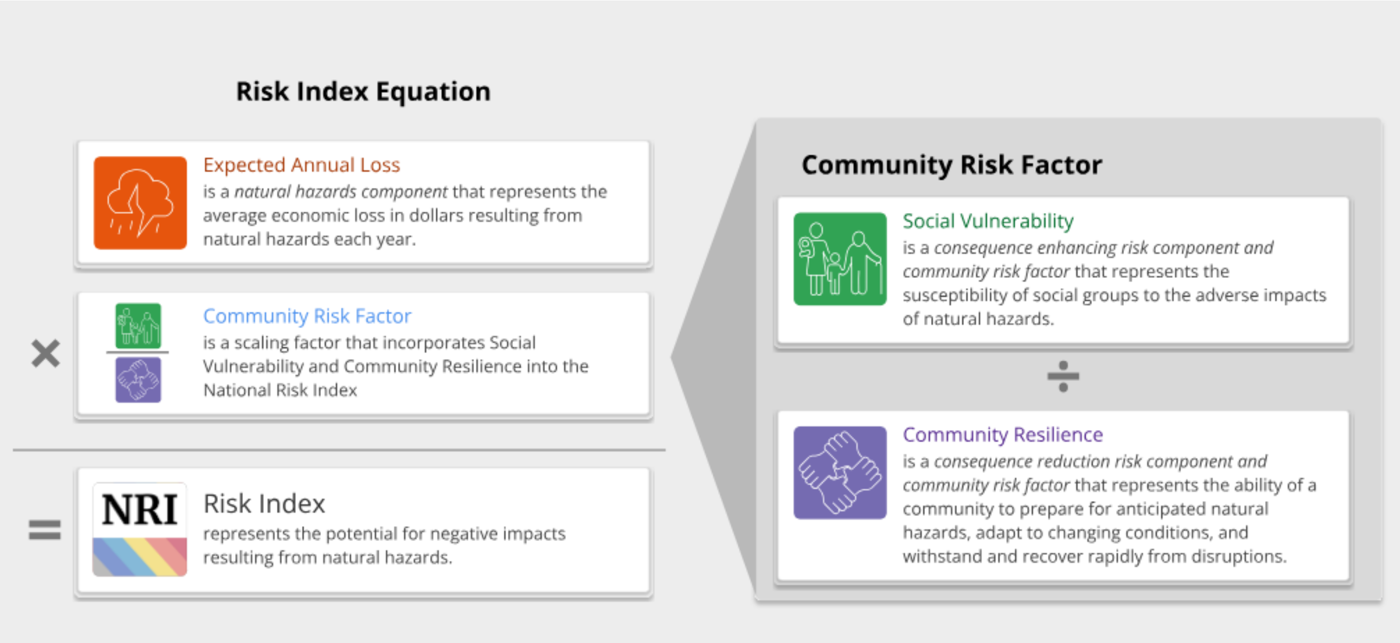
FEMA

Risk Indices vs Life Safety



Risk Indices





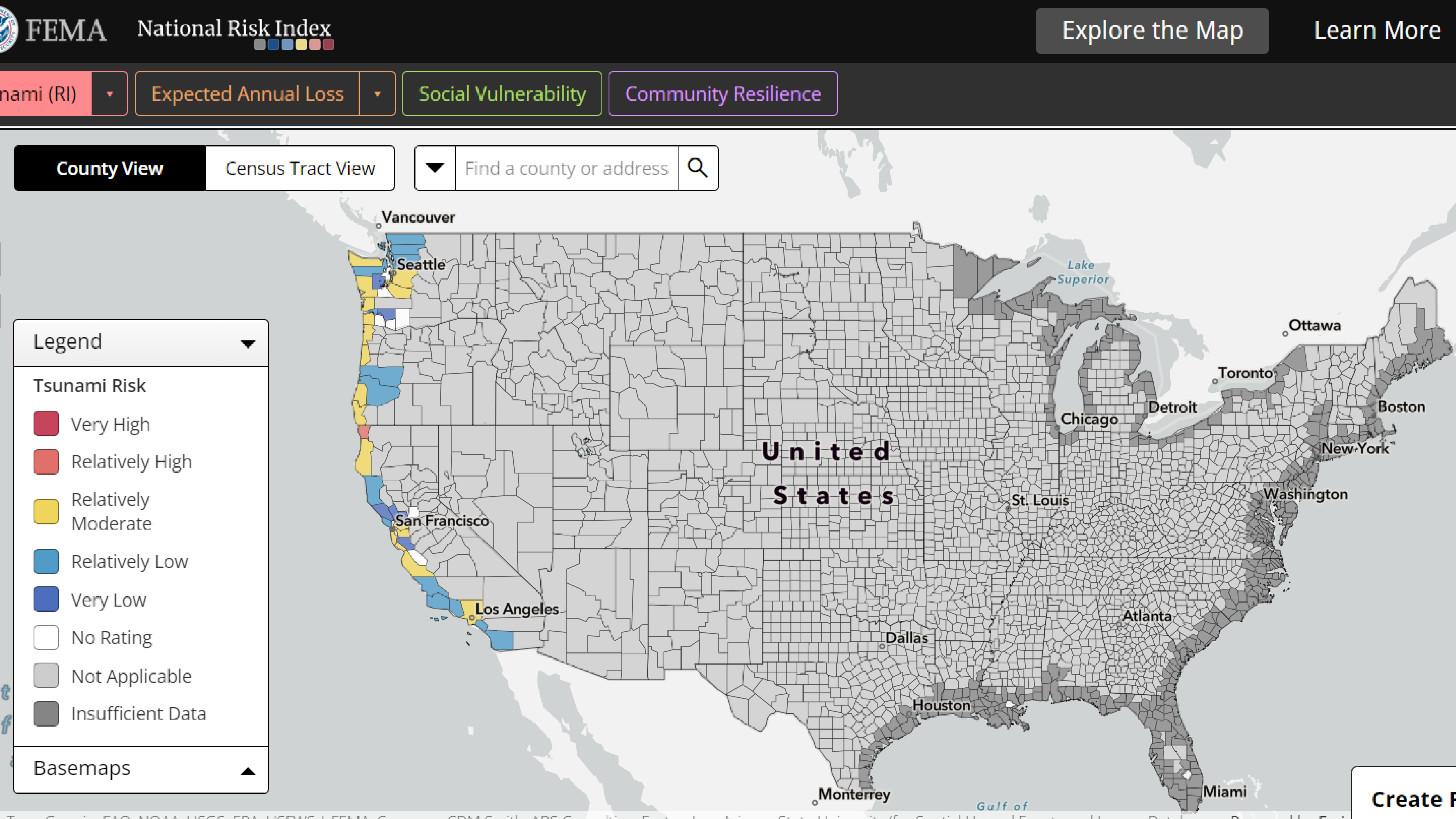
$$\text{Risk} = \text{EAL} \times \text{CRF} \qquad \text{CRF} = f\left(\frac{\text{Social Vulnerability}}{\text{Community Resilience}}\right)$$

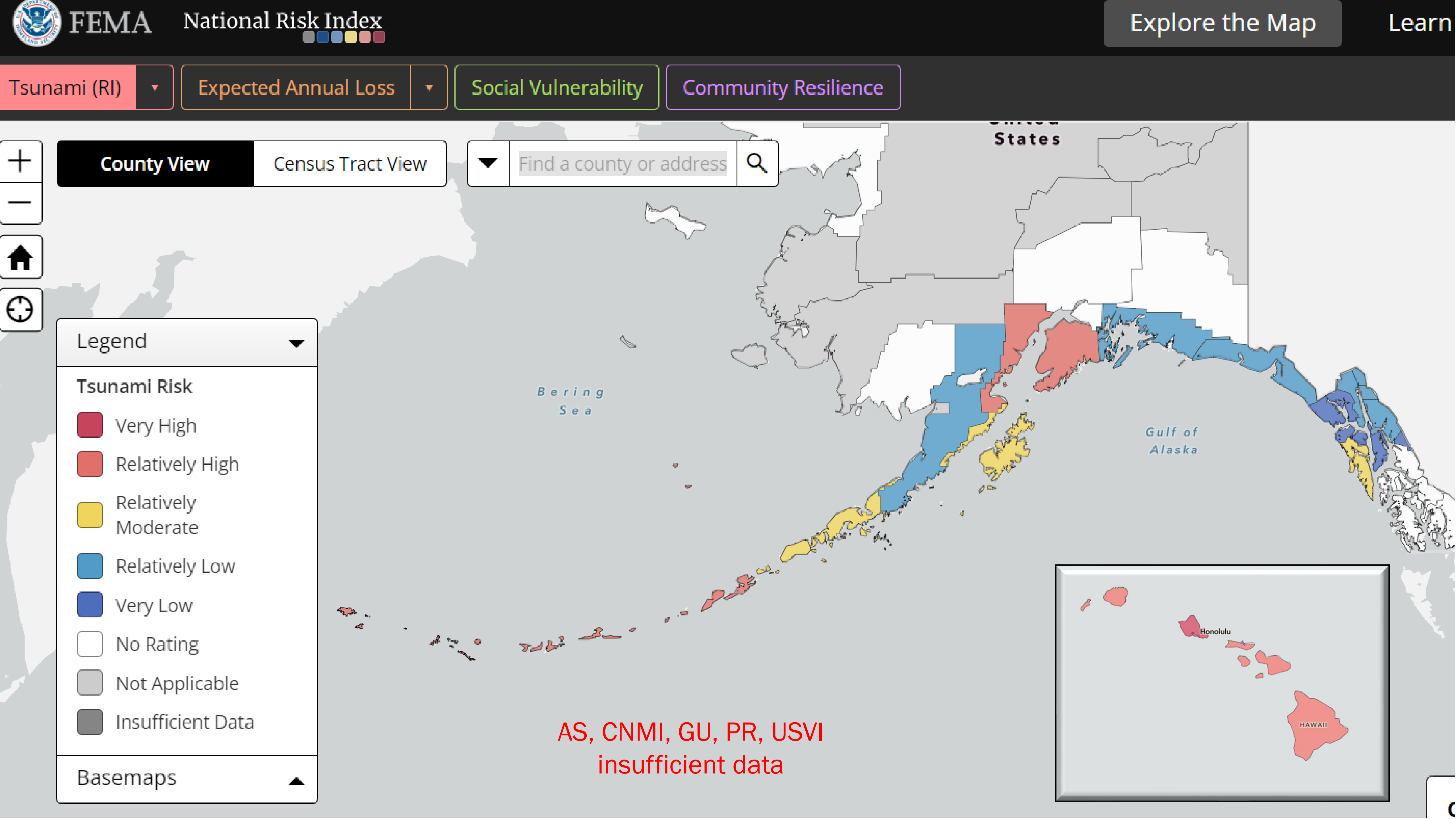
EAL / Social Vulnerability	Rating Category	Community Resilience
↑ Higher EAL & Social Vulnerability = Higher Risk	Very High	↓ Lower Community Resilience = Higher Risk
	Relatively High	
	Relatively Moderate	
	Relatively Low	
	Very Low	

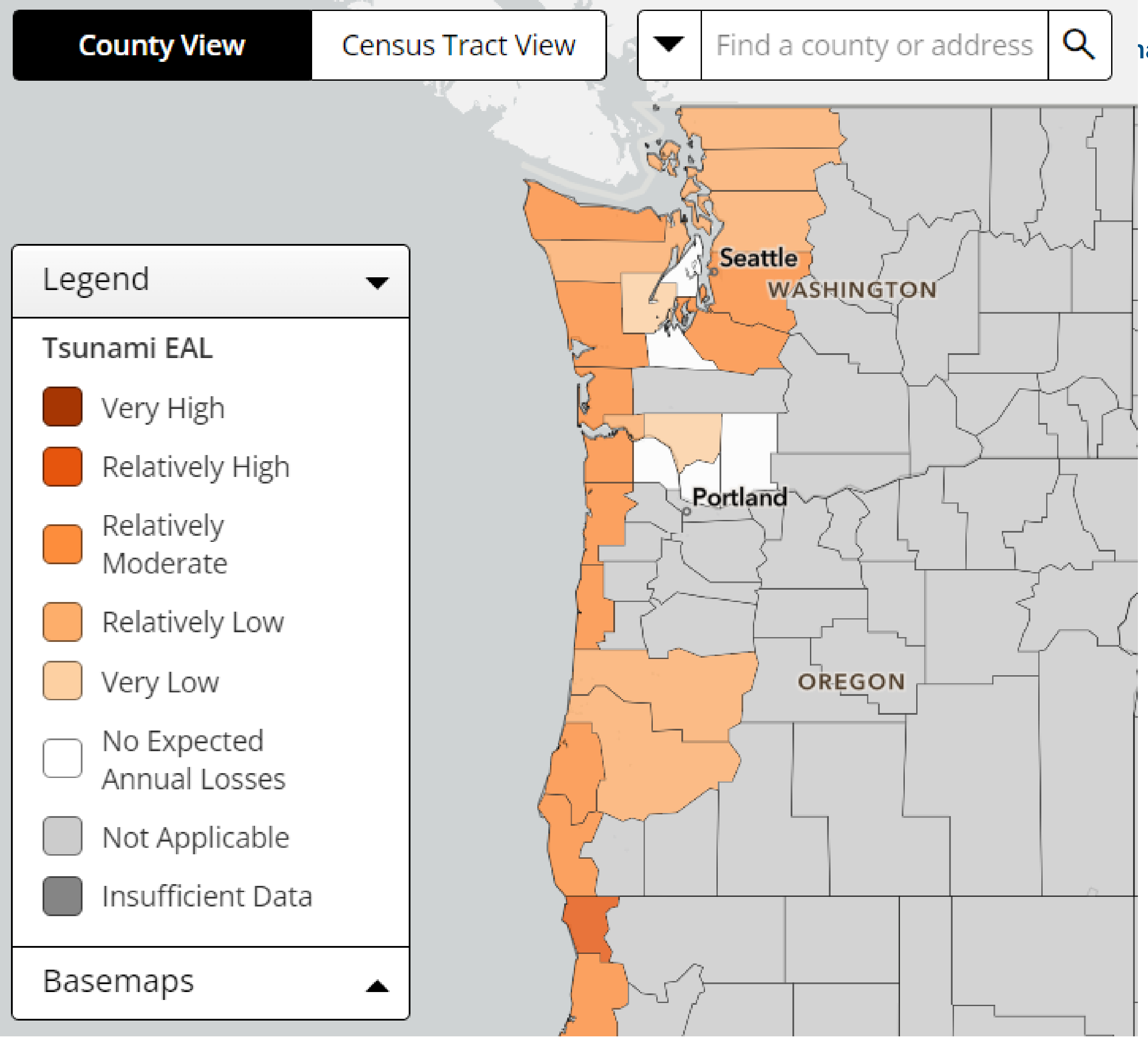
Illustration of Risk Component Scores

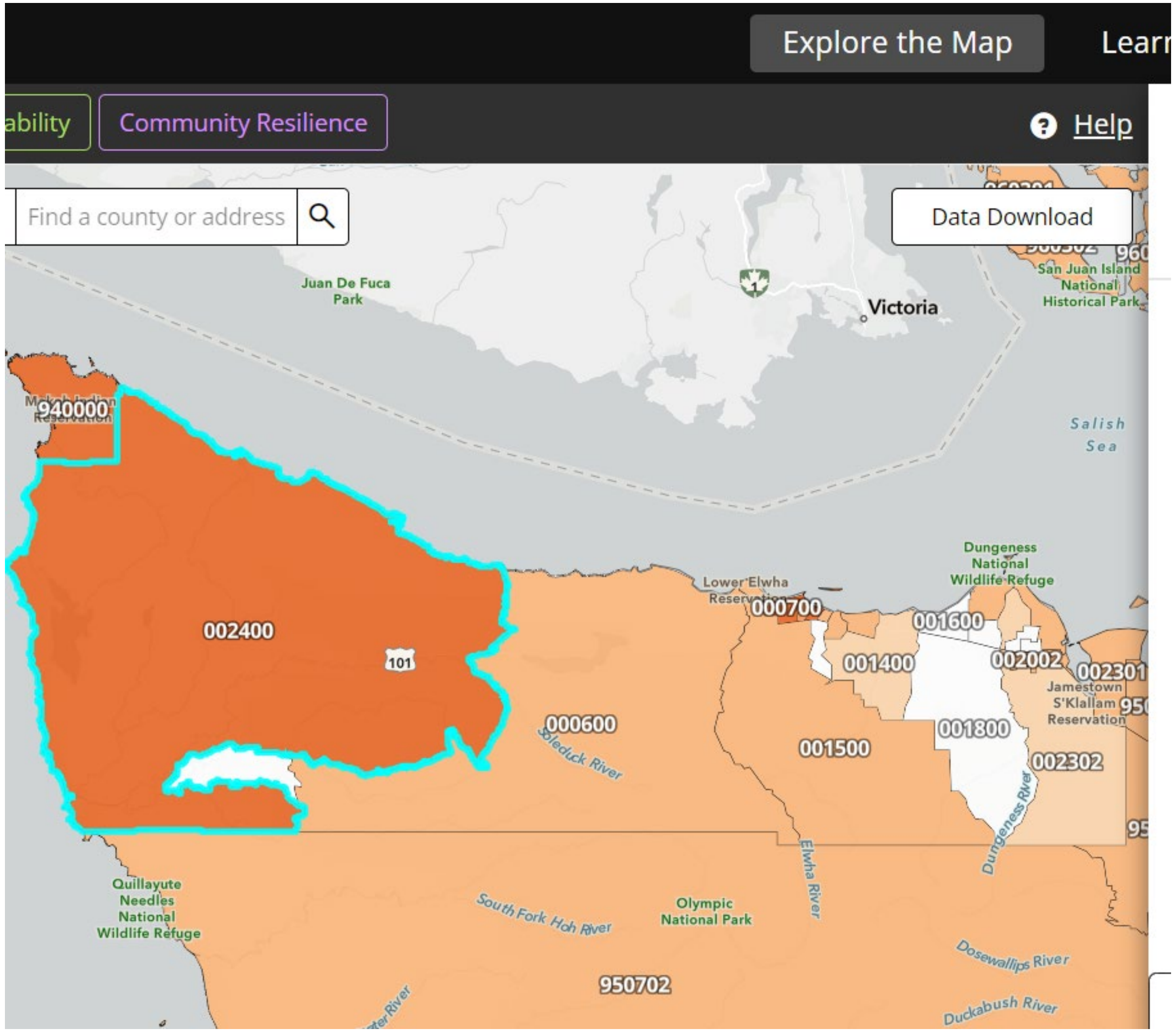
County	EAL	Social Vulnerability	Community Resilience	Risk
County 1	99.66	78.84	23.65	99.68
County 2	99.87	37.43	78.36	99.65
County 3	99.51	73.07	70.85	99.55
County 4	97.59	98.82	1.15	98.31
County 5	97.09	53.85	45.23	96.85
County 6	81.40	99.71	1.30	87.75
County 7	77.41	71.96	0.86	84.98
County 8	52.40	12.35	94.30	47.98
County 9	47.38	50.06	33.90	48.49
County 10	9.19	28.13	75.84	7.86

Hazard Type	FREQUENCY: Data Source	FREQUENCY: Period of Record	FREQUENCY: Hazard Occurrence Basis	EXPOSURE: Consequence Types (People)	EXPOSURE: Consequence Types (Buildings)	EXPOSURE: Consequence Types (Agriculture)	EXPOSURE: Exposure Area	EXPOSURE: Method for Exposure Value Estimation	HISTORIC LOSS RATIO: Data Source	HISTORIC LOSS RATIO: Period of Record	HISTORIC LOSS RATIO: Event Duration Cap	HISTORIC LOSS RATIO: Loss Aggregation	HISTORIC LOSS RATIO: Zero-Loss Padding	HISTORIC LOSS RATIO: Urban Rural Split	Bayesian Levels: County	Bayesian Levels: Area	Bayesian Levels: Region	Bayesian Levels: National
Avalanche	ASU	1960-2019	Event	✓	✓		**Representative Exposure**	Default population & building exposure	ASU	1996-2019		Timeframe			✓			✓
Coastal Flooding		Annualized probability	Event	✓	✓		**Susceptible Area:** Developed area in the unioned sub-type layers	Developed area density	ASU	1996-2019		Consecutive day			✓	✓	✓	
Cold Wave		2005-2021	Event day	✓	✓	✓	**Widespread:** Average hazard occurrence size	Developed area & agriculture value densities		1996-2019	*31 days*	Single day	✓	✓	✓	✓	✓	✓
Drought	NDMC	2000-2021	Event day			✓	**Widespread:** Average agricultural area hazard occurrence size	Agriculture value density	ASU	1996-2019	*365 days*	Single day	✓		✓	✓		✓
Earthquake	USGS FEMA	Annualized probability	Event	✓	✓		Expected annual loss & exposure from the FEMA P-366 study: *Hazus® Estimated Annualized Earthquake Losses for the U.S.*		ASU	1960-2019		Timeframe			✓	✓		✓
Hail		1986-2021	Event	✓	✓	✓	**Widespread:** County/Census Tract	Total value	ASU	1996-2019		Single day	✓	✓	✓	✓	✓	✓
Heat Wave		2005-2021	Event day	✓	✓	✓	**Widespread:** Average hazard occurrence size	Developed area & agriculture value densities	ASU	1996-2019	*31 days*	Single day	✓	✓	✓	✓	✓	✓
Hurricane		ATL: 1851-2021 PAC: 1949-2021	Event	✓	✓	✓	**Widespread:** Average hazard occurrence size	Developed area & agriculture value densities	ASU	1996-2019		Consecutive day	✓	✓	N/A: Regression Model			
Ice Storm	CRREL	1946-2014	Event day	✓	✓		**Widespread:** Average hazard occurrence size	Developed area density	ASU	1996-2019	*31 days*	Single day	✓	✓	✓	✓	✓	✓
Landslide	NASA	2010-2021	Event	✓	✓		**Susceptible Area:** Landslide susceptible area	Developed area density	ASU	1996-2019					✓			
Lightning		1991-2012	Event	✓	✓		**Widespread:** County/Census Tract	Total value	ASU	1996-2019		Single day	✓	✓	✓	✓		✓
Riverine Flooding		1996-2019	Event day	✓	✓	✓	**Susceptible Area:** Land use area within 1% annual chance floodplain	Developed area & agriculture value densities	ASU	1996-2019	*31 days*	Single day	✓		✓		✓	
Strong Wind		1986-2021	Event	✓	✓	✓	**Widespread:** County/Census Tract	Total value	ASU	1996-2019		Single day	✓	✓	✓	✓	✓	✓
Tornado		F0-1:1986-2021 F2-5:1950-2021	Event	✓	✓	✓	**Representative Exposure:** Average historical damage size by sub-type	Average density	ASU	1996-2019			✓		✓	✓	✓	✓
Tsunami		1800-2021	Event	✓	✓		**Susceptible Area:** Developed area within inundation zone area	Developed area density	ASU	1996-2019		Consecutive day	✓		✓	✓		✓
Volcanic Activity		9310 BCE-2022	Event	✓	✓		**Susceptible Area:** 100-km buffer around active volcano locations	Developed area density	ASU	1960-2019		Timeframe			✓	✓		✓
Wildfire		Annualized probability	Event	✓	✓	✓	**Susceptible Area:** Areas where modeled flame length > 8'	Average density	ASU	1996-2019		Timeframe			✓	✓		✓
Winter Weather		2005-2021	Event day	✓	✓	✓	**Widespread:** Average hazard occurrence size	Developed area & agriculture value densities	ASU	1996-2019	*31 days*	Single day	✓	✓	✓	✓	✓	


FEMA
National Risk Index
Explore the Map
Learn More
nami (RI)
Expected Annual Loss
Social Vulnerability
Community Resilience
County View
Census Tract View
Find a county or address
Legend
Tsunami Risk
Very High
Relatively High
Relatively Moderate
Relatively Low
Very Low
No Rating
Not Applicable
Insufficient Data
Basemaps
Vancouver
Seattle
Lake Superior
Ottawa
Toronto
Boston
Detroit
Chicago
New York
Washington
United States
St. Louis
San Francisco
Los Angeles
Atlanta
Dallas
Houston
Miami
Monterrey
Gulf of
Create


FEMA
National Risk Index
Explore the Map
Learn
Tsunami (RI)
Expected Annual Loss
Social Vulnerability
Community Resilience
County View
Census Tract View
Find a county or address
Legend
Tsunami Risk
Very High
Relatively High
Relatively Moderate
Relatively Low
Very Low
No Rating
Not Applicable
Insufficient Data
Basemaps
States
Bering Sea
Gulf of Alaska
Honolulu
HAWAII
AS, CNMI, GU, PR, USVI
insufficient data


County View
Census Tract View
Find a county or address
Legend
Tsunami EAL
Very High
Relatively High
Relatively Moderate
Relatively Low
Very Low
No Expected Annual Losses
Not Applicable
Insufficient Data
Basemaps
Seattle
WASHINGTON
Portland
OREGON


Explore the Map
ability
Community Resilience
Help
Find a county or address
Data Download
Juan De Fuca Park
Victoria
San Juan Island National Historical Park
Salish Sea
940000
002400
101
000600
000700
001600
001400
002002
002301
001500
001800
002302
Jamestown S'Klallam Reservation
Dungeness National Wildlife Refuge
Lower Elwha Reservation
Quillayute Needles National Wildlife Refuge
Olympic National Park
950702

NRI Tsunami Methodology Update Goals

Goal 1

Building EAL – Hazus based AAL using scenarios or probabilistic data and NSI.

Population EAL - USGS Evacuation Tool for Population Exposure in run-up zones based on pedestrian evacuation times.

Priority – Pacific and Caribbean

Estimated Completion: September 2024

Goal 2

Expand Hazus Tsunami to East Coast and Gulf of Mexico

Hazus Tsunami is not currently available in these areas. GBS data needs to be developed.

Develop Hazus analysis for Gulf of Mexico and Atlantic Coasts.

Estimated Completion: TBD

Dependencies:

- Hazus East Coast data development
- NTHMP East Coast data

Goal 3

Harbor Facilities, Liveaboards, and Other Facilities without Hazus Generated Losses

Develop method for estimating losses for this in coordination with NTHMP.

Enhanced Population Exposure

Implement any updates around distant event and tourist populations

Hazus Analysis

Hazus analysis level conducted is dependent on the available source data

For each scenario provided by the state/territory level entities:

- Data preprocessing to standardize data types and clean data across states
- Incorporate non-randomized National Structure Inventory data for exposure
- Conduct a Hazus analysis to calculate Building and Contents losses at the Census block level
  - **Level 1**: Runup only
  - **Level 2**: Flow depth grid and velocity data
  - **Level 3**: Flow depth grid and momentum flux data

Building Loss

- Estimated using HAZUS 6.1
- Measured as Capital Stock Loss which is the replacement value of structural, non-structural, and content damage
- Building data comes from the National Structure Inventory (USACE)

This study only evaluates population loss for permanent residential populations

Population Loss

Population losses were estimated using a USGS evacuation analysis study. This study estimated the number of permanent residents who could not evacuate from a local tsunami in time, assuming they began walking to high ground 10 minutes after ground shaking started.

To calculate the population equivalence loss in dollars, the Value of a Statistical Life (VSL) of $12.5 million (2022) was used to convert population loss estimates into a monetary population equivalence value.

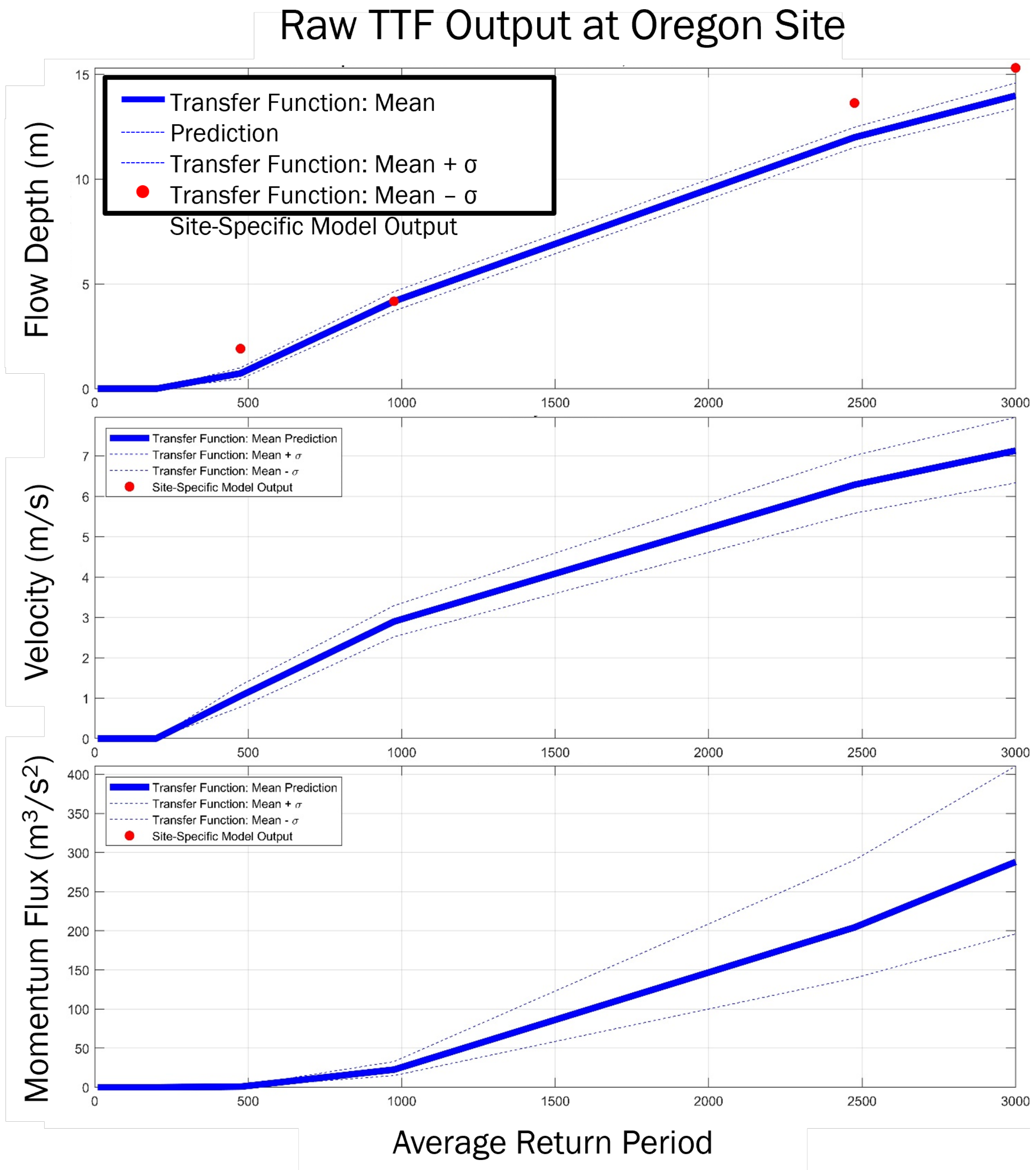
Works in Progress

- Update to the NRI with methodology improvements
- PTHA method using transfer functions
- HAZUS 7.0 (ArcGIS Pro)
    - Expanding tsunami module to East and Gulf Coasts

Future Goals

Further research areas include the potential impacts to marine and harbor facilities, non-permanent populations, additional tsunamigenic event types beyond earthquakes, and tsunami risk analysis for the East and Gulf Coasts

PTHA with Transfer Function



Tsunami Transfer Function

- Data-driven approach capitalizing on existing PTHA from CGS, ASCE, Hawaii OPSD, western state DOTs
- "Transfers" tsunami hazard from offshore tsunami amplitude curves to onshore inundation metrics: flow depth, velocity, and momentum flux
- Efficient methodology to develop consistent data from 10 to 3000-year return periods across Pacific geography

Tsunami Losses

- Hazus 6.1 modeling to compute return period and annualized losses

Currently testing at three Pacific sites, goal to share findings in 2025.

Region 10 Tsunami Investments

Cooperating Technical Partners Investments FY 2024

Washington

- $481,000 over 3 years for Probabilistic Tsunami Hazard Assessment
    - Original scope included evacuation walk maps – this was determined to not fit under RiskMAP and had to be removed in order for HQ to approve the project and delegate extra funding to cover the gap in Region 10's CTP budget
    - Extra $350,000 granted to Region to meet the $481,000 total

Alaska

- $210,000 over 2 years for Alaska tsunami portal: A GIS hub for tsunami mitigation products
    - anticipating approximately 60 communities with existing info to be on the pilot database
- $100,000 for Alaska Geohazards Summit – will feature multiple hazards including tsunamis

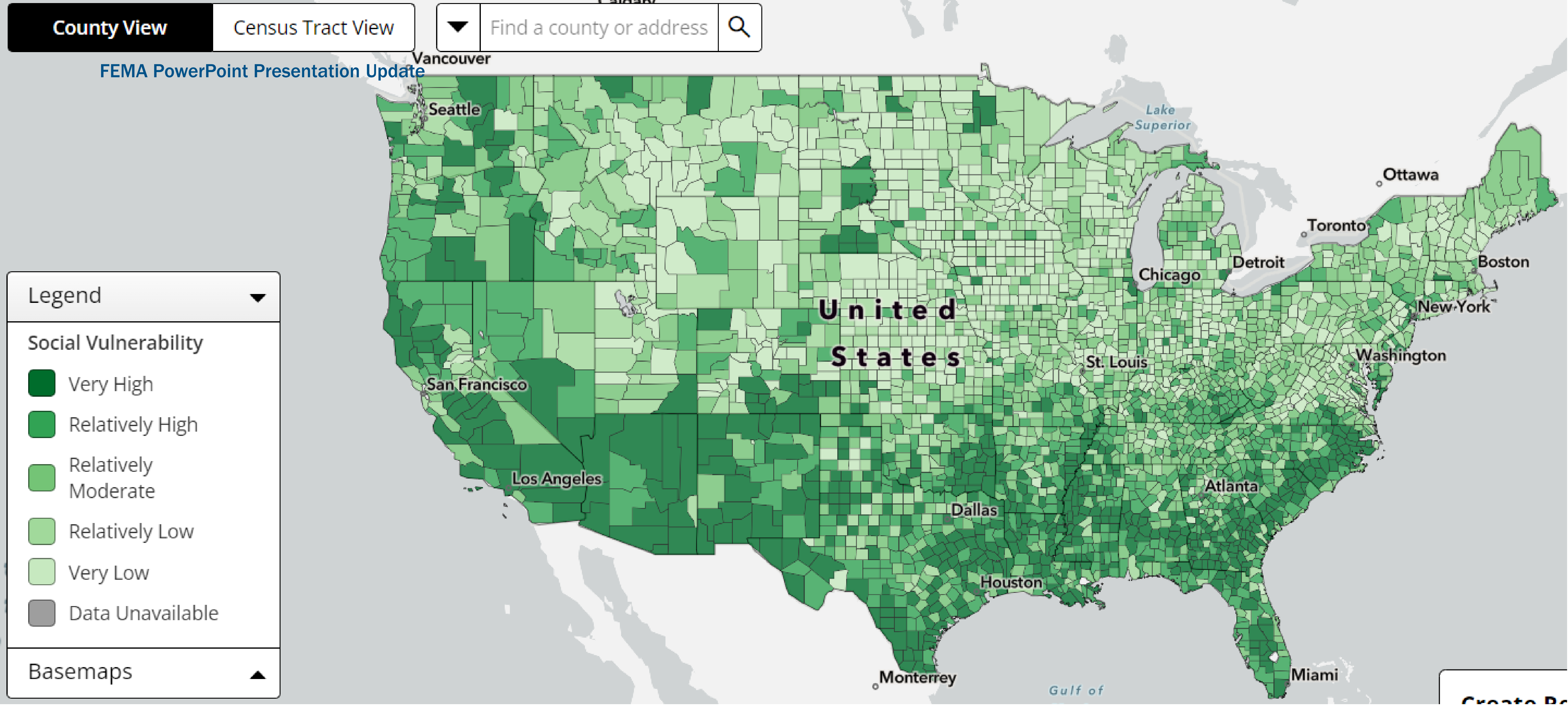
FEMA R10 Points of Contact

Hannah Rabinowitz (Primary)
Earthquake Program Manager
Hannah.Rabinowitz@fema.dhs.gov

Kara Jacobacci
Risk Analyst
Kara.jacobacci@fema.dhs.gov

FEMA

FEMA PowerPoint Presentation Update



HAZUS Levels

1

Uses runup amplitude and DEM using an empirical equation to produce a velocity grid.

The empirical method misses high velocity areas related to constrictions where flow depths may be shallow.

AK – AS – GU – CNMI – HI*

2

Assumes that max velocity and flow depth occurs at the same time and place.

3

Uses median flux and flow depth to produce the most accurate analysis from a hazard input data perspective.

California, Hawai'i, Oregon, U.S. Virgin Islands, Washington