National Risk Index

Discover the landscape of natural hazard risk

Casey Zuzak, Senior Risk Analyst
Risk Management Directorate

FEMA

Natural Hazards Risk Assessment Program

Natural Hazards Risk Assessment Program

The NHRAP will provide a common understanding of hazard and consequence data to reduce disaster suffering

Natural Hazards Risk Assessment Program Goals

1

Institutionalize an innovative and integrated risk assessment process to link risk with policy and program implementation

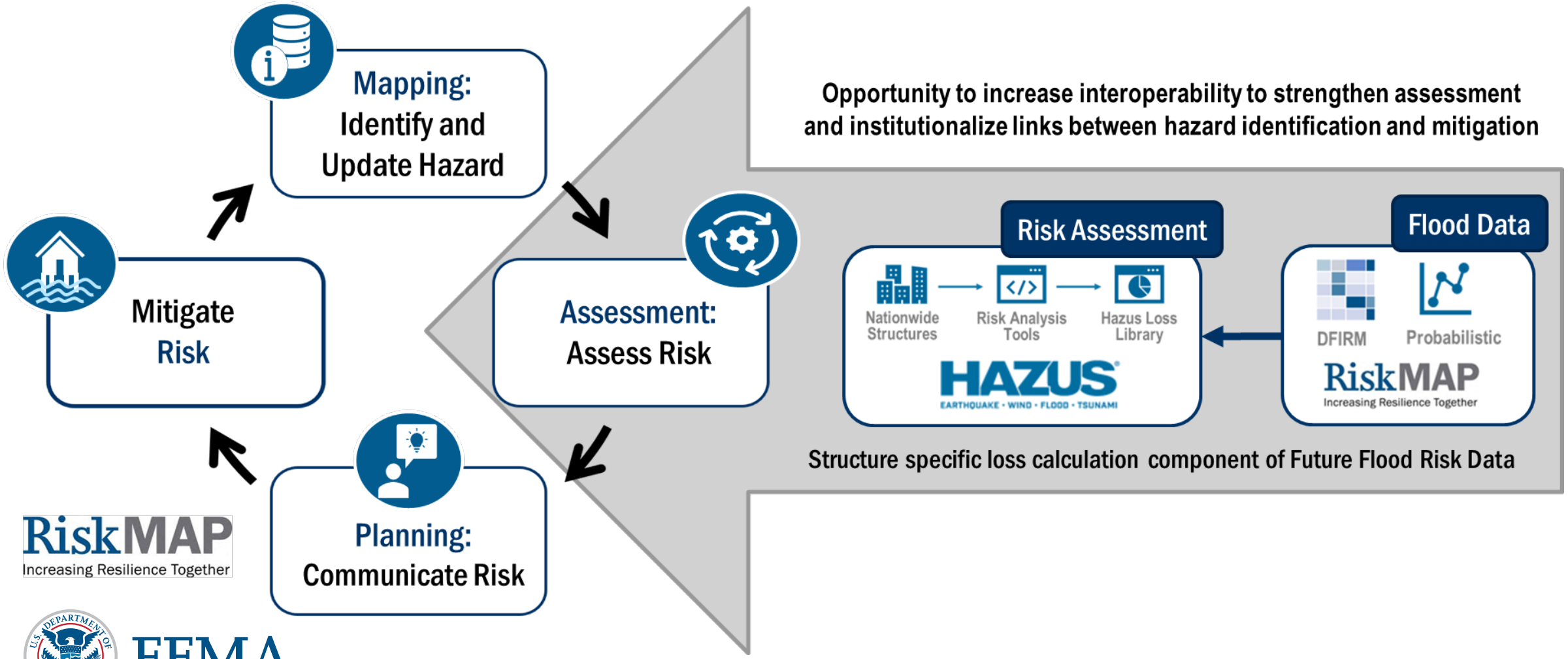
2

Leverage partnerships with hazard identification experts and other FEMA program areas to promote use of credible risk assessment data and practices

3

Empower states, local governments, tribes, and territories to reduce disaster suffering and to contribute to a more resilient nation

Risk Assessment within the FEMA Risk MAP Program



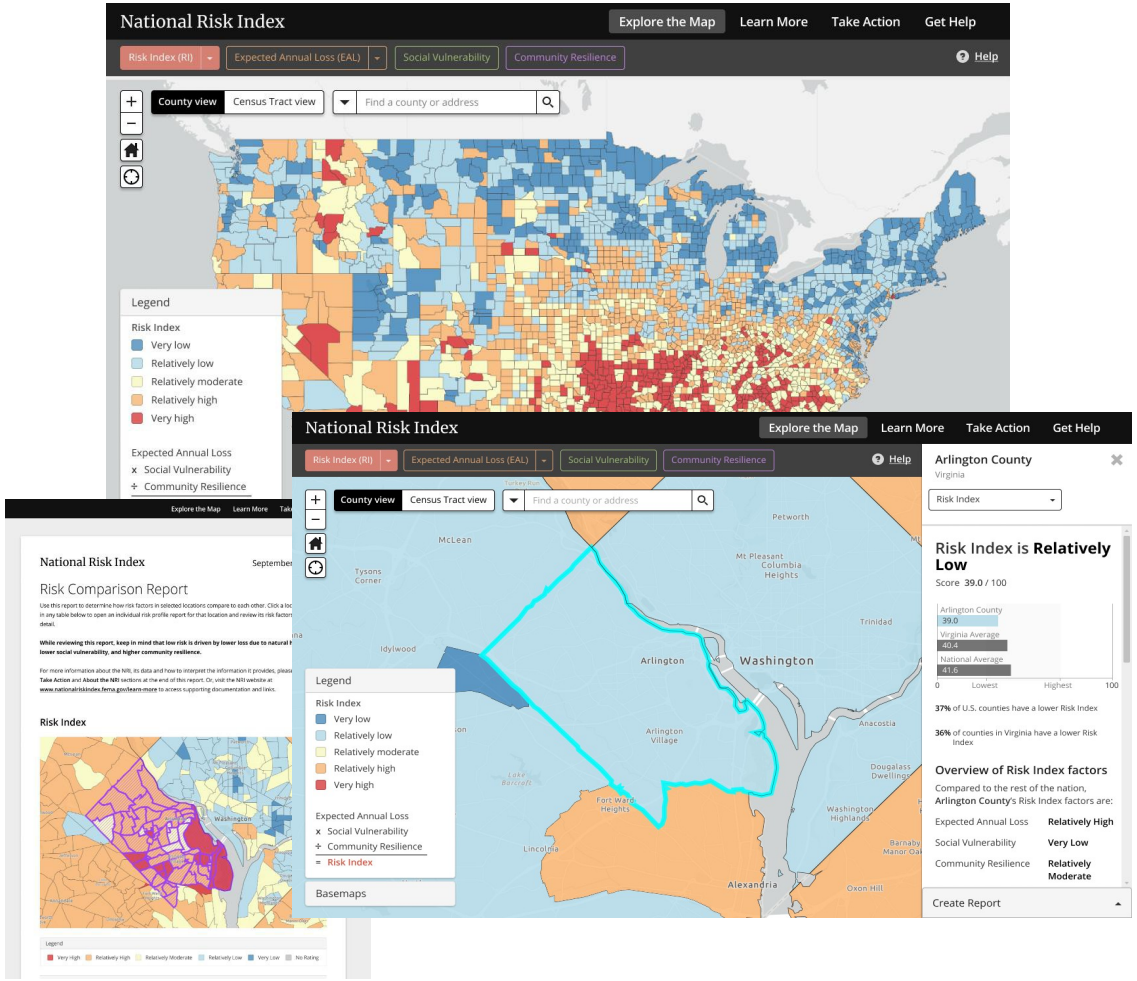
RiskMAP
Increasing Resilience Together

FEMA

National Risk Index

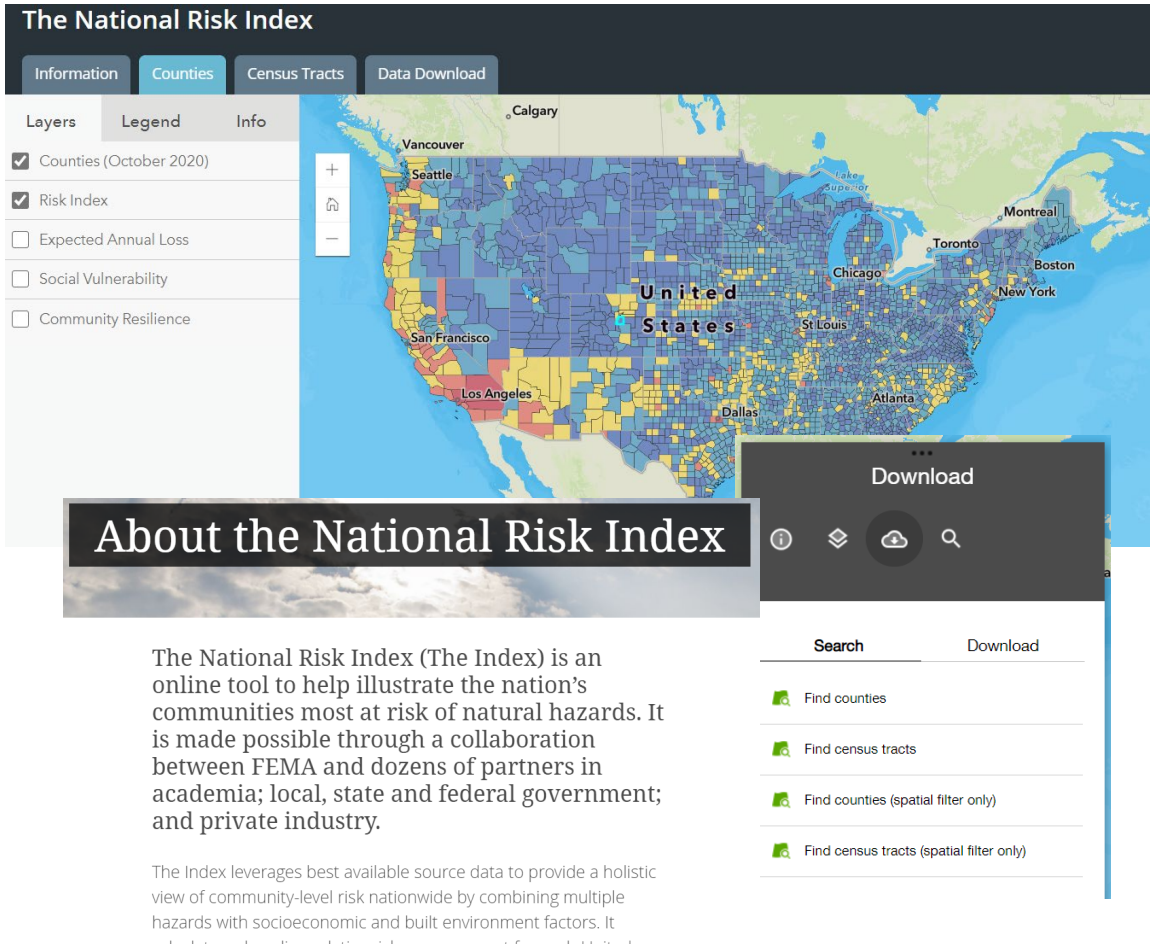
National Risk Index

- Began as a strategy for reducing cost and eliminating inconsistent risk assessments in planning
- Identifies areas that offer high return on mitigation investment
- Reduces the cost of risk assessment allowing community planners to prioritize action
- Provides pre-calculated, top- down national baseline risk assessment



National Risk Index

- A free, consistent, and comprehensive nation-wide risk assessment that is multi-hazard and inclusive of social vulnerability and community resilience did not exist.
- Successful FEMA, state and local program implementation can be enhanced with credible risk assessment information.
- Provides a mechanism by which social equity and future conditions can be explored
- Allows for easy and effective dialogue around all hazards risk for a community.



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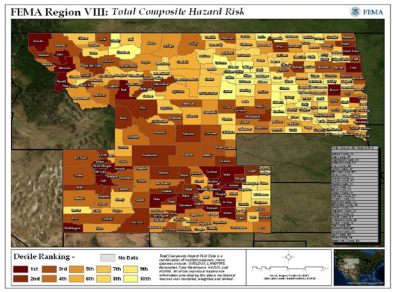
Timeline of Development

2008

FEMA Region 8 developed the Vulnerability Index to identify and prioritize flood mitigation projects.

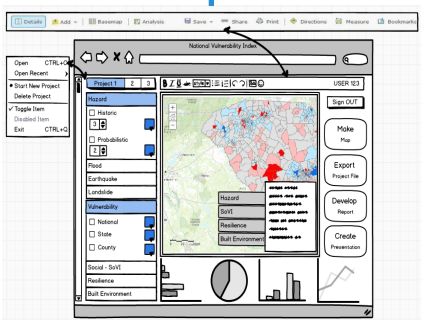


2016-2017

NRI team engages subject matter experts and begins data development and application design phase.

2018-2019

Refine Risk Equation based on additional review and update backend database.

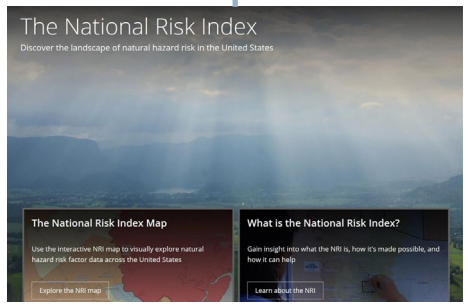


2020

Release of National Risk Index data through Phase 1 in Fall 2020.

2021

Data update and release of Full National Risk Index Application in Summer 2021.



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National Risk Index Contributors

National Risk Index Contributors

National Risk Index Development through Working Groups

Social Vulnerability and Community Resilience

How to incorporate social equity and what data to leverage

Natural Hazards

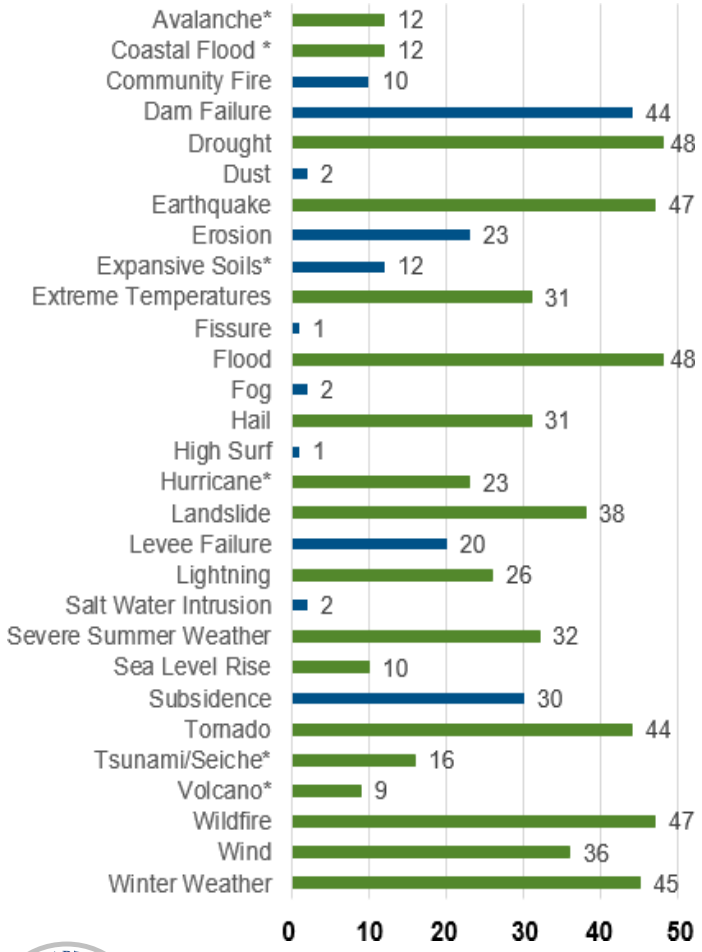
Identify best available databases and appropriate datasets

Data Processing and Visualization

Develop and design NRI

FEMA

National Risk Index Hazard Selection



- Reviewed the 50 State Hazard Mitigation Plans
  - Initial list developed from rate of occurrence in each state plan
- Natural hazards only
  - Man-made hazards or hazards related to anthropogenic activities not included

Hazard Included in Analysis
Hazard Excluded from Analysis
* Significant Regional Hazard for Consideration

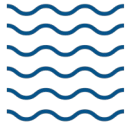
NOTES:
- Coastal Flood and Sea Level Risk Hazards were combined
- Extreme Temperature is both Hot and Cold
- Severe Summer Weather is covered by Wind, Hail, Tornado, and Lightning
- Winter Weather is both Snow and Ice

National Hurricane Center
NDMC
Storm Prediction Center
NOAA
FEMA
USGS science for a changing world
national avalanche center
IEM
US Army Corps of Engineers
Smithsonian Institution
National Museum of Natural History
Global Volcanism Program

FEMA

National Risk Index - Hazards


Avalanche


Coastal Flooding


Cold Wave


Drought


Earthquake


Hail


Heat Wave


Hurricane


Ice Storm


Landslide


Lightning


Riverine Flooding


Strong Wind


Tornado


Tsunami


Volcanic Activity


Wildfire


Winter Weather

Social Vulnerability and Community Resilience

Social Vulnerability Index: SoVI 2010-2014

- Developed by the University of South Carolina's HVRI
- Grouped into 7 components with 29 variables (SoVI 2010):
  - Race and class (7 variables), Wealth (5 variables), Elderly residents (6 variables), Hispanic ethnicity (5 variables), Special needs individuals (2 variables), Native American ethnicity (1 variables), and Service industry employment (2 variables)
- Comparative index at the county or subcounty level
- Positive and negative component loading

Baseline Resilience Indicators for Communities: BRIC 2010-2014

- Developed by the University of South Carolina's HVRI
- 6 resilience category scores, plus total score
  - Social, Economic, Community capital, Institutional, Infrastructural, Environmental
- Comparative indicators at the county level
- Indicators analyze the relationship between resilience, vulnerability, and the relative impact of disasters on rural and urban places

HVRI HAZARDS & VULNERABILITY RESEARCH INSTITUTE

UNIVERSITY OF SOUTH CAROLINA

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Determining Risk

National Risk Index = Expected Annual Loss **x** Social Vulnerability ÷ Community Resilience

Expected Annual Loss = Natural Hazard Exposure **x** Natural Hazard Frequency **x** Historical Loss

- Risk is defined as the potential for negative impacts as a result of a natural hazard
- Considers the probabilities or frequencies of 18 natural hazards, and the population and property value exposed within hazard extents
- Expected Annual Loss is calculated separately for each natural hazard, then summed to generate a composite score for all 18 natural hazards
- Equation supports traditional hazards risk approach of risk being defined as the product of Hazard Frequency, Vulnerability, and Exposure

Spatial Hazard Events and Losses Database for the United States

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Arizona State University

Calculating Risk

Risk = Expected Annual Loss x Social Vulnerability ÷ Community Resilience

where Expected Annual Loss (EAL) =

Annual Frequency		Exposure		Historic Loss Ratio
Rate of occurrence	**X**	• **Property Value** • **People** • **Agriculture**	**X**	**Percentage of property/people/crop losses**
How likely is hazard to occur?		How many people & how much property are potentially at risk?		What percent of property/people have historically been lost from hazard in a given area?

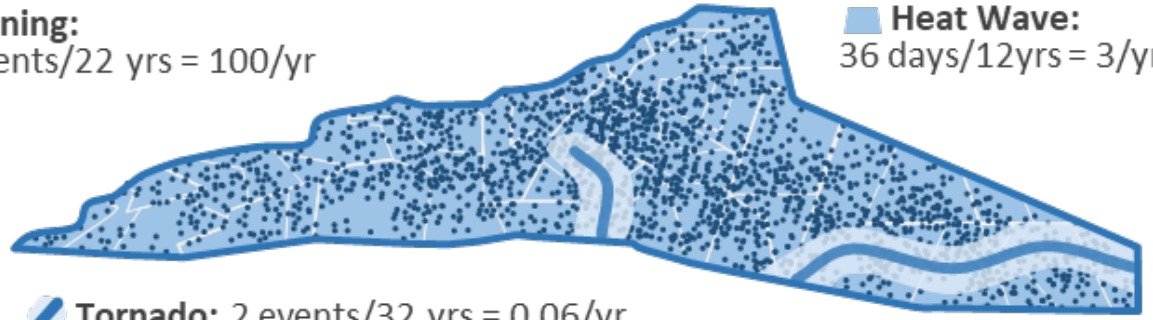
Establishing Annualized Frequency

FREQUENCY

Expected frequency or probability of a hazard happening per year. Frequency is derived from the count of historical events or event days depending on hazard.

Lightning:
2200 events/22 yrs = 100/yr

Heat Wave:
36 days/12yrs = 3/yr



Tornado: 2 events/32 yrs = 0.06/yr

Common analytical approach for consistent estimates across hazards with source datasets with varying scopes, periods of record, data formats, & assumptions.

data

USGS

FEMA

Calculating Hazard Exposure

EXPOSURE

Measure of population, building, & agriculture values that are potentially exposed to a specific hazard. Exposure varies by hazard. Many hazards impact the entire county or census tract while some are limited to susceptible zones.

HAZARD SUSCEPTIBLE ZONE

- **Population:** 300K
- **Building Value:** $90B
- **Agriculture:** $120M

COUNTYWIDE

- **Population:** 1.3M
- **Building Value:** $250B
- **Agriculture:** $720M

Population | Building Value | Agriculture

data | HAZUS EARTHQUAKE · WIND · FLOOD · TSUNAMI | 2017 CENSUS OF AGRICULTURE

HAZUS 4.2, Service Pack 01 (SP1)

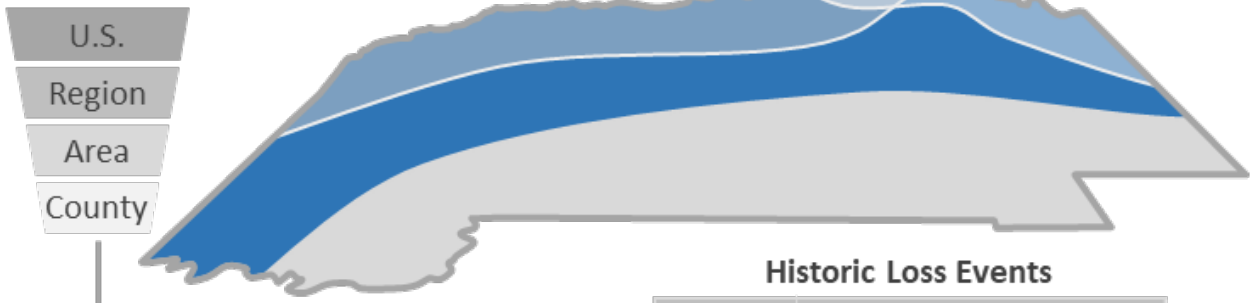
Historic Loss Ratio

HISTORIC LOSS RATIO

Average percentage of loss from occurrences of a hazard for each consequence type.

BAYESIAN CREDIBILITY APPROACH

To address variance & lack of enough events for statistical significance, county ratios are calculating using Bayesian adjustments informed by averages from multiple geographic levels.



County Historic Loss Ratio

Adjusted	Simple
1.3%	2.1%

Historic Loss Events

Event	Loss / Exposure
9/91	$50M/$250B = **0.02%**
6/07	$300M/$250B = **0.1%**
8/14	$15B/$250B = **6%**

data

Arizona State University

Spatial Hazard Events & Losses Database for the U.S. (SHELDUS)

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Calculating Expected Annual Loss

$$EAL = EAL_{Buildings} + EAL_{People} (*\$7.4M) + EAL_{Agriculture}$$

where

$$EAL_{Buildings} = \text{Annualized Frequency} * \text{Exposure}_{Buildings} * \text{Historic Loss Ratio}_{Buildings}$$

$$EAL_{People} = \text{Annualized Frequency} * \text{Exposure}_{People} * \text{Historic Loss Ratio}_{People}$$

$$EAL_{Agriculture} = \text{Annualized Frequency} * \text{Exposure}_{Agriculture} * \text{Historic Loss Ratio}_{Agriculture}$$

- EAL for Agriculture is only calculated for hazards where historic agriculture losses are > 5% of total historic loss (Drought, Hail, Strong Wind, Cold Wave, and Riverine Flooding)
- For Drought, only the EAL for Agriculture was calculated

Value of a Statistical Life (VSL)

- Use VSL to convert fatalities to dollars ($7.4 M/life)
- Enables combined expected losses for property damage, crop loss, and fatalities

Table 5: AIS Injury Severity Levels, Fraction of VSL, and Economic Values (2015 Dollars)

AIS Code	Description of Injury	Fraction of VSL	Economic Value
AIS 1	Minor	.0020	$14,000
AIS 2	Moderate	.0155	$107,000
AIS 3	Serious	.0575	$397,000
AIS 4	Severe	.1875	$1,294,000
AIS 5	Critical	.7625	$5,261,000
AIS 6	Fatal	1.0000	$6,900,000

Source for Fraction of VSL: FAA, 2008.

BENEFIT-COST SUSTAINMENT AND ENHANCEMENTS

CONTRACT #: HSFEHQ-10-D-0806
TASK ORDER #: HSFE60-16-J-1424

Baseline Standard Economic Value Methodology Report

July 28, 2016

FEMA

Federal Emergency Management Agency
Department of Homeland Security
500 C Street, SW
Washington, D.C. 20472

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SHELDUS Data Summary

Arizona State University

Hazard	Property Damage	Crop Losses	Fatalities
Hurricane/Tropical Storm	$179,279,932,143	$1,392,092,788	1045
Flooding	$107,680,427,740	$1,614,273,548	1852
Tornado	$ 36,265,848,108	$18,757,422	1680
Severe Storm/Thunder Storm	$13,031,736,421	$32,705,029,493	378
Wind	$17,432,750,117	$3,748,517,418	1018
Winter Weather	$11,629,438,042	$6,162,536,349	1125
Coastal	$1,780,325,862	$23,843	875
Lightning	$1,156,774,567	-	858
Landslide	$4,829,570,018	-	181
Earthquake	$4,159,099,805	$4,583,019	7
Tsunami/Seiche	$65,732,837	-	1
Volcano	$15,020,996	$127,469	1
Hail	$28,744,435,195	$8,971,453,803	25
Heat	$49,401,721	$5,922,985,923	3827
Avalanche	$12,021,312	-	305
Drought	$2,826,919,900	$48,537,462,507	66
Wildfire	$13,315,293,019	$21,709,345	132

Property Value

Area

People

Methodology Consequences

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Historic Hazard Losses

Hazard	Property Damage	Crop Losses	Fatality Monetized	Combined Loss
Hurricane/Tropical Storm	$179,279,932,143	$1,392,092,788	$7,732,926,000	$188,404,950,931
Flooding	$107,680,427,740	$1,614,273,548	$13,702,913,000	$122,997,614,288
Drought	$2,826,919,900	$48,537,462,507	$491,989,000	$51,856,371,407
Tornado	$36,265,848,108	$18,757,422	$12,430,248,642	$48,714,854,172
Severe Storm/Thunderstorm	$13,031,736,421	$32,705,029,493	$2,795,855,568	$48,532,621,482
Hail	$28,744,435,195	$8,971,453,803	$187,565,210	$37,903,454,208
Heat	$49,401,721	$5,922,985,923	$28,323,167,000	$34,295,554,644
Wind	$17,432,750,117	$3,748,517,418	$7,535,826,926	$28,717,094,461
Winter Weather	$11,629,438,042	$6,162,536,349	$8,324,149,000	$26,116,123,391
Wildfire	$13,315,293,019	$21,709,345	$976,726,000	$14,313,728,364
Coastal	$1,780,325,862	$23,843	$6,472,237,358	$8,252,587,063
Lightning	$1,156,774,567	$ -	$6,346,240,000	$7,503,014,567
Landslide	$4,829,570,018	$ -	$1,339,252,000	$6,168,822,018
Earthquake	$4,159,099,805	$4,583,019	$51,726,000	$4,215,408,824
Avalanche	$12,021,312	$ -	$2,257,296,000	$2,269,317,312
Tsunami/Seiche	$65,732,837	$ -	$7,400,000	$73,132,837
Volcano	$15,020,996	$127,469	$7,400,000	$22,548,465

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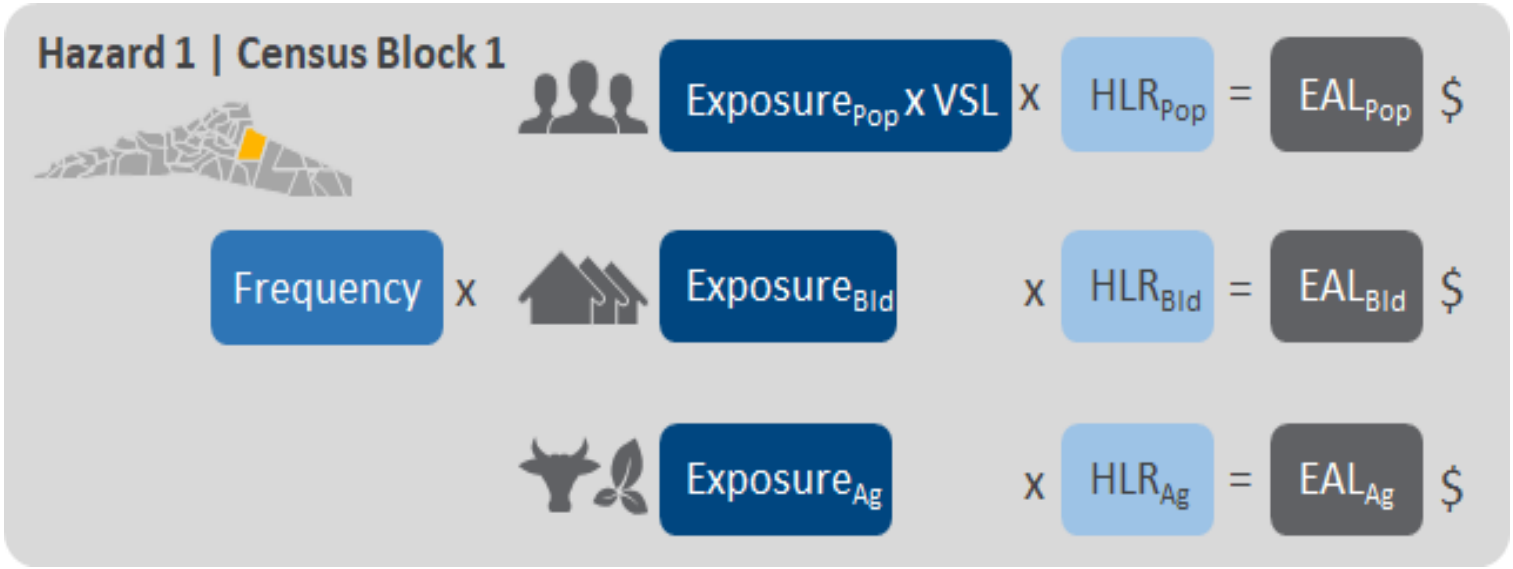
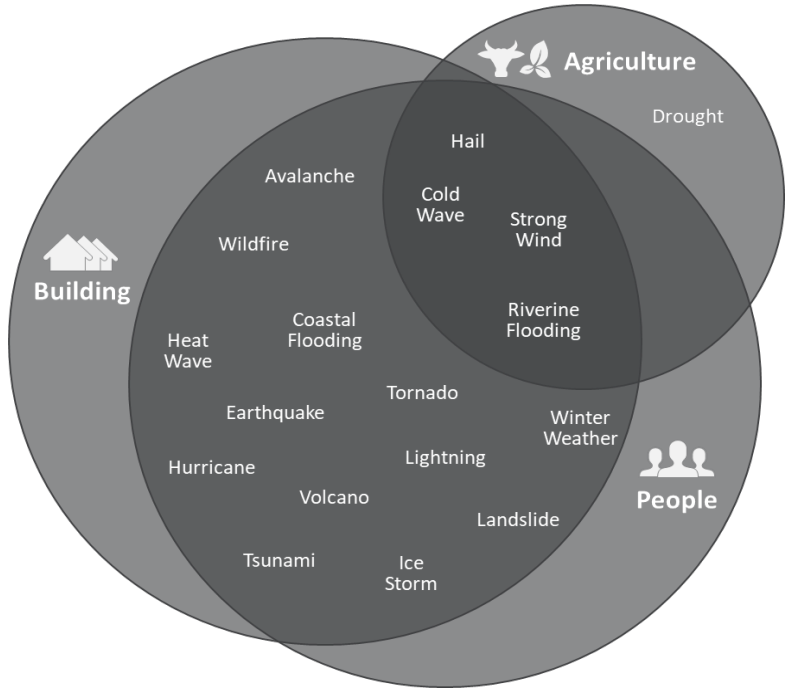
Calculating Expected Annual Loss





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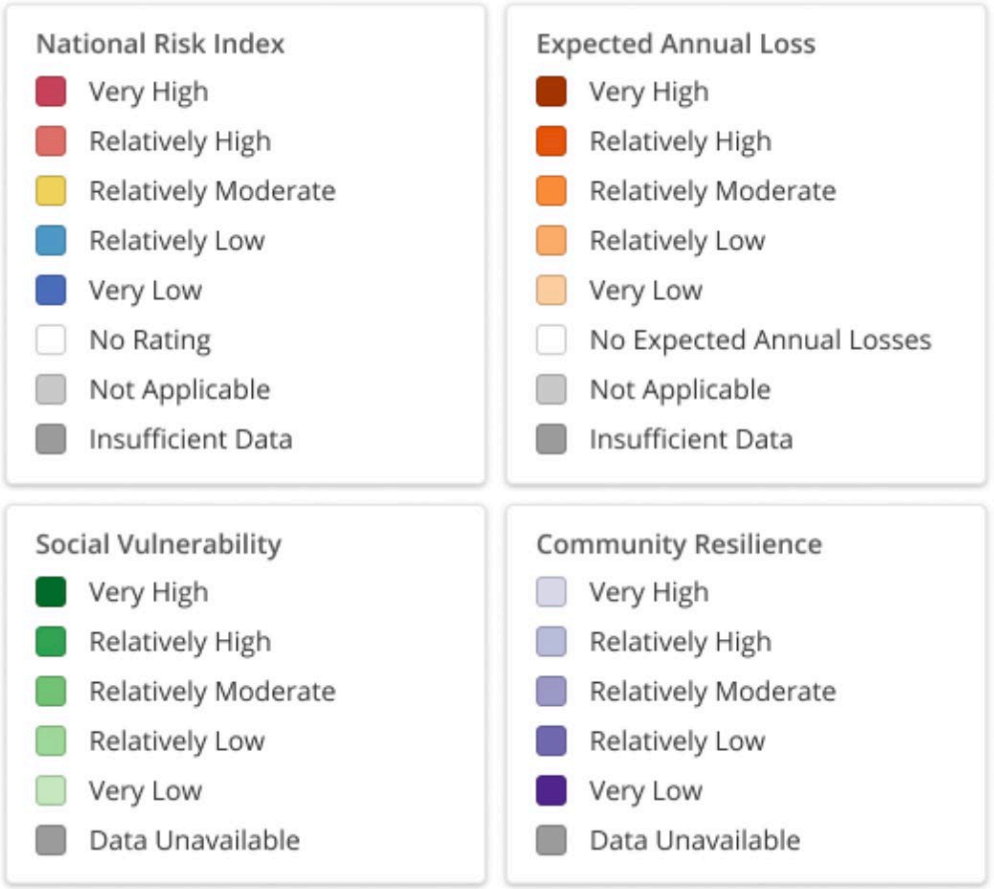
Risk Scores and Ratings

- The NRI provides **relative Risk Index scores** and ratings based on data for Expected Annual Loss due to Natural Hazards, Social Vulnerability, and Community Resilience.
- Separate scores and ratings are also provided for Expected Annual Loss, Social Vulnerability, and Community Resilience.
- Scores and ratings can be viewed as an overall score for all hazards or for any of the 18 individual hazards for the Risk Index or Expected Annual Loss.



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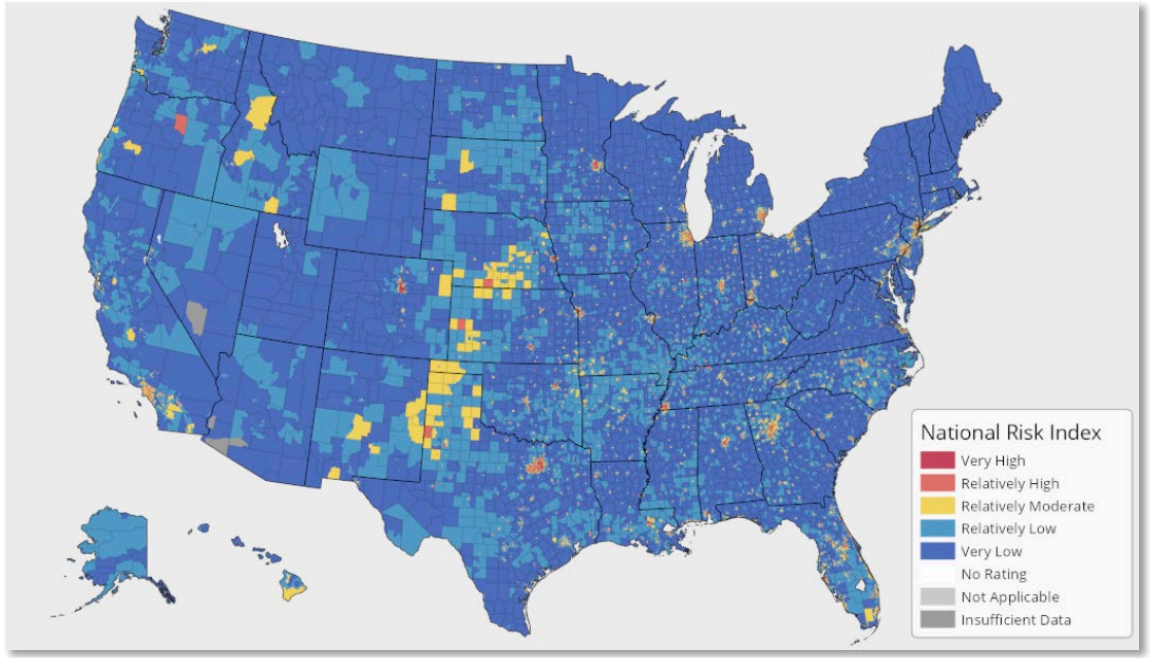
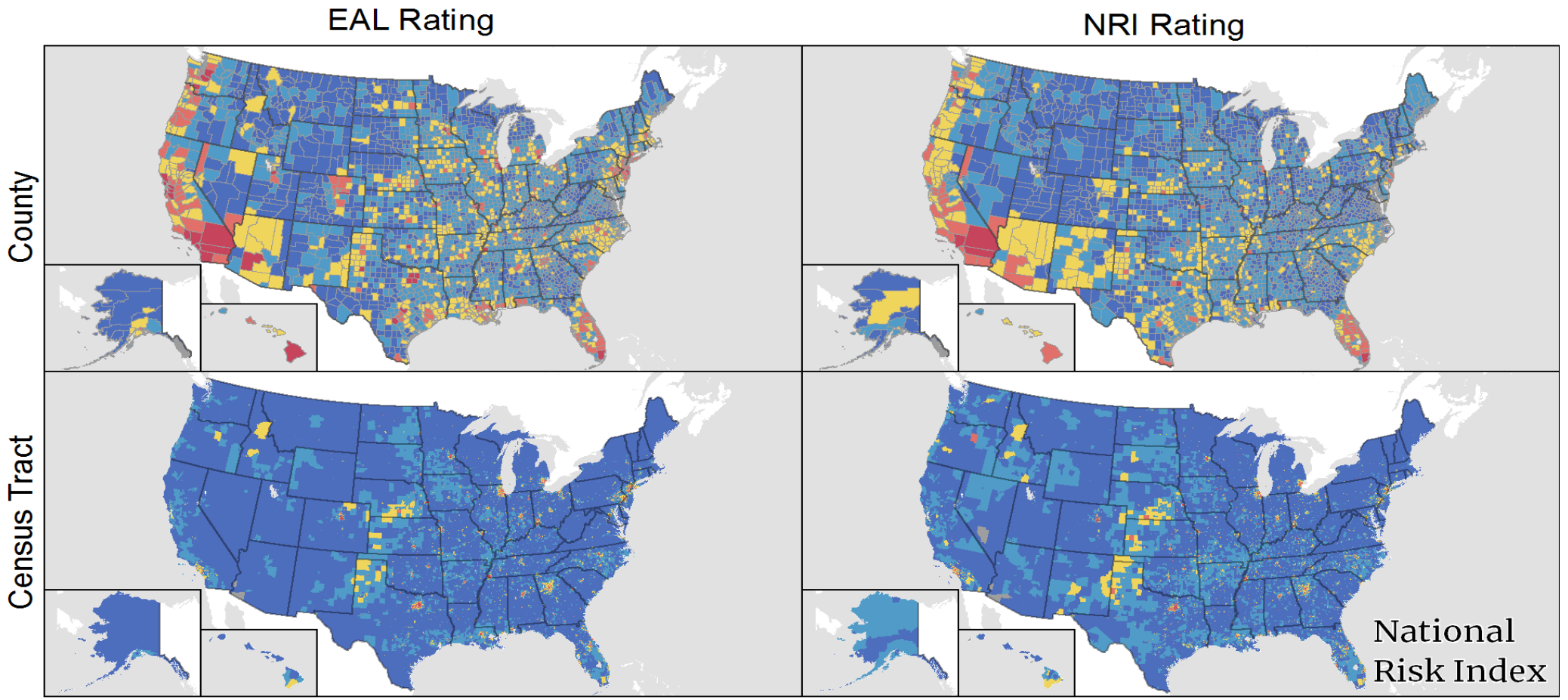
Risk Scores and Ratings

- A community's **score** describes its relative position among all other communities for a given component.
- For every score, there is a qualitative **rating** that describes the nature of a community's score in comparison to all other communities, ranging from "Very Low" to "Very High."
  - There are no specific numeric values that determine the rating.



National Risk Index Scores



Ratings Legend

- Very High
- Relatively High
- Relatively Moderate
- Relatively Low
- Very Low
- Insufficient Data

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Stakeholder Use

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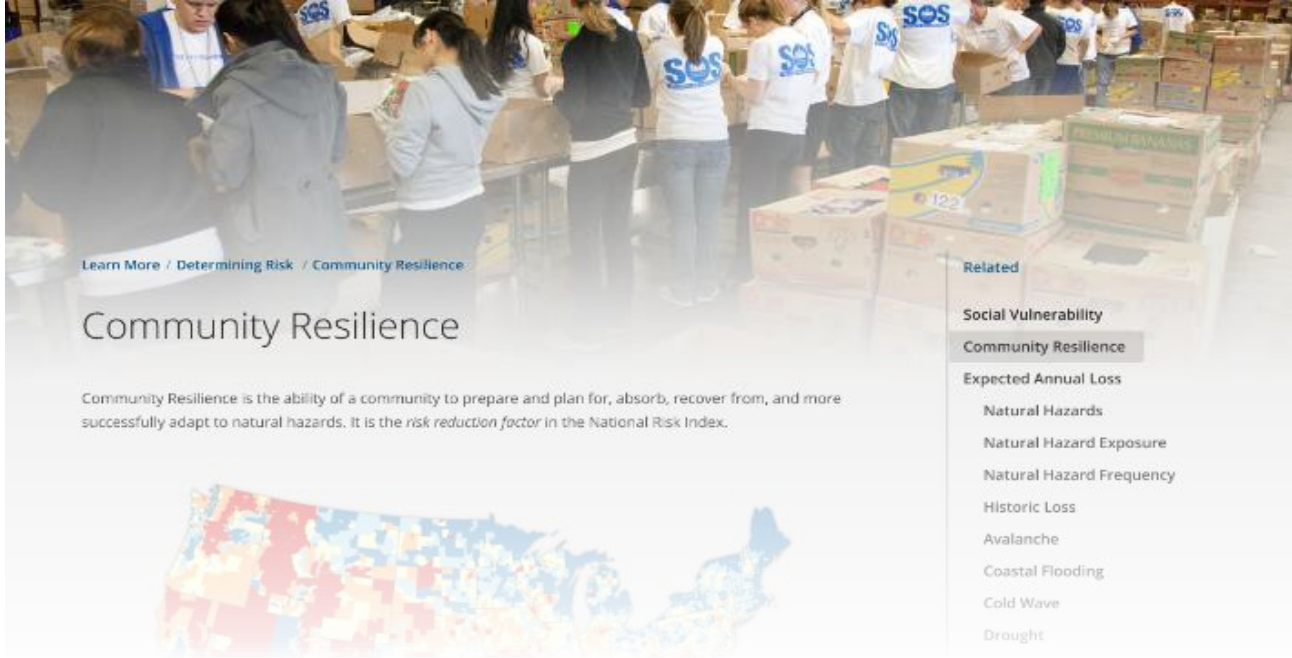
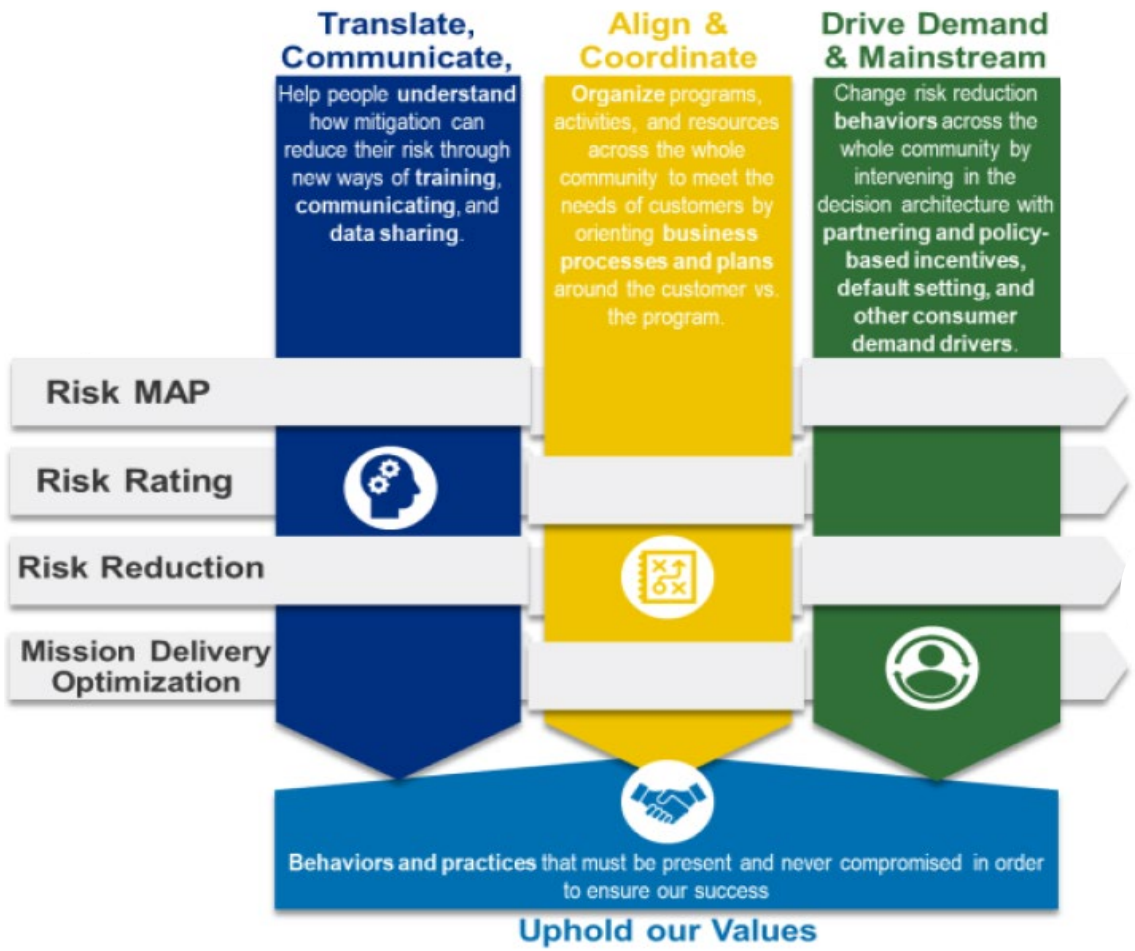


- Multiple states, including, New York, Virginia, Florida, and Pennsylvania, want to use the NRI for local planning efforts to increase community resilience
- Online real estate tools are exploring incorporating NRI data into their interfaces to increase risk awareness to potential home buyers and renters
- Support continued baseline hazard risk assessments for both public and private planning and awareness campaigns

Transformative Work to Achieve Strategic Goals



The NRI and Mitigation Planning

Hazard mitigation planning helps communities reduce future disasters' effects on lives, property, and the economy.

- In the initial stages of mitigation planning, the NRI can help communities identify their hazards, associated risks, and the community's current level of resilience.
- The NRI can also inform community outreach during the planning process by identifying risk areas.

For communities with limited local data and mapping capabilities, the NRI can act as best available information for mitigation plans.

The NRI and Mitigation Planning

Mitigation planning regulations require a risk assessment that describes each hazard identified by the community in terms of location, potential magnitude, past events, and future probability.

- While drafting the plan, the NRI can help communities meet requirements by providing an efficient, standardized risk assessment methodology.
- The NRI incorporates physical and social vulnerability data to identify communities more at risk and review risk from multiple hazards.

The NRI and Hazard Mitigation Assistance (HMA) Grants

- The NRI calculates a baseline relative risk measurement for each U.S. county and census tract that can be used in hazard mitigation grants.
- Specific hazard data is also available for:
  - Expected annual loss in dollars.
  - Frequency/Probability of event (hazard dependent).
  - Exposed population in dollars.
- The data can support multi-jurisdictional projects or large-scale infrastructure project across HMA programs.

The NRI and Risk Communication

- Communicating potential risks can be challenging. The NRI can help illustrate natural hazard risks to bridge the gap between awareness and action.
- The NRI can identify areas with a higher risk index where additional communication on a community's risk is needed for targeted messaging.
- By providing data or proof points, the NRI can support messaging on natural hazard risks when communicating with stakeholders or the general public.

Summer 2021 Release

Email FEMA-NRI@fema.dhs.gov for more information

Application Improvements

- Visualize 18 natural hazard type-specific Expected Annual Loss and Risk Index score layers on the map.
- Explore and review NRI information for communities with our enhanced web map user interface.
- Create a complete Community Risk Profile Report for any or multiple county(ies) or Census tract(s).
- Downloadable ISO-compliant metadata files.
- Relational tribal datasets are available for download to help identify the spatial relationships between tribal areas and the National Risk Index data.

Data Updates

- Agricultural losses added for Heat Wave, Hurricane, Tornado, Wildfire, and Winter Weather hazard types.
- Historic Loss Ratio methodology updated to use SHELDUS Version 19.0 data
- Coastal Flooding sea level rise and high tide frequency adjusted to regional frequency based on tide gauge data.
- Landslide includes available source data for 2010-2019.
- Tornado EAL is now calculated separately for 3 severity-based.

NRI Release Schedule

- Phase 1 Release – November 16, 2020
  https://www.fema.gov/nri
- Full Application – Tentative Summer 2021

Thank You

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