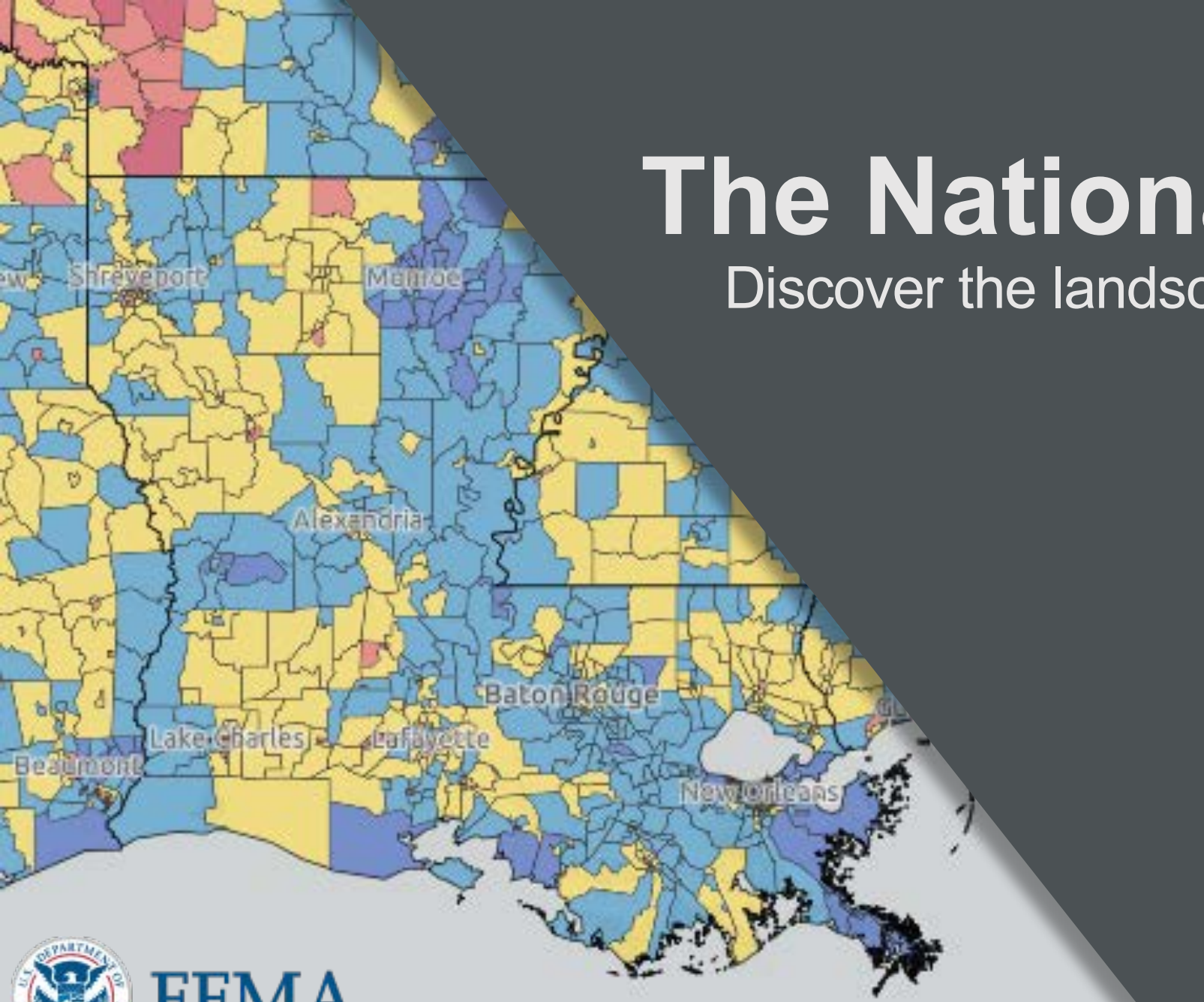


The National Risk Index

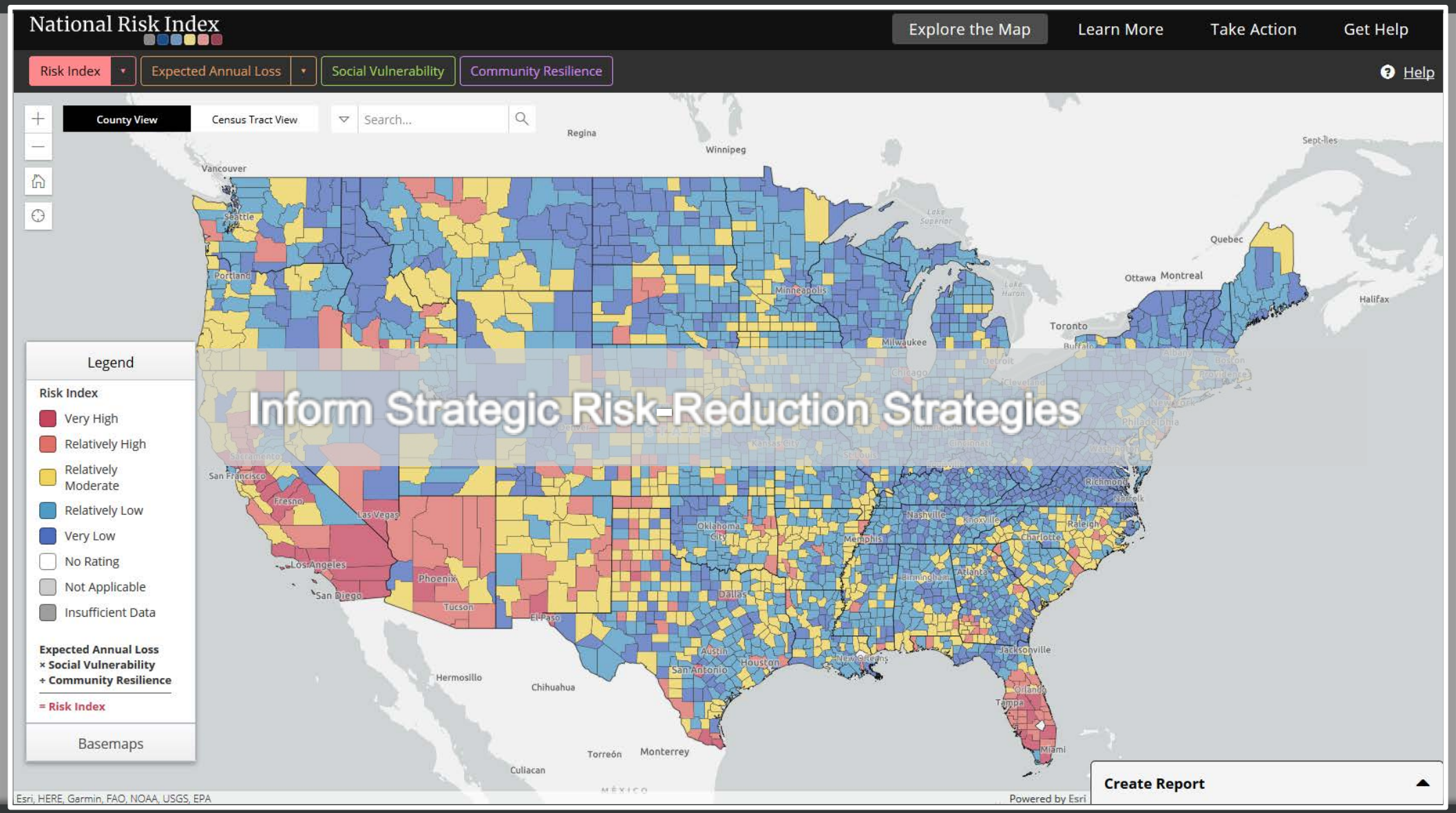
Discover the landscape of natural hazard risk

Casey Zuzak, GISP
Senior Risk Analyst

FEMA Natural Hazards Risk Assessment Program

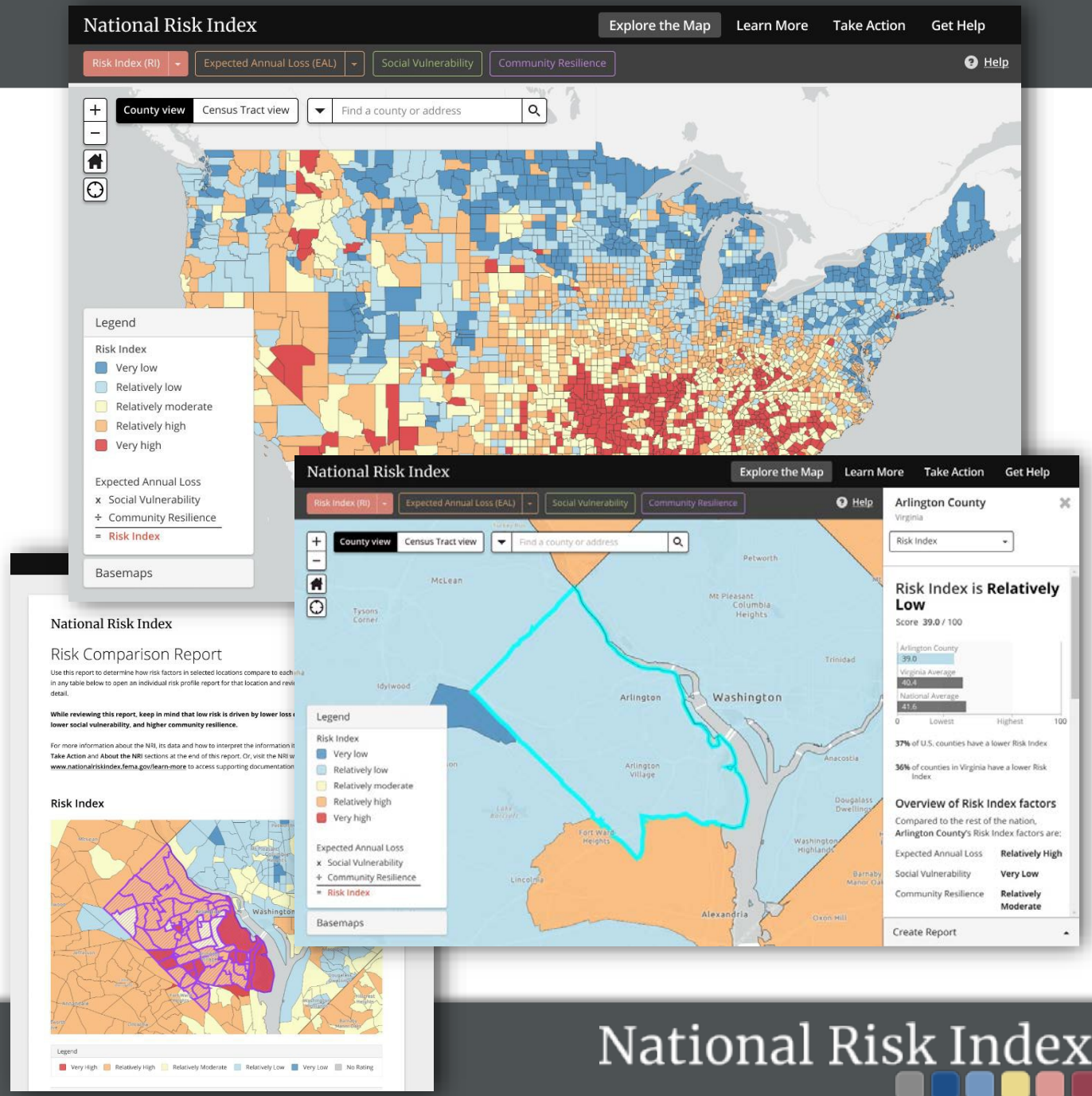
FEMA

What is the National Risk Index?



National Risk Index

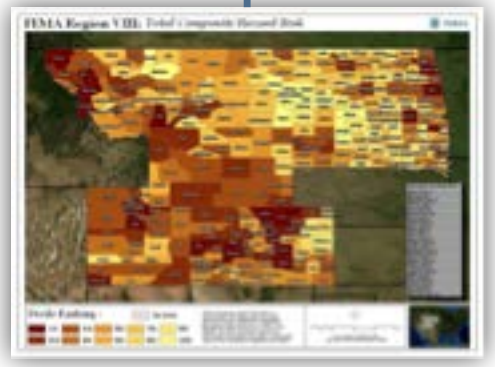
- Began as a strategy for reducing cost and eliminating inconsistent risk assessments in planning
- Identifies areas that offer high return on mitigation investment
- Reduces the cost of risk assessment allowing community planners to prioritize action
- Provides pre-calculated, top-down national baseline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



NRI Development History (2008; 2016-2019)

FEMA Region VIII developed Vulnerability Index to identify and prioritize new mitigation projects based on data

2008



2016

Paul H. and Scott M. fund update of RVIII Index nationally under PTS SO2 Risk Assessment

Jesse/Casey take over NRI, led SME working groups, and take initial delivery of application

2017

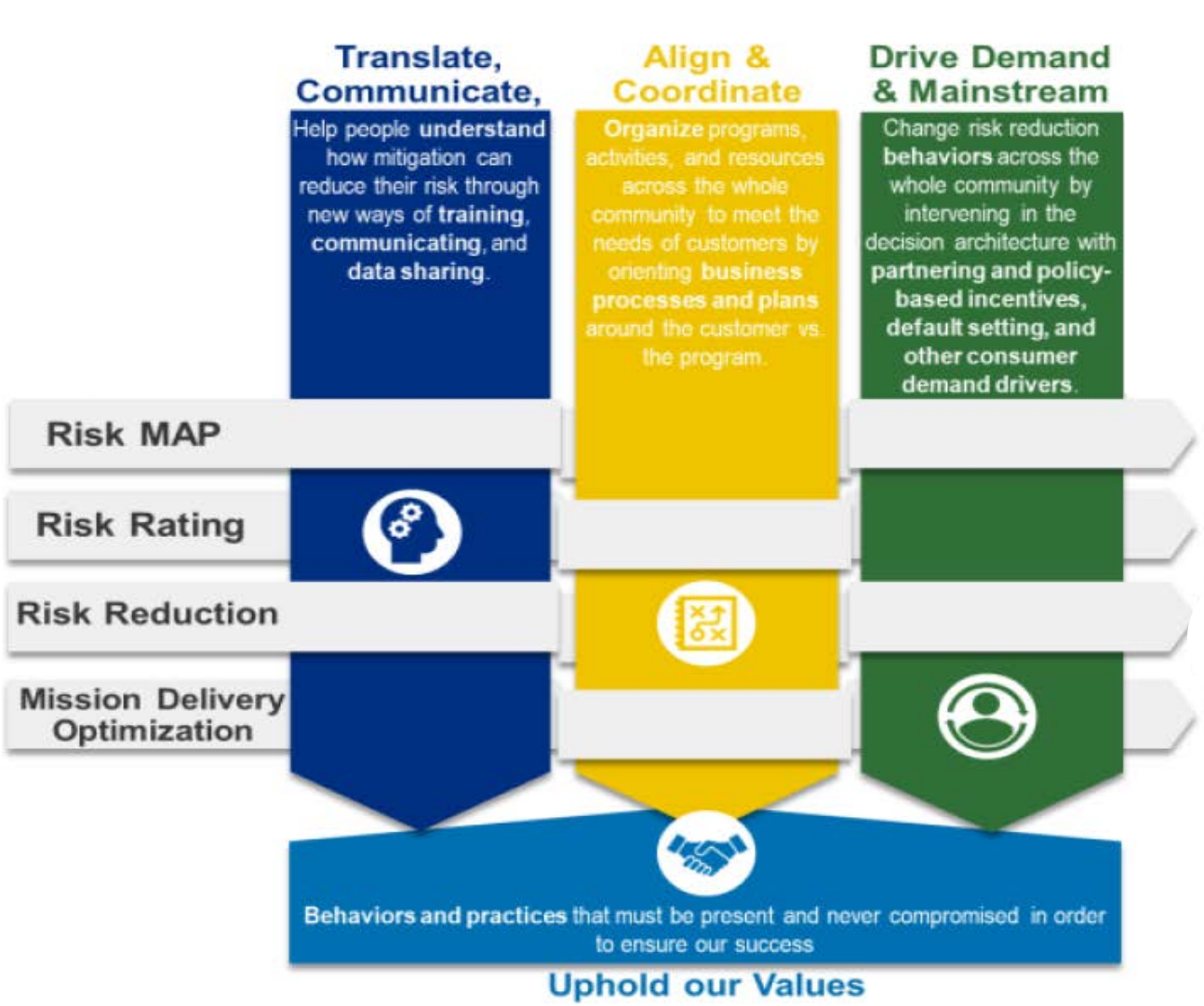
2018

Update Risk Equation based on RMD and Mitigation leadership review and update backend database

Delivery of final test application with updated data and NRI ready for production deployment in CDS

2019

Transformative Work Achieving Strategic Goals



National Risk Index Contributors

State Government

Regional Government

Federal Government

Local Government

Academia

Private

Non-Profit

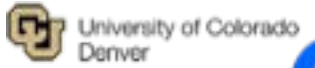
FEMA

National Risk Index Contributors

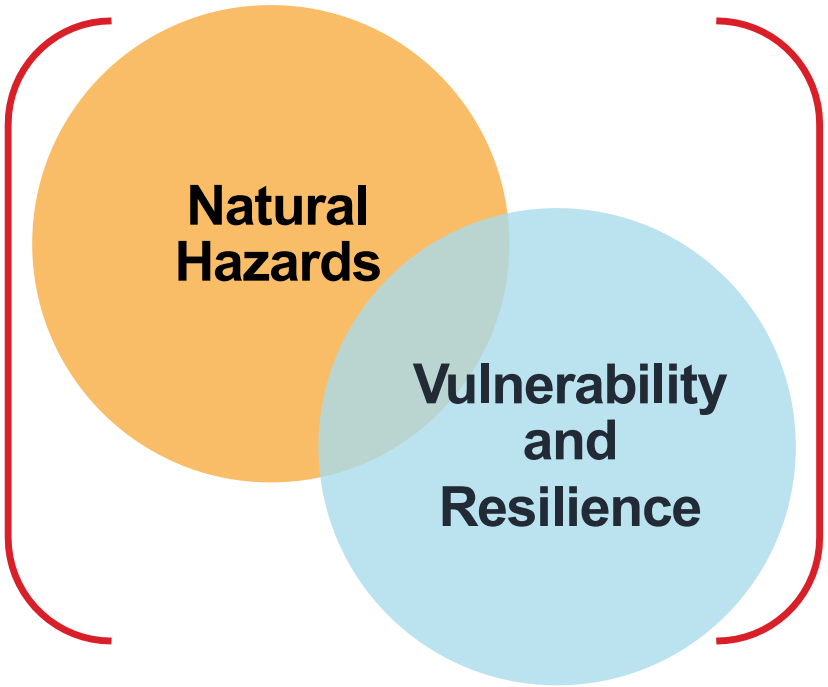






National Risk Index Working Groups



Identify Hazard Types & Dataset Sources

Design & Develop a the National Risk Index Tool

Final Design Team

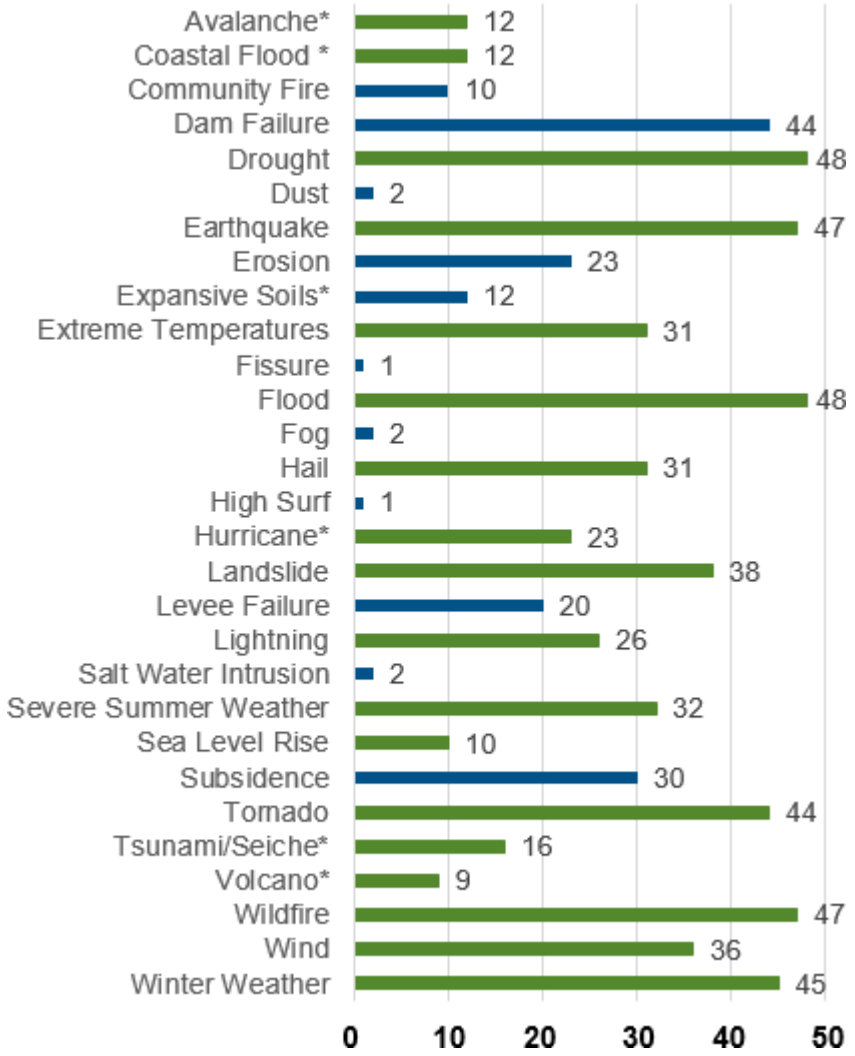
Focused SMEs in Risk Science and Hazard & Data Analysis

RMD Leadership

Large Data Processing and Analytics Experts

User Interface, User Experience Experts

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
USGS science for a changing world
FEMA
NOAA
Storm Prediction Center
Forest Service U.S. Department of Agriculture
National Drought Mitigation Center NDMC University of Nebraska
IEM
UNISDR United Nations Office for Disaster Risk Reduction
nehrp
Colorado Avalanche Information Center
US Army Corps of Engineers

Natural Hazards Data Sources

Hazard	Source
Avalanche	CO Avalanche Information Center
Coastal Flood	NOAA National Weather Service, Storm Events Database, and Coastal sea level rise
Cold Wave	NOAA North American Climate Extremes Monitoring, National Weather Service, and Storm Events Database
Drought	National Drought Mitigation Center
Earthquake	National Earthquake Hazards Reduction Program
Hail	NOAA Storm Prediction Center and Storm Events Database
Heat Wave	NOAA North American Climate Extremes Monitoring and Storm Events Database
Hurricane	NOAA National Hurricane Center and Storm Events Database, Hazus Wind Probabilistic Geodatabase
Ice Storm	U.S. Army Corps of Engineers

Hazard	Source
Landslide	U.S. Geological Survey
Lightning	NOAA Severe Weather Data Inventory, Storm Events Database, and National Center for Environmental Information
Riverine Flood	FEMA Special Flood Hazard Exposure Map and National Flood Hazard Layer
Snowstorm/Blizzard	NOAA Storm Events Database and National Operating Hydrologic Remote Sensing Center
Strong Wind	NOAA Storm Prediction Center and Storm Events Database
Tornado	NOAA Storm Prediction Center and Storm Events Database
Tsnuami/Seiche	NOAA National Center for Environmental Information, individual state sponsored datasets from HI, CA, OR, WA, and AK
Volcano	UN Office for Disaster Risk Reduction
Wildfire	U.S. Geological Survey and U.S. Forest Service

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):
  1. Race and class (7 variables)
  2. Wealth (5 variables)
  3. Elderly residents (6 variables)
  4. Hispanic ethnicity (5 variables)
  5. Special needs individuals (2 variables)
  6. Native American ethnicity (1 variables)
  7. 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
  1. Social
  2. Economic
  3. Community capital
  4. Institutional
  5. Infrastructural
  6. 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

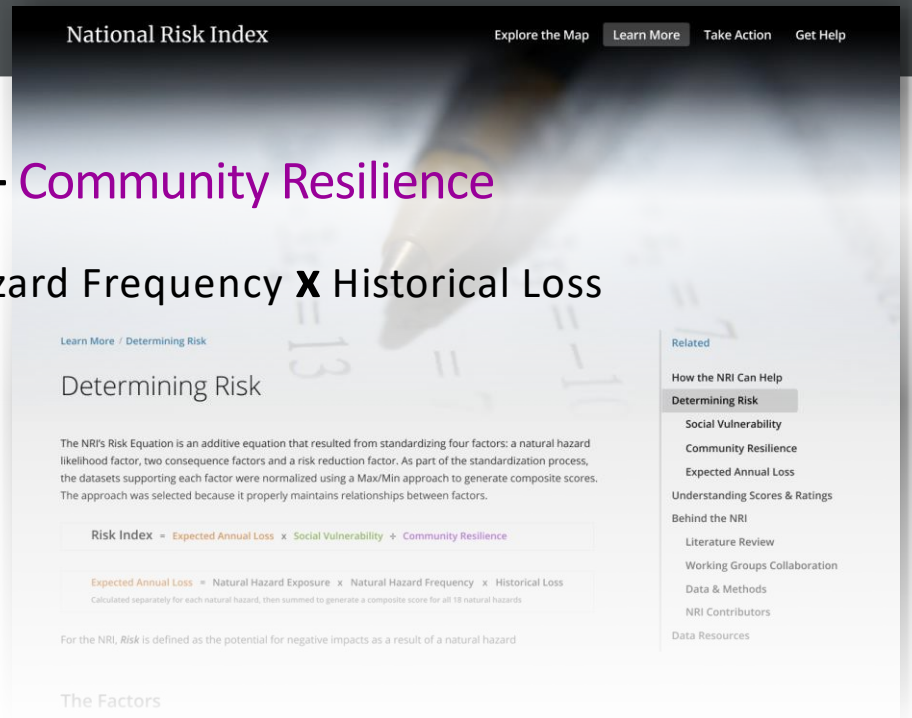
HVRI HAZARDS & VULNERABILITY RESEARCH INSTITUTE

UNIVERSITY OF SOUTH CAROLINA

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, property value, and crop 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, Vulnerability, and Exposure

Risk Calculation

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 • Crop	X	Percentage of property/people/crop losses
How likely is hazard to occur?		How many people & how much property and crops are potentially at risk?		What percent of property/people have historically been lost from hazard in a given area?

Expected Annual Loss (EAL) Calculation Considerations

Option 1. Initial Approach: Hazard Dependent Consequence

- Uses either building damage or population as consequence type for a given hazard
- EALs are not directly comparable across hazards because consequences types vary; so, EAL scores are normalized to all other counties for that hazard
- Normalized values are summed across hazards to represent the "all hazard" EAL
  - Treats all hazards as having equivalent EALs
  - Historical loss for hazards spans 4 orders of magnitude (Hurricane >8000x higher than Volcano loss)

Option 2. Current Approach: Consequence Equivalency

- Apply Value of Statistical Life (VSL) to combine property, people, & crop into one loss metric
- Sum un-normalized EALs across hazards to represent the "all hazard" EAL

Value of Statistical Life (VSL)

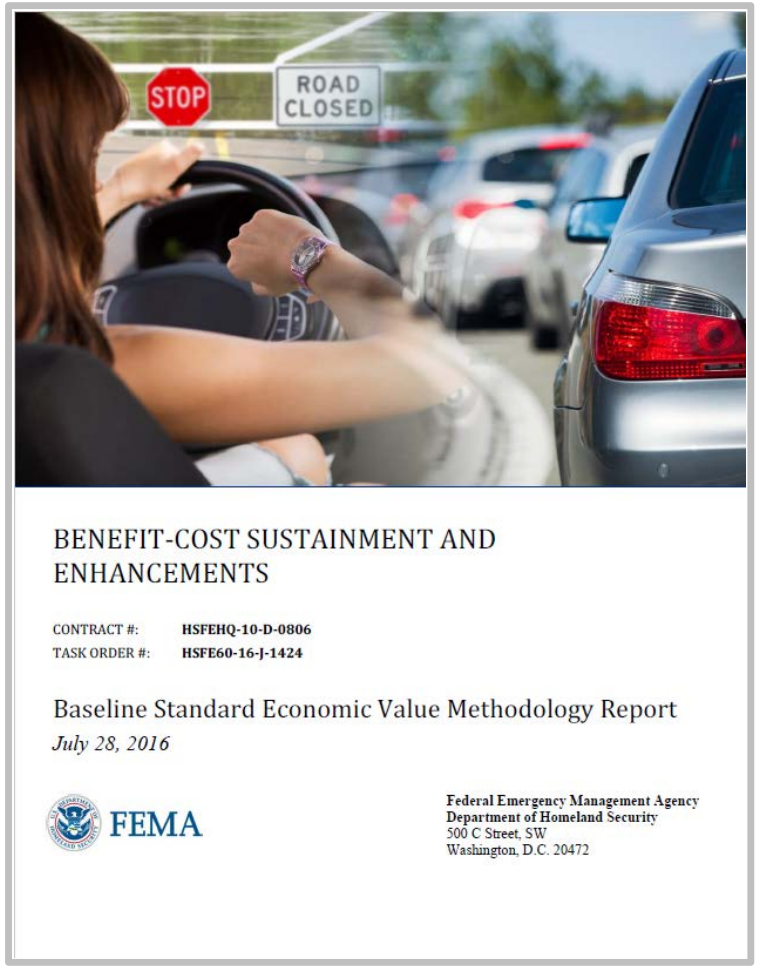
- Use VSL to convert fatalities to dollars $7.4M/life

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.

- Enables combined expected loss for property damage, crop loss, and fatalities



EAL Calculation Options

$EAL_{Property}$ = Annualized Frequency * $Exposure_{Property}$ * Historic Loss $Ratio_{Property}$

EAL_{People} = Annualized Frequency * $Exposure_{People}$ * Historic Loss $Ratio_{People}$

EAL_{Crop} = Annualized Frequency * $Exposure_{Crop}$ * Historic Loss $Ratio_{Crop}$

Option 1. Initial Approach: Hazard Dependent Consequence

EAL= $EAL_{Property}$ or EAL_{People}

Option 2. Current Approach: Consequence Equivalency

EAL= $EAL_{Property}$+ (EAL_{People} * $7.4M) + EAL_{Crop}

*Notes

- Drought EAL only considers EAL_{Crop}
- EAL_{Crop} is only included for select hazards: Hail, Wind, & Riverine Flood

Summary of SHELDUS Loss Data (1995-2016)

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	1
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	$5,922,993,923	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

Combined Loss Using VSL

- Denominator for crop losses
- Look at peril level for hail & thunderstorm to determine
- Move wildfire to property damage vs. crop
- Run sensitivity analysis w/VSL

Hazard	Property Damage	Crop Losses	Fatality Monetized	Combined Loss	Methodology Consequence %
Hurricane/Tropical Storm	$179,279,932,143	$1,392,092,788	$7,732,926,000	$188,404,950,931	95%
Flooding	$107,680,427,740	$1,614,273,548	$13,702,913,000	$122,997,614,288	88%
Drought	$2,826,919,900	$48,537,462,507	$491,989,000	$51,856,371,407	94%
Tornado	$36,265,848,108	$18,757,422	$12,430,248,642	$48,714,854,172	74%
Severe Storm/Thunder Storm	$13,031,736,421	$32,705,029,493	$2,795,855,568	$48,532,621,482	27%
Hail	$28,744,435,195	$8,971,453,803	$187,565,210	$37,903,454,208	0%
Heat	$49,401,721	$5,922,985,923	$28,323,167,000	$34,295,554,644	83%
Wind	$17,432,750,117	$3,748,517,418	$7,535,826,926	$28,717,094,461	61%
Winter Weather	$11,629,438,042	$6,162,536,349	$8,324,149,000	$26,116,123,391	45%
Wildfire	$13,315,293,[illegible]	$21,709,345	$976,726,000	$14,313,728,364	0%
Coastal	$1,780,325,862	$23,843	$6,472,237,358	$8,252,587,063	22%
Lightning	$1,156,774,567	$ -	$6,346,240,000	$7,503,014,567	15%
Landslide	$4,829,570,018	$ -	$1,339,252,000	$6,168,822,018	78%
Earthquake	$4,159,099,805	$4,583,019	$51,726,000	$4,215,408,824	99%
Avalanche	$12,021,312	$ -	$2,257,296,000	$2,269,317,312	99%
Tsunami/Seiche	$65,732,837	$ -	$7,400,000	$73,132,837	90%
Volcano	$15,020,996	$127,469	$7,400,000	$22,548,465	67%

Sequence of min-max can Dramatically Impact Results

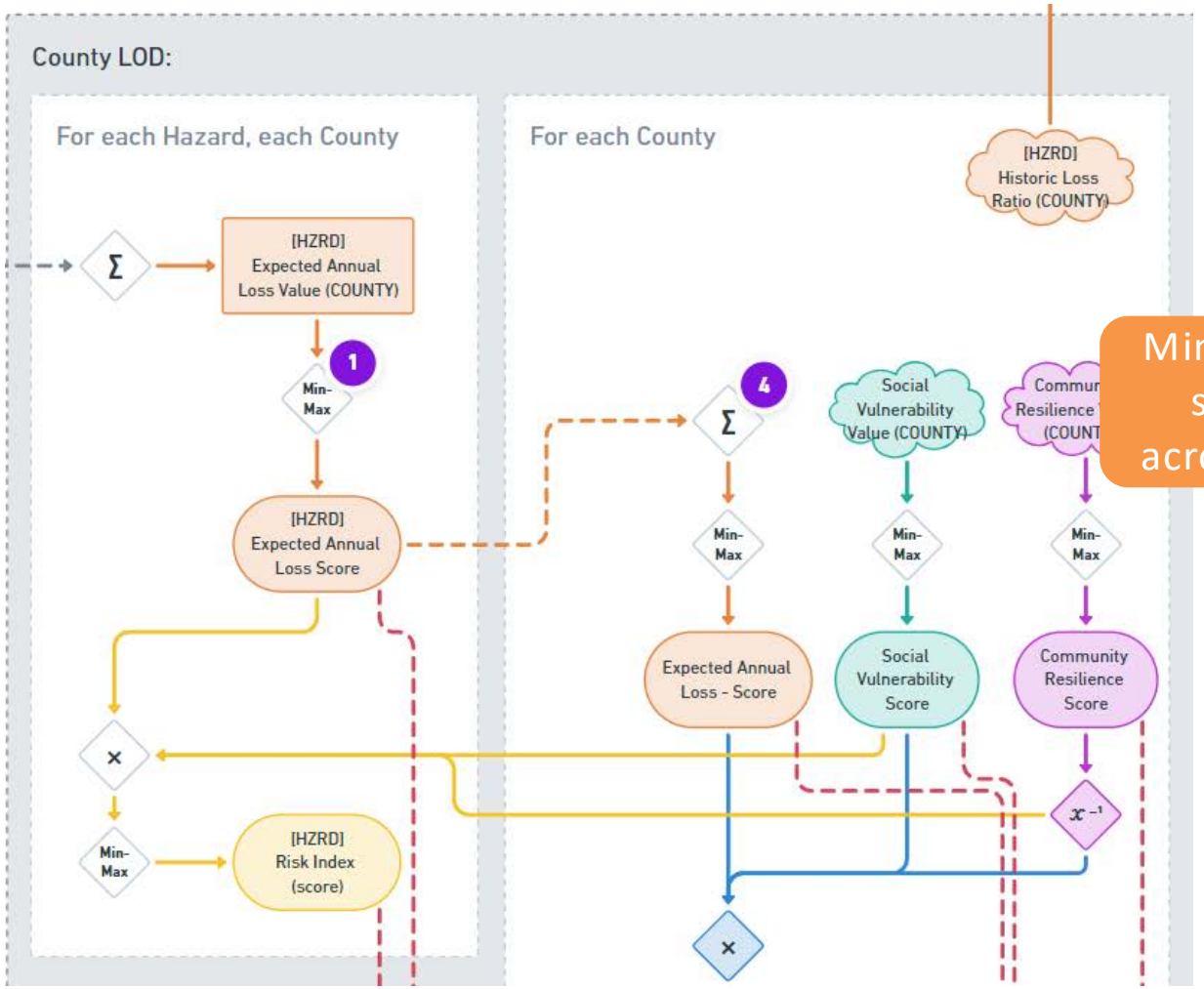
Option 2: Current

Option 1

County	Expected Annual Loss: Combined					Min-max Total	Expected Annual Loss: Hazard Normalized					Min-max Total
	Hurricane	Flood	Drought	Hail	Total		Hurricane	Flood	Drought	Hail	Total	
A	5,301	436	19	84	5,840	0.57	0.55	0.98	0.09	0.34	1.96	0.72
B		221	55	28	304	0.01		0.50	0.26	0.11	0.87	0.15
C	1,999	165			2,164	0.20	0.21	0.37			0.58	0.00
D	2,059	17		111	2,187	0.20	0.21	0.04		0.44	0.70	0.06
E		360	25	230	615	0.04		0.81	0.12	0.92	1.85	0.66
F		444	26	13	483	0.02		1.00	0.12	0.05	1.17	0.31
G	2,586	76	212		2,874	0.27	0.27	0.17	1.00		1.44	0.45
H	5,946			18	5,964	0.59	0.61			0.07	0.69	0.06
I				250	250	0.00				1.00	1.00	0.22
J	9,672		191	148	10,011	1.00	1.00		0.90	0.59	2.49	1.00

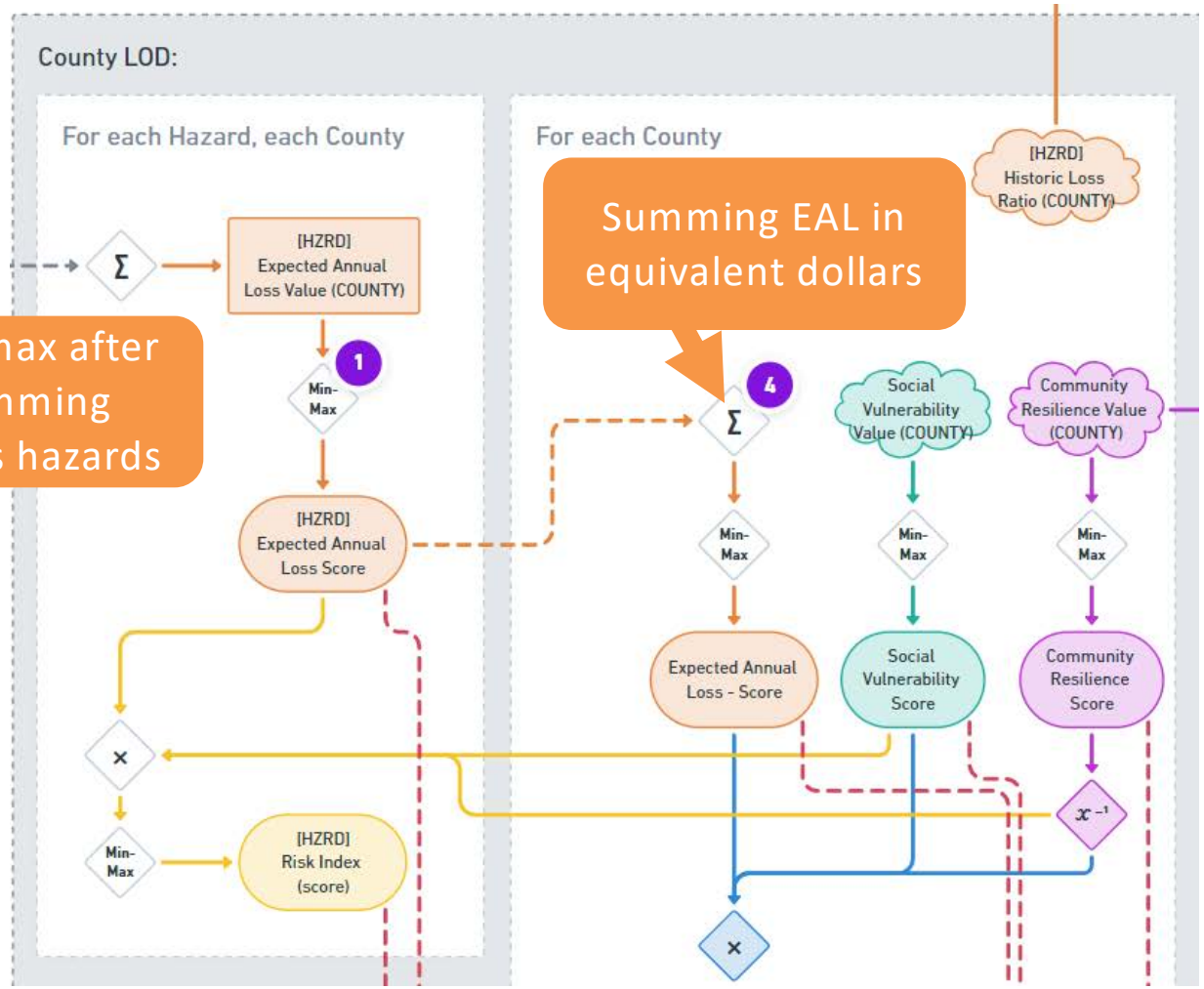
Normalization Sequence for Methodologies 1 and 2

Option 1. Current Approach

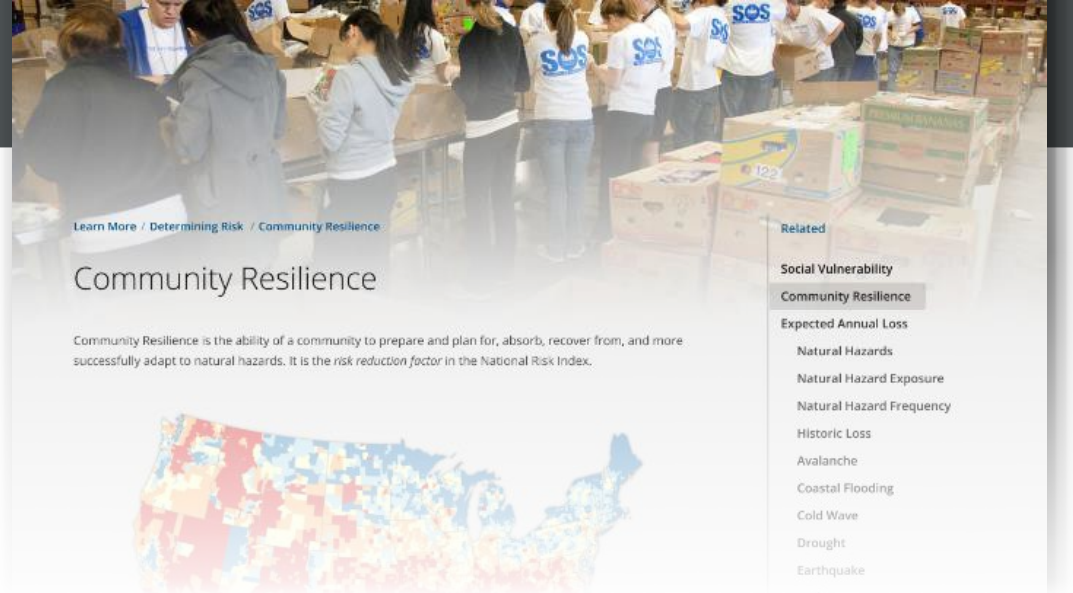


Min-max after summing across hazards

Option 2. Consequence Equivalency

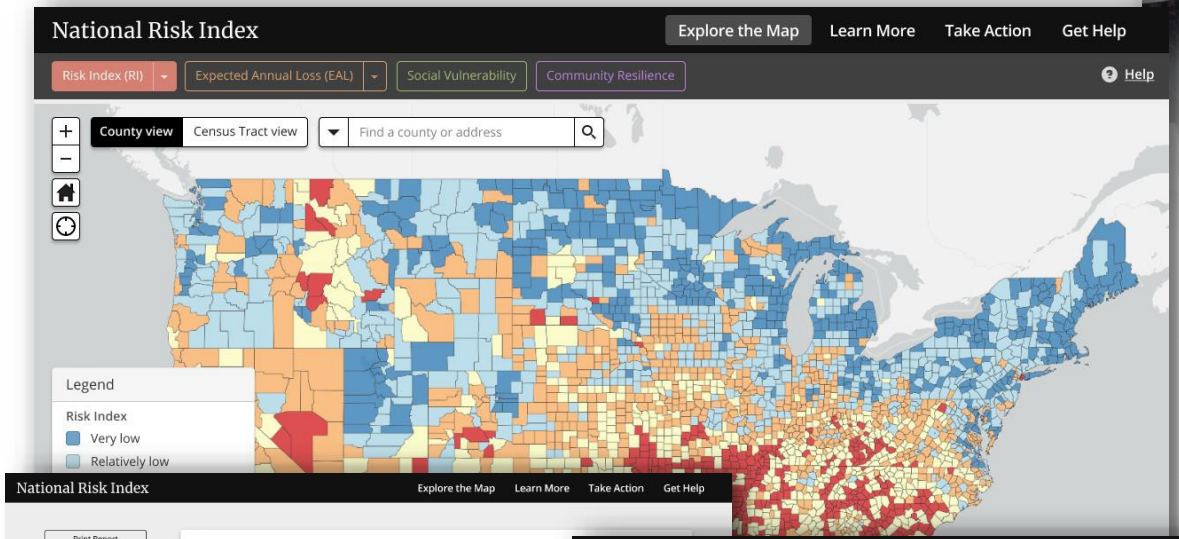


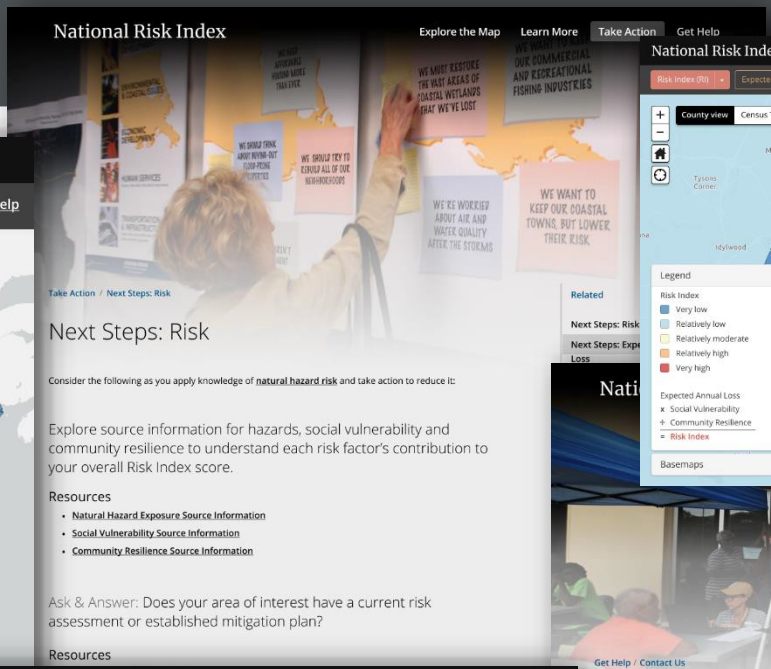
Stakeholder Use

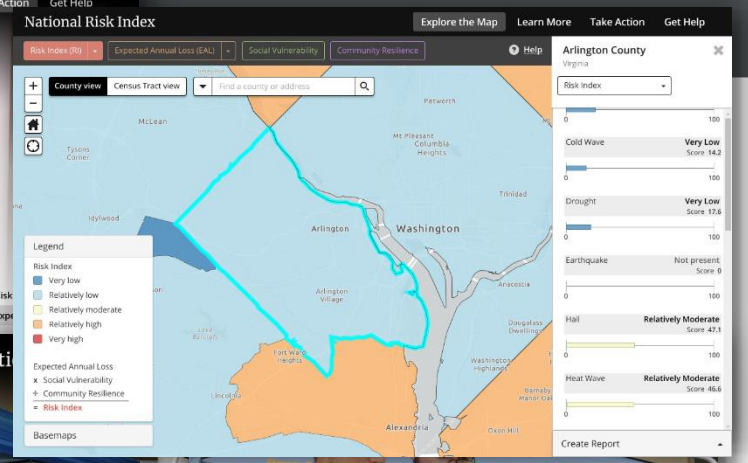


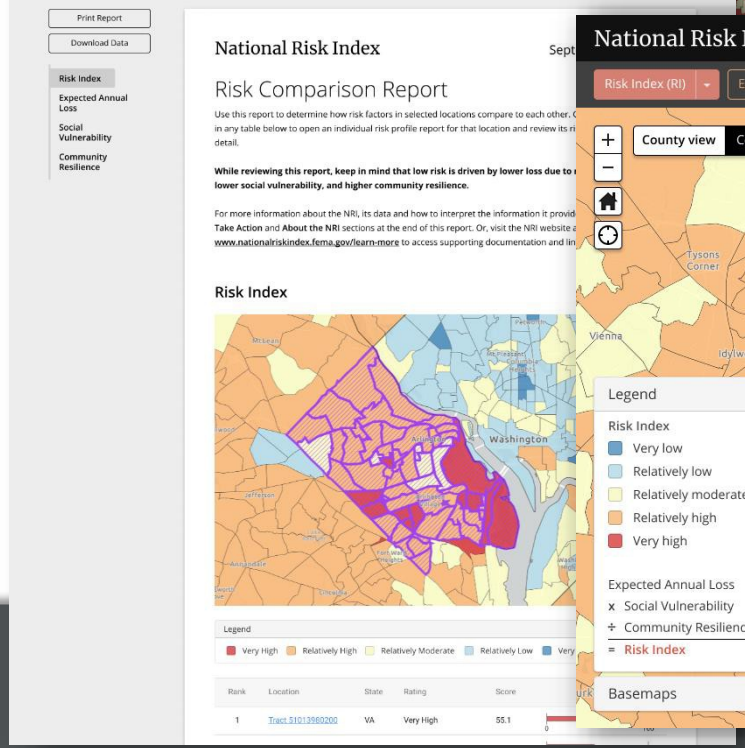
- Multiple states, including, New York, Virginia, Florida, and Pennsylvania, want to use the NRI for local planning efforts to increase community resilience
- Online real estate tools are exploring incorporating NRI data into their interfaces to increase risk awareness to potential home buyers and renters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

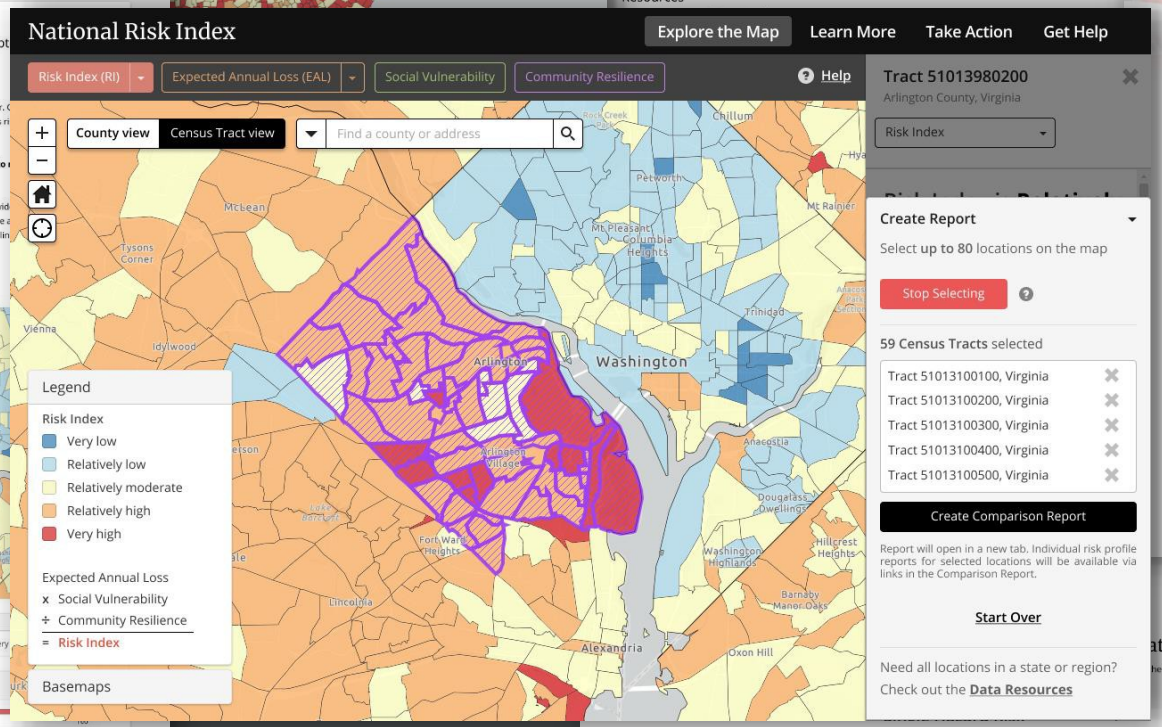
Final Products

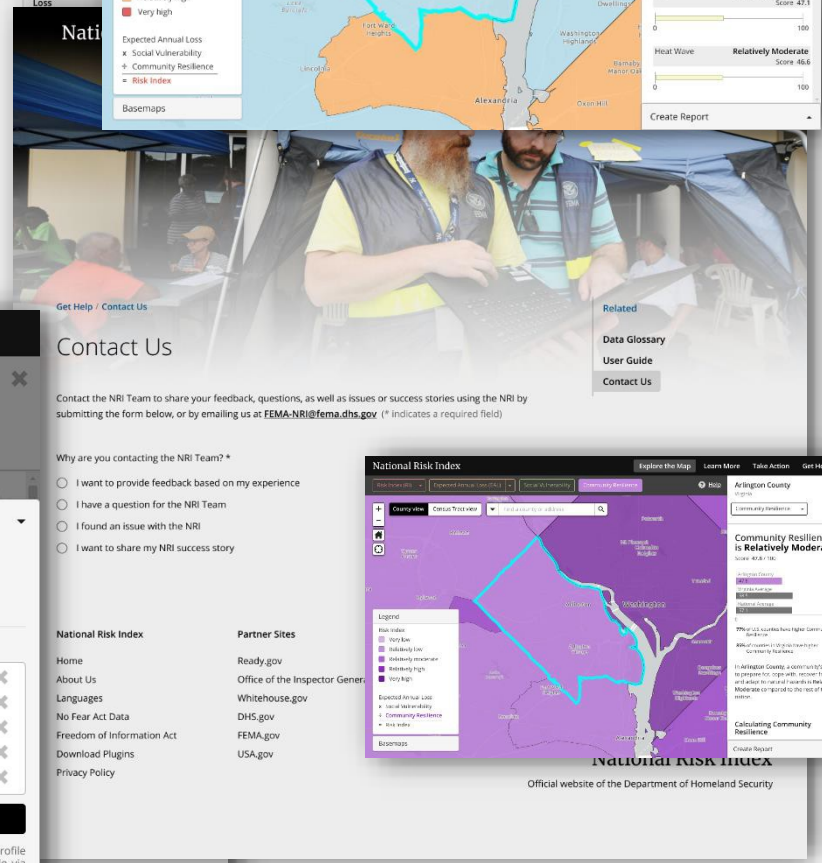












National Risk Index

http://nationalriskindex-test.fema.gov

This is very much a work on progress website, loaded with basic datasets that may not represent the final product.

Questions?

Casey Zuzak, GISP
Senior Risk Analyst
FEMA NHRAP
Casey.Zuzak@fema.dhs.gov