



CRSI (Climate Resilience Screening Index) – Development and Application

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RESILIENCE

The capacity to **prepare** for disruptions, **recover** from shocks and stresses, and **adapt** and **grow** from a disruptive experience.

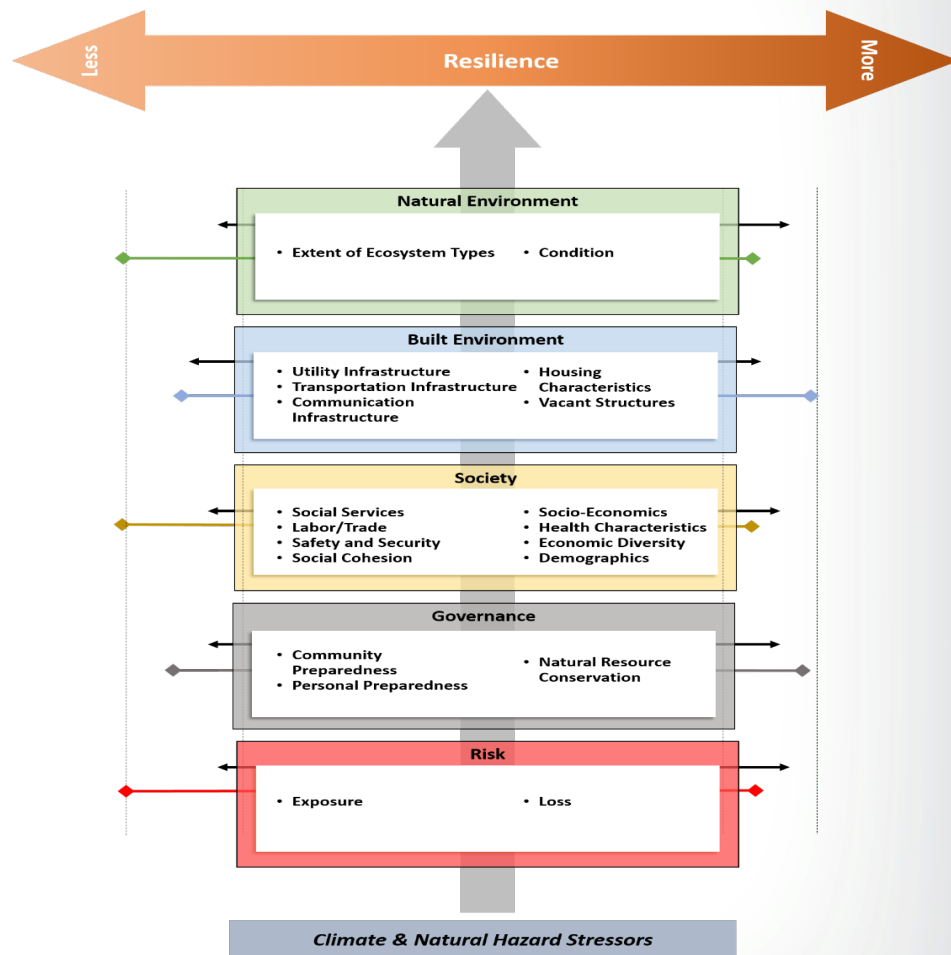
*#Rebuild***BETTER**



What is CRSI?

- The Climate Resilience Screening Index (CRSI) is a composite measure developed to characterize the resilience of socio-ecological systems in the context of governance and risk to natural hazard events.
- Comprised of five domains (Risk, Governance, Society, Built Environment, and Natural Environment)
- Represented by 20 indicators
- Calculated from 117 metrics


























Intended Use: Help communities target potential areas for resources to increase relative resilience given specific hazard profiles.



Legend							
CRSI Composite Index Gradient				<i>Italicized Text</i> External Influence			
Bold Text	Domain	• Bullet	Indicator		Domain Resilience Range		Indicator Resilience Range



CRSI Domains and Indicators

Domain Description	Indicator Description (# of metrics)		Domain Description	Indicator Description (# of metrics)	
<p>The Risk domain represents the characteristics of a place that contribute to a level of exposure or loss resulting from specific hazards.</p> 	 <p>Exposure</p>	The probability of hazard occurrence across a full spectrum of natural hazard events as well as additional technological hazards that may coincide with, or be exacerbated by such events (18)	<p>The Natural Environment domain describes resilience of natural and managed ecosystems through measures of extent and condition.</p> 	 <p>Extent</p>	the proportion of land that is undeveloped and includes the spatial extent or acreage of each ecosystem type (9 metrics)
	 <p>Loss</p>	Characteristics of vulnerability represented through historical loss of life and property (including crops) associated with specific hazard events (3)		 <p>Condition</p>	Condition-represents the ecological condition of the ecosystems identified in the extent indicator (9 metrics)
<p>The Governance domain describes the collaboration of government agencies and Non-Governmental Organization (NGOs) or private citizens towards joint objectives within a system of rules and regulations in context of increasing community resilience</p> 	 <p>Community Preparedness</p>	County and community resilience strengthening and structure hazard mitigation (2 metrics)	<p>The Society domain includes all human aspects of a community except the built environment. These are the constructs that represent the economic, demographic, and social interactions.</p> 	 <p>Demographics</p>	Demographics-measures that reflect general vulnerability attributes of a community's general population (5 metrics)
	 <p>Personal Preparedness</p>	Individual or household activities that help protect personal property from acute climate events (2 metrics)		 <p>Economic Diversity</p>	Diversity-represents factors associated with economic stability and ability to monetarily respond and recover from hazard events (2 metrics)
	 <p>Natural Resource Conservation</p>	Protection of natural resources from anthropogenic activities (1 metric)		 <p>Health Characteristics</p>	Factors associated with healthcare access, special health vulnerability populations, and specific health problems (9 metrics)
	 <p>Communication Infrastructure</p>	communications continuity (7 metrics)		 <p>Trade and Labor Services</p>	represents measures of the appropriate construction skills needed to provide for accelerated recovery (8 metrics)
<p>The Built Environment domain describes the man-made surroundings that support human activities and reflects structural vulnerability and critical functions needed for recovery from hazard events.</p> 	 <p>Utilities Infrastructure</p>	Measures of the relative availability of drinking water, sewer and power services based on number and location (3 metrics)	 <p>Safety and Security</p>	 <p>Social Cohesion</p>	addresses the provisioning of emergency and civil services (metrics 4)
	 <p>Housing Characteristics</p>	addresses issues of home overcrowding, housing density, type of housing and structural condition (5 metrics)		 <p>Social Services</p>	Cohesion-represents social bonds and the willingness of members of a society to cooperate with each other in the wake of natural hazard events (4 metrics)
	 <p>Vacant Structures</p>	measures of the number of vacant business structures residences and other vacant buildings (3 metrics)		 <p>Socio-economics</p>	Services-characterizes services critical for recovery and includes the availability of services unrelated to labor/trade, emergency services and civil control (15 metrics)
	 <p>Transportation Infrastructure</p>	represents transportation flow continuity described with related measures for bridges, roads and airports (6 metrics)			Socio-economics-relates to employment opportunity and issues associated with personal economics, primarily level of income (2 metrics)



Domain Overviews

- **Risk Domain: Characteristics of a place that contribute to level of exposure or loss resulting from specific hazards**
 - **Exposure : Probability of hazard occurrence over full spectrum of natural hazards (13) and technological hazards (5)**
 - **Loss: Historical loss of life and property (3)**
- **Governance Domain: Collaboration of government agencies and NGOs and private citizens towards joint objectives with a system of rules and regs for increasing community resilience**
 - **Community Preparedness: County and community resilience strengthening and structure hazard mitigation (2)**
 - **Personal Preparedness: Individual or household activities that help protect personal property for acute climate events (2)**
 - **Natural Resource Conservation: Protection of natural resources (1)**



Domain Overviews

- **Built Environment Domain: Man-made surroundings that support human activities and reflect structural vulnerability and critical functions for recovery**
 - **Communications Infrastructure: Communications Continuity (7)**
 - **Utilities Infrastructure: Relative availability of drinking water, sewer and power services (3)**
 - **Transportation Infrastructure: Transportation flow continuity (6)**
 - **Housing Characteristics: Home overcrowding, housing density, type of housing and structural condition of housing (5)**
 - **Vacant Structures: Number of vacant buildings (3)**
- **Natural Environment Domain: Resilience of natural and managed ecosystems**
 - **Extent: Proportion of land that is undeveloped and acreage in each ecosystem type (9)**
 - **Condition: Ecological condition of each ecosystem type (9)**




























Domain Overviews

- **Society Environment Domain:** All human aspects of a community except built environment (include economic, demographic and social interactions)
 - **Demographics:** General vulnerability attributes of a community's population (5)
 - **Economic Diversity:** Factors associated with economic stability and ability to monetarily respond and recover (2)
 - **Health Characteristics:** Factors associated with healthcare access, special health vulnerability populations, and specific health problems (9)
 - **Trade and Labor Services:** Appropriate construction skills needed to provided for accelerated recovery (8)
 - **Safety and Security:** Emergency and civil services (4)
 - **Social Cohesion:** Social bonds and willingness of society members to cooperate (4)
 - **Social Services:** Critical services for recovery unrelated to labor/trade, safety/security and civil control (15)
 - **Socio-Economics:** Employment opportunities and issues associated with personal economics (2)



CRSI Domains and Indicators

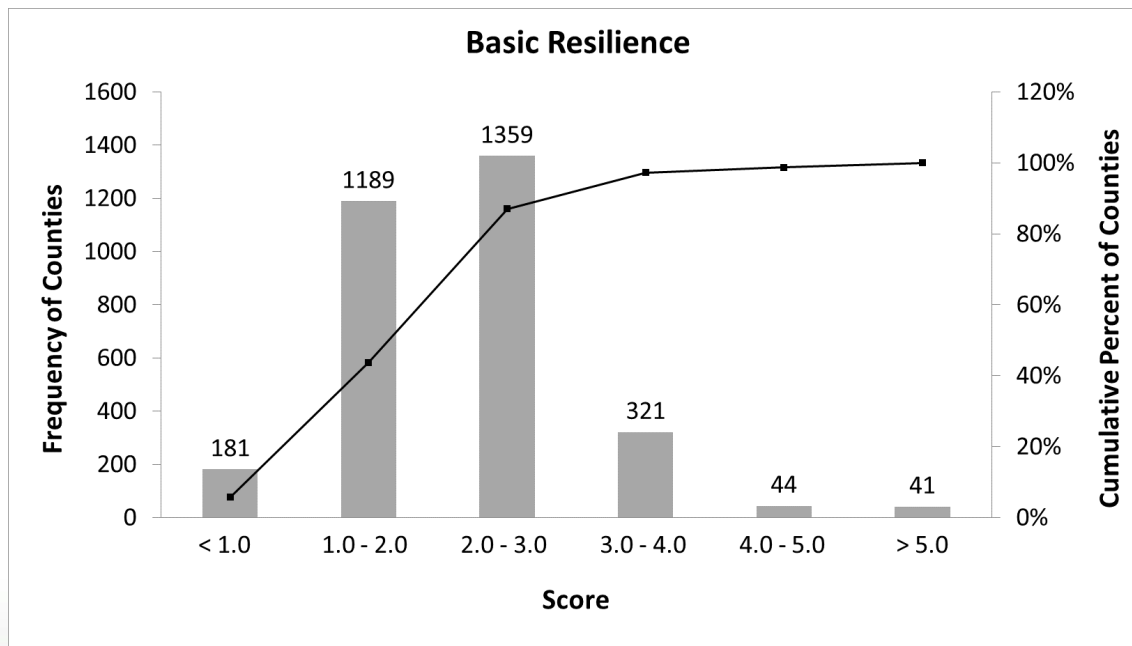
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Calculating Basic Resilience

- **Ratio of Governance and Risk Domains (G/R)**
- **Basic Resilience scores were calculated for each county as follows:**

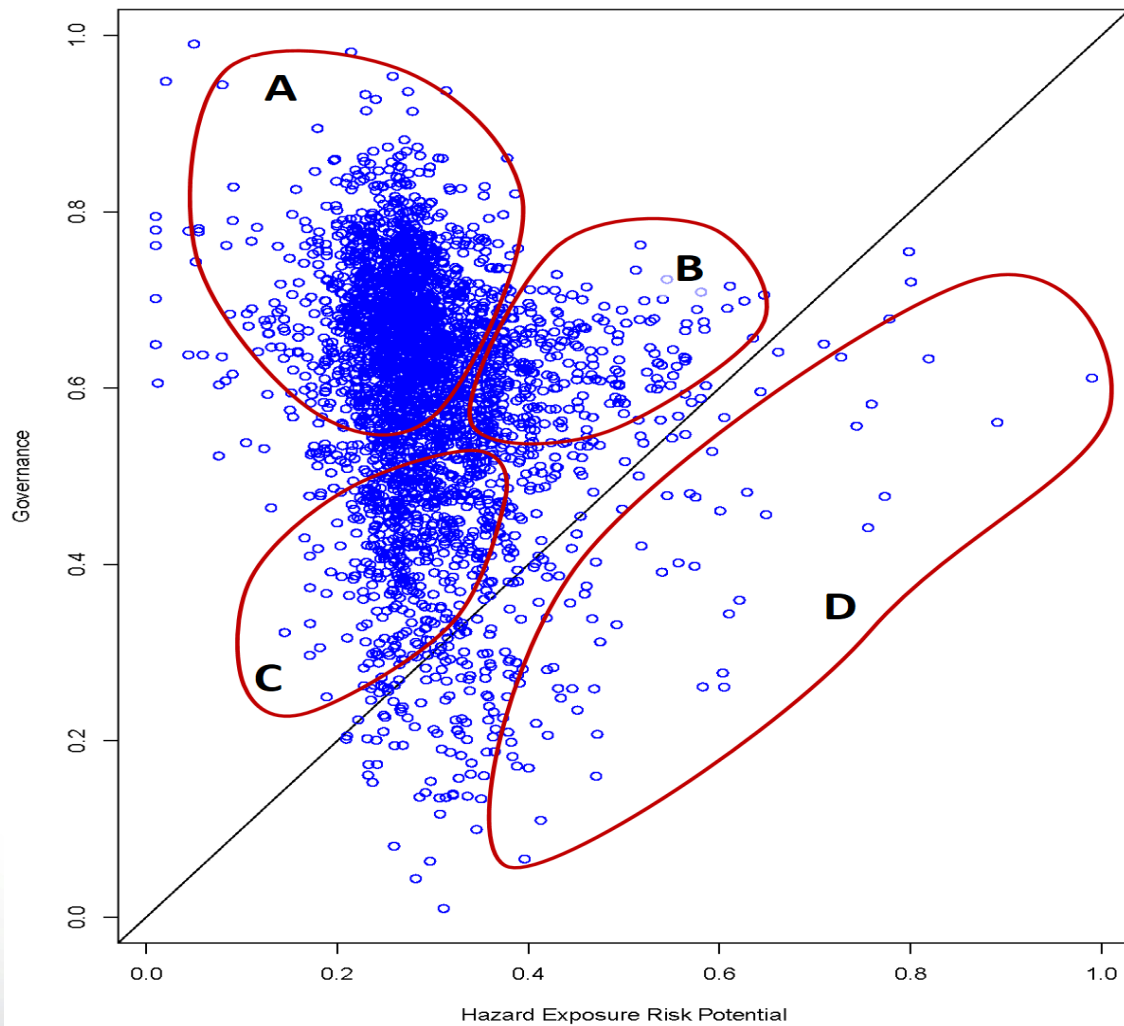
$$\text{Basic Resilience} = \text{Gov}/\text{Risk}$$





Hazard Exposure Score vs. Governance Score – All Counties

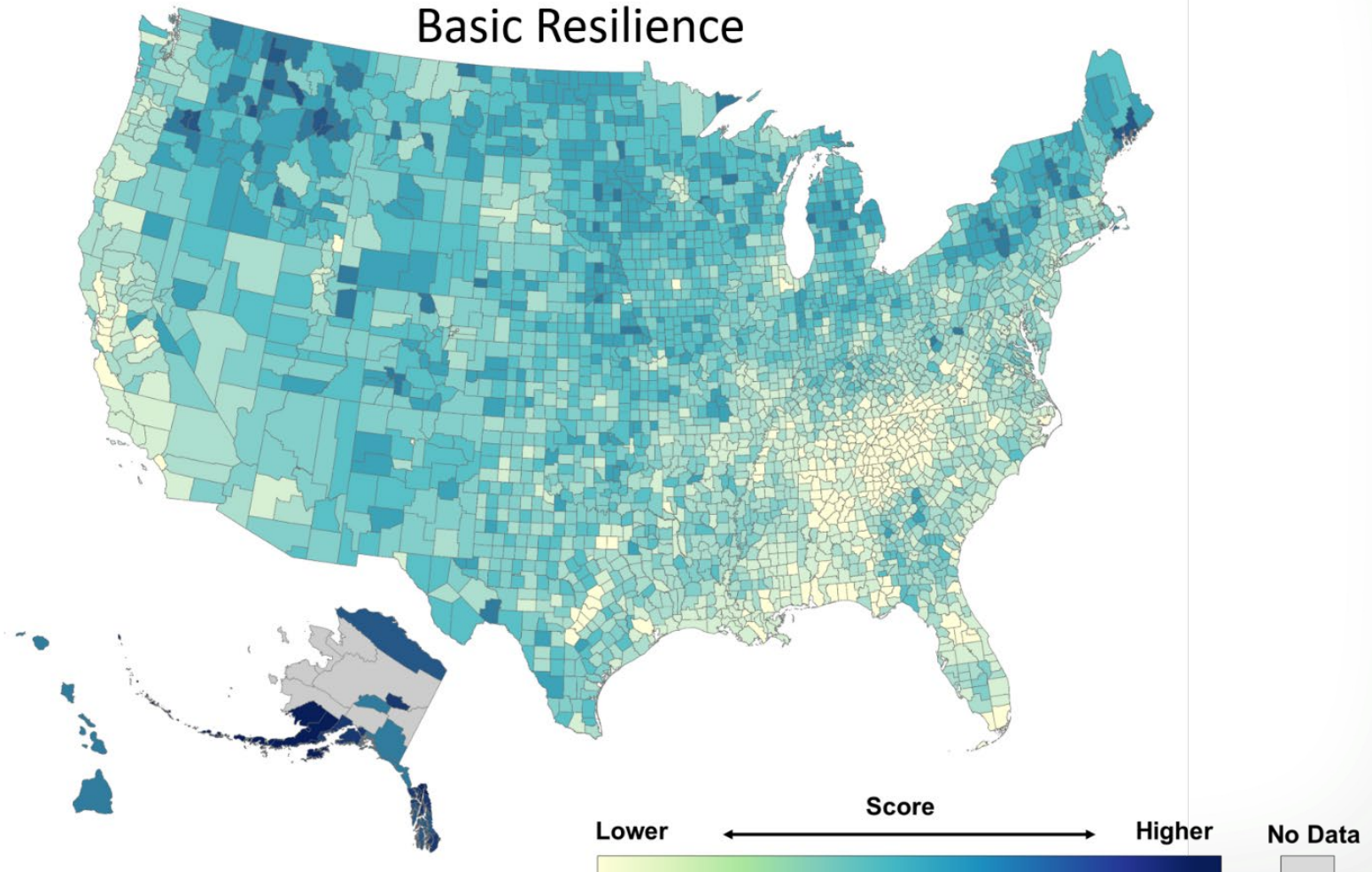
Using All County-Level Domain Scores





Basic Resilience (Governance/Risk)

Basic Resilience





Calculating CRSI

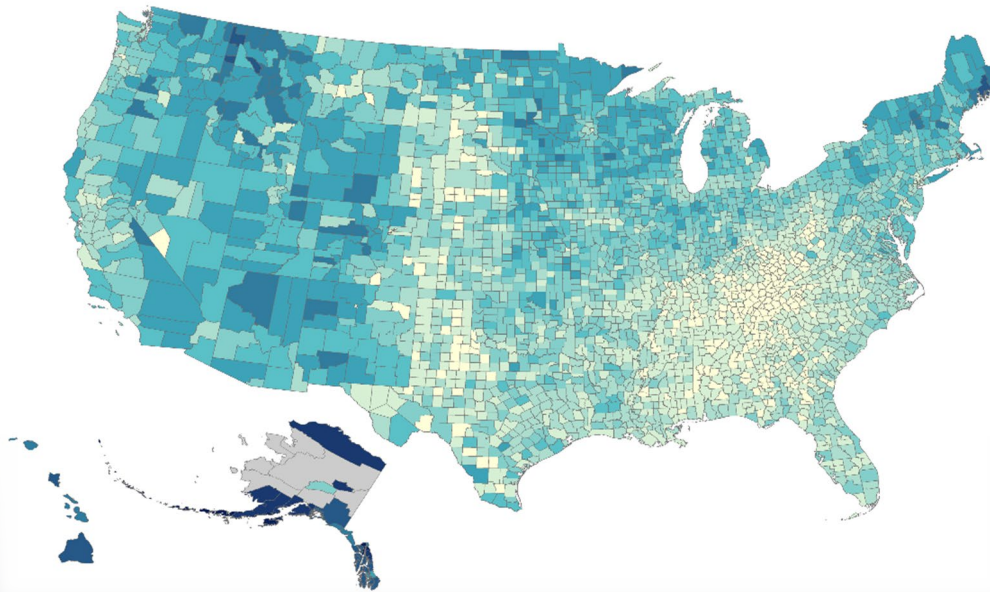
- **Society, Natural Environment and Built Environment domain scores for each county were first adjusted to become factors in the county level CRSI calculation as follows:**

Adj.County Domain Score= (County Domain Score-Median Domain Score for all counties)/(Median Domain Score for all counties)

- **CRSI scores were then calculated for each county as follows:**

$$\text{CRSI} = \frac{\text{Gov} + (\text{Gov} * \text{Adj Society}) + (\text{Gov} * \text{Adj Built}) + (\text{Gov} * \text{Adj Natural})}{\text{Risk}}$$

Risk



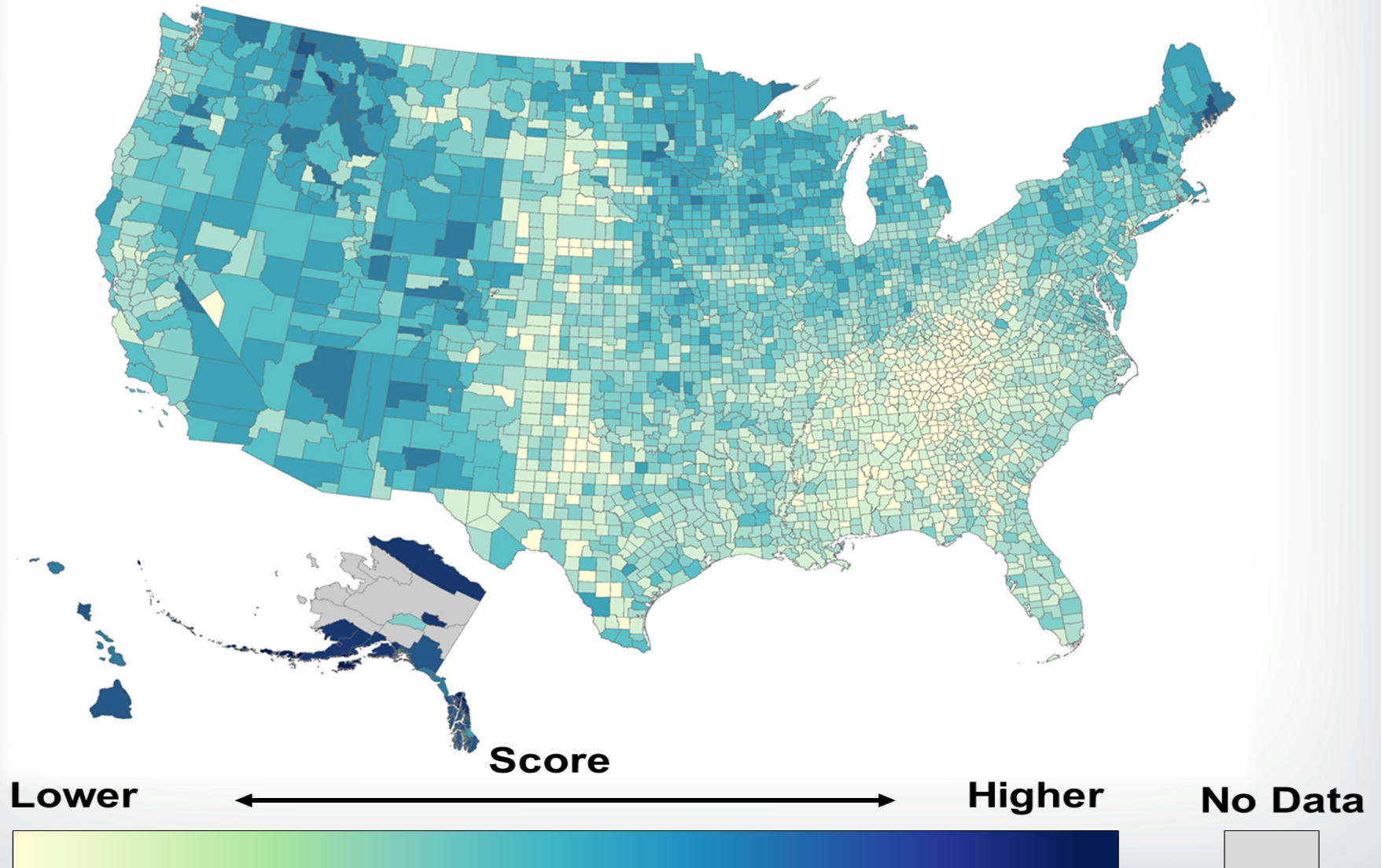


National CRSI Scores

		Risk	Governance	Built Environment	Natural Environment	Society	CRSI
National Average	Including Alaska	0.29590	0.59674	0.39320	0.41333	0.51561	2.71349
	Excluding Alaska	0.29758	0.59575	0.39262	0.41182	0.51587	2.37534

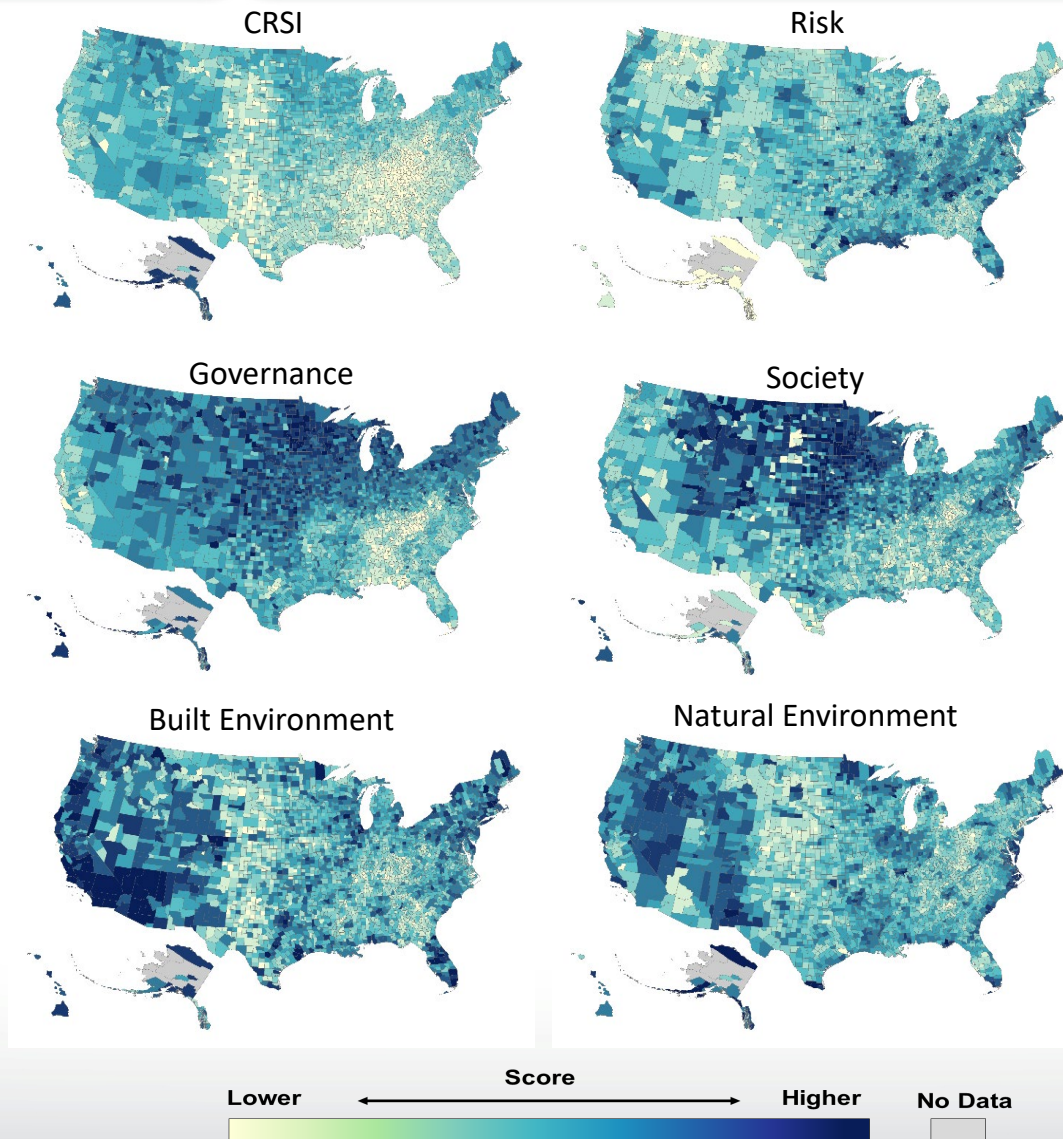


Map of CRSI County Scores



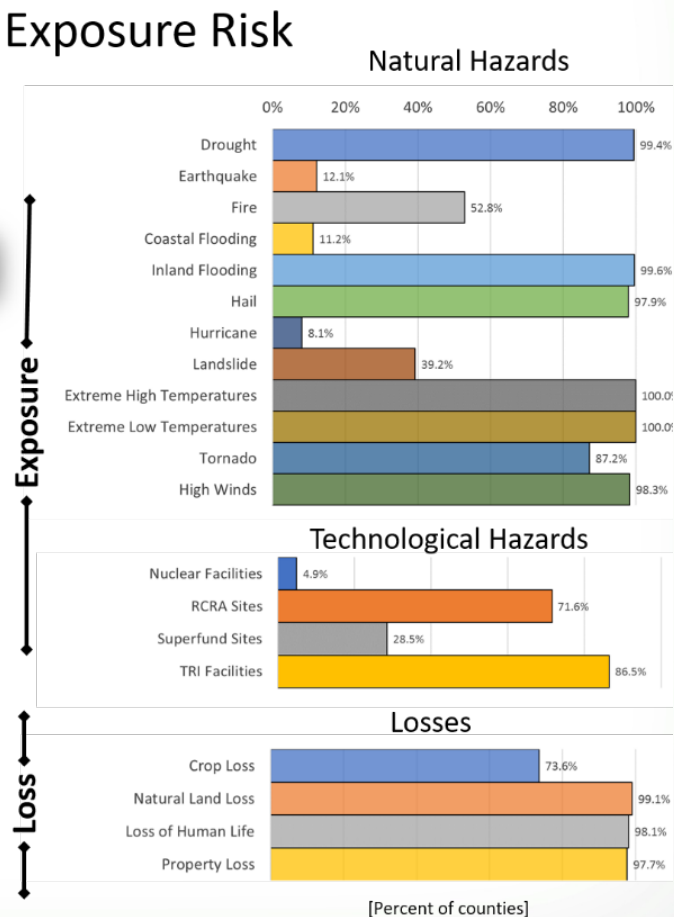
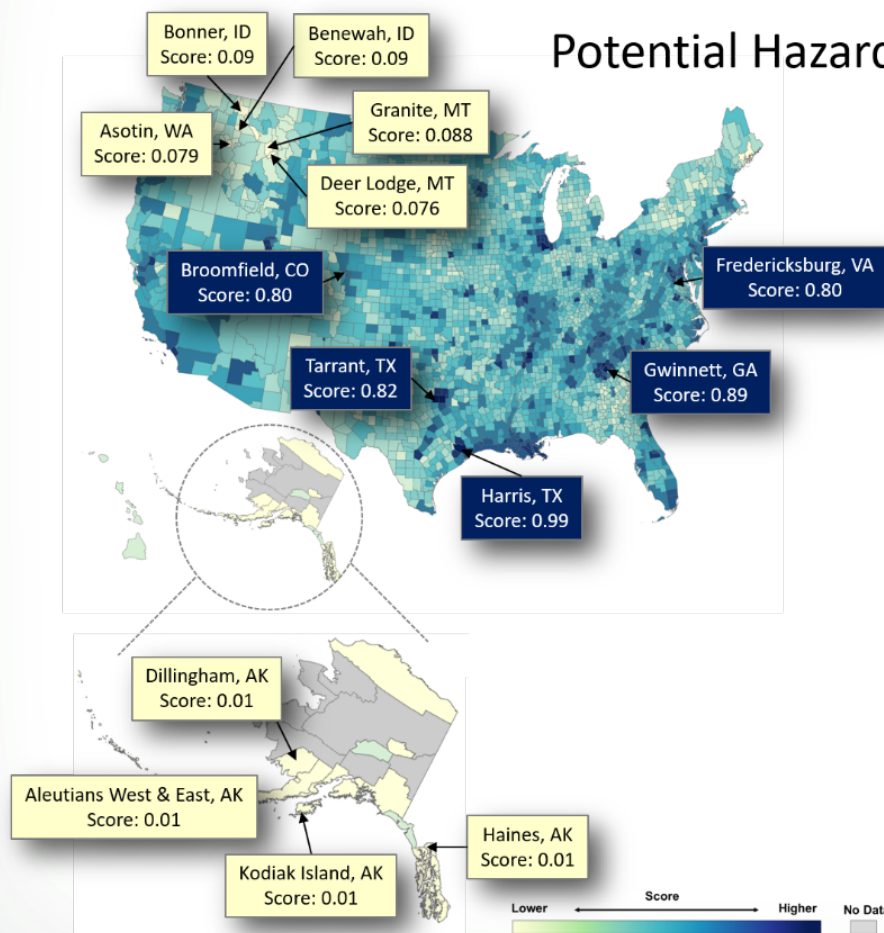


National CRSI and Domain Scores



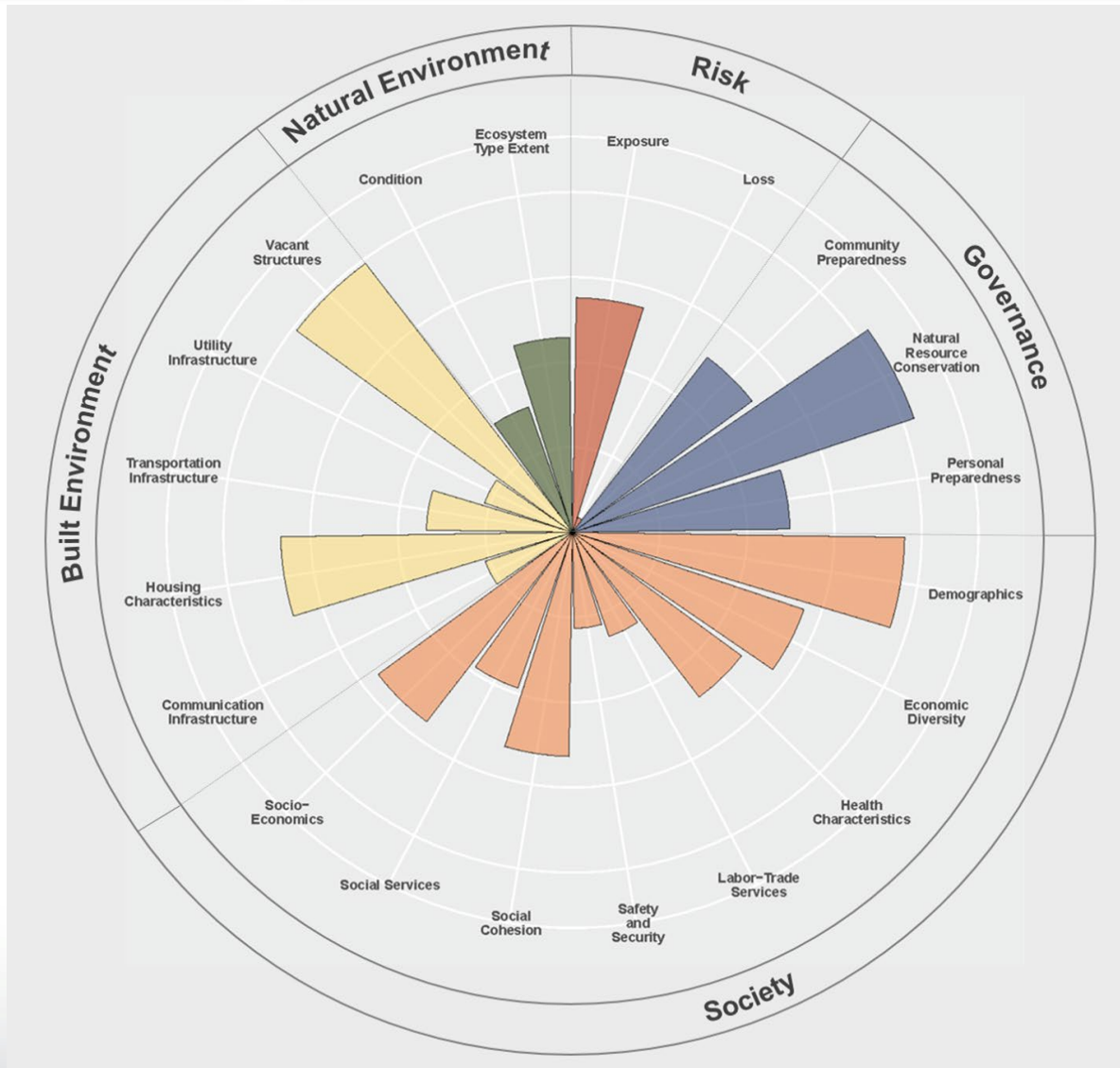


Risk Domain Scores





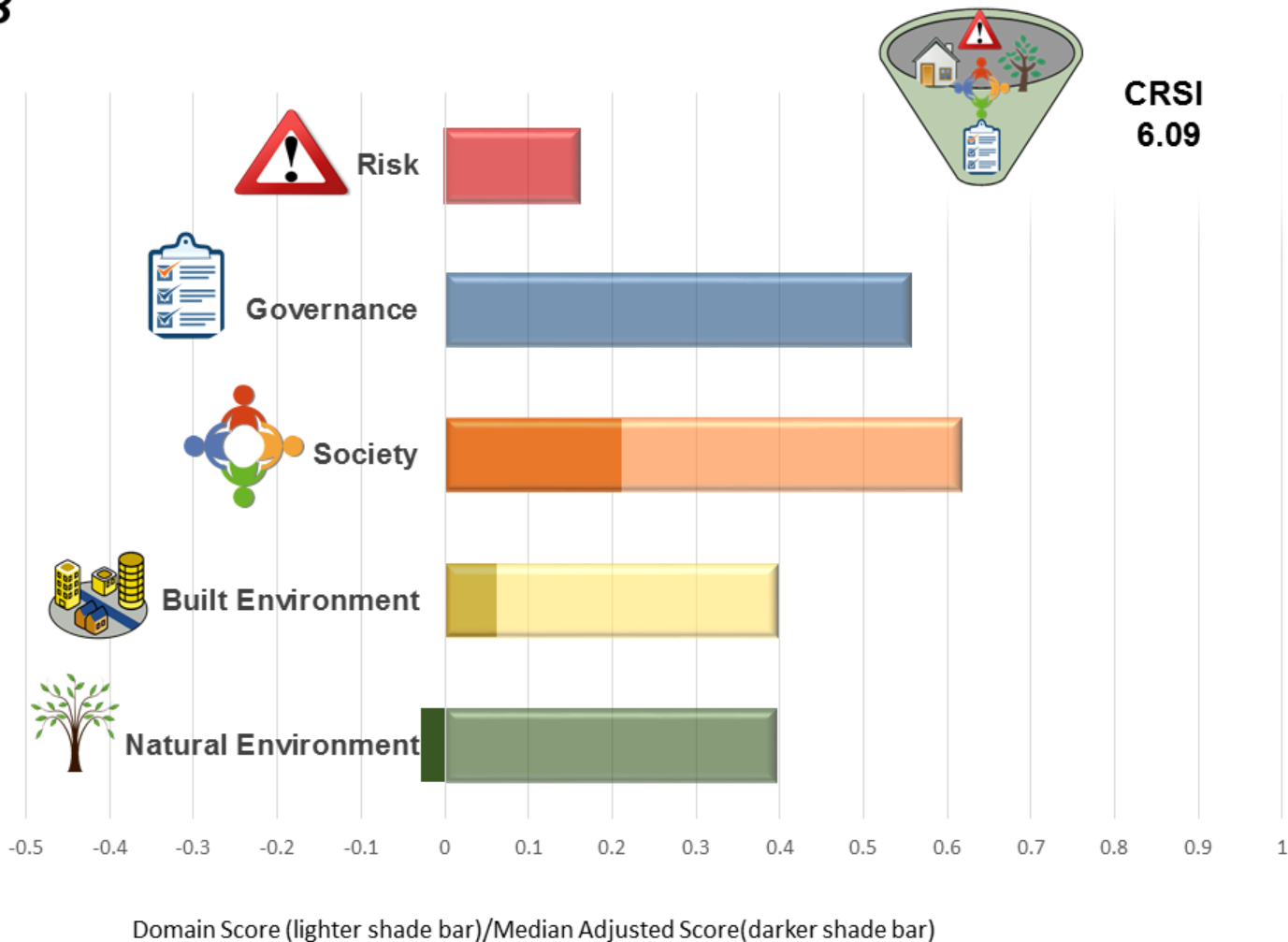
Polar Plot of Contributions





CRSI and Domain Scores – Region 8

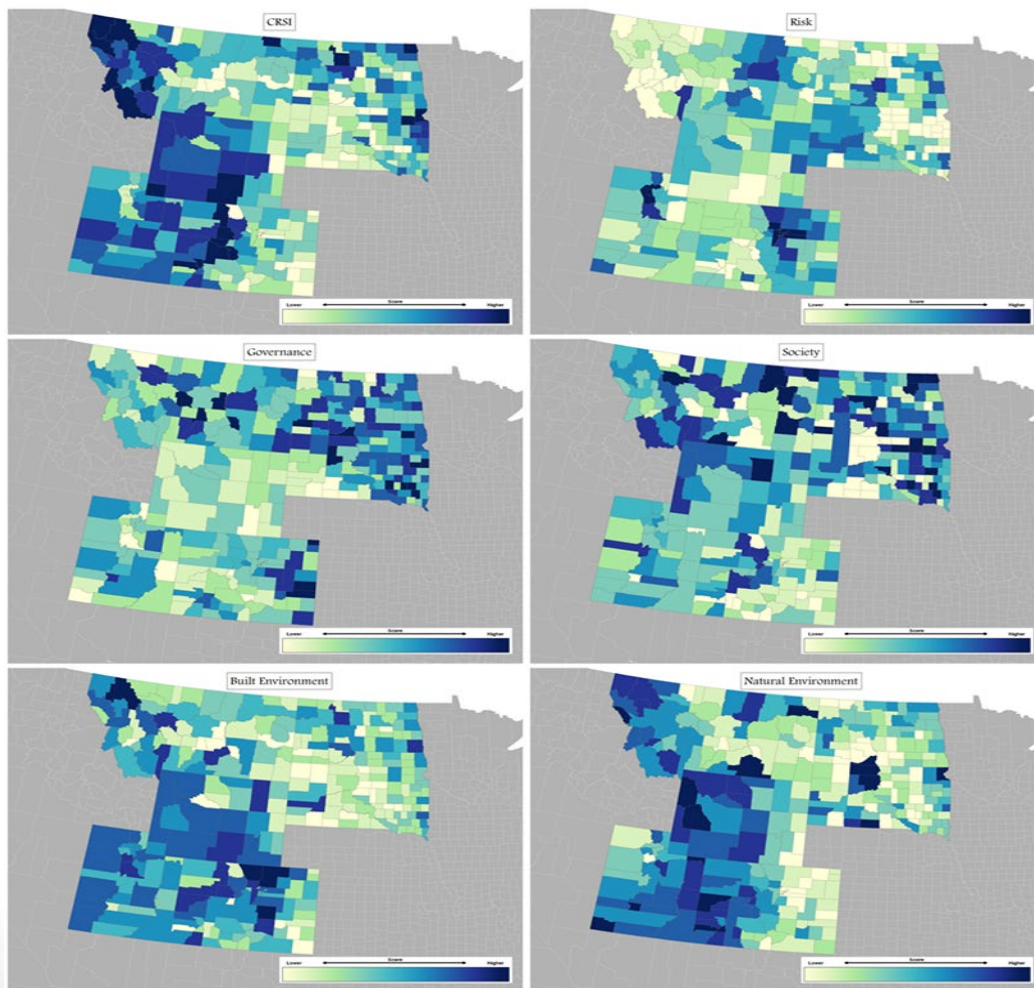
EPA Region 8





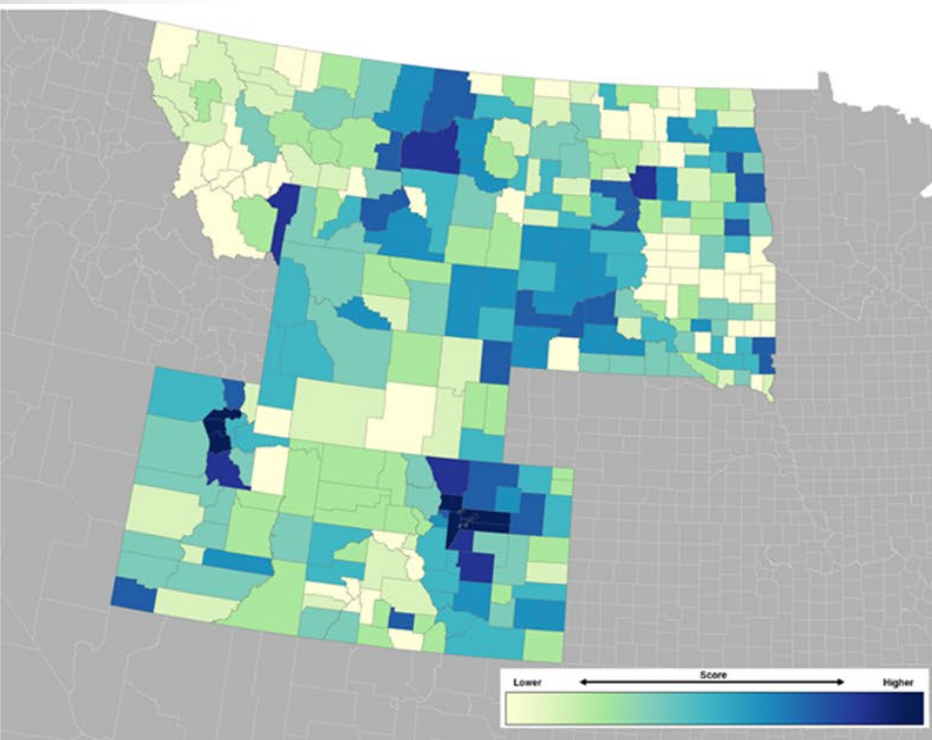
Maps of Region 8 CRSI and Domain Scores

Region 8





Risk Statistics – Region 8



Three Primary Exposures:

1- Drought

2- Extreme Temps – Highs

3- Extreme Temps - Lows

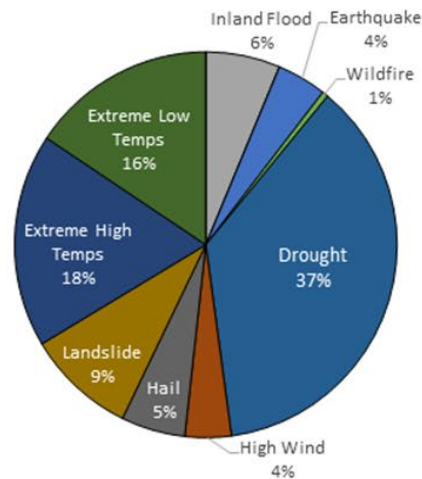
Risk Range:

High – Meade, SD – 4.14

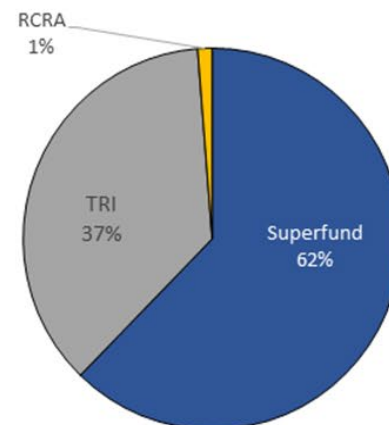
Low – Daniels, MT – 1.42

Mean – 2.54

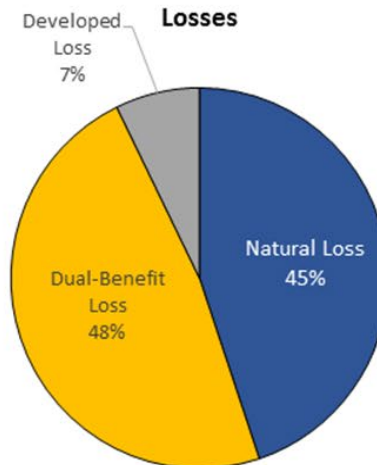
Natural Exposures



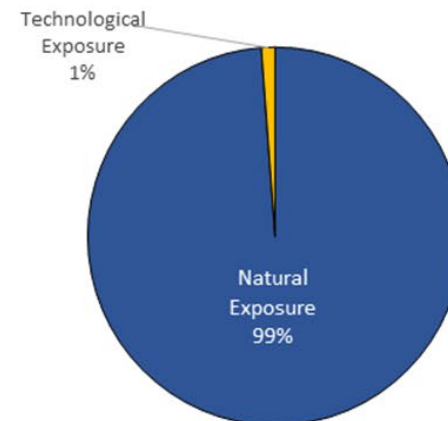
Technological Exposures

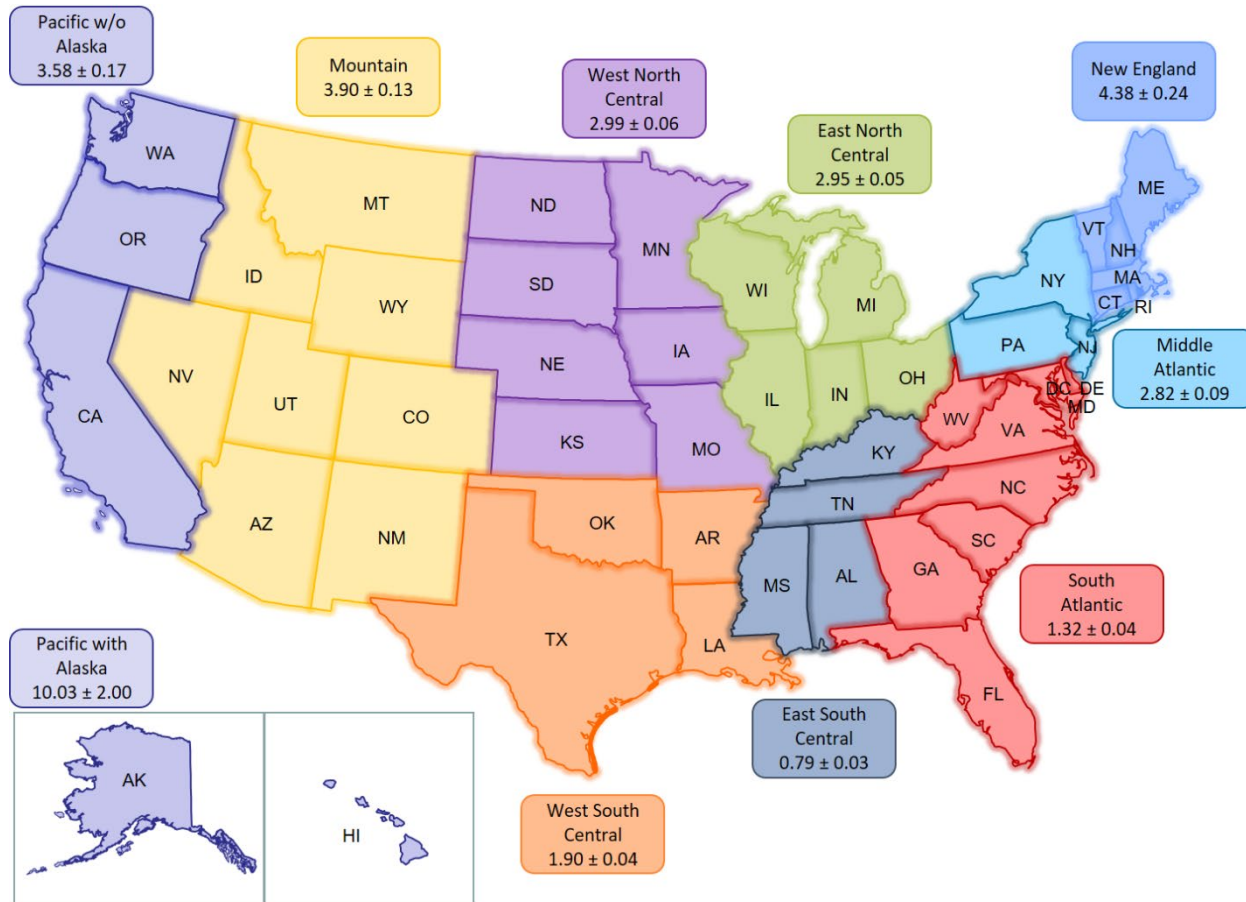


Losses

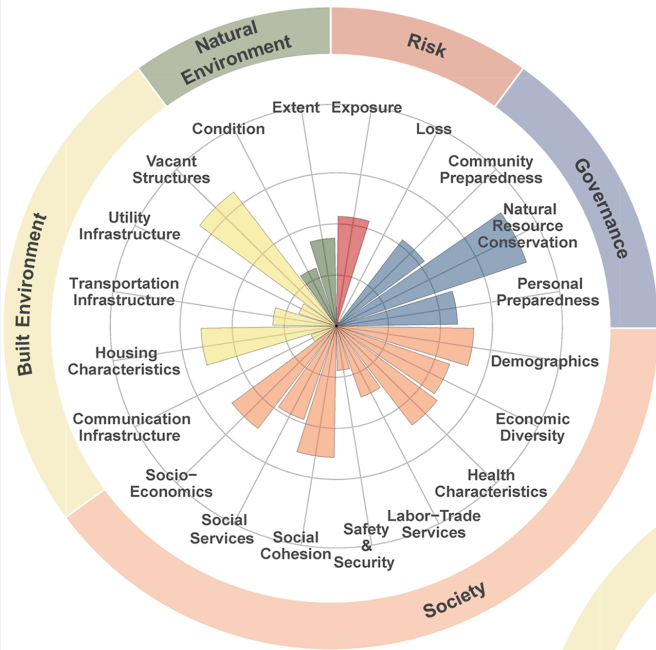


Exposure Type

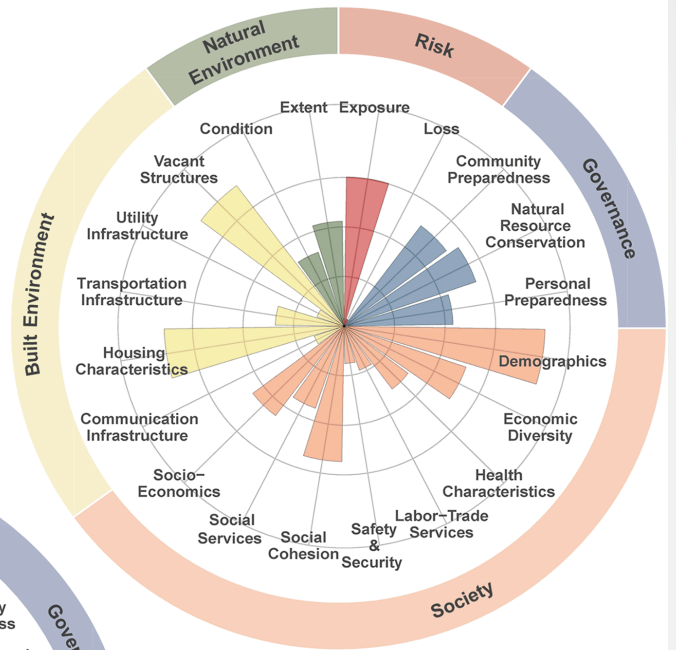




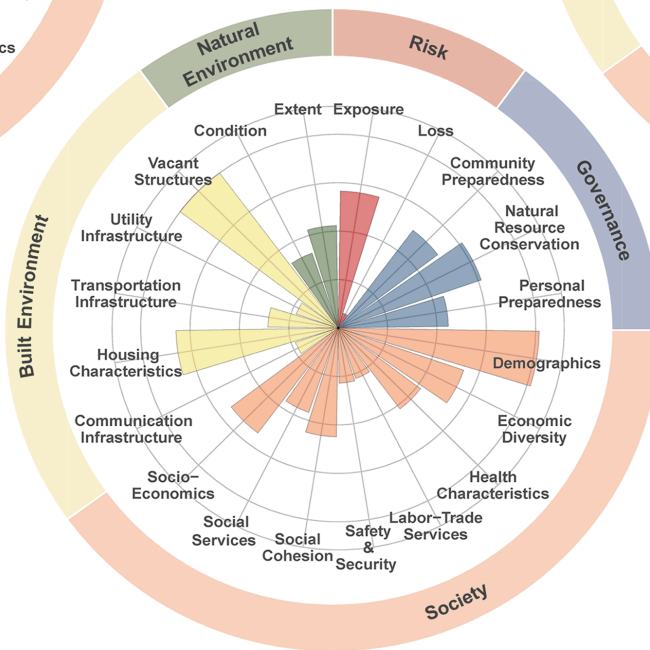
West North Central



East South Central



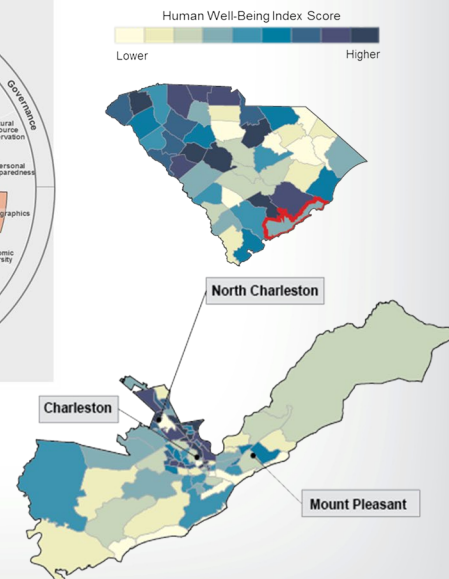
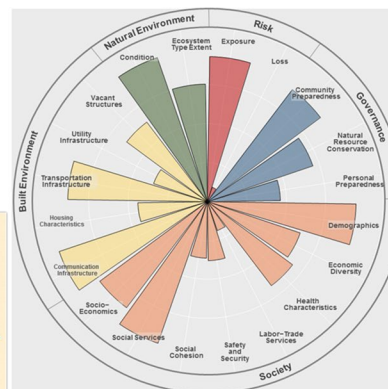
South Atlantic





Climate Resilience Screening Index: Future Applications

- **Adaptation of CRSI to Superfund sites**
- **Retrospective Analyses of Hurricanes of 2017-2018**
- **Analyses of Specific Natural Hazards in US**
- **Cases Studies for CRSI at Community Level**
- **Working with Regions to Assess Research Needs to Support Improvement of Resilience**
- **Evaluation of Relationship between Well-Being and Resilience**



- **National assessments are needed to address widespread socio-ecological impacts of natural hazard events from a policy perspective.**
- **Assessments for geographically specific areas are useful in identifying potential strengths and weaknesses in resilience aspects given similar hazard profiles and governance structures (counties).**
- **As constructed, CRSI allows for a drill down not only in scale, but also at the indicator level which could be useful for targeting resources to increase resilience.**
- **CRSI provides a “starting point” for resilience assessments. Locally held data should be used to supplement CRSI characterizations.**



Available Manuscripts and Reports

- **Summers, J.K., L.M. Smith, L.C. Harwell and K.D. Buck. 2017. Conceptualizing Holistic Community Resilience to Climate Events: Foundation for a Climate Resilience Screening Index. *GeoHealth* 1: 151-164.**
- **Summers, J.K., L.C. Harwell, K.D. Buck, L.M. Smith, D.N. Vivian. J.E. Harvey, M.D. McLaughlin and S.F. Hafner. 2017. Development of a Climate Resilience Screening Index (CRSI) Sustainable and Healthy Communities Research Program Technical Report. EPA600/R-17/238. Office of Research & Development, Washington, DC.**
- **Buck, K.D., J.K. Summers, L.C. Harwell, L.M. Smith and S.F. Hafner. 2018. Development of a Multi-Hazard Landscape for Exposure and Risk Interpretation: The PRISM Approach. *Current Environmental Engineering* 6: doi:[10.2174/2212717806666190204103455](https://doi.org/10.2174/2212717806666190204103455)**
- **Summers, J.K., L.M. Smith, L.C. Harwell, K.D. Buck. 2018. Measuring resilience to acute meteorological events: The Natural Hazard Resilience Screening Index (NaHRSI) – Development and application to the United States. *GeoHealth* 2: 372-394.**
- **Summers, K., L. Harwell, L. Smith and K. Buck 2018. Regionalizing resilience to acute meteorological events: Comparison of regions in the U.S. *Frontiers in Environmental Science*. <https://doi.org/10.3389/fenvs.2018.00147>**
- **Smith, L.M., L.C. Harwell, J.K. Summers, J. Bousquin, J. Harvey and K.D. Buck. 2019. A Demonstration Application of the Climate Resilience Screening Index (CRSI) in U.S. Coastal Shoreline Counties. *Frontiers in Environmental Science*. In Review.**
- **Buck, K.D., J.K. Summers, L.M. Smith and L.C. Harwell. 2019. Application of U.S. Multi-Hazard Risk Assessment: Land and Population Estimates at the Local Scale. *Journal of Natural Hazards*. In review.**
- **Harwell, L.C., D.N. Vivian, M.D. McLaughlin and S.F. Hafner. 2019. Scientific data management in the age of big data: An approach supporting resilience index development effort. *Frontiers in Data Management*. In Review.**
- **Summers, J.K., L.C. Harwell, L.M. Smith and K.D. Buck. 2019. Community Resilience to Natural Hazards – The Climate Resilience Screening Index (CRSI). In: F. Ridzi, M. Davern and C. Stevens (eds.). *Community Quality-of-Life Indicators: Best Cases VIII*. Springer Publishing. In Review.**



THANK YOU



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