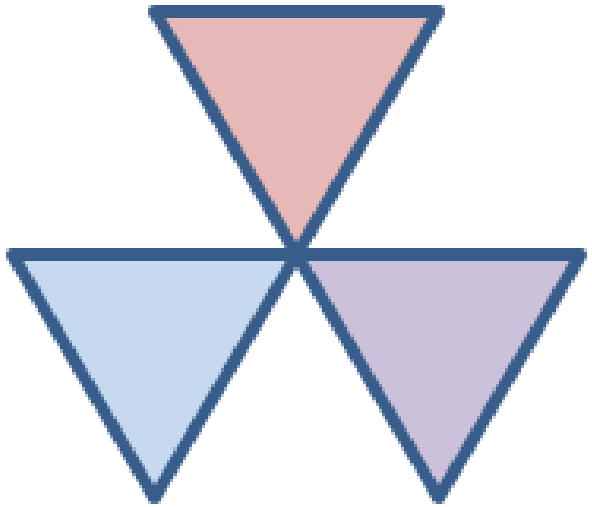
Community Resilience Study

Janey Smith Camp, PhD, PE, GISP, CFM

Research Associate Professor, Department of Civil and Environmental Engineering

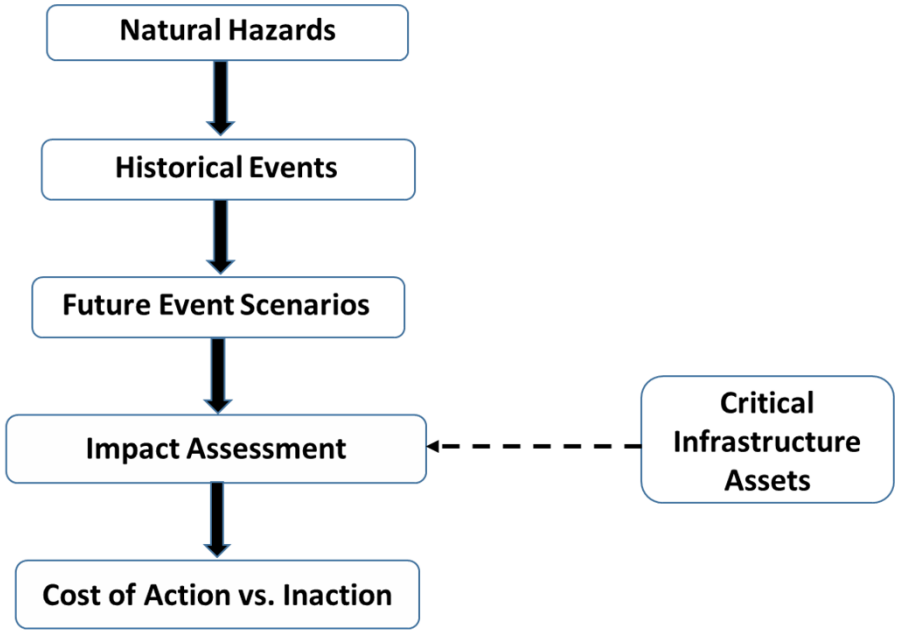
Associate Director, Vanderbilt Engineering Center for Transportation and Operational Resiliency



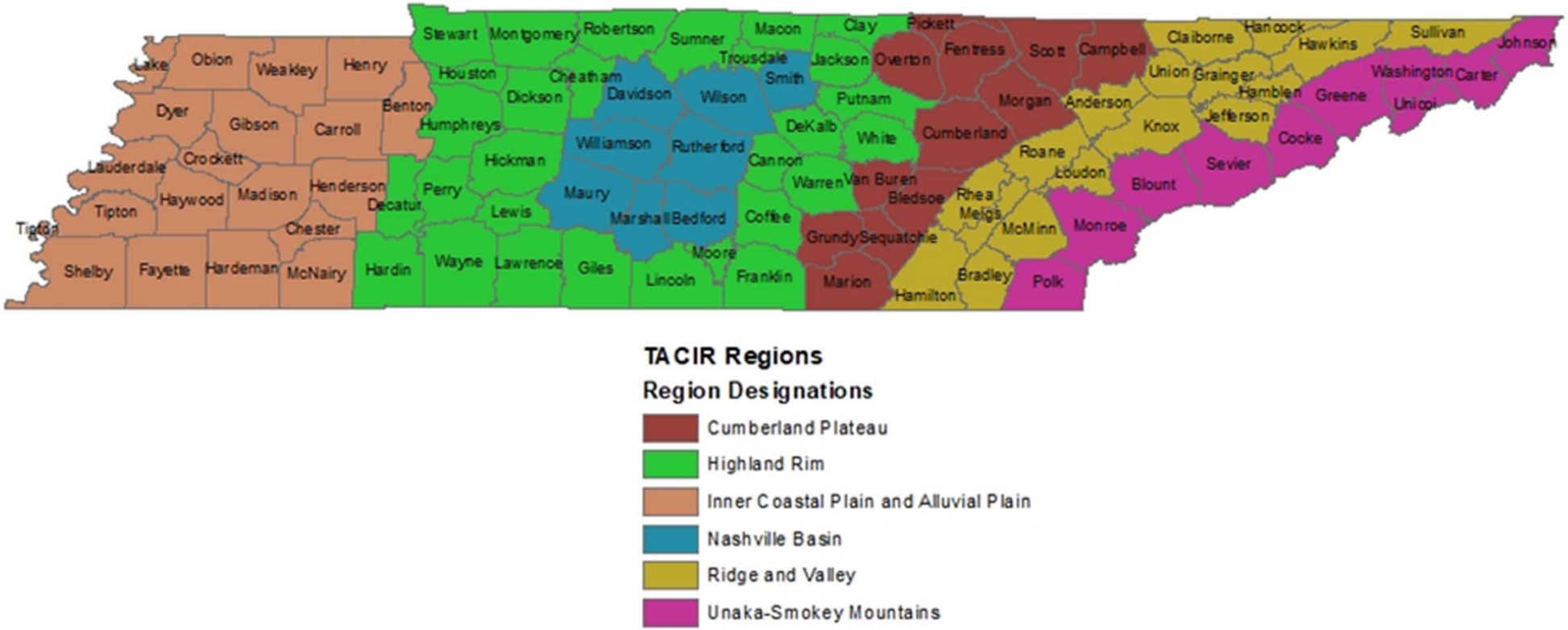
3 Sigma Consultants, LLC

Study Objectives

- Identify different natural hazard risks across the state
  - Extreme weather
  - Earthquakes
- Estimate the potential cost of action and inaction related to community resiliency



Tennessee Climate Regions



Historical Average Annual Extreme Weather Events: 1996-2018

Average Annual Frequency: 1996-2018							
Hazard	Cumberland Plateau	Highland Rim	Inner Coastal & Alluvial Plain	Nashville Basin	Ridge & Valley	Unaka-Smokey Mountains	**TOTAL**
Cold	0.0	1.8	0.4	0.1	0.1	0.0	2.4
Dry	5.7	21.7	14.0	6.0	1.0	0.5	48.8
Frozen Precipitation	46.8	122.3	88.1	49.0	82.7	38.0	427.0
Heat	0.0	3.7	20.9	0.5	0.2	0.0	25.3
Hydrologic	13.7	47.9	32.5	23.0	24.3	8.6	150.0
Lightning	1.6	5.2	4.3	5.4	1.7	0.3	18.5
Rotational Winds	3.2	15.7	7.4	7.6	5.8	2.2	41.8
Straight Winds	59.4	167.4	81.5	94.8	160.3	54.7	618.1
Wildfire	13.9	13.9	13.9	13.9	13.9	13.9	83.6
TOTAL	144.4	399.6	262.9	200.4	289.9	118.3	1415.5

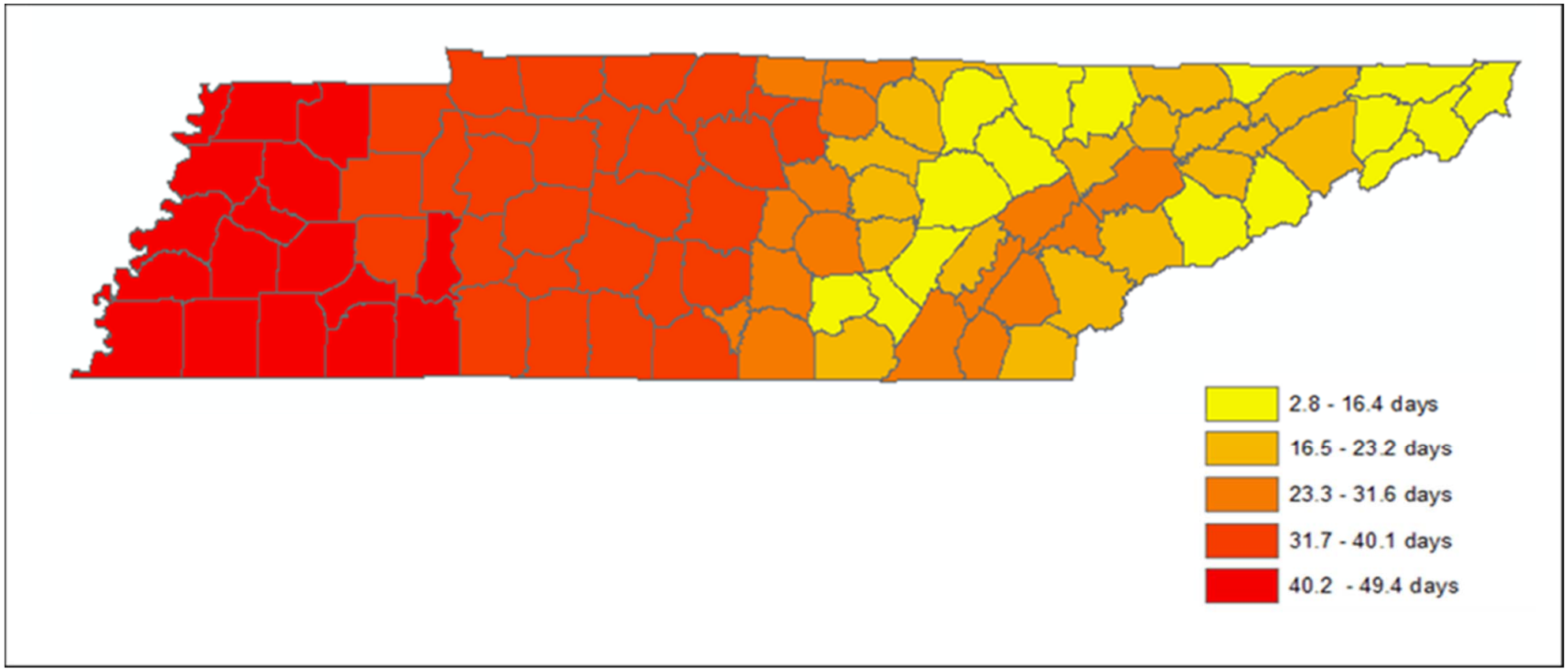
- Tennessee is exposed to a variety of natural hazard events each year.
- All locations in the state are exposed to multiple natural hazards.
- Straight wind, frozen precipitation and hydrologic events are most common.

Projected Average Annual Extreme Weather Events: 2035-2055

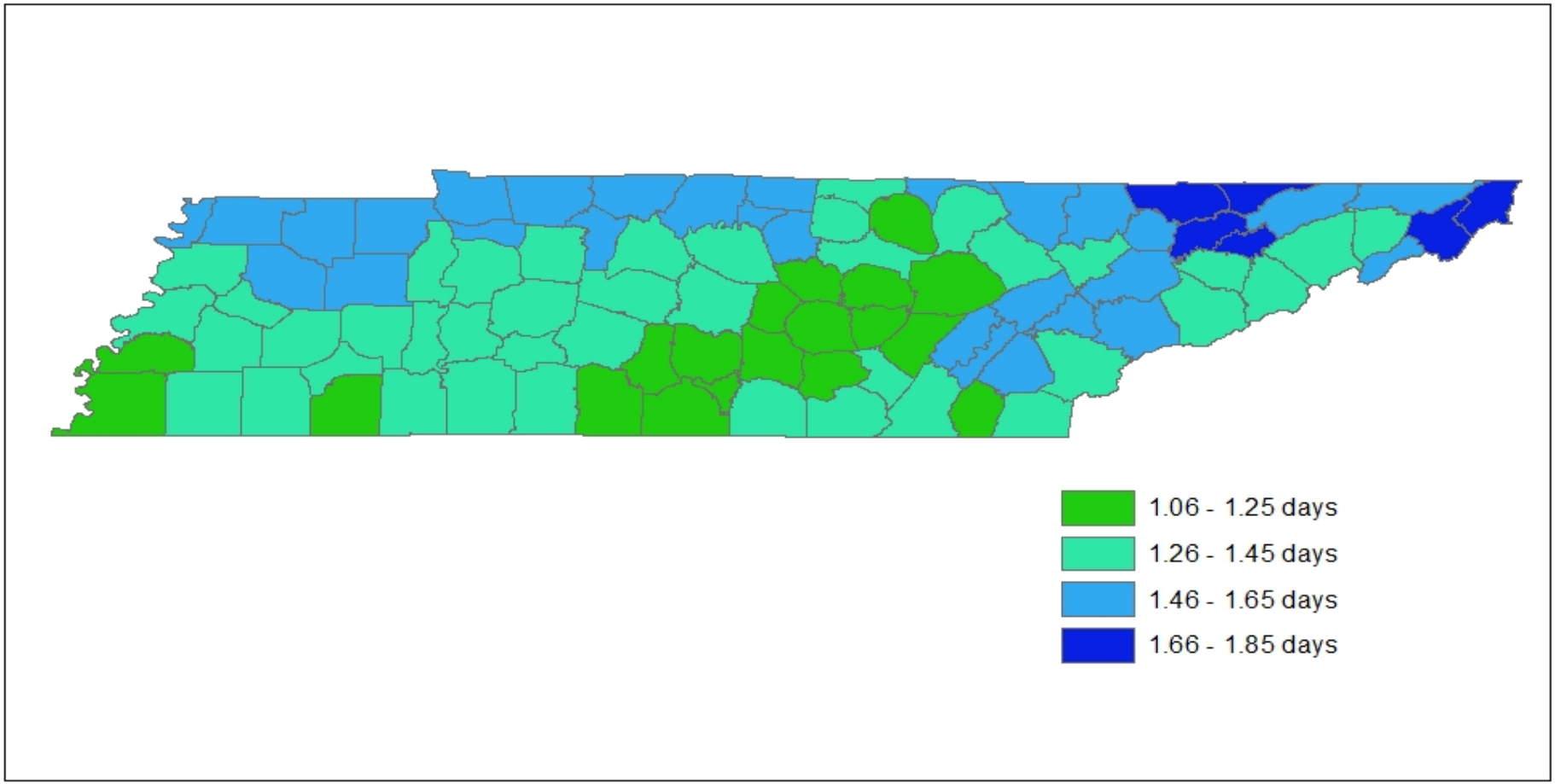
Average Annual Frequency: 2035-2055							
Hazard	Cumberland Plateau	Highland Rim	Inner Coastal & Alluvial Plain	Nashville Basin	Ridge & Valley	Unaka-Smokey Mountains	**TOTAL**
Cold	0.0	1.3	0.3	0.1	0.1	0.0	1.8
Dry	16.1	61.4	39.6	17.0	2.8	1.4	138.3
Frozen Precipitation	54.3	141.9	102.2	56.8	95.9	44.1	495.2
Heat	0.0	15.5	83.8	2.4	1.2	0.0	102.9
Hydrologic	16.8	58.0	37.4	27.6	29.4	10.4	179.6
Lightning	3.3	10.2	8.9	11.2	3.5	0.6	37.7
Rotational Winds	6.6	32.7	15.4	15.8	12.1	4.6	87.2
Straight Winds	123.6	348.0	169.5	197.2	333.4	113.8	1285.5
Wildfire	16.0	16.0	16.0	16.0	16.0	16.0	96.0
TOTAL	236.7	685.0	473.1	344.1	494.4	190.9	2424.2

- Extreme weather event frequency is expected to increase in the future, nearly doubling by mid-century.
- Rising temperatures will be a significant concern.

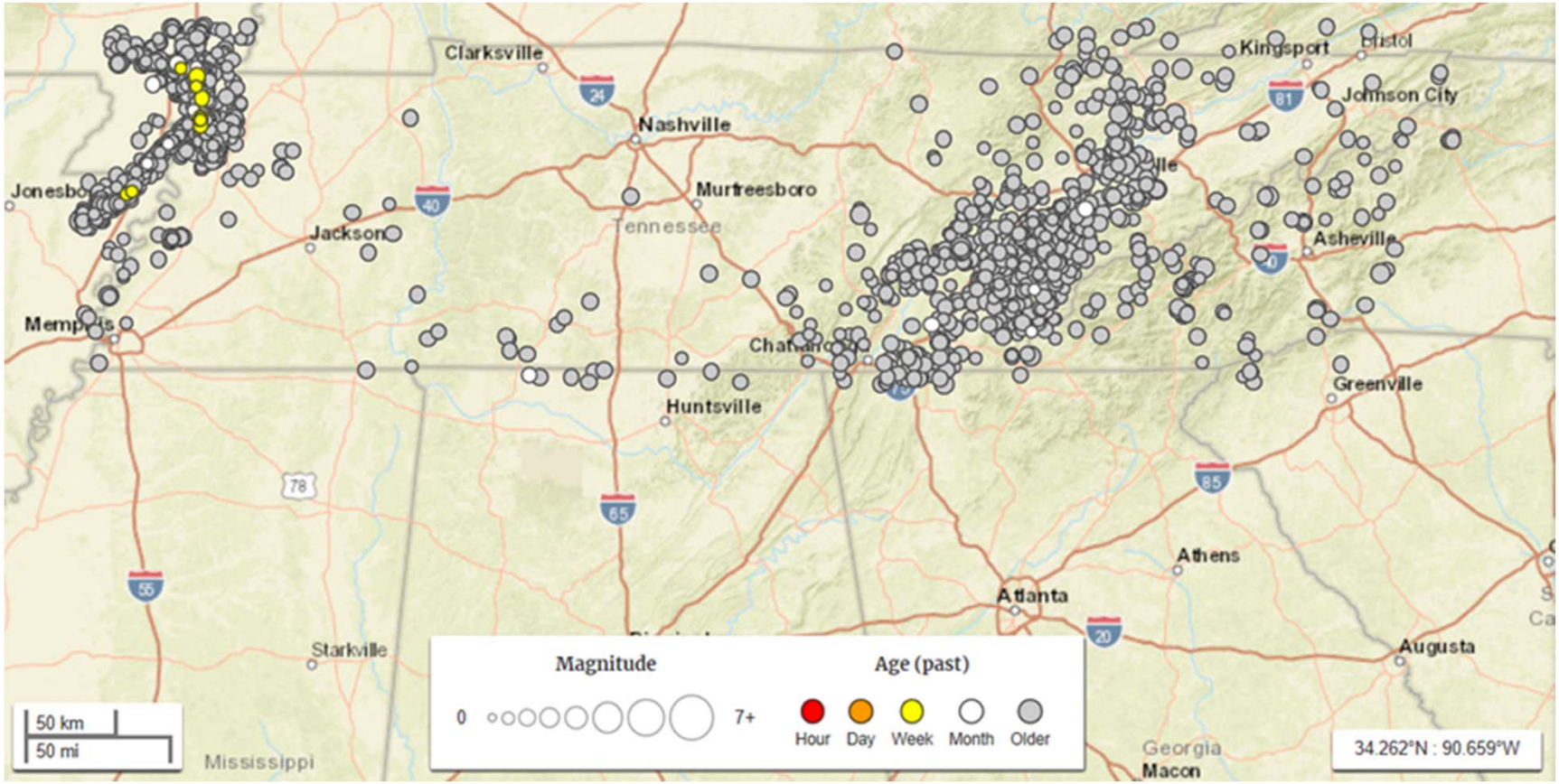
Projected Increase in Days Per Year with Maximum Temperature at or Above 95°F



Projected Change in Average Annual Total Precipitation

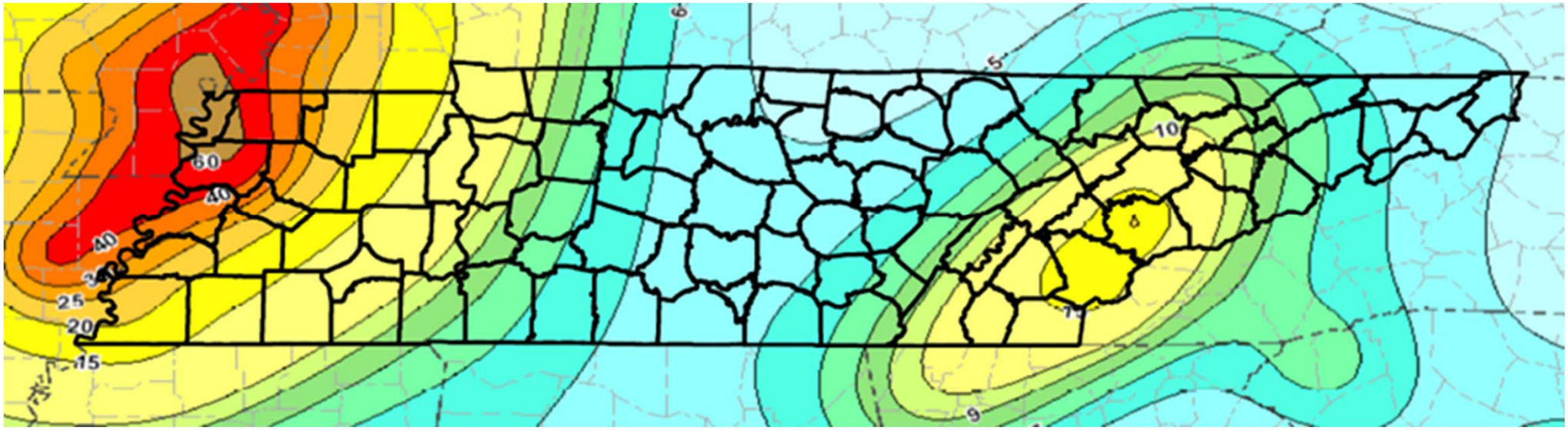


Historical Earthquake Events: 1996-2018



- Seismic zone exists in east TN in addition to New Madrid zone in west TN.

Projected Seismic Hazard Map for Tennessee Based on Estimated Peak Ground Acceleration



Critical Infrastructure

- Defined as Risk Categories III and IV according to International Building Code (IBC)
- Critical infrastructure categories
  - Mass gathering places
  - Power generation
  - Communication
  - Water and wastewater treatment plants
  - Public health facilities
  - Law enforcement
  - Emergency response
  - Transportation
- Virtually every county in the state has each critical infrastructure type in its jurisdiction
- Counties with larger amounts of critical infrastructure correspond to locations that have urbanized areas (e.g., Shelby - Memphis; Davidson - Nashville; Knox - Knoxville; Hamilton - Chattanooga)

Cost of Inaction

Average Annual Risk Cost: 1996-2018

Hazard	Cumberland Plateau	Highland Rim	Inner Coastal & Alluvial Plain	Nashville Basin	Ridge & Valley	Unaka-Smokey Mountains	**TOTAL**
Cold	0	0	0	0	0	0	0
Dry	226	807230	0	456	0	0	807912
Frozen Precipitation	2078423	1586287	254659	1544134	22481	44701	5530686
Heat	0	0	0	5000	0	0	5000
Hydrologic	3733613	7109013	135093418	81844373	12580878	2494260	242855555
Lightning	78393	353958	198821	382589	190638	191987	1396387
Rotational Winds	2599400	15118576	25656877	15416168	8998612	1106085	68895718
Straight Winds	581629	1807993	5611000	1413288	2306955	769404	12490270
Wildfire	754441	754441	754441	754441	754441	754441	4526644
TOTAL	9826124	27537499	167569216	101360448	24854006	5360878	336508171

Average Annual Risk Cost: 2035-2055

Hazard	Cumberland Plateau	Highland Rim	Inner Coastal & Alluvial Plain	Nashville Basin	Ridge & Valley	Unaka-Smokey Mountains	**TOTAL**
Cold	0	0	0	0	0	0	
Dry	670	2809947	0	1848	0	0	2812464
Frozen Precipitation	0	2263745	322052	2557338	29737	59072	5231943
Heat	0	0	0	35878	0	0	35878
Hydrologic	4763094	10594561	169339600	140444944	17349189	3452562	345943949
Lightning	167245	851146	452668	1136559	437372	431478	3476468
Rotational Winds	5621540	38849826	57927227	45778268	21465547	2668142	172310551
Straight Winds	1257932	4623260	12723153	4202868	5471194	1824940	30103347
Wildfire	900490	1065003	943783	1238174	987076	987076	6121602
TOTAL	12710971	61057487	241708482	195395878	45740114	9423270	566036202

- Present cost of inaction – hundreds of million dollars a year.
- Amount expected to nearly double by mid-century.

Cost of Action Versus Inaction

- National Institute of Building Sciences (NIBS) study on financial impacts of investing in natural hazard mitigation actions:

	Exceed 2015 Code Requirements	Meet 2018 Code Requirements	Utilities & Transportation Case Studies	Federally Funded Programs
Overall Hazard B/C Ratio	4:1	11:1	4:1	6:1
Riverine Flood	5:1	6:1	8:1	7:1
Wind	5:1	10:1	7:1	5:1
Earthquake	4:1	12:1	3:1	3:1
Wildland-Urban Interface Fire	4:1	N/A	N/A	3:1

- Benefits accrue to developers, property owners, lenders, tenants, and the community at large
- In addition gains due to avoided disaster losses, investment in risk mitigation actions can act as an economic stimulus by providing job opportunities and other forms of economic development

Takeaway Messages

- Tennessee is exposed to a variety of natural hazard events on an annual basis.
- All locations in the state are exposed to multiple natural hazards.
- The frequency and severity of these events are expected to increase in the future.
- The cost of inaction is at least several hundred million dollars a year, an amount that is could nearly double by mid-century.
- Available risk mitigation actions that the state could undertake show a return-on-investment of anywhere from 3:1 to 12:1.
- Prudent investment of risk mitigation resources could save hundreds of millions of dollars a year in expected disaster costs.