National Risk Index Data Methodology and Hazards Overview

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FEMA

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Table of Contents

List of Figures

1. National Risk Index Data Methodology

1.1. Expected Annual Loss

Expected Annual Loss (EAL) represents the average economic loss in dollars resulting from natural hazards each year. It is calculated for each hazard type and quantifies loss for relevant consequence types: buildings, people, and agriculture.

As the natural hazards component of the National Risk Index data, an Expected Annual Loss score and rating represent a community's relative level of expected losses each year when compared to all other communities at the same level. The Expected Annual Loss is positively associated with a community's risk; thus, a higher Expected Annual Loss value results in a higher National Risk Index value.

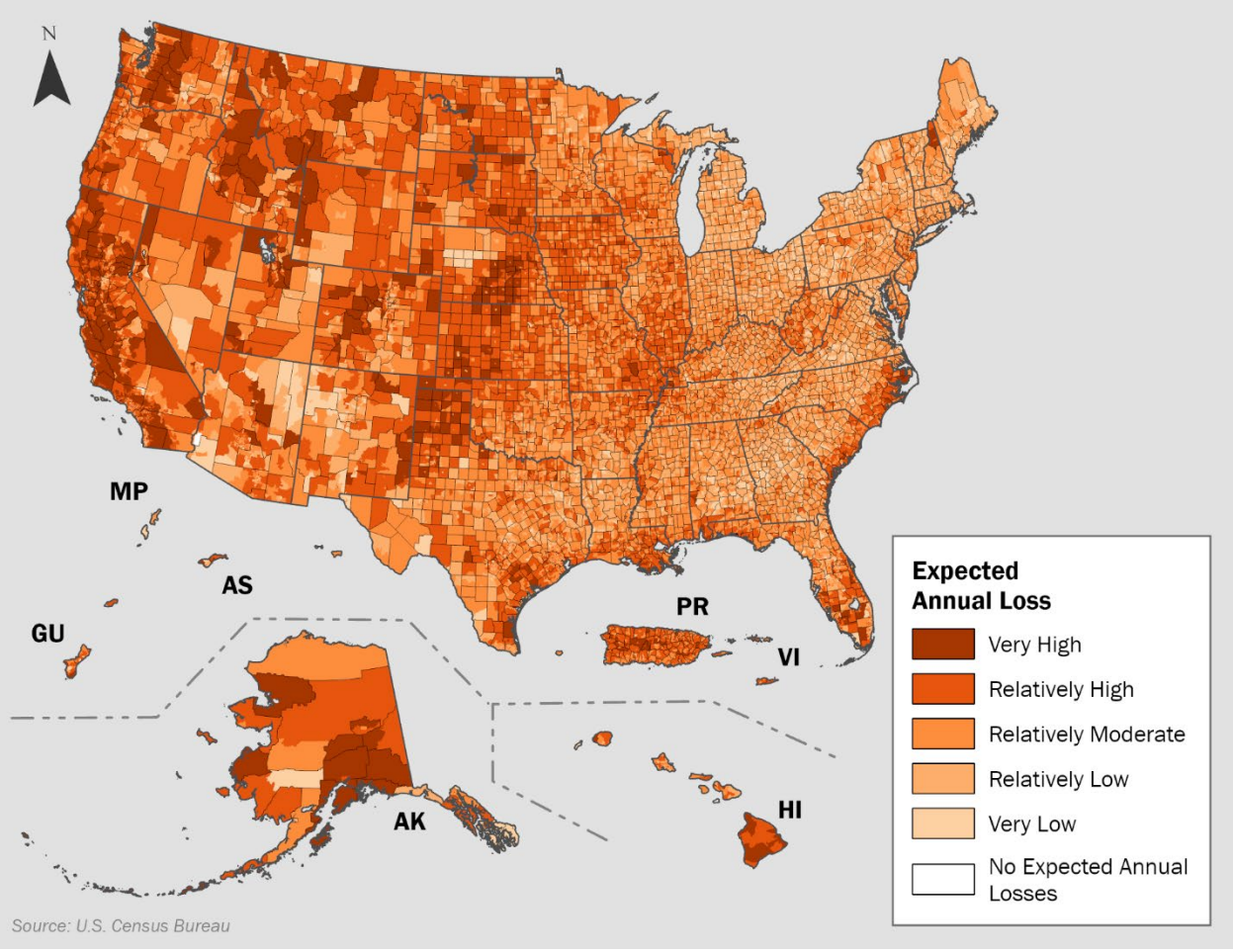

Figure 1: Composite Expected Annual Loss from All Hazards by County

1.1.1. CALCULATE EXPECTED ANNUAL LOSS

Expected Annual Loss is calculated using a multiplicative equation that includes exposure, annualized frequency, and historic loss ratio risk factors for 18 natural hazards.

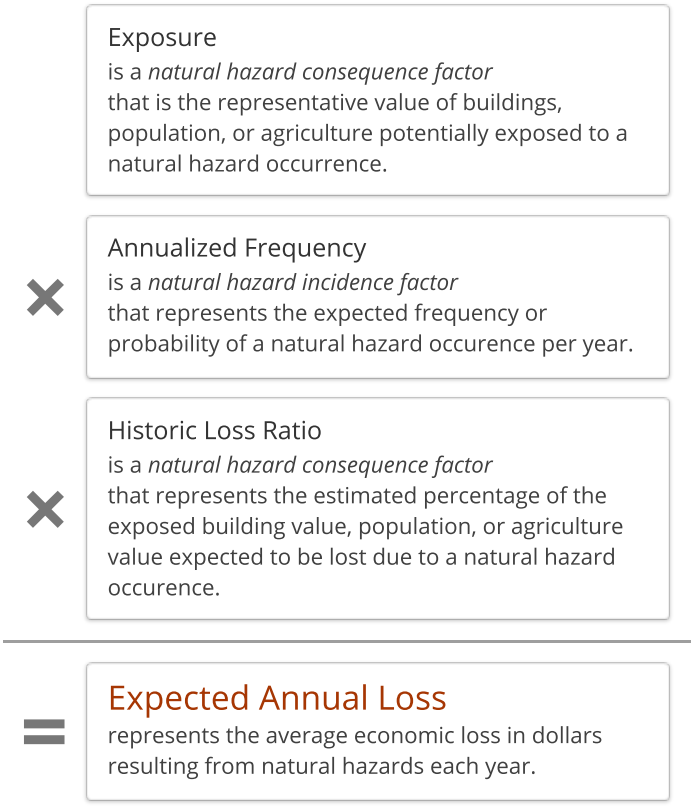

Figure 2: Expected Annual Loss Calculation Equation

The Expected Annual Loss is calculated independently for each consequence type—buildings, population, and agriculture—for each community (county and Census tract).

While building and agriculture values are measured in dollars, population is measured in fatalities and injuries. To ensure a common unit of measurement in the Risk Index, the population Expected Annual Loss is monetized into a population equivalence using a value of statistical life (VSL) approach where each fatality or ten injuries is treated as $13.7 million of economic loss.

To generate the relative hazard type Expected Annual Loss scores, the Expected Annual Loss values for each of the three consequence types—building, population equivalence, and agriculture—are summed to represent the total Expected Annual Loss for each hazard type in each community and are then ranked across communities of the same type. Each community's Expected Annual Loss score is then determined based on its rank nationally.

A composite Expected Annual Loss score measures the national percentile ranking of total Expected Annual Loss of a community considering all 18 natural hazards, while a hazard-type Expected Annual Loss score measures the national rank or percentile of Expected Annual Loss of a community from that specific hazard type.

1.1.2. EXPECTED ANNUAL LOSS RATE

Expected Annual Loss Rate is defined as the proportion of the total value expected to be lost annually for a given community. Expected Annual Loss Rate is calculated separately for building, population, and agriculture consequence types for all 18 natural hazard types (individually and composite).

Total Expected Annual Loss Rates, which consider all three consequence types, are not calculated. However, Total Expected Annual Loss Rate National Percentiles are provided for all 18 hazard types (individually and composite). These metrics rank communities by a weighted average of Expected Annual Loss Rates across all consequence types.

1.2. Exposure

Exposure is defined as the representative value of buildings (in dollars), population (in both people and population equivalence dollars), or agriculture (in dollars) potentially exposed to a natural hazard occurrence. Exposure is a natural hazard consequence factor for Expected Annual Loss, the natural hazard component of the National Risk Index data. A higher exposure value results in higher Expected Annual Loss and Risk Index scores.

Depending on the hazard type, exposure areas were determined by historical events, hazard-susceptible zones, or probabilistic modeling.

1.2.1. SOURCE DATA

Exposure data sources were selected for their accuracy, long period of record, and spatial components based on the best available, national-level data per natural hazard. Sources were identified through public knowledge, subject matter expert recommendations, and research, and came from several federal government agencies and academic institutions. Data for territories were included in this data release based on the availability, compatibility, and reliability of source data for those geographies.

1.2.2. CONSEQUENCE TYPES

Exposure is based on three consequence types: buildings, population, and agriculture.

Note: Not all consequence types are considered for all hazard types. Building and population exposure are modeled for all hazard types except Drought, which only modeled agriculture exposure. Agriculture exposure was also modeled for the Cold Wave, Hail, Heat Wave, Hurricane, Inland Flooding, Strong Wind, Tornado, Wildfire, and Winter Weather datasets.

- **Buildings**

Building exposure is defined as the dollar value of the buildings determined to be exposed to a hazard according to a hazard-specific methodology. The maximum possible building exposure of a Census tract, or county is its building value as recorded in Hazus 6.1, which provides 2022 valuations.

- **Population**

Population exposure is defined as the number of people determined to be exposed to a hazard according to a hazard-specific methodology. The maximum possible population exposure of a Census tract, or county is its population as recorded in Hazus 6.1. Population exposure is also monetized using a value of statistical life (VSL) approach in which each fatality or ten injuries is treated as $13.7 million of economic loss.

- **Agriculture**

Agriculture exposure is defined as the dollar value of the crops and livestock determined to be exposed to a hazard according to a hazard-specific methodology. This is derived from the United States Department of Agriculture 2017 Census of Agriculture county-level value of crop and pastureland.

1.2.3. EXPOSURE METHODOLOGY

Exposure is typically calculated at the Census block level for each consequence type and then aggregated to the Census tract and county level by summing the Census block exposure values within the parent Census tract and parent county.

While there are significant differences in the nature of the hazard types and diversity of source data formats, each hazard type can be thought of as having a footprint or exposure area where the hazard can occur and result in loss. Exposure areas associated with each hazard type are modeled in one of three ways:

1. **Widespread exposure areas** were used for hazard types where, if the hazard were to occur, it could happen anywhere in the community with equal likelihood (*e.g.*, Lightning, Hail, Strong Wind datasets).
2. **Hazard susceptible zones** were used for hazard types where there are specific areas within the community where the hazard can occur (*e.g.*, flood zones along a river).
3. **Fixed exposure sizes** were used for the Tornado hazard dataset representing the average area impacted by a hazard occurrence.

Once the exposure areas were defined for each hazard type using one of the approaches, the National Risk Index data estimated the exposure values for building, population, and agriculture using a hazard-specific methodology.

1.3. Annualized Frequency

Annualized frequency is defined as the expected frequency or probability of a hazard occurrence per year. It is a natural hazard incidence factor for Expected Annual Loss, the natural hazards component of the National Risk Index dataset. A higher annualized frequency value results in higher Expected Annual Loss and National Risk Index scores.

Annualized frequency is derived from either the number of recorded hazard occurrences each year over a given period or the modeled probability of a hazard occurrence each year.

1.3.1. SOURCE DATA

Annualized frequency data come from multiple sources and depend on the hazard type. Data sources were identified through public knowledge, guidance by subject matter experts, and research. Providers of frequency data include federal and state government agencies, intergovernmental organizations, academic institutions, and research organizations.

Please see each natural hazard to learn more about the annualized frequency source data for specific hazard types.

1.3.2. ANNUALIZED FREQUENCY METHODOLOGY

Annualized frequency can be calculated as the number of historical occurrences of a natural hazard within a known period of record per geographic area using the following equation:

Annualized Frequency = Number of Recorded Events or Event-Days / Period of Record

Hazards cause losses over different durations. Lightning losses may take minutes, hurricane losses may take hours, while drought losses may take months. For hazards with shorter durations, *event counts* are the basis for representing annualized frequency (*i.e.*, number of events/year). For longer duration hazards, *event-days* are the basis for estimating annualized frequency (*e.g.*, number of event-days/year). This distinction in characterizing the frequency basis was important to ensure alignment with the calculation of the historic loss ratio.

The standard equation introduced above is one approach used in the National Risk Index data for calculating annualized frequency for some hazard types. It is particularly applicable to hazard types that occur in large geographic areas, and those with a statistically significant number of historical occurrences. However, as geographic boundaries are partitioned into smaller areas (*i.e.*, Census tracts, Census blocks), those that have no recorded hazard occurrences would receive an annualized frequency of zero. Because the Expected Annual Loss and National Risk Index equations are multiplicative, any individual risk factor of zero results in an overall Expected Annual Loss and National Risk Index score of zero.

To address this issue, the National Risk Index data applied three approaches to estimate annualized frequency:

1. **Hazard Event Counting Using a Fishnet Grid**: This approach involved creating a 49-by-49 km fishnet grid covering the United States and counting the number of hazard occurrences (events or event-days) within each cell. Communities within the cell inherit the hazard occurrence count, and annualized frequency is then calculated according to the standard equation. Hazard datasets using this approach include Hail, Hurricane, Ice Storm, Strong Wind, and Tornado.
2. **Minimum Annual Frequency**: A minimum annual frequency is assigned to areas that have not experienced a hazard occurrence recorded by the source data during the period of record but are determined to be at some risk due to their location. Appropriate minimum annual frequency values were identified by experts for specific hazard types. The estimated values were typically small given the fact that no hazard occurrences had been recorded over the period of record. Minimum values were typically defined in the format of "once in the period of record," or similar. Hazard datasets using this approach include Avalanche, Hurricane, Ice Storm, Landslide, Inland Flooding, Tornado, and Tsunami.
3. **Hazard Event Shape Buffering**: For hazard types with widespread and/or unpredictable locations, hazard occurrence locations or paths were buffered by expert-determined distances to create more representative areas of where the hazard could occur. Hazard datasets using this approach include Hail, Hurricane, Strong Wind, Tornado, Tsunami, and Volcanic Activity.

Some hazard types did not require any of these solutions due to the nature of the source data or the widespread prevalence of the hazard. For example, the spatial data for Cold Wave, Heat Wave, and Winter Weather occurrences cover areas the size and shape of National Weather Service Forecast Zones and counties. These hazards can occur across the entire United States, so it is not necessary to spread their area of influence any further.

For most hazard types, annualized frequency was first calculated at the Census block level. Then values were aggregated to their parent Census tract and county levels. For a few hazard types, annualized frequency was first calculated at the Census tract level before aggregating to the county level. Avalanche and Inland Flooding are the only hazards where annualized frequency was first calculated at the county level, after which Census tracts and Census blocks inherited the value of their parent county.

1.4. Historic Loss Ratio

The historic loss ratio (HLR) is defined as a hazard- and county-specific estimate of the percentage of the exposed consequence type (building value, population, or agriculture value) expected to be lost due to a hazard occurrence. For example, building historic loss ratio is the estimated percentage of the exposed building value expected to be damaged by a hazard occurrence.

Historic loss ratio is a natural hazard consequence factor for Expected Annual Loss, the natural hazards component of the National Risk Index data. A higher historic loss ratio results in higher Expected Annual Loss and National Risk Index scores.

1.4.1. SOURCE DATA

Arizona State University's Center for Emergency Management and Homeland Security's Spatial Hazard Events and Losses Database for the United States (SHELDUS) loss data are used in the calculation of historic loss ratios for all hazard types, except the Cold Wave dataset. SHELDUS provides county-level data that corresponds to nearly all the natural hazards represented by the National Risk Index dataset. SHELDUS offers a further degree of description by identifying events by peril as well as hazard. SHELDUS aggregates property damage, crop losses, injuries, and fatalities due to a peril by month, year, and county. Because SHELDUS hazards do not directly map into the hazard types included in the National Risk Index data were downloaded at the more granular peril level and then mapped to the appropriate National Risk Index hazard type. Cold Wave is the only hazard type that did not use SHELDUS and instead leveraged the National Oceanic and Atmospheric Administration's National Centers for Environmental Information's Storm Events Database, which provides consequence estimates from hazard occurrences.

Census data and various natural hazard-specific exposure and susceptibility data are also used in the calculation of historic loss ratio.

1.4.2. HISTORIC LOSS RATIO METHODOLOGY

To begin with the determination of historic loss ratio, a Loss Ratio per Basis (LRB) was calculated for each loss-causing hazard occurrence using the following equation:

LRB = Loss / Exposure

- **LRB** represents the ratio of loss to exposure experienced by a county from a hazard occurrence of a specific hazard type. This value is calculated for each relevant consequence type.
- **Loss** is the loss, by consequence type, experienced from each hazard occurrence documented in the source data.
- **Exposure** is the total value, by consequence type, estimated to have been exposed to the hazard occurrence.

Loss Ratios per Basis were calculated for each loss-causing hazard occurrence in the source data. However, hazards may occur without resulting in any recorded losses to buildings, population, or agriculture. For example, Lightning may strike with a high frequency but have few loss-causing hazard occurrences. SHELDUS only documents events where losses occurred.

To ensure that the historic loss ratio is calculated more appropriately, zero-loss hazard occurrences were inserted into the set of Loss Ratios per Basis to make up the difference between known hazard occurrences (using the annualized frequency source data) and loss-causing hazard occurrences (using the historic loss ratio source data). The result is an historic loss ratio calculation that considers both loss-causing and zero-loss hazard occurrences.

Conceptually, a county's historic loss ratio is the average of Loss Ratios per Basis from past hazard occurrences of a specific hazard type. But often there is wide variance in the Loss Ratios per Basis or not enough hazard occurrences in a community for a statistically significant average. To address this, the National Risk Index methodology and resultant dataset applied a Bayesian credibility approach to balance accuracy with geographic precision for areas where small sample sizes result in volatile estimates. This approach blends historic loss estimates based on their credibility (a function of standard error) to smooth the impact of local hazard occurrences over a broader geographic area. Specifically, the averages, variances, and sample size counts of the Loss Ratios per Basis were calculated for each consequence type at four levels:

1. County
2. 115 km surrounding area buffer
3. 208 km Surrounding Area Buffer
4. Region (hazard-specific areas larger than states in size)
5. Nation

Credibility increases as a function of sample size and decreases with Loss Ratio per Basis variance. The higher the credibility at a geographic level, the higher the contribution that a geographic level's value has to the county's final, Bayesian-adjusted historic loss ratio. Consider these two examples:

- County A, in a part of the country with high tornado frequency, had many Tornadoes over the period of record. While the Loss Ratios per Basis vary based on the severity and touchdown locations, there is a relatively high average historic loss and relatively low variance for the county. For County A, the county-level will be a significant contributor to the final, Bayesian-adjusted historic loss ratio for the county.

- County B is in a low Tornado frequency area where a Tornado has not occurred during the period of record. County B's Bayesian-adjusted historic loss ratio will rely on the values from higher geographic levels: surrounding area, region, and nation.

2. Natural Hazards

Natural hazards are defined as environmental phenomena that have the potential to impact societies and the human environment. These should not be confused with other types of hazards, such as human-caused hazards. For example, a flood resulting from changes in river flows is a natural hazard, while a cyber-attack is considered a human-caused hazard, therefore annualized losses from cyber-attacks are excluded from the National Risk Index dataset.

In the National Risk Index dataset, natural hazards are represented in terms of Expected Annual Loss, which incorporate data for exposure, annualized frequency, and historic loss ratio. For more information please review the National Risk Index Data Technical Documentation.

The 18 natural hazards included in the National Risk Index dataset are detailed within this document.

Natural hazards can also cause secondary natural hazard events that create additional hazards. For example, Volcanic Activity can create other hazards, such as ash and lava spread. The National Risk Index data only considers main natural hazard events and not their results or after-effects.

Natural hazards and disasters are different. A natural hazard is the threat of an event that will likely have a negative impact. Natural hazards only become disasters when they significantly impact communities negatively. The National Risk Index dataset is designed to help communities understand their relative natural hazard risk and the impacts they could expect during or after a disaster.

2.1. Avalanche

An Avalanche is a mass of snow in swift motion traveling down a slope.

In the National Risk Index, an Avalanche Risk Index score and rating represent a community's relative risk for Avalanches when compared to the rest of the United States. An Avalanche Expected Annual Loss score and rating represent a community's relative level of expected building and population loss each year due to Avalanches when compared to the rest of the United States.

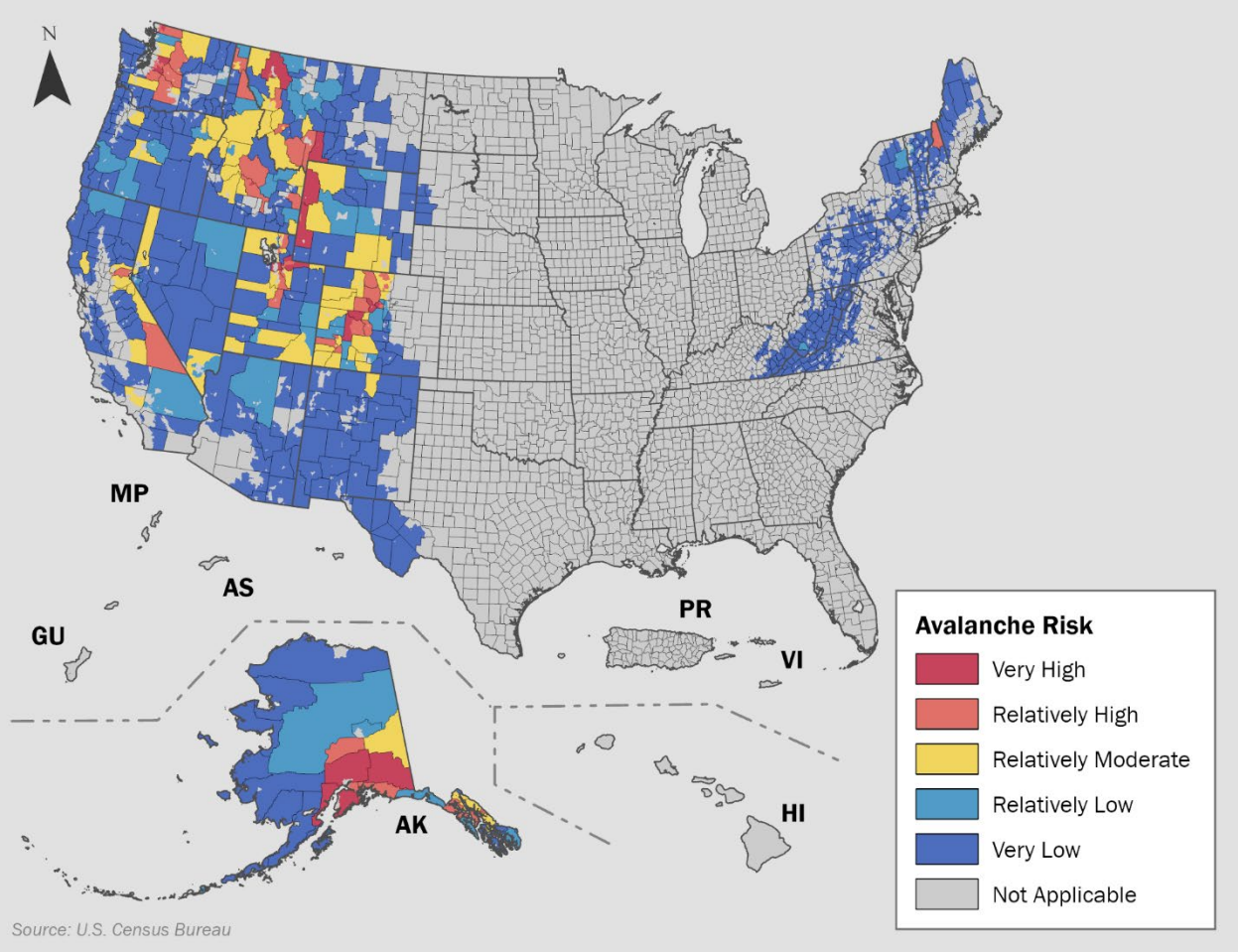

Figure 3: Avalanche Risk Index Rating by County

2.1.1. AVALANCHE EXPOSURE

An Avalanche exposure value represents a community's building value (in dollars) and population (in both people and population equivalence) exposed to Avalanches.

2.1.2. AVALANCHE ANNUALIZED FREQUENCY

An Avalanche annualized frequency value represents the average number of recorded Avalanche hazard occurrences (events) per year over the period of record (28 years).

Source Data

USGS The National Map (v2.0), 1/3 arc-second Digital Elevation Model (DEM)

Snow Data Assimilation System (SNODAS) Data Products at NSIDC, Version 1, Historical Snow Depth Data

National Water and Climate Center (NWCC), Snow Survey and Water Supply Forecasting Program (SSWSF), Snow Telemetry (SNOTEL) Network, Snow Depth Data

Northern Hemisphere 0.25 Degree Resolution Machine Learning Snow Depth Data

Colorado Avalanche Information Center (CAIC) Accident Data

Arizona State University's Center for Emergency Management and Homeland Security's Spatial Hazard Events and Losses Database of the United States (SHELDUS)

2.1.3. AVALANCHE HISTORIC LOSS RATIO

An Avalanche historic loss ratio is the representative percentage of the exposed consequence type value (building or population) expected to be lost due to an Avalanche hazard occurrence.

2.1.4. AVALANCHE PROCESSING METHODOLOGY

For comprehensive details about the Avalanche processing methodology, see the National Risk Index Data Technical Documentation.

2.2. Coastal Flooding

Coastal Flooding is when water inundates or covers normally dry coastal land as a result of high or rising tides or storm surges.

In the National Risk Index data, a Coastal Flooding Risk Index score and rating represent a community's relative risk for Coastal Flooding when compared to the rest of the United States. A Coastal Flooding Expected Annual Loss score and rating represent a community's relative level of expected building and population loss each year due to Coastal Flooding when compared to the rest of the United States.

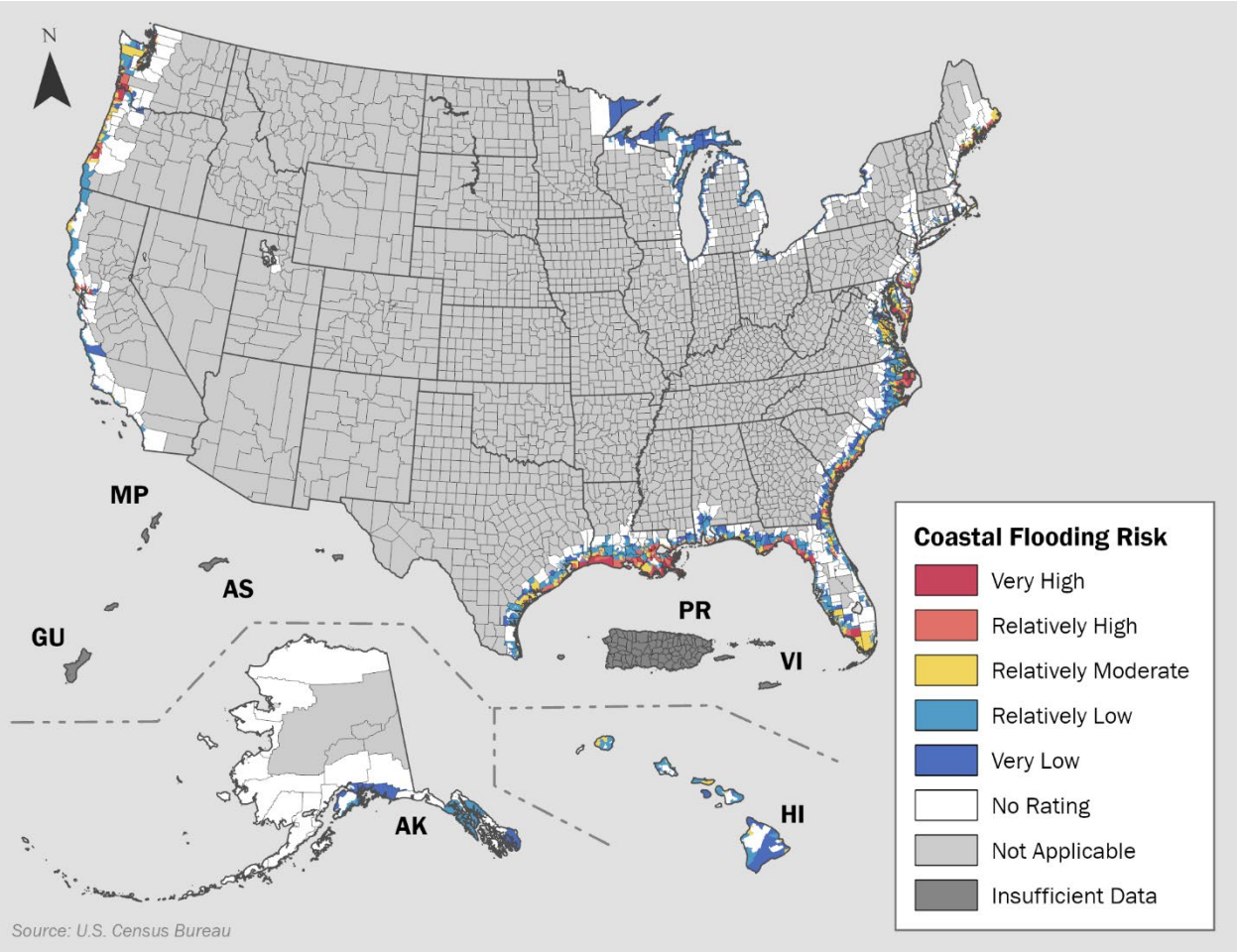

Figure 4: Coastal Flooding Risk Index Rating by County

2.2.1. COASTAL FLOODING EXPOSURE

A Coastal Flooding exposure value represents a community's building value (in dollars) and population (in both people and population equivalence) exposed to Coastal Flooding.

2.2.2. COASTAL FLOODING ANNUALIZED FREQUENCY

A Coastal Flooding annualized frequency value represents the modeled frequency of Coastal Flooding hazard occurrences (events) per year.

Source Data

FEMA's National Flood Insurance Program's National Flood Hazard Layer (NFHL)

National Oceanic and Atmospheric Administration (NOAA)'s High Tide Flooding Probability

For counties that border the Great Lakes, hazard source data has been updated to incorporate new data from FEMA's Geospatial Flood Risk Assessment. This new data source enhances the National Risk Index dataset's ability to capture impacts due to flood hazard outside of traditional flood plain extents. This improved assessment helps communities better understand and prepare for flooding risks in previously underrepresented areas.

2.2.3. COASTAL FLOODING HISTORIC LOSS RATIO

A Coastal Flooding historic loss ratio is the representative percentage of the exposed consequence type value (building or population) expected to be lost due to a Coastal Flooding hazard occurrence.

2.2.4. COASTAL FLOODING PROCESSING METHODOLOGY

For comprehensive details about the Coastal Flooding processing methodology, see the National Risk Index Data Technical Documentation.

2.3. Cold Wave

A Cold Wave is a rapid fall in temperature within 24 hours and extreme low temperatures for an extended period. The temperatures classified as a cold wave are dependent on the location and defined by the local National Weather Service (NWS) weather forecast office.

In the National Risk Index data, a Cold Wave Risk Index score and rating represent a community's relative risk for Cold Waves when compared to the rest of the United States. A Cold Wave Expected Annual Loss score and rating represent a community's relative level of expected building, population, and agriculture loss each year due to Cold Waves when compared to the rest of the United States.

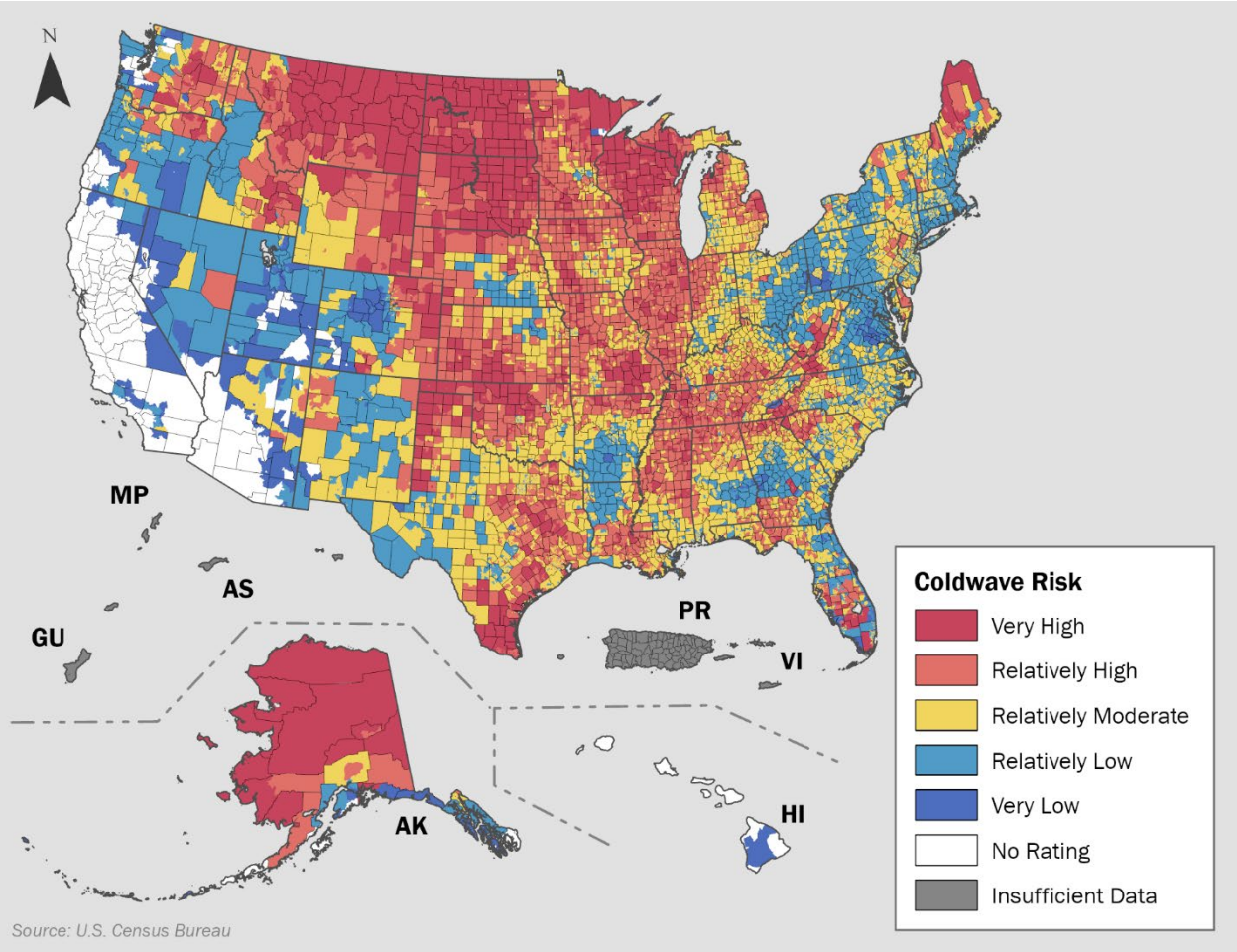

Figure 5: Cold Wave Risk Index Rating by County

2.3.1. COLD WAVE EXPOSURE

A Cold Wave exposure value represents a community's building value (in dollars), population (in both people and population equivalence), and agriculture value (in dollars) exposed to Cold Waves.

2.3.2. COLD WAVE ANNUALIZED FREQUENCY

A Cold Wave annualized frequency value represents the average number of recorded Cold Wave hazard occurrences (event-days) per year over the period of record (18 years).

Source Data

National Oceanic and Atmospheric Administration's National Weather Service Weather Alerts compiled and archived by Iowa State University's Iowa Environmental Mesonet

CDC Compressed Mortality File (1999-2016)

2.3.3. COLD WAVE HISTORIC LOSS RATIO

A Cold Wave historic loss ratio is the representative percentage of the exposed consequence type value (building, population, or agriculture) expected to be lost due to a Cold Wave hazard occurrence.

2.3.4. COLD WAVE PROCESSING METHODOLOGY

For comprehensive details about the Cold Wave processing methodology, see the National Risk Index Data Technical Documentation.

2.4. Drought

A Drought is a deficiency of precipitation over an extended period of time resulting in a water shortage.

In the National Risk Index data, a Drought Risk Index score and rating represent a community's relative risk for Droughts when compared to the rest of the United States. A Drought Expected Annual Loss score and rating represent a community's relative level of expected agriculture loss each year due to Droughts when compared to the rest of the United States.

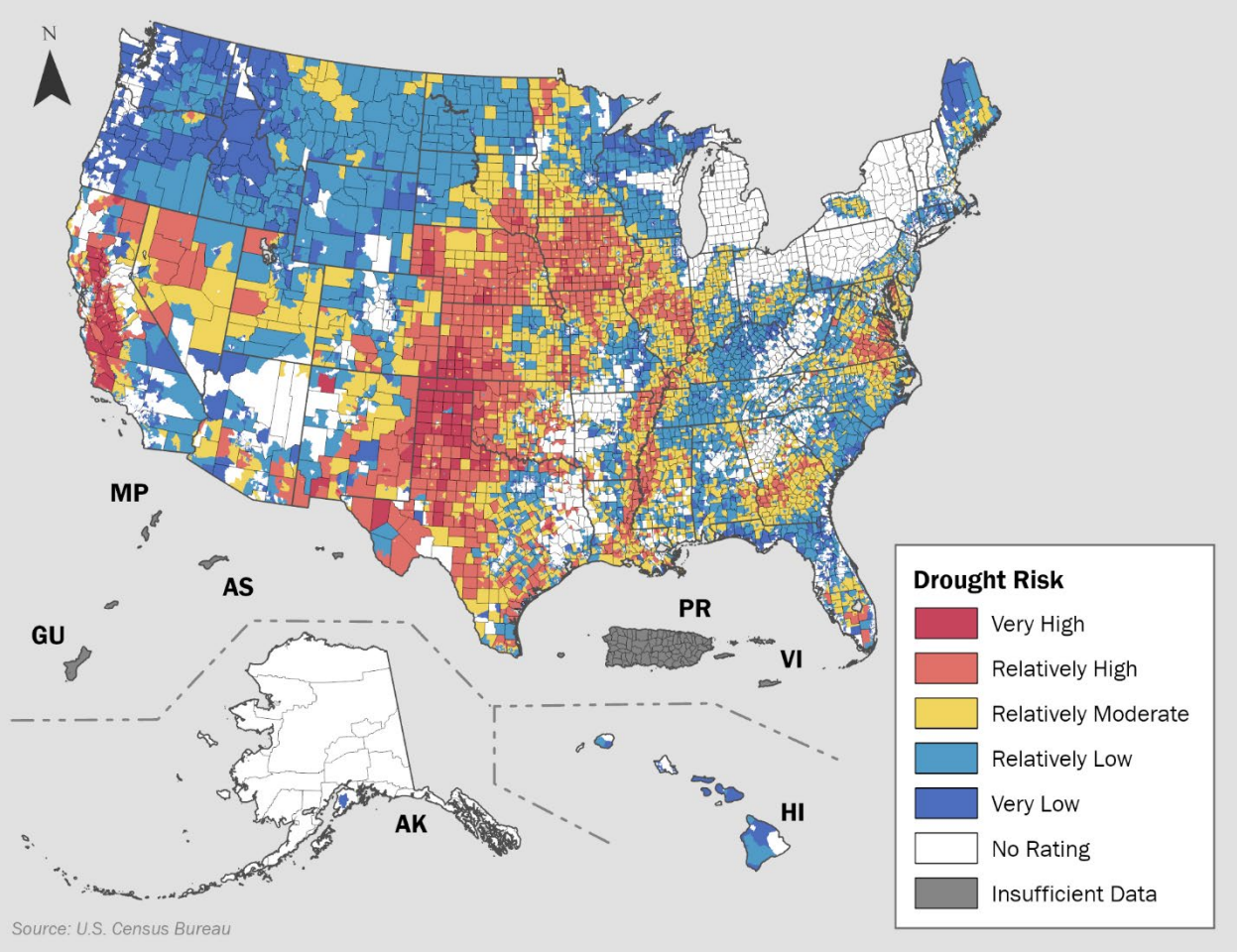

Figure 6: Drought Risk Index Rating by County

2.4.1. DROUGHT EXPOSURE

A Drought exposure value represents a community's agriculture (crop only) value (in dollars) exposed to Drought.

2.4.2. DROUGHT ANNUALIZED FREQUENCY

A Drought annualized frequency value represents the average number of recorded Drought hazard occurrences (event-days) per year over the period of record (22 years).

Source Data

University of Nebraska-Lincoln's National Drought Mitigation Center's U.S. Drought Monitor

2.4.3. DROUGHT HISTORIC LOSS RATIO

A Drought historic loss ratio is the representative percentage of the exposed agriculture value expected to be lost due to a Drought hazard occurrence.

2.4.4. DROUGHT PROCESSING METHODOLOGY

For comprehensive details about the Drought processing methodology, see the National Risk Index Data Technical Documentation.

2.5. Earthquake

An Earthquake is a shaking of the earth's surface by energy waves emitted by slowly moving tectonic plates overcoming friction with one another underneath the earth's surface.

In the National Risk Index data, an Earthquake Risk Index score and rating represent a community's relative risk for Earthquakes when compared to the rest of the United States. An Earthquake Expected Annual Loss score and rating represent a community's relative level of expected building and population loss each year due to Earthquakes when compared to the rest of the United States.

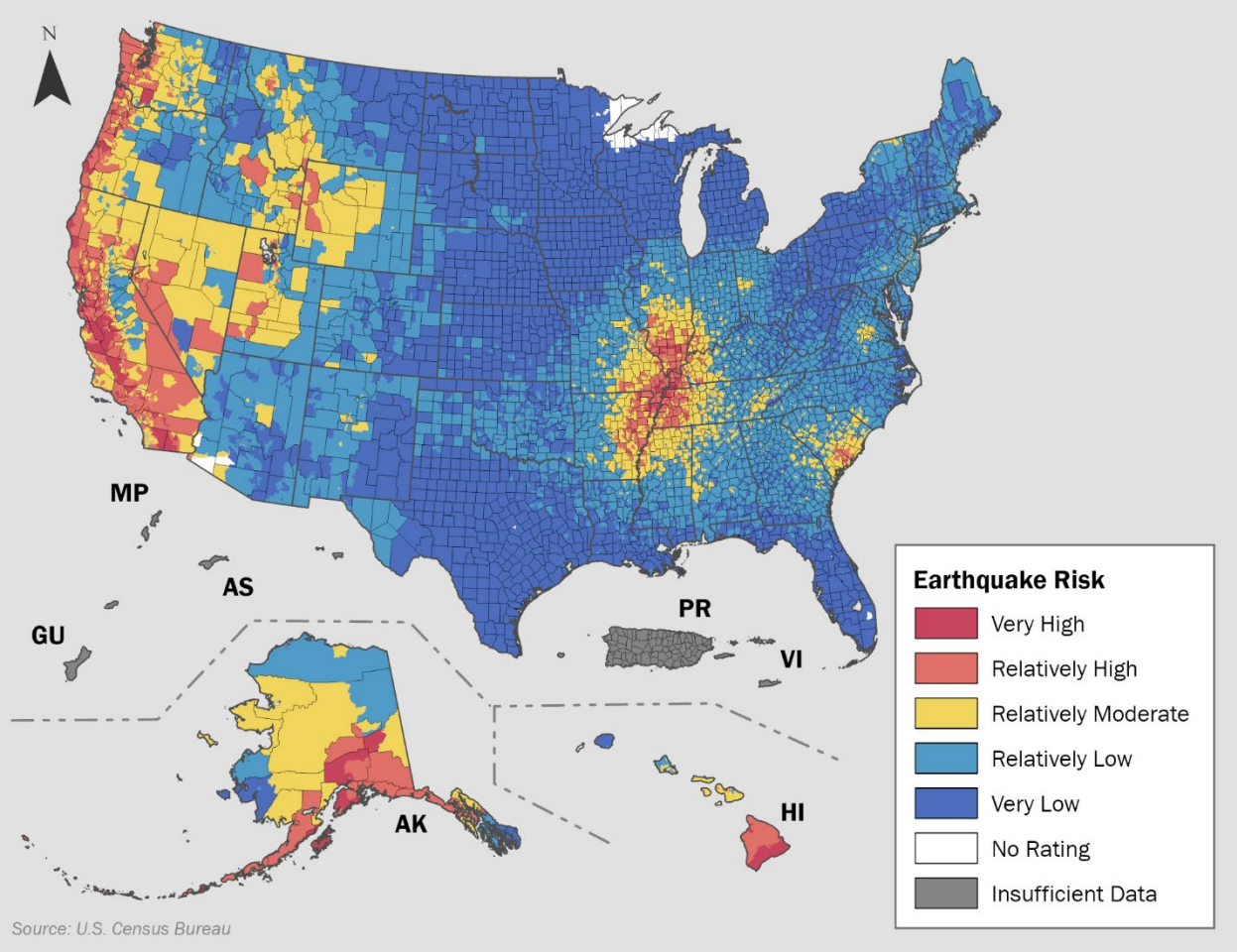

Figure 7: Earthquake Risk Index Rating by County

2.5.1. EARTHQUAKE EXPOSURE

An Earthquake exposure value represents a community's building value (in dollars) and population (in both people and population equivalence) exposed to Earthquake.

2.5.2. EARTHQUAKE ANNUALIZED FREQUENCY

An Earthquake annualized frequency value represents the modeled frequency of Earthquake hazard occurrences (events) per year.

Source Data

FEMA's Hazus Estimated Annualized Earthquake Losses for the United States using hazard data from the 2023 National Seismic Hazard Model Update, inventory data from Hazus 6.1 and methods from FEMA's Publication 366 (also known as the P-366 Report)

2.5.3. EARTHQUAKE HISTORIC LOSS RATIO

An Earthquake historic loss ratio is the representative percentage of the exposed consequence type value (building or population) expected to be lost due to an Earthquake hazard occurrence.

2.5.4. EARTHQUAKE PROCESSING METHODOLOGY

For comprehensive details about the Earthquake processing methodology, see the National Risk Index Technical Documentation and P-366 Report.

2.6. Hail

Hail is a form of precipitation that occurs during thunderstorms when raindrops, in extremely cold areas of the atmosphere, freeze into balls of ice before falling towards the earth's surface.

In the National Risk Index data, a Hail Risk Index score and rating represent a community's relative risk for Hail when compared to the rest of the United States. A Hail Expected Annual Loss score and rating represent a community's relative level of expected building, population, and agriculture loss each year due to Hail when compared to the rest of the United States.

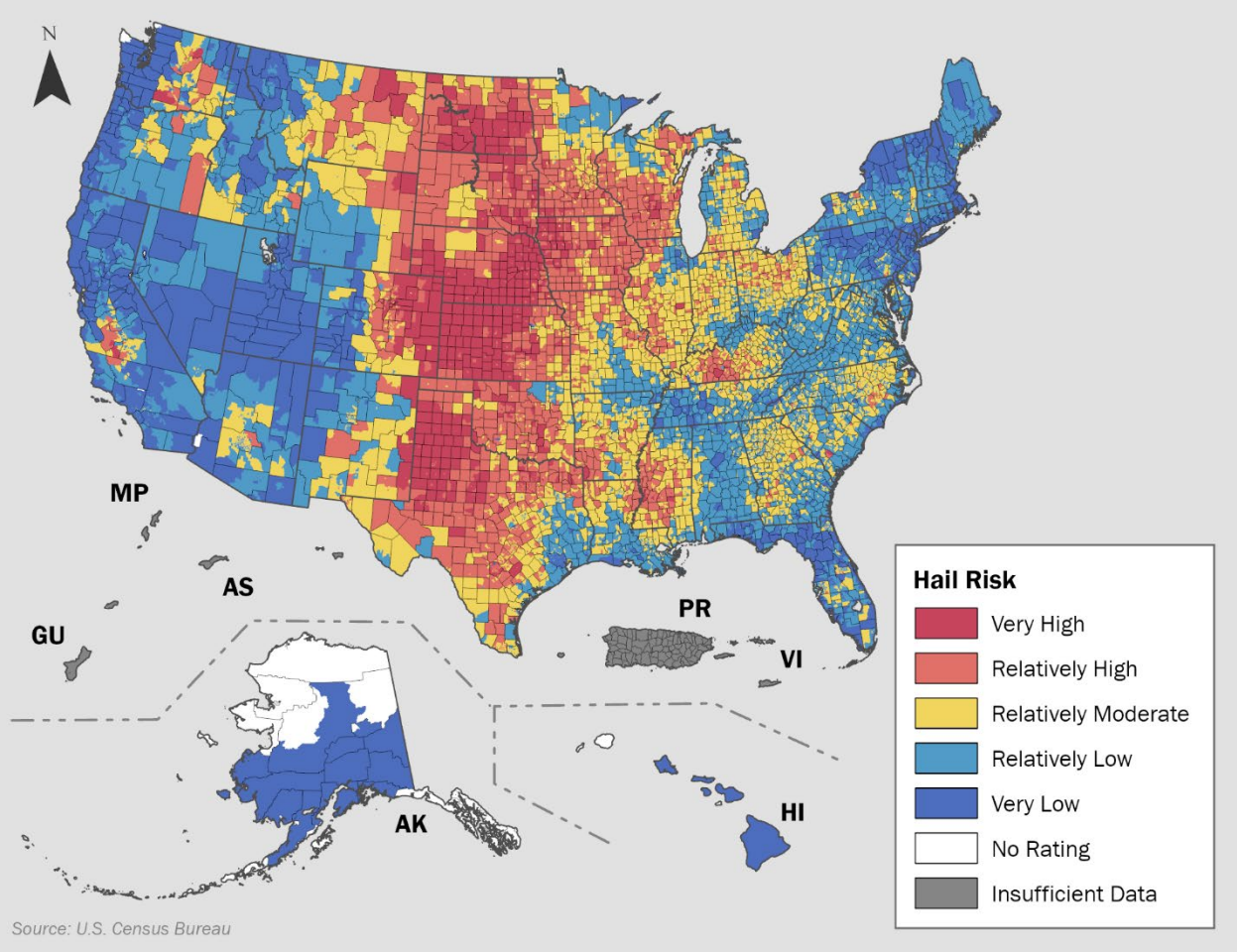

Figure 8: Hail Risk Index Rating by County

2.6.1. HAIL EXPOSURE

A Hail exposure value represents a community's building value (in dollars), population (in both people and population equivalence), and agriculture value (in dollars) exposed to Hail.

2.6.2. HAIL ANNUALIZED FREQUENCY

A Hail annualized frequency value represents the average number of recorded Hail hazard occurrences (events) per year over the period of record (37 years).

Source Data

National Oceanic and Atmospheric Administration's Storm Prediction Center's Severe Weather Database

2.6.3. HAIL HISTORIC LOSS RATIO

A Hail historic loss ratio is the representative percentage of the exposed consequence type value (building, population, or agriculture) expected to be lost due to a Hail hazard occurrence.

2.6.4. HAIL PROCESSING METHODOLOGY

For comprehensive details about the Hail processing methodology, see the National Risk Index Data Technical Documentation.

2.7. Heat Wave

A Heat Wave is a period of abnormally and uncomfortably hot and unusually humid weather typically lasting two or more days with temperatures outside the historical averages for a given area.

In the National Risk Index data, a Heat Wave Risk Index score and rating represent a community's relative risk for Heat Waves when compared to the rest of the United States. A Heat Wave Expected Annual Loss score and rating represent a community's relative level of expected building and population loss each year due to Heat Waves when compared to the rest of the United States.

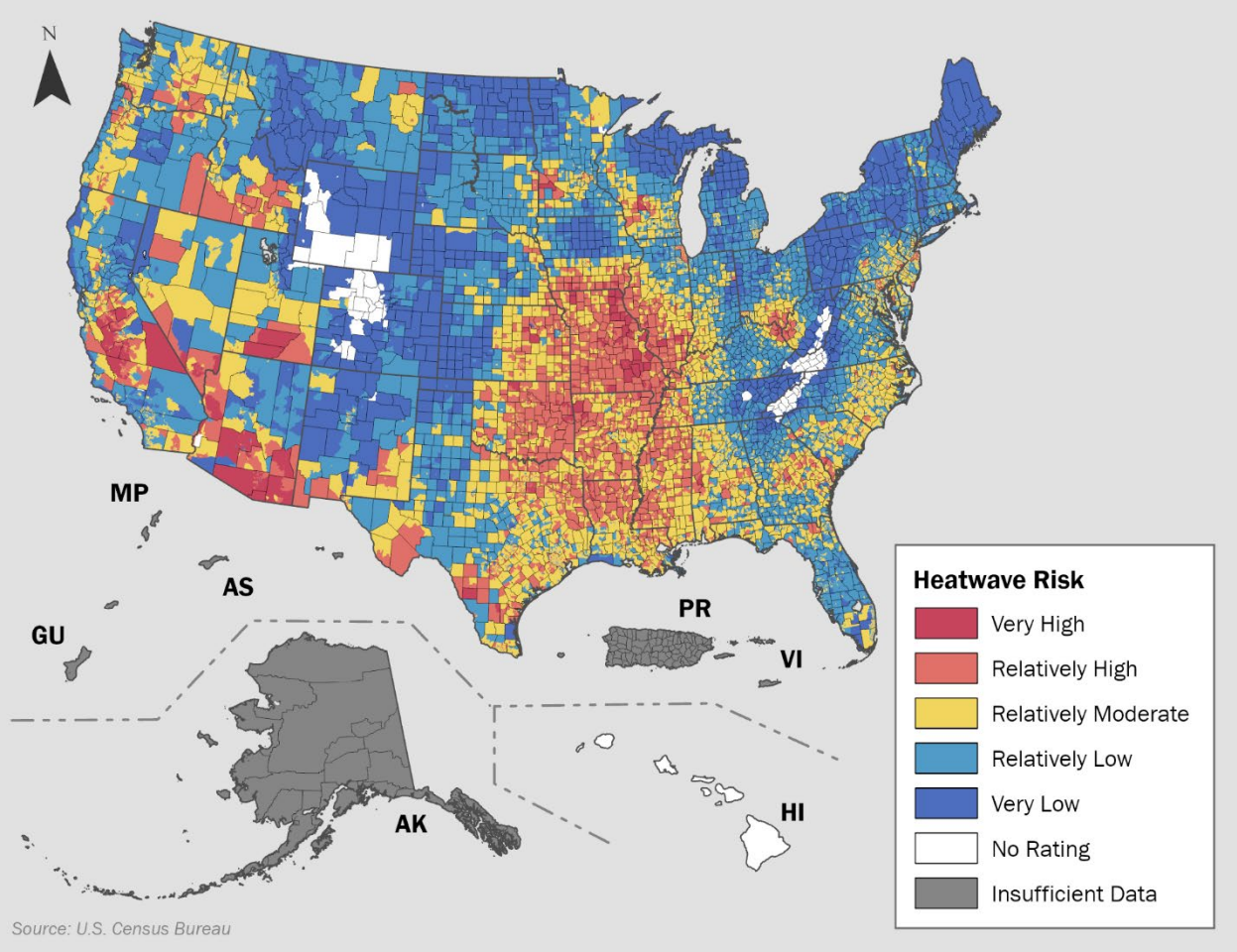

Figure 9: Heat Wave Risk Index Rating by County

2.7.1. HEAT WAVE EXPOSURE

A Heat Wave exposure value represents a community's building value (in dollars), population (in both people and population equivalence), and agriculture value (in dollars) exposed to Heat Waves.

2.7.2. HEAT WAVE ANNUALIZED FREQUENCY

A Heat Wave annualized frequency value represents the average number of recorded Heat Wave hazard occurrences (event-days) per year over the period of record (18 years).

Source Data

National Oceanic and Atmospheric Administration's National Weather Service Weather Alerts compiled and archived by Iowa State University's Iowa Environmental Mesonet

CDC Compressed Mortality File (1999-2016)

2.7.3. HEAT WAVE HISTORIC LOSS RATIO

A Heat Wave historic loss ratio is the representative percentage of the exposed consequence type value (building, population, or agriculture) expected to be lost due to a Heat Wave hazard occurrence.

2.7.4. HEAT WAVE PROCESSING METHODOLOGY

For comprehensive details about the Heat Wave processing methodology, see the National Risk Index Data Technical Documentation.

2.8. Hurricane

A Hurricane is a tropical cyclone or localized, low-pressure weather system that has organized thunderstorms but no front (a boundary separating two air masses of different densities) and maximum sustained winds of at least 74 mph.

In the National Risk Index data, a Hurricane Risk Index score and rating represent a community's relative risk for Hurricanes when compared to the rest of the United States. A Hurricane Expected Annual Loss score and rating represent a community's relative level of expected building and population loss each year due to Hurricanes when compared to the rest of the United States.

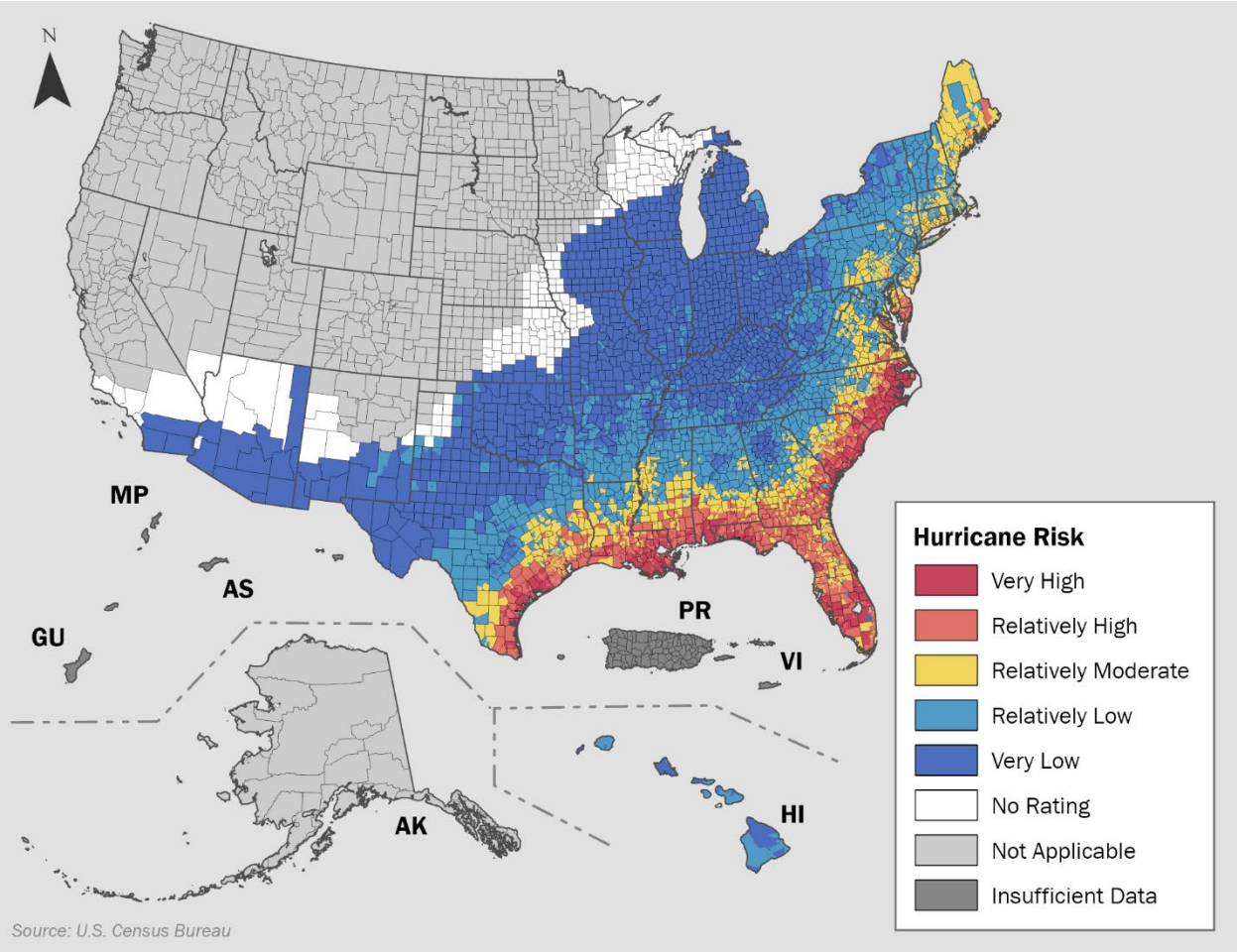

Figure 10: Hurricane Risk Index Rating by County

2.8.1. HURRICANE EXPOSURE

A Hurricane exposure value represents a community's building value (in dollars), population (in both people and population equivalence), and agriculture value (in dollars) exposed to Hurricanes.

2.8.2. HURRICANE ANNUALIZED FREQUENCY

A Hurricane annualized frequency value represents the average number of recorded Hurricane hazard occurrences (events) per year over the period of record (172 years for the Atlantic Basin and 74 years for the Pacific Basin).

Source Data

National Oceanic and Atmospheric Administration's National Hurricane Center's HURDAT2 Best Track Data

2.8.3. HURRICANE HISTORIC LOSS RATIO

A Hurricane historic loss ratio provides an estimate for the representative percentage of the exposed consequence type value (building, population, or agriculture) expected to be lost due to a Hurricane hazard occurrence.

For comprehensive details about the Hurricane historic loss ratio methodology, see the National Risk Index Data Technical Documentation.

2.8.4. HURRICANE PROCESSING METHODOLOGY

For comprehensive details about the Hurricane processing methodology, see the National Risk Index Data Technical Documentation.

2.9. Ice Storm

An Ice Storm is a freezing rain situation (rain that freezes on surface contact) with significant ice accumulations of 0.25 inches or greater.

In the National Risk Index data, an Ice Storm Risk Index score and rating represent a community's relative risk for Ice Storms when compared to the rest of the United States. An Ice Storm Expected Annual Loss score and rating represent a community's relative level of expected building and population loss each year due to Ice Storms when compared to the rest of the United States.

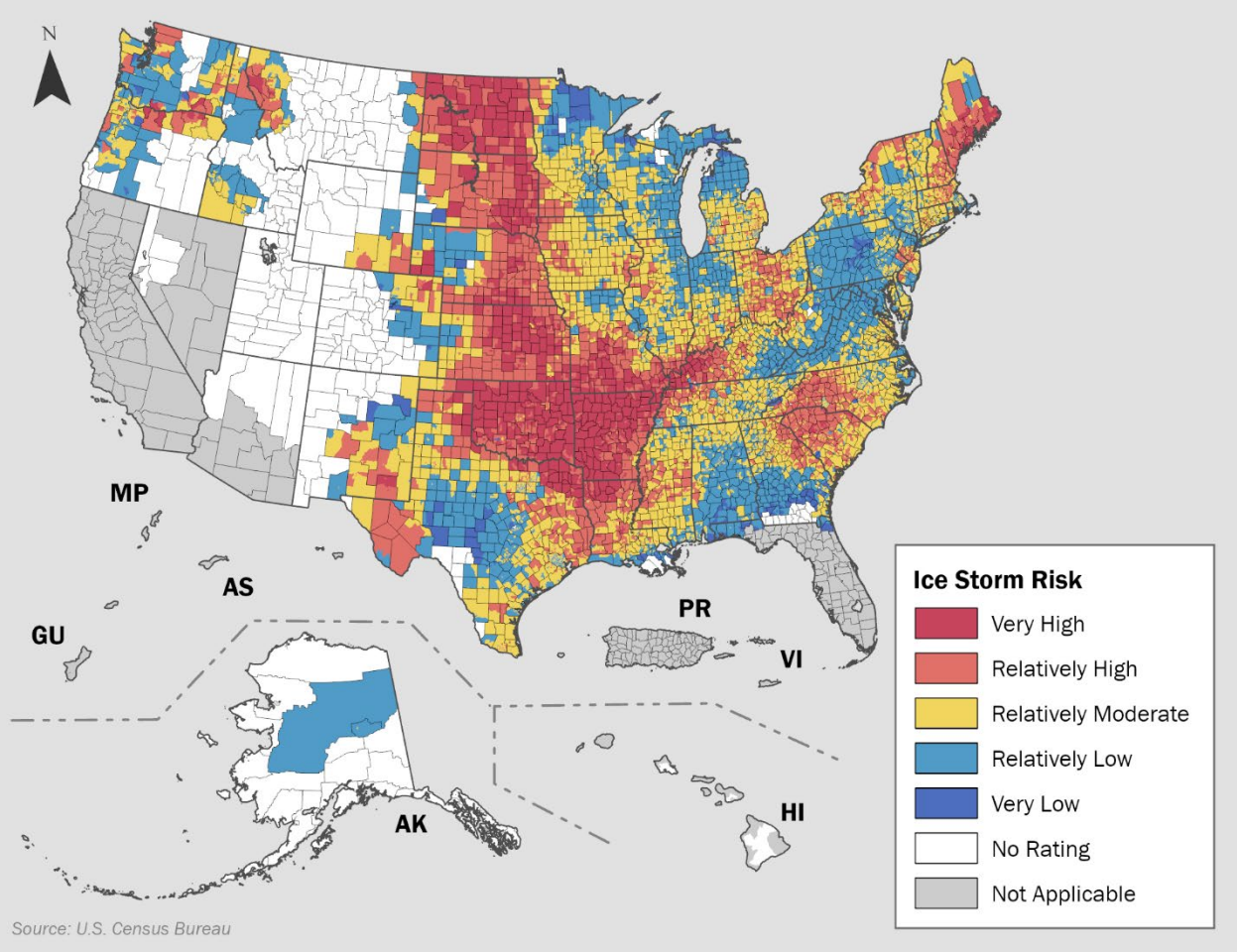

Figure 11: Ice Storm Risk Index Rating by County

2.9.1. ICE STORM EXPOSURE

An Ice Storm exposure value represents a community's building value (in dollars) and population (in both people and population equivalence) exposed to Ice Storms.

2.9.2. ICE STORM ANNUALIZED FREQUENCY

An Ice Storm annualized frequency value represents the average number of recorded Ice Storm hazard occurrences (event-days) per year over the period of record (68 years).

Source Data

U.S. Army Corps of Engineers' Cold Regions Research and Engineering Laboratory's Damaging Ice Storm Geographic Information System

2.9.3. ICE STORM HISTORIC LOSS RATIO

An Ice Storm historic loss ratio is the representative percentage of the exposed consequence type value (building or population) expected to be lost due to an Ice Storm hazard occurrence.

2.9.4. ICE STORM PROCESSING METHODOLOGY

For comprehensive details about the Ice Storm processing methodology, see the National Risk Index Data Technical Documentation.

2.10. Inland Flooding

Inland Flooding occurs when streams and rivers exceed the capacity of their natural or constructed channels to accommodate water flow and water overflows the banks, spilling into adjacent low-lying, dry land (fluvial flooding), or when excessive rainfall overwhelms drainage systems leading to surface water accumulation (pluvial flooding). Inland flooding can occur anywhere it rains, even if there are no nearby waterbodies.

In the National Risk Index data, an Inland Flooding Risk Index score and rating represent a community's relative risk for Inland Flooding when compared to the rest of the United States. An Inland Flooding Expected Annual Loss score and rating represent a community's relative level of expected building, population, and agriculture loss each year due to Inland Flooding when compared to the rest of the United States.

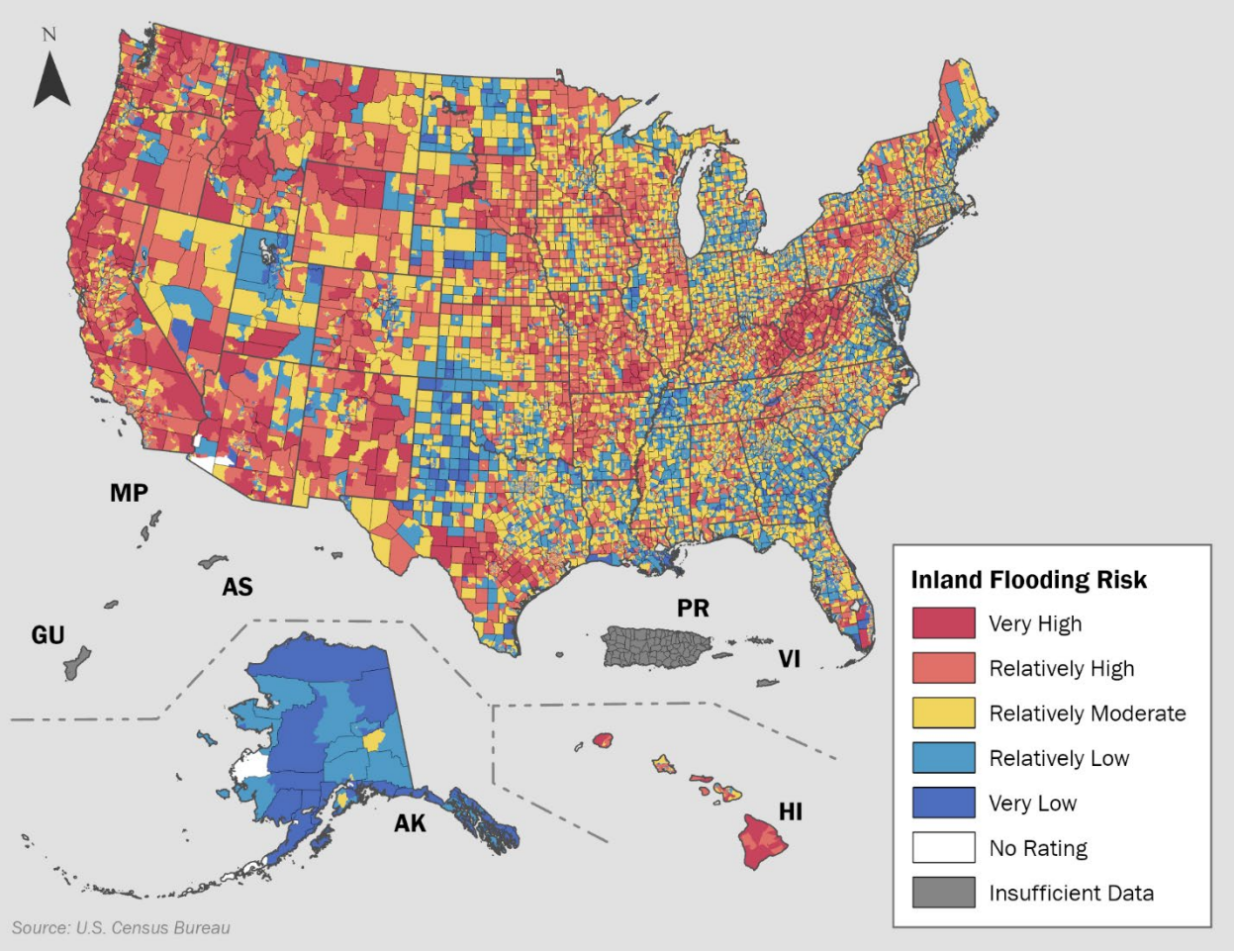

Figure 12: Inland Flooding Risk Index Rating by County

2.10.1. INLAND FLOODING EXPOSURE

An Inland Flooding exposure value represents a community's building value (in dollars), population (in both people and population equivalence), and agriculture value (in dollars) exposed to Inland Flooding.

2.10.2. INLAND FLOODING ANNUALIZED FREQUENCY

An Inland Flooding annualized frequency value represents the average number of recorded Inland Flooding hazard occurrences (event-days) per year over the period of record (26 years).

Source Data

FEMA's National Flood Insurance Program's National Flood Hazard Layer (NFHL)

CoreLogic's Flood Services' Special Flood Hazard Area Layer

National Oceanic and Atmospheric Administration's National Centers for Environmental Information's Storm Events Database

FEMA Geospatial Flood Risk Assessment

2.10.3. INLAND FLOODING HISTORIC LOSS RATIO

An Inland Flooding historic loss ratio is the representative percentage of the exposed consequence type value (building, population, or agriculture) expected to be lost due to an Inland Flooding hazard occurrence.

2.10.4. INLAND FLOODING PROCESSING METHODOLOGY

For comprehensive details about the Inland Flooding processing methodology, see the National Risk Index Data Technical Documentation.

2.11. Landslide

A Landslide is the movement of a mass of rock, debris, or earth down a slope.

In the National Risk Index data, a Landslide Risk Index score and rating represent a community's relative risk for Landslides when compared to the rest of the United States. A Landslide Expected Annual Loss score and rating represent a community's relative level of expected building and population loss each year due to Landslides when compared to the rest of the United States.

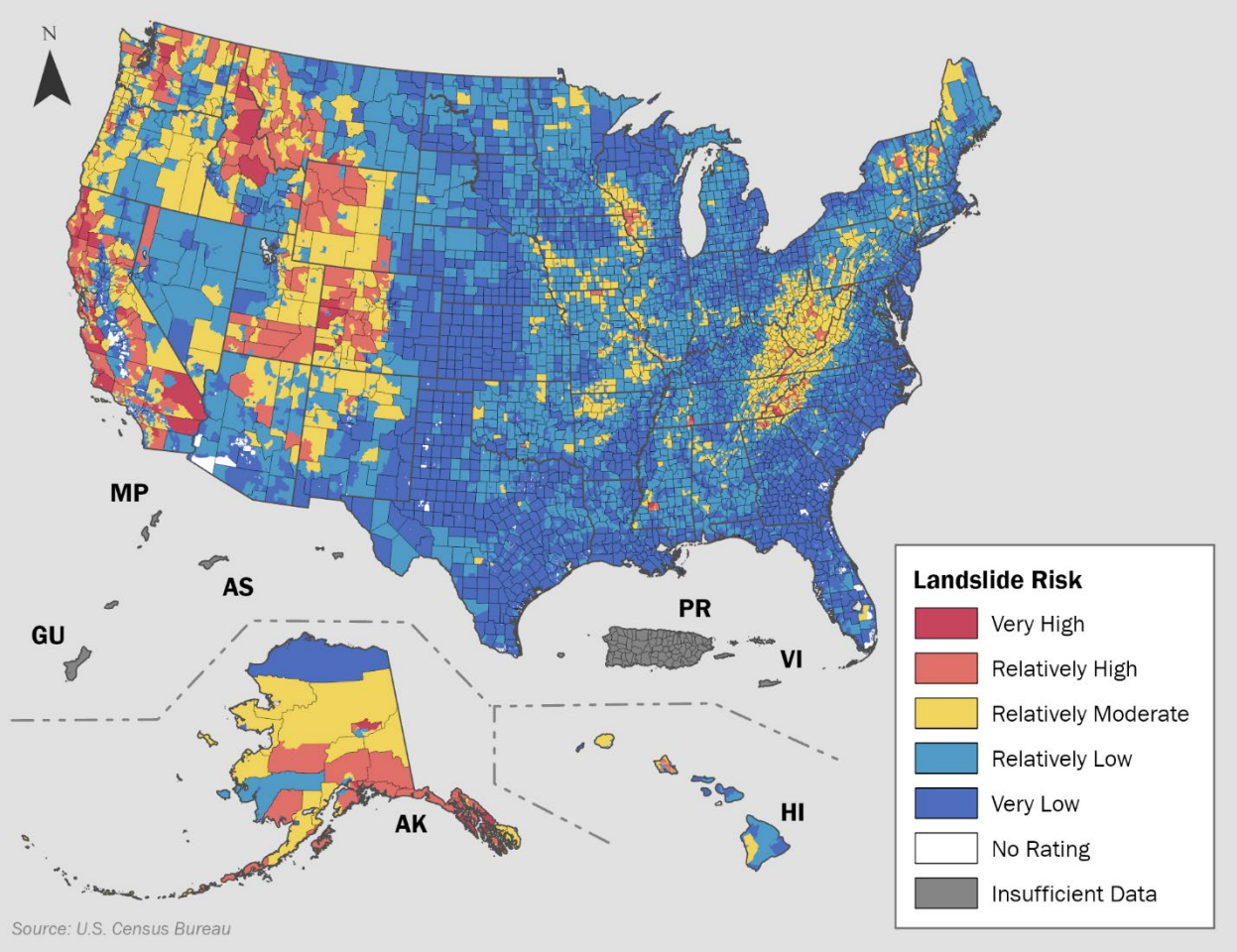

Figure 13: Landslide Risk Index Rating by County

2.11.1. LANDSLIDE EXPOSURE

A Landslide exposure value represents a community's building value (in dollars) and population (in both people and population equivalence) exposed to Landslides.

2.11.2. LANDSLIDE ANNUALIZED FREQUENCY

A Landslide annualized frequency value represents the annualized probability of a county encountering a specific number of landslides per year.

Source Data

USGS 2024 Parsimonious High-Resolution Landslide Susceptibility Modeling at Continental Scales

USGS Landslide Inventories across the US, 2025 Update

Constraining landslide frequency across the United States to inform county-level risk reduction (Luna et al., 2025)

2.11.3. LANDSLIDE HISTORIC LOSS RATIO

A Landslide historic loss ratio is the representative percentage of the exposed consequence type value (building or population) expected to be lost due to a Landslide hazard occurrence.

2.11.4. LANDSLIDE PROCESSING METHODOLOGY

For comprehensive details about the Landslide processing methodology, see the National Risk Index Data Technical Documentation.

2.12. Lightning

Lightning is a visible electrical discharge or spark of electricity in the atmosphere between clouds, the air and/or the ground often produced by a thunderstorm.

In the National Risk Index data, a Lightning Risk Index score and rating represent a community's relative risk for Lightning when compared to the rest of the United States. A Lightning Expected Annual Loss score and rating represent a community's relative level of expected building and population loss each year due to Lightning when compared to the rest of the United States.

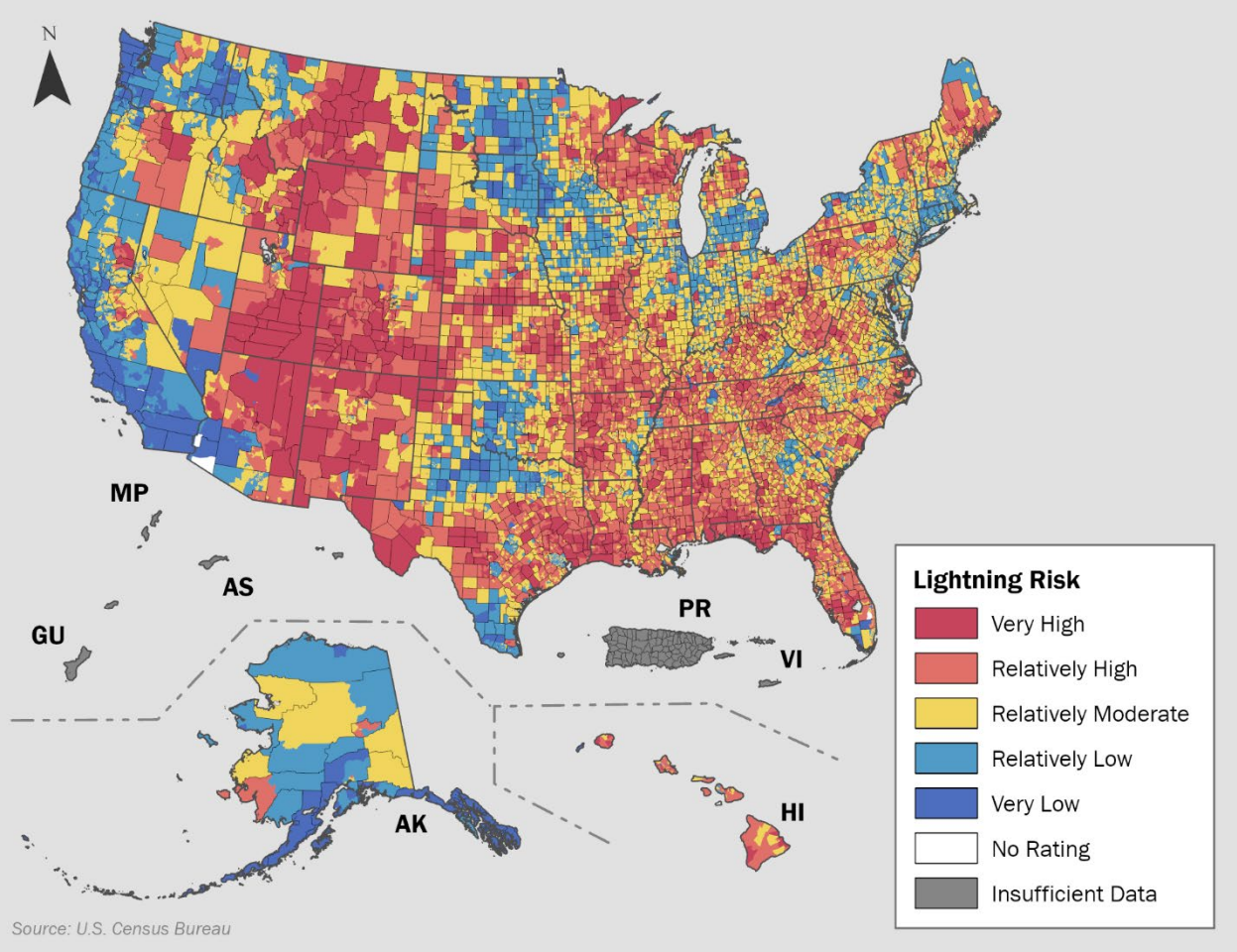

Figure 14: Lightning Risk Index Rating by County

2.12.1. LIGHTNING EXPOSURE

A Lightning exposure value represents a community's building value (in dollars) and population (in both people and population equivalence) exposed to Lightning.

2.12.2. LIGHTNING ANNUALIZED FREQUENCY

A Lightning annualized frequency value represents the average number of recorded Lightning hazard occurrences (events) per year over the period of record (24 years).

Source Data

National Weather Service, Storm Prediction Center Daily Lightning Climatology (1995-2019)

2.12.3. LIGHTNING HISTORIC LOSS RATIO

A Lightning historic loss ratio is the representative percentage of the exposed consequence type value (building or population) expected to be lost due to a Lightning hazard occurrence.

2.12.4. LIGHTNING PROCESSING METHODOLOGY

For comprehensive details about the Lightning processing methodology, see the National Risk Index Data Technical Documentation.

2.13. Strong Wind

Strong Wind consists of damaging winds, often originating from thunderstorms, that are classified as exceeding 58 mph.

In the National Risk Index data, a Strong Wind Risk Index score and rating represent a community's relative risk for Strong Wind when compared to the rest of the United States. A Strong Wind Expected Annual Loss score and rating represent a community's relative level of expected building, population, and agriculture loss each year due to Strong Wind when compared to the rest of the United States.

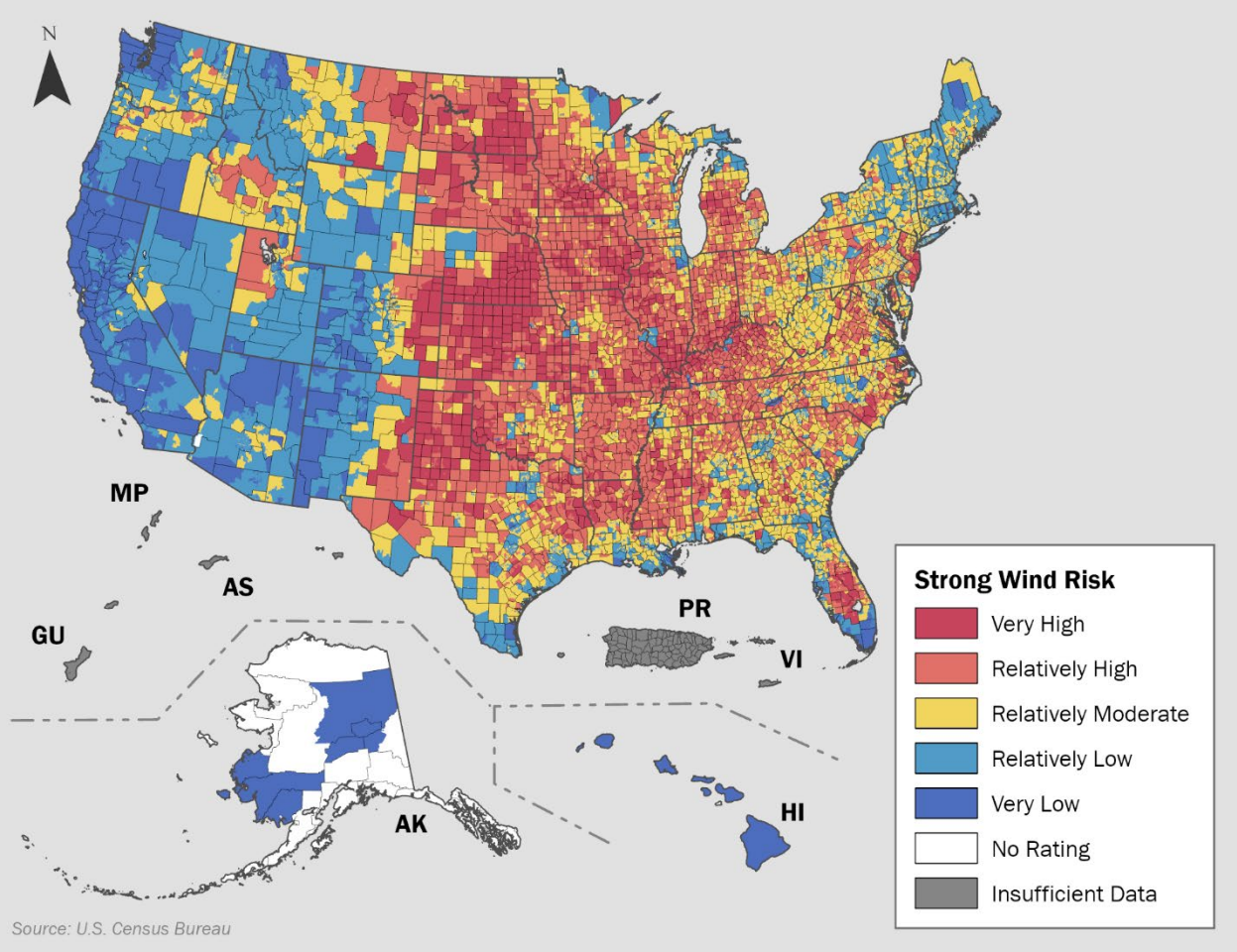

Figure 15: Strong Wind Risk Index Rating by County

2.13.1. STRONG WIND EXPOSURE

A Strong Wind exposure value represents a community's building value (in dollars), population (in both people and population equivalence), and agriculture value (in dollars) exposed to Strong Wind.

2.13.2. STRONG WIND ANNUALIZED FREQUENCY

A Strong Wind annualized frequency value represents the average number of recorded Strong Wind hazard occurrences (events) per year over the period of record (38 years).

Source Data

National Oceanic and Atmospheric Administration's National Weather Service's Storm Prediction Center's Severe Weather Database

2.13.3. STRONG WIND HISTORIC LOSS RATIO

A Strong Wind historic loss ratio is the representative percentage of the exposed consequence type value (building, population, or agriculture) expected to be lost due to a Strong Wind hazard occurrence.

2.13.4. STRONG WIND PROCESSING METHODOLOGY

For comprehensive details about the Strong Wind processing methodology, see the National Risk Index Data Technical Documentation.

2.14. Tornado

A Tornado is a narrow, violently rotating column of air that extends from the base of a thunderstorm to the ground and is visible only if it forms a condensation funnel made up of water droplets, dust, and debris.

In the National Risk Index data, a Tornado Risk Index score and rating represent a community's relative risk for Tornados when compared to the rest of the United States. A Tornado Expected Annual Loss score and rating represent a community's relative level of expected building and population loss each year due to Tornados when compared to the rest of the United States.

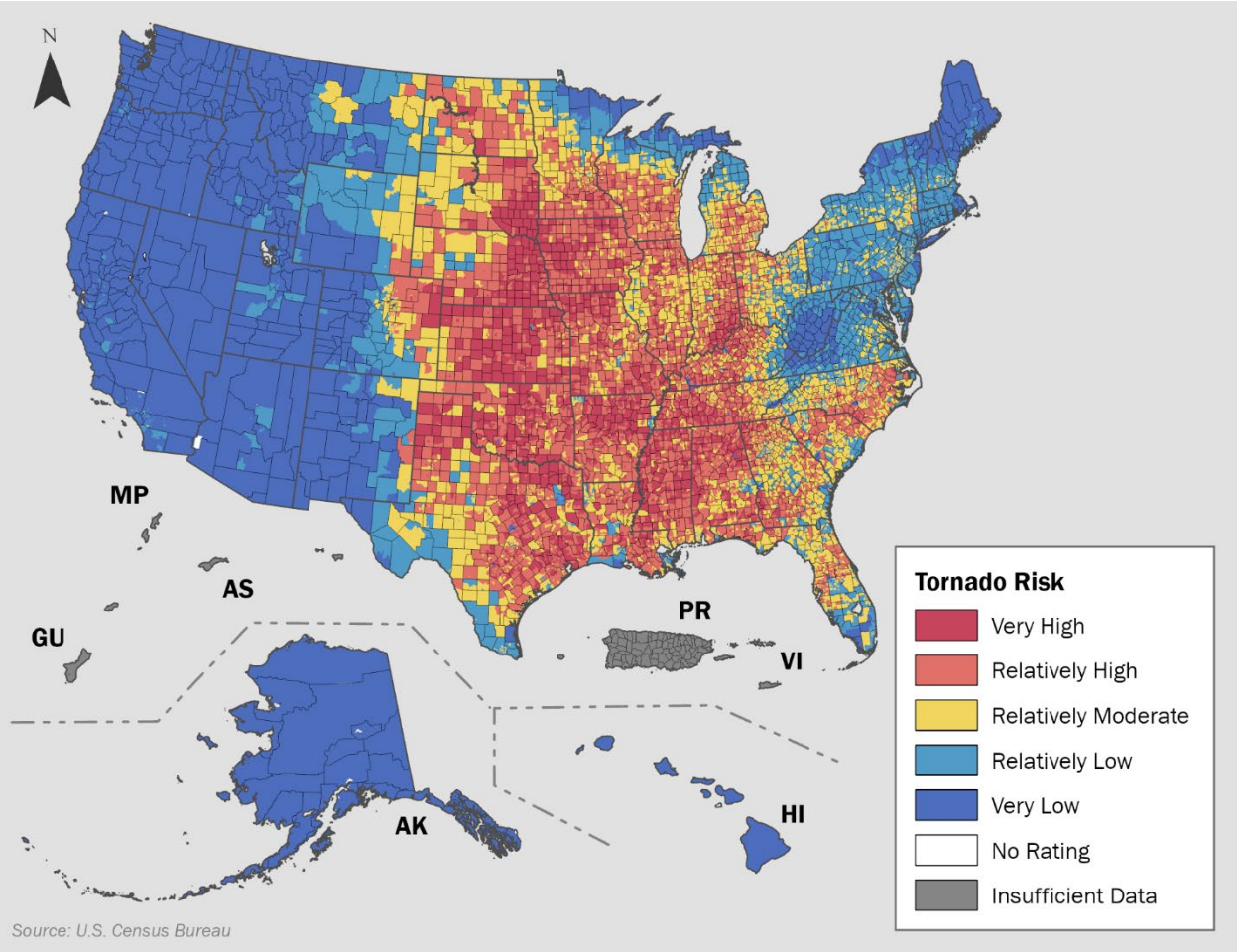

Figure 16: Tornado Risk Index Rating by County

2.14.1. TORNADO EXPOSURE

A Tornado exposure value represents a community's building value (in dollars), population (in both people and population equivalence), and agriculture value (in dollars) exposed to Tornadoes.

2.14.2. TORNADO ANNUALIZED FREQUENCY

A Tornado annualized frequency value represents the average number of recorded Tornado hazard occurrences (events) per year over the period of record (38 years).

Source Data

National Oceanic and Atmospheric Administration's National Weather Service's Storm Prediction Center's Severe Weather Database

2.14.3. TORNADO HISTORIC LOSS RATIO

A Tornado historic loss ratio is the representative percentage of the exposed consequence type value (building, population, or agriculture) expected to be lost due to a Tornado hazard occurrence.

2.14.4. TORNADO PROCESSING METHODOLOGY

For comprehensive details about the Tornado processing methodology, see the National Risk Index Data Technical Documentation.

2.15. Tsunami

A Tsunami is a wave or series of waves generated by an Earthquake, Landslide, volcanic eruption, or even a large meteor hitting the ocean and causing a rise or mounding of water at the ocean surface. A Tsunami can travel across open ocean at about 500 mph and slow down to about 30 mph as it approaches land, causing it to grow significantly in height.

In the National Risk Index data, a Tsunami Risk Index score and rating represent a community's relative risk for Tsunamis when compared to the rest of the United States. A Tsunami Expected Annual Loss score and rating represent a community's relative level of expected building and population loss each year due to Tsunamis when compared to the rest of the United States.

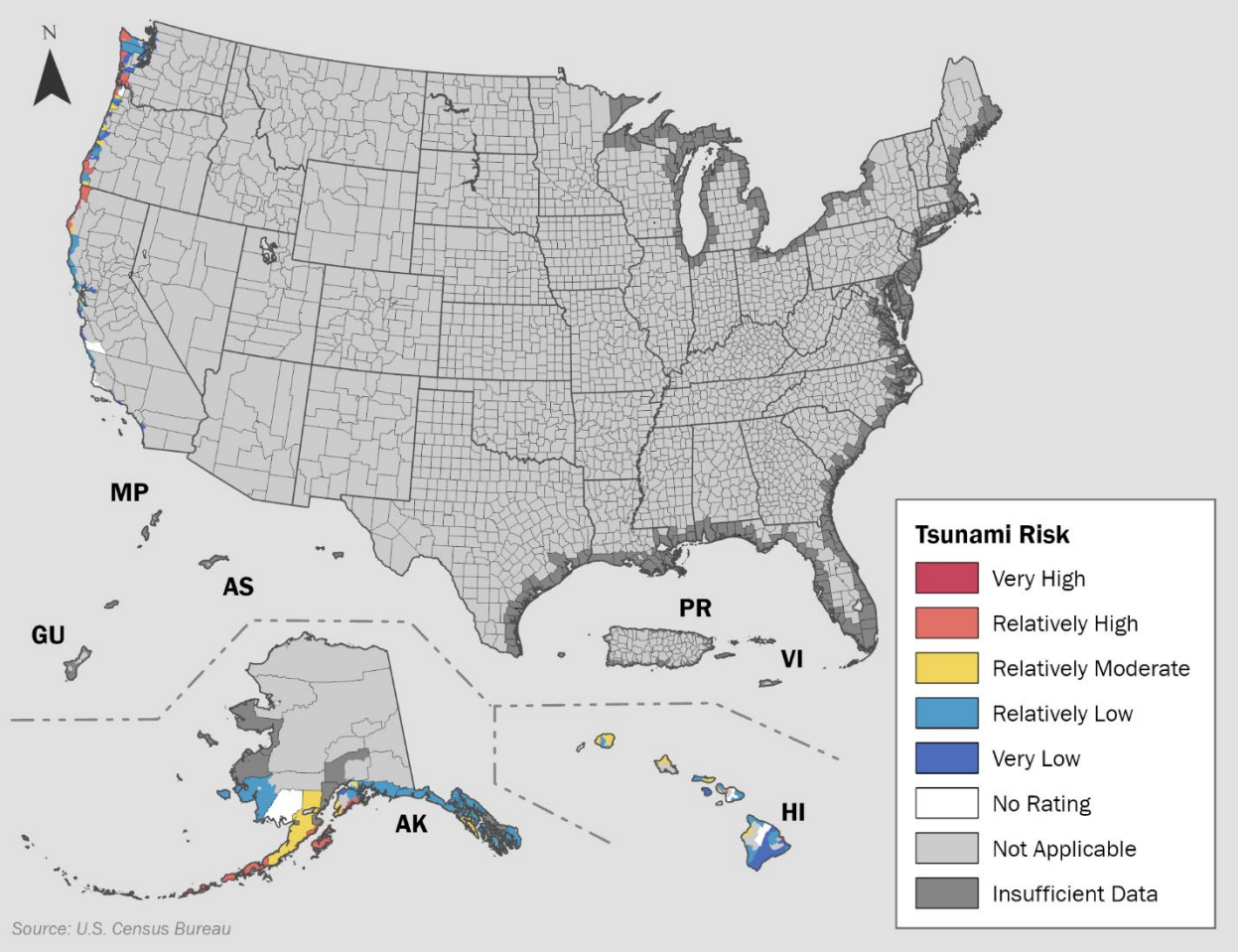

Figure 17: Tsunami Risk Index Rating by County

2.15.1. TSUNAMI EXPOSURE

A Tsunami exposure value represents a community's building value (in dollars) and population (in both people and population equivalence) exposed to Tsunamis.

2.15.2. TSUNAMI ANNUALIZED FREQUENCY

A Tsunami annualized frequency value represents the average number of recorded Tsunami hazard occurrences (events) per year, calculated on a region-specific basis that combines historical data with the results of probabilistic modeling.

Source Data

FEMA's Tsunami Study: P-2426 Estimated Average Annualized Tsunami Losses for the United States

National Oceanic and Atmospheric Administration and National Geophysical Data Center's National Centers for Environmental Information's Global Historical Tsunami Database

2.15.3. TSUNAMI HISTORIC LOSS RATIO

A Tsunami historic loss ratio is the representative percentage of the exposed consequence type value (building or population) expected to be lost due to a Tsunami hazard occurrence.

2.15.4. TSUNAMI PROCESSING METHODOLOGY

For comprehensive details about the Tsunami processing methodology, see the National Risk Index Technical Documentation and FEMA's P-2426 Report.

2.16. Volcanic Activity

Volcanic Activity occurs via vents that act as a conduit between the Earth's surface and inner layers, and erupt gas, molten rock, and volcanic ash when gas pressure and buoyancy drive molten rock upward and through zones of weakness in the Earth's crust.

In the National Risk Index data, a Volcanic Activity Risk Index score and rating represent a community's relative risk for Volcanic Activity when compared to the rest of the United States. A Volcanic Activity Expected Annual Loss score and rating represent a community's relative level of expected building and population loss each year due to Volcanic Activity when compared to the rest of the United States.

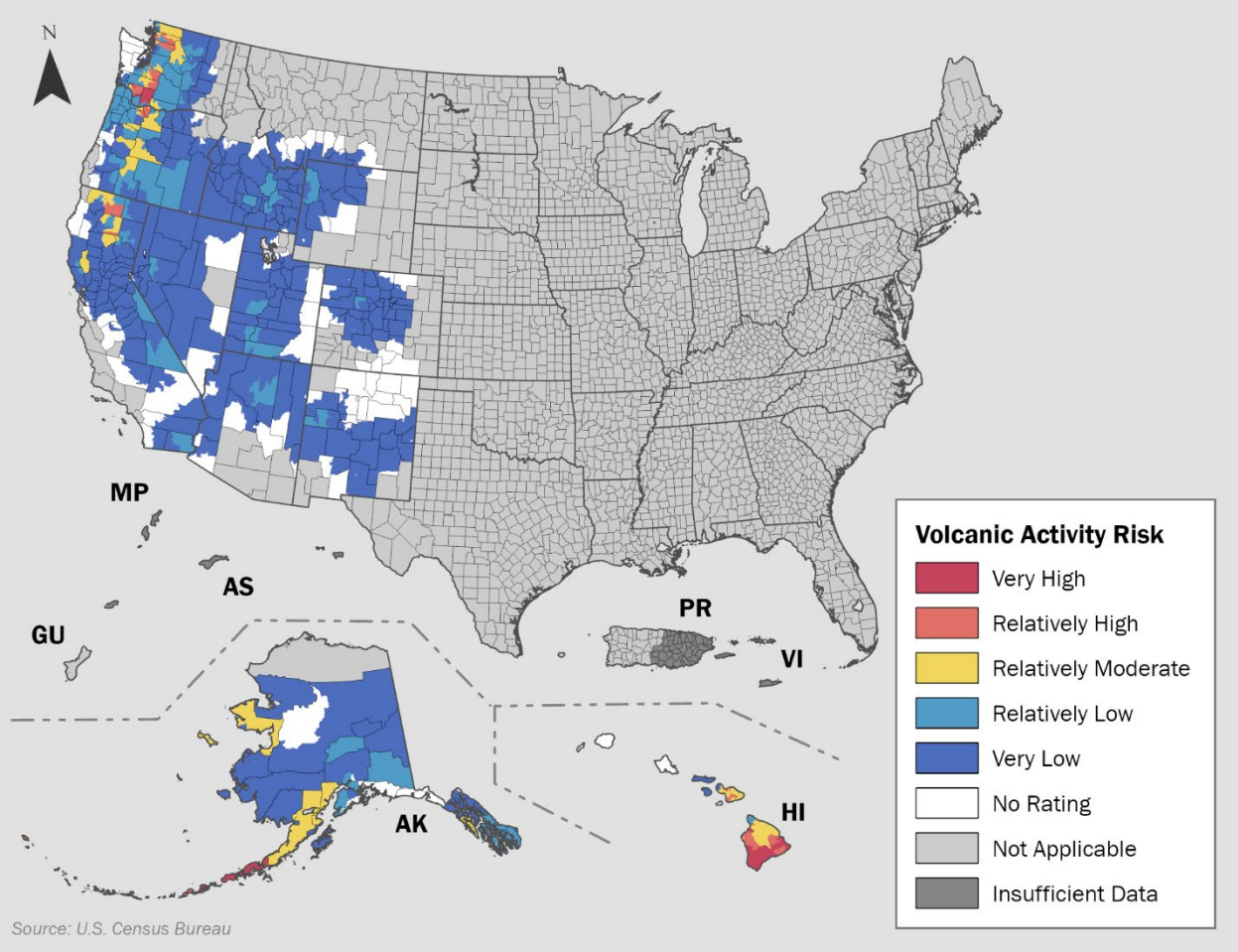

Figure 18: Volcanic Activity Risk Index Rating by County

2.16.1. VOLCANIC ACTIVITY EXPOSURE

A Volcanic Activity exposure value represents a community's building value (in dollars) and population (in both people and population equivalence) exposed to Volcanic Activity.

2.16.2. VOLCANIC ACTIVITY ANNUALIZED FREQUENCY

A Volcanic Activity annualized frequency value is based on the expected recurrence interval of a volcanic eruption event.

Source Data

USGS's National Volcanic Threat Layer

2018 Update to the U.S. Geological Survey National Volcanic Threat Assessment

2.16.3. VOLCANIC ACTIVITY HISTORIC LOSS RATIO

A Volcanic Activity historic loss ratio is the representative percentage of the exposed consequence type value (building or population) expected to be lost due to a Volcanic Activity hazard occurrence.

2.16.4. VOLCANIC ACTIVITY PROCESSING METHODOLOGY

For comprehensive details about the Volcanic Activity processing methodology, see the National Risk Index Data Technical Documentation.

2.17. Wildfire

A Wildfire is an unplanned fire burning in natural or wildland areas such as forests, shrub lands, grasslands, or prairies.

In the National Risk Index data, a Wildfire Risk Index score and rating represent a community's relative risk for Wildfires when compared to the rest of the United States. A Wildfire Expected Annual Loss score and rating represent a community's relative level of expected building and population loss each year due to Wildfires when compared to the rest of the United States.

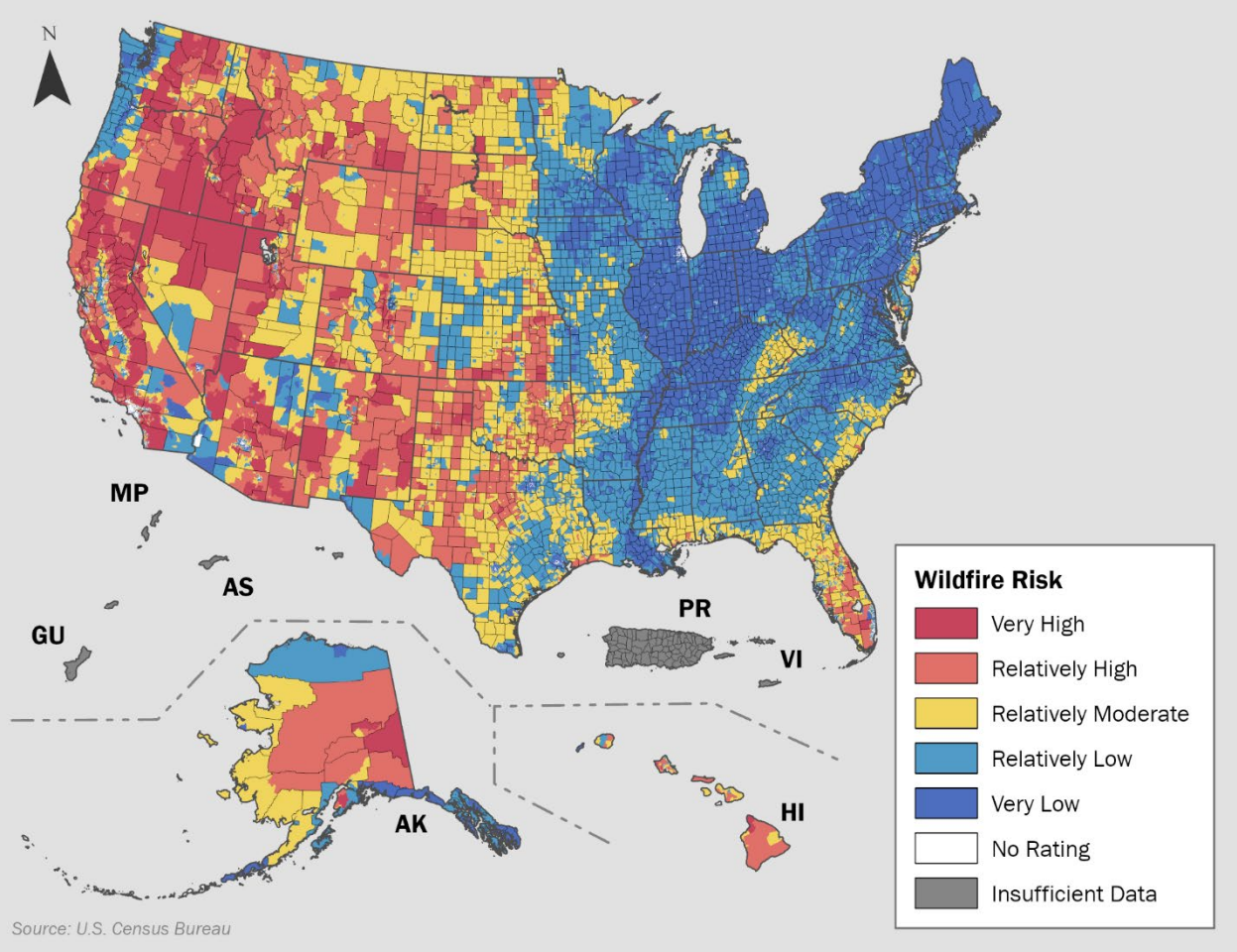

Figure 19: Wildfire Risk Index Rating by County

2.17.1. WILDFIRE EXPOSURE

A Wildfire exposure value represents a community's building value (in dollars), population (in both people and population equivalence), and agriculture value (in dollars) exposed to Wildfires.

2.17.2. WILDFIRE ANNUALIZED FREQUENCY

A Wildfire annualized frequency value represents the modeled frequency of Wildfire hazard occurrences (events) per year.

Source Data

U.S. Department of Agriculture's Forest Services' FSIM Burn Probability and Fire Intensity Level Data

2.17.3. WILDFIRE HISTORIC LOSS RATIO

A Wildfire historic loss ratio is the representative percentage of the exposed consequence type value (building, population, or agriculture) expected to be lost due to a Wildfire hazard occurrence.

2.17.4. WILDFIRE PROCESSING METHODOLOGY

For comprehensive details about the Wildfire processing methodology, see the National Risk Index Data Technical Documentation.

2.18. Winter Weather

Winter Weather consists of winter storm events in which the main types of precipitation are snow, sleet, or freezing rain.

In the National Risk Index data, a Winter Weather Risk Index score and rating represent a community's relative risk for Winter Weather when compared to the rest of the United States. A Winter Weather Expected Annual Loss score and rating represent a community's relative level of expected building and population loss each year due to Winter Weather when compared to the rest of the United States.

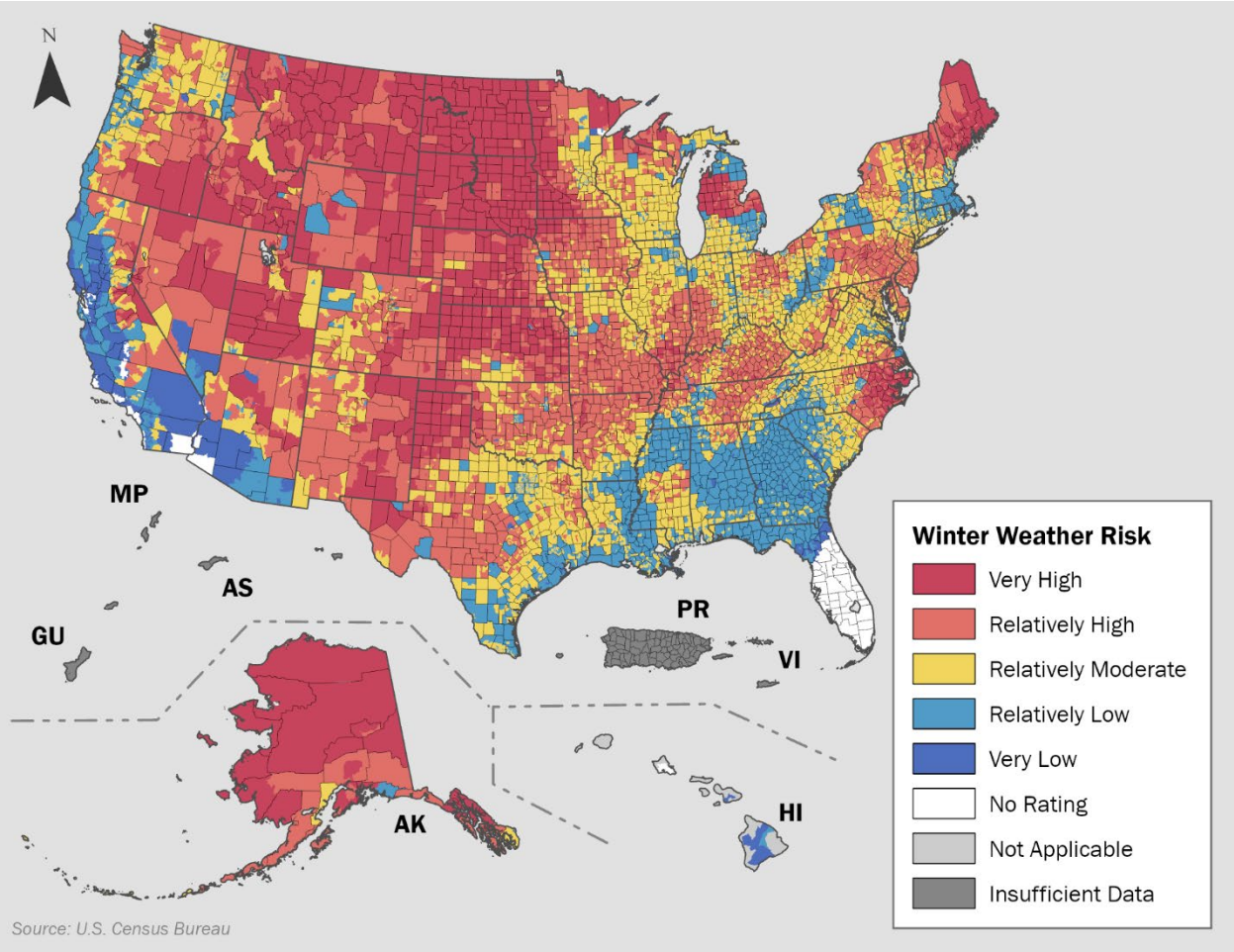

Figure 20: Winter Weather Risk Index Rating by County

2.18.1. WINTER WEATHER EXPOSURE

A Winter Weather exposure value represents a community's building value (in dollars), population (in both people and population equivalence), and agriculture value (in dollars) exposed to Winter Weather.

2.18.2. WINTER WEATHER ANNUALIZED FREQUENCY

A Winter Weather annualized frequency value represents the average number of recorded Winter Weather hazard occurrences (events) per year over the period of record (18 years).

Source Data

National Oceanic and Atmospheric Administration's National Weather Service Weather Alerts compiled and archived by Iowa State University's Iowa Environmental Mesonet

2.18.3. WINTER WEATHER HISTORIC LOSS RATIO

A Winter Weather historic loss ratio is the representative percentage of the exposed consequence type value (building, population, or agriculture) expected to be lost due to a Winter Weather hazard occurrence.

2.18.4. WINTER WEATHER PROCESSING METHODOLOGY

For comprehensive details about the Winter Weather processing methodology, see the National Risk Index Data Technical Documentation.

Appendix A: Data Glossary

Agriculture Exposure Value

Agriculture exposure value refers to the estimated dollar value of crops and livestock determined to be exposed to a hazard according to a hazard-specific methodology.

Annualized Frequency

Annualized frequency is a natural hazard incidence factor for Expected Annual Loss, a risk component of the National Risk Index data. It is the expected frequency or probability of a hazard occurrence per year.

Building Exposure Value

Building exposure value refers to the dollar value of the buildings determined to be exposed to a hazard according to a hazard-specific methodology.

Census Blocks

Census blocks are statistical areas bounded by visible features—such as streets, roads, streams, and railroad tracks—and nonvisible boundaries—such as selected property lines and city, township, school district, and county boundaries. Census blocks are the smallest geographic area for which the U.S. Census Bureau collects and tabulates decennial Census data.

Census Tracts

Census tracts are small, relatively permanent statistical subdivisions of a county or equivalent entity that is updated by local participants prior to each decennial Census as part of the U.S. Census Bureau's Participant Statistical Areas Program. The primary purpose of Census tracts is to provide a stable set of geographic units for the presentation of statistical data.

Community Resilience

Community Resilience is a consequence reduction risk component and community risk factor that represents the ability of a community to prepare for anticipated natural hazards, adapt to changing conditions, and withstand and recover rapidly from disruptions.

Consequence Types

Consequences of natural hazard occurrences are categorized into three distinct types: buildings, population, and agriculture.

Expected Annual Loss

Expected Annual Loss (EAL) is a natural hazards component of the National Risk Index data that represents the average loss in dollars to buildings, population, and/or agriculture (consequence types) each year due to natural hazards.

Expected Annual Loss Rate

Expected Annual Loss Rate is a measure of relative natural hazard intensities independent of the community's exposure value. They represent the average percentage losses to buildings, population, and/or agriculture (consequence types) each year due to natural hazards.

Exposure

Exposure is a natural hazard consequence factor for Expected Annual Loss, a risk component of the National Risk Index. It is the representative value of buildings, population, or agriculture potentially exposed to a natural hazard occurrence.

Fishnet Grid

A fishnet grid is a geographic information system (GIS) feature containing a net of rectangular cells that can be used for sampling locations or as aggregation areas.

Geographic Information Systems (GIS)

A geographic information system (GIS) is a database system with software that can analyze and display data in a visual environment using digitized maps and tables. Maps and data may be layered, displayed, edited, and analyzed in a wide variety of ways.

Historic Loss Ratio

Historic loss ratio (HLR) is a natural hazard consequence factor of the Expected Annual Loss component of the National Risk Index. It is a hazard- and county-specific estimate of the percentage of the exposed consequence type (building value, population, or agriculture value) expected to be lost due to a hazard occurrence.

Natural Hazard Risk

Natural hazard risk is the potential for negative impacts as a result of a natural hazard.

Natural Hazards

Natural hazards are environmental phenomena that impact societies and the human environment.

Population Exposure

Population exposure refers to the estimated number of people determined to be exposed to a hazard according to a hazard-specific methodology.

Raster

A raster consists of a matrix of cells (or pixels) organized into rows and columns (or a grid) where each cell contains a value representing information. Cell values represent the phenomenon portrayed by the raster dataset, such as category or magnitude.

Risk Value

Risk value represents the average loss in dollars to buildings, population, and/or agriculture (consequence types) each year to a community due to natural hazards adjusted based on the community's Social Vulnerability and Community Resilience.

Social Vulnerability

Social vulnerability is a consequence enhancing risk component and community risk factor that represents the susceptibility of social groups to the adverse impacts of natural hazards, including disproportionate death, injury, loss, or disruption of livelihood.

Value of Statistical Life (VSL)

Monetary value of preventing one statistical death. Within the National Risk Index data, a VSL of $13.7M per fatality or 10 injuries is used to monetize population losses so that a total expected annual loss value can be computed that considers losses to buildings, population, and agriculture.