# US Vulnerability to Natural Hazards

NATURAL DISASTERS result from the coincidence of natural events with the built environment. To reduce natural disasters, we need to increase awareness of natural disasters and the predictable consequences of high-risk land-use. By superimposing population density with predicted ground motion from earthquakes, historical hurricane tracks, historical tornado locations, and areas within the flood plain, we are able to identify locations of high vulnerability within the United States. Although their frequency varies considerably, the annualized losses for disaster relief from hurricanes, earthquakes, and floods are approximately equivalent and represent over 75% of federal emergency assistance. Tornadoes cause less damage, but are responsible for a significant percentage of deaths.

### Federal Disaster Relief as a Percentage of GDP
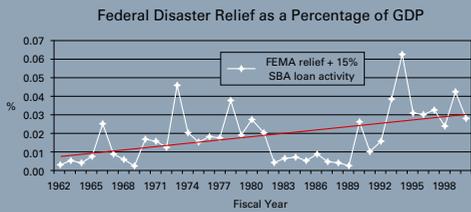
The costs of natural disasters have been increasing exponentially, largely due to increases in population and wealth density in disaster-prone areas. The figure above shows the federal government's expenditures for natural disasters as a percentage of Gross Domestic Product (GDP). Even when accounting for the exponential rise in GDP over the last four decades, the costs of natural disasters have tripled.

Aggregate Income versus Population by County
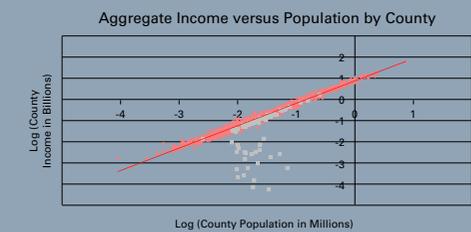
For the purposes of this analysis, population is used not only to represent human exposure to risk, but also vulnerable societal infrastructure. In the figure above, the correlation coefficient of income and population by county is .9919. With the exception of about two dozen counties, where the estimated value is too high, and a few large counties where the estimated value is too low, population density can be used as a proxy for societal infrastructure.

Earthquake Frequency w/ Selected Events
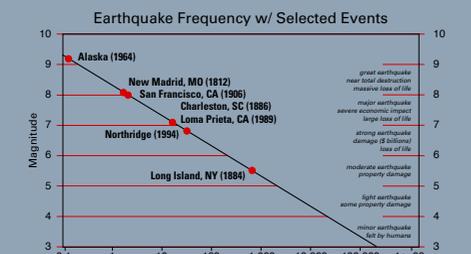
In general, the number of seismic events in a region increases by a factor of 10 for each unit of decrease in magnitude. This empirical observation, known as the Guttenberg-Richter relation, applies to earthquakes in the United States. As the figure above shows, we should expect approximately 2 magnitude 8, and 20 magnitude 7 earthquakes each century.

Tornado Frequency (TX, OK, KS)
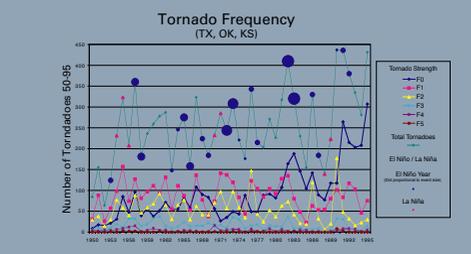
There are about 1,500 tornadoes in the US each year. The increase, particularly in F0 tornadoes, is probably due to improved detection capabilities. The correlation with El Niño years is not well-defined.

Legend

Hurricanes (1899-2000)	Tornadoes (1950-2000)	Population (2000 Census)	Hurricane Landfalls/Century	Earthquake Acceleration	Values on Map Correspond to the Percentage of Each State Within the Floodplain
S3 S4 S5	30	100,000	11 – 30 31 – 72	8 – 10 11 – 20 21 – 40 41 – 100 Peak Ground Acceleration (%g) with 10% Probability of Exceedance in 50 Years	

Percent of Area in Floodplain by State
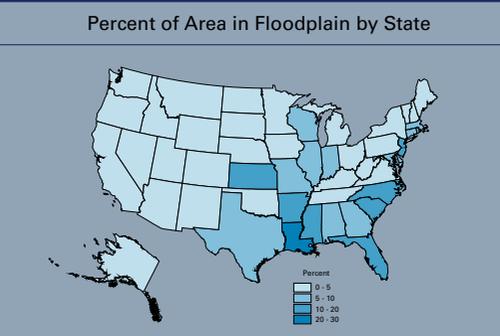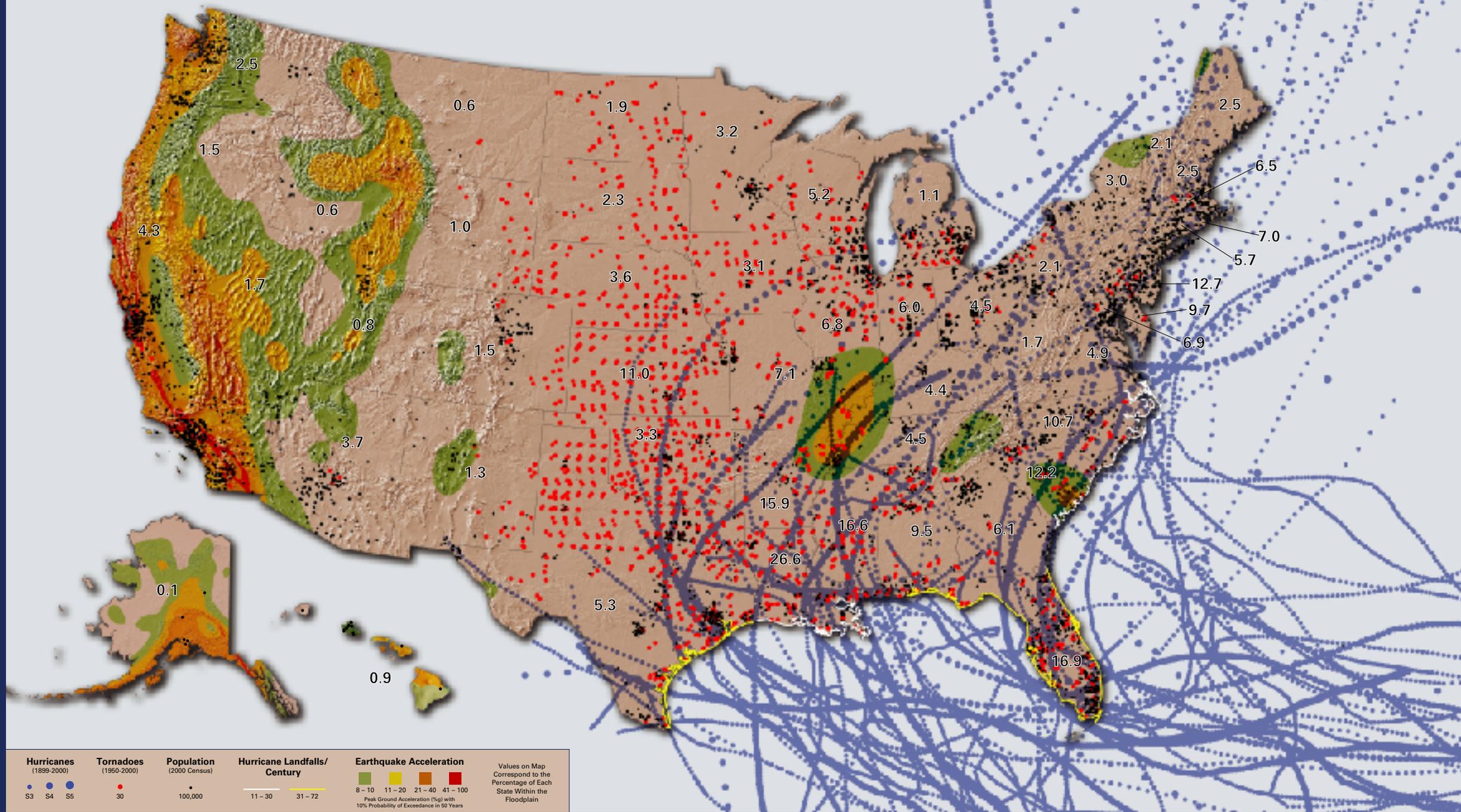
The area of the United States within the 100-year floodplain is approximately that of Texas. At present, more than 3 million households are in floodplains, and each year, the number increases. States that have the greatest percentage of area in the floodplain however, do not necessarily incur the largest number of flood disasters on a per capita basis – perhaps reflecting better land-use policies for those states. According to FEMA, only 2% of the flood insurance policy base is responsible for nearly 40% of the payments made by the National Flood Insurance Fund.

Percent: 0 - 5, 5 - 10, 10 - 20, 20 - 30

FEMA Cost per Person in Floodplain per Year

Dollars: 0 - 100, 100 - 1000, 4500 - 8000

Hurricane Tracks at Approximately 30 Year Intervals

1899 - 1927
1928 - 1960
1928 - 1960
1961 - 1990
1961 - 1990
1991 - 2000
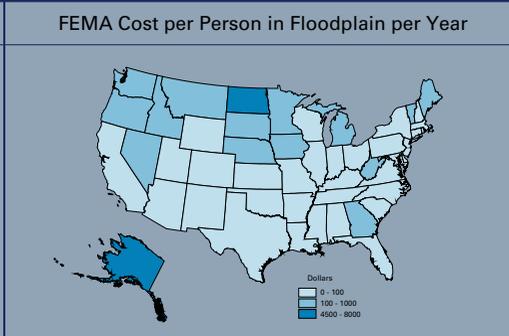
In the last century about 170 hurricanes have struck the United States. Each year in the Atlantic, approximately six hurricanes form, with one or two making landfall. The frequency, strength, and location are affected by wind shear and sea-surface temperatures, both of which are part of the greater El Niño and multi-decadal cycles and patterns. Historical tracks show East-West oscillations in 30-year periods. If this 30-year oscillation continues, hurricanes will become more frequent along the northern part of the Eastern Coast.