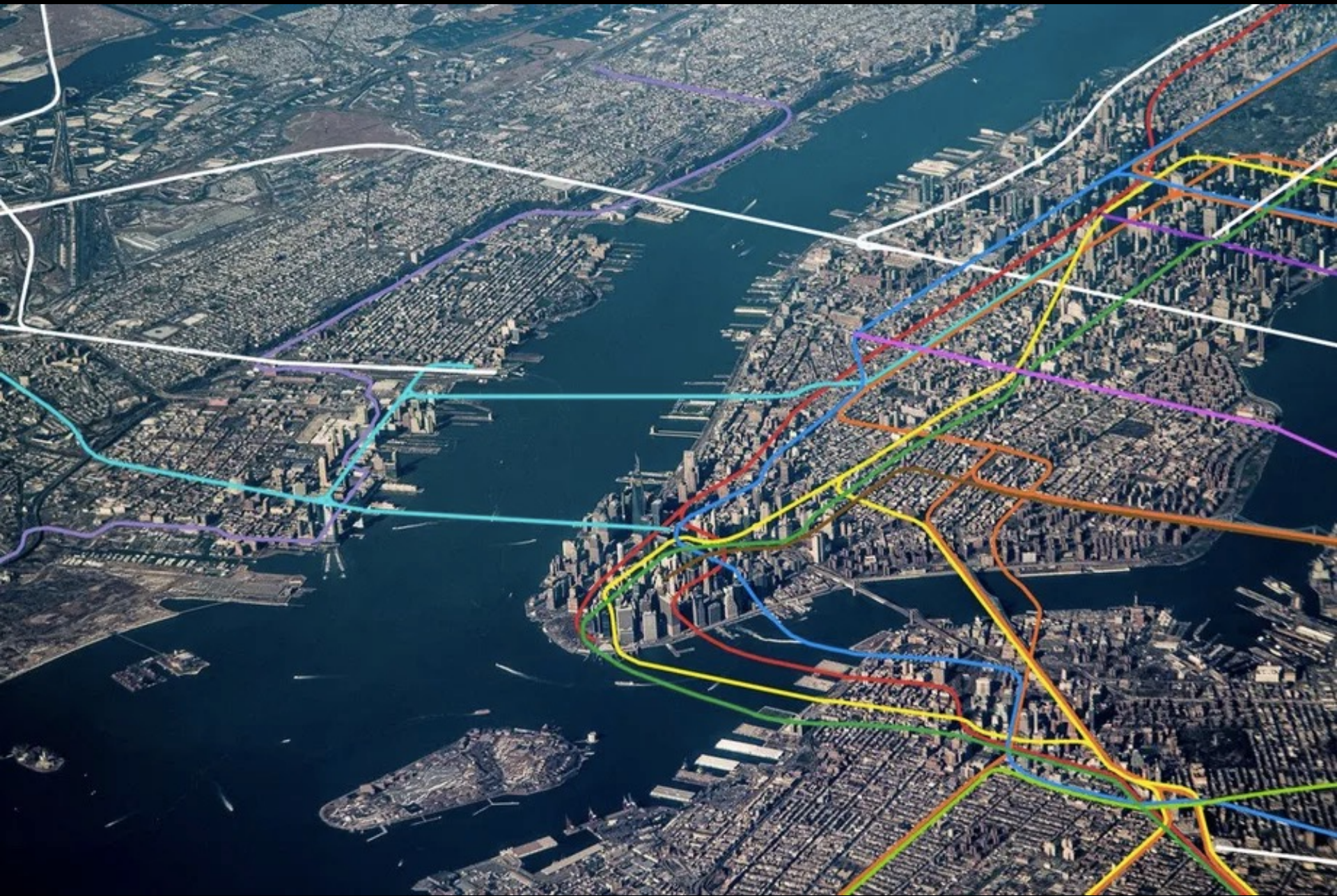
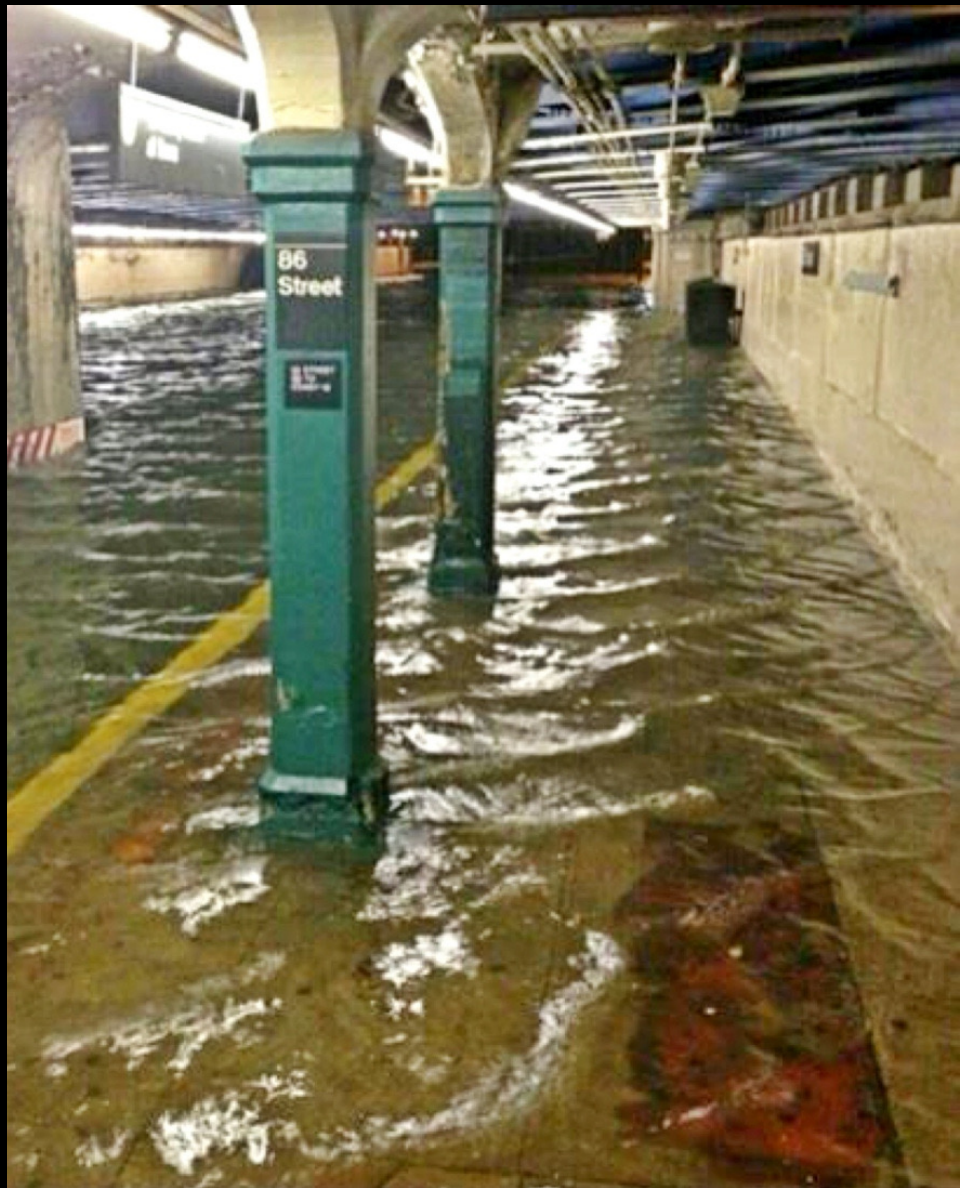
An aerial photograph of a city, likely New York City, showing a dense grid of buildings and streets. A large body of water, possibly a river or harbor, winds through the city. The text "The Limits of Predictions" and "An Example" is overlaid in white on the water. The image is framed by a black border.

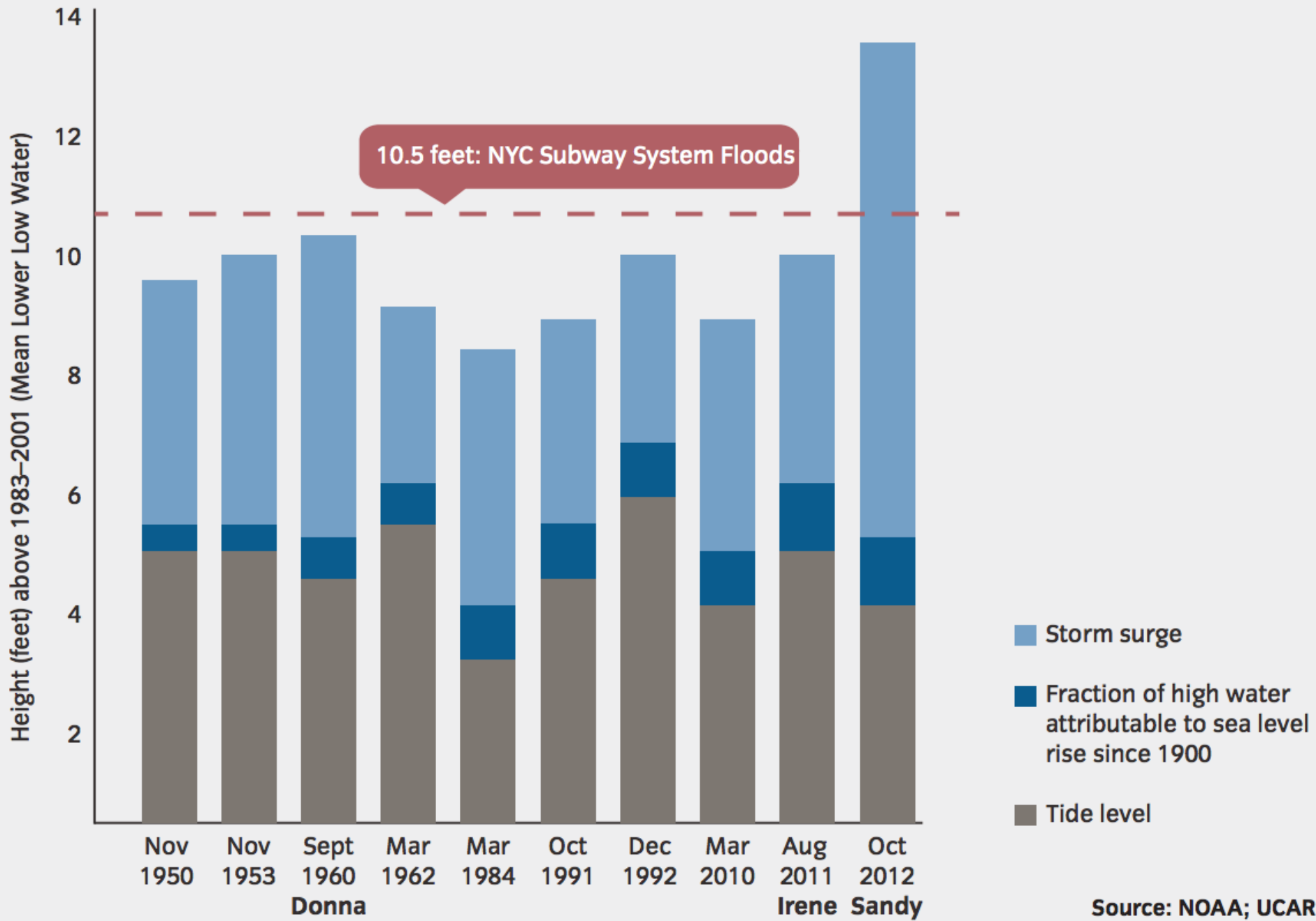
The Limits of Predictions

An Example









Source: NOAA; UCAR

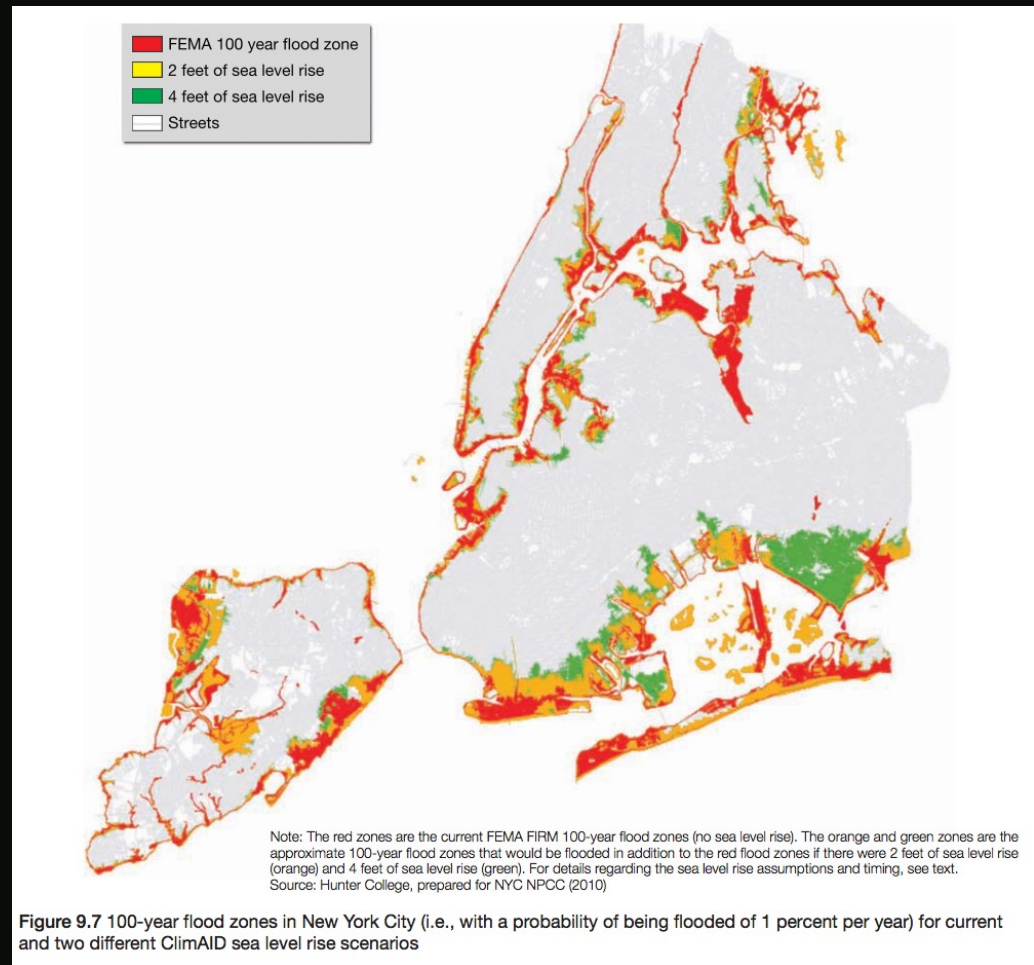
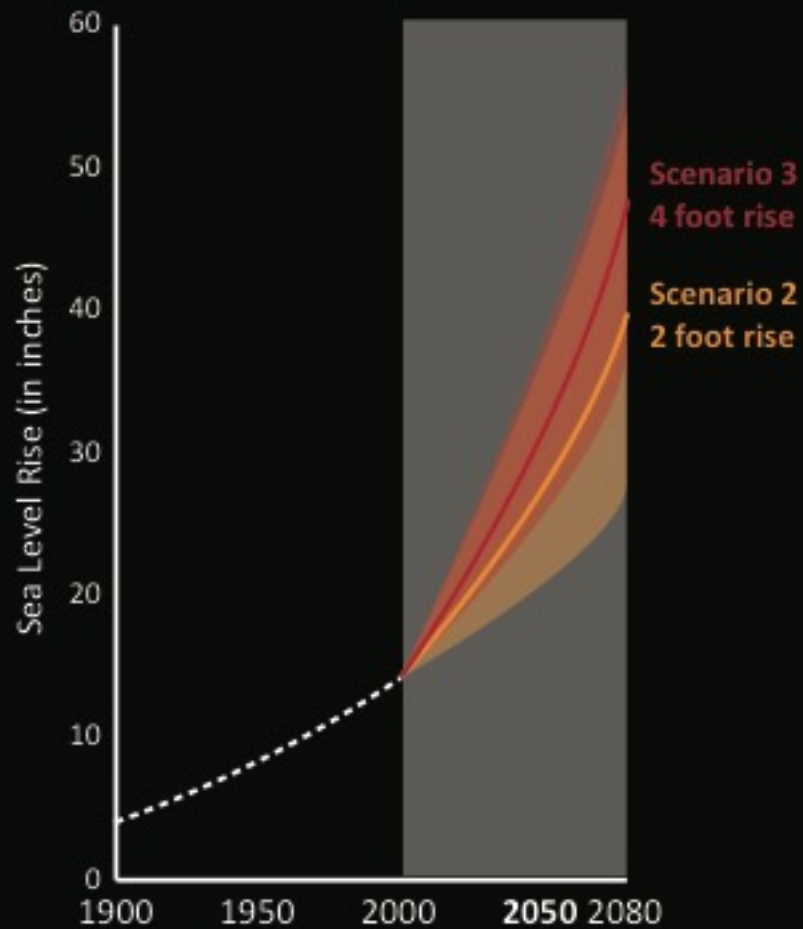
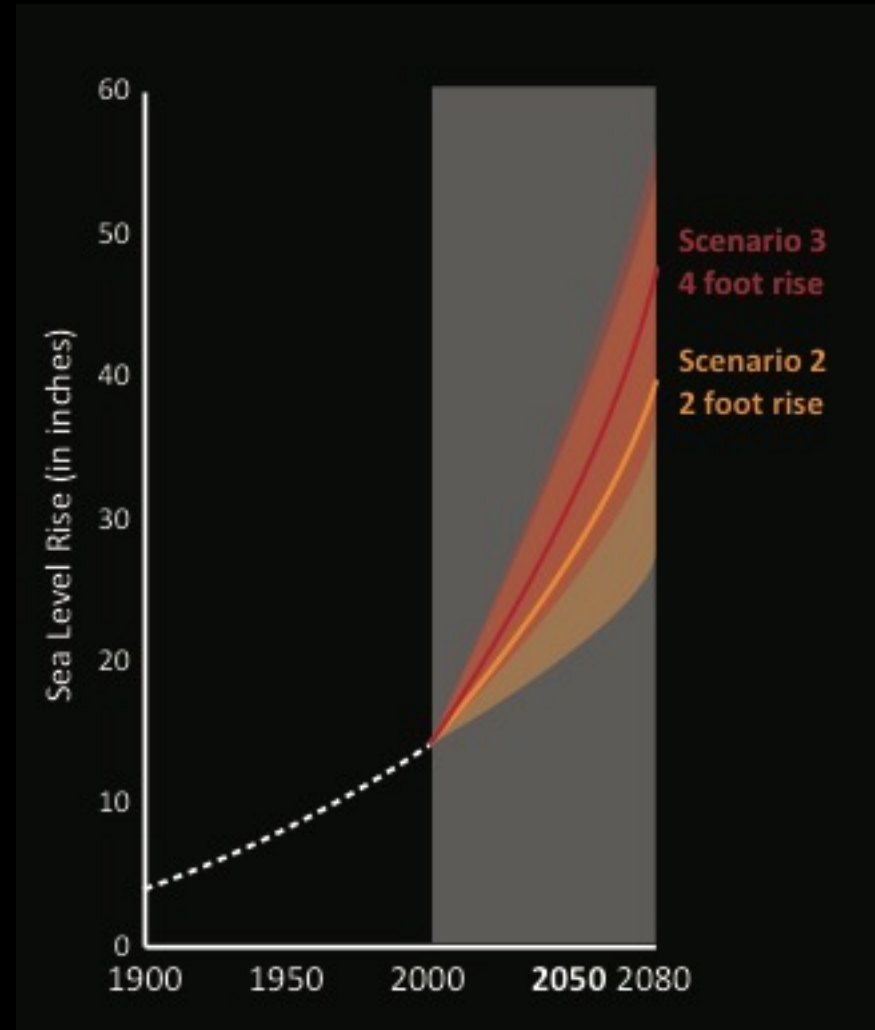
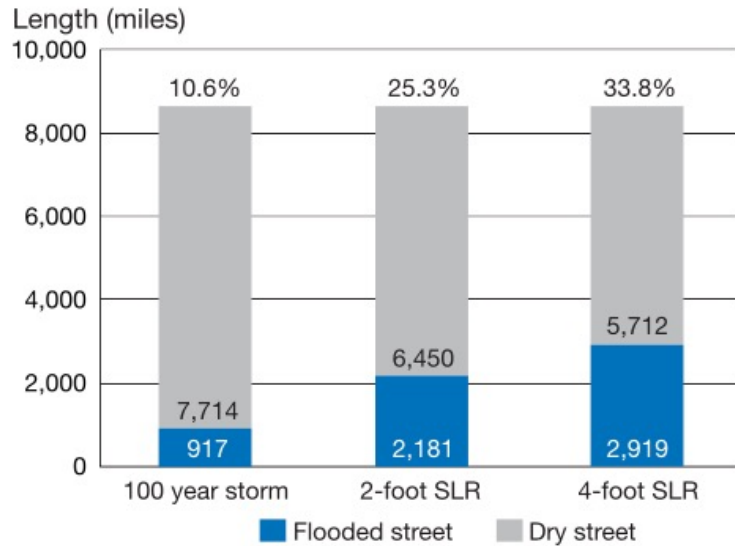


Figure 9.7 100-year flood zones in New York City (i.e., with a probability of being flooded of 1 percent per year) for current and two different ClimAID sea level rise scenarios

Climate Change

Variable	Slower Pace
Temperature	Slow warming
Extreme Precipitation Events	A few more events per year
Sea level rise	Projected rise of 2 feet
Coastal storms	Similar to current intensity
Variable	Faster Pace
Temperature	Rapid increase in heat
Extreme precipitation events	Double the number of extreme events per year.
Sea level rise	Projected rise of 4 feet
Coastal storms	Sandy-like storms a more likely occurrence





Total length (miles) of NYC streets that fall inside the respective flood zones as a function of sea level rise.

Scenario	Combined Economic (\$ billion)	Physical Damage (\$ billion)	Total Loss (\$ billion)
S1 (current sea level)	48	10	\$58
S2 (2-foot rise in sea level)	57	13	\$70
S3 (4-foot rise in sea level)	68	16	\$84

Combined economic and physical damage losses for the NYC metro region for a 100-year storm surge under current conditions and two sea level rise scenarios.

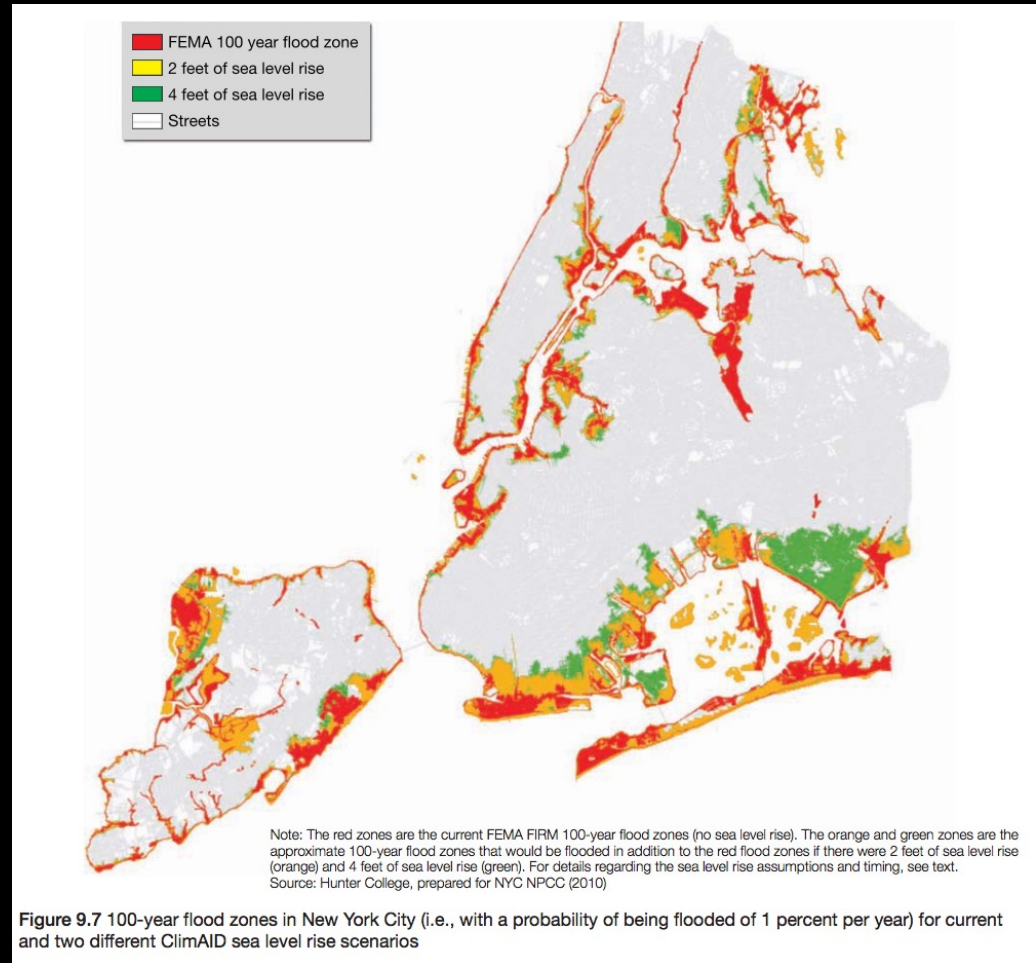
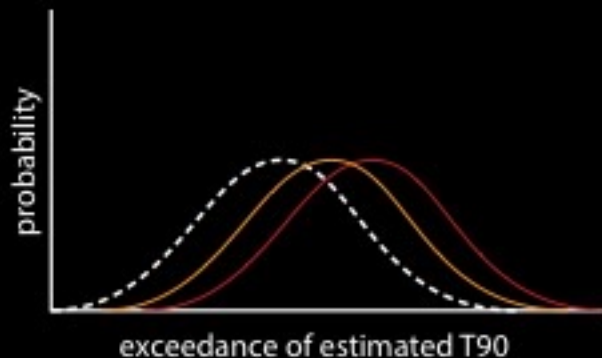
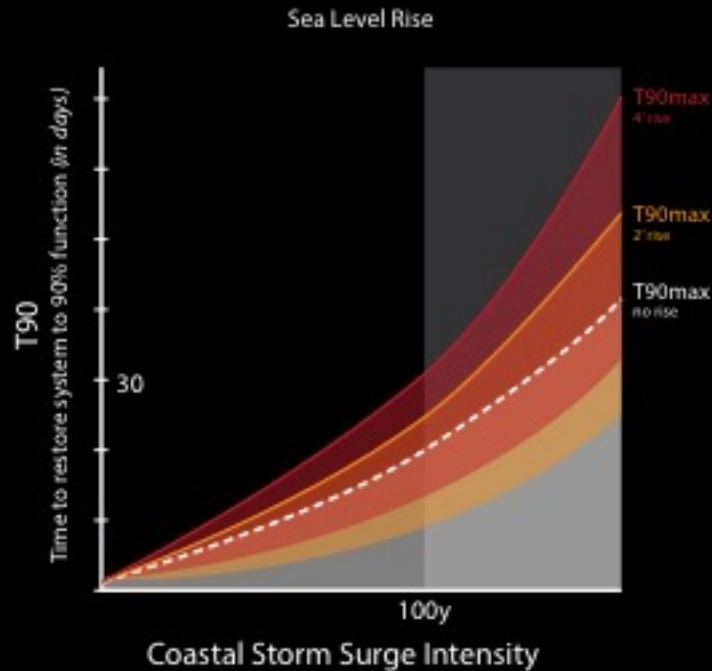


Figure 9.7 100-year flood zones in New York City (i.e., with a probability of being flooded of 1 percent per year) for current and two different ClimAID sea level rise scenarios

Flood Mitigation Technology



Variable	Reactive	Adaptive
Example	Sea wall	Sand Engine
Natural cycles	Fight the force of nature	Accommodate nature
Approach	Hard engineering through a protective armor	Soft engineering through a barrier sponge
Efficacy	Well tested; effective for design storms	Novel; more efficient in long term or for unprecedented events
Soil health	Depleting	Nourishing



- The time it takes to restore the system's functionality is a common transportation metric to evaluate risk.
- T90 is a measure of the number of days it takes to restore the system to 90% function. For example, after Sandy, T90 = 8 days
- A 100 year coastal storm surge with a 2 foot rise is modeled to result in a T90 of 1-25 days (orange).
- A 4' rise may increase T90 max to 30 days (red).
- Higher coastal storm surge intensities are expected to result in greater T90 values.

Sea Level Rise
Slower pace



Flood Mitigation Technology

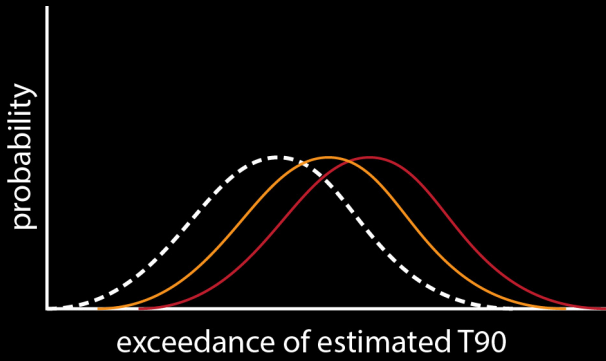
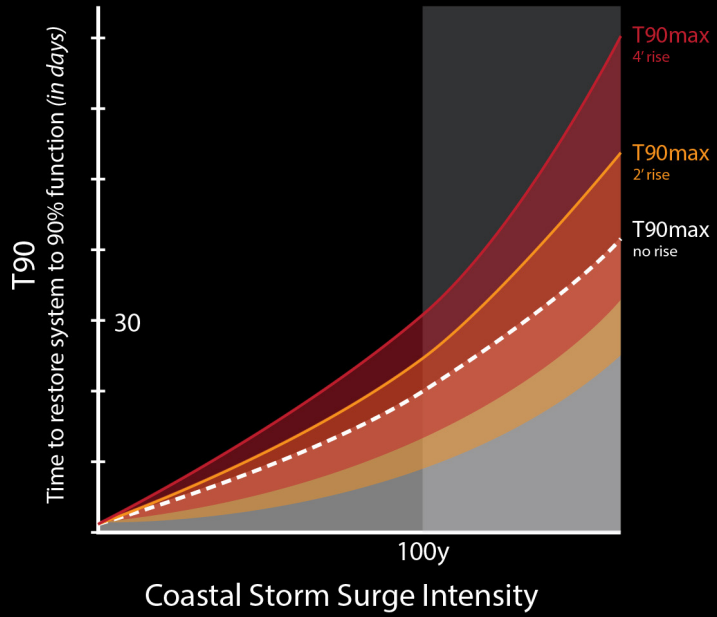
Reactive

Adaptive

Faster pace

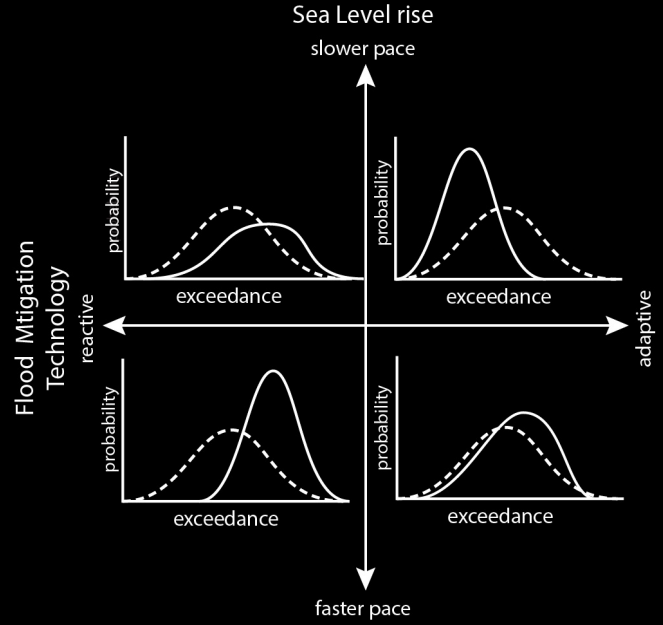
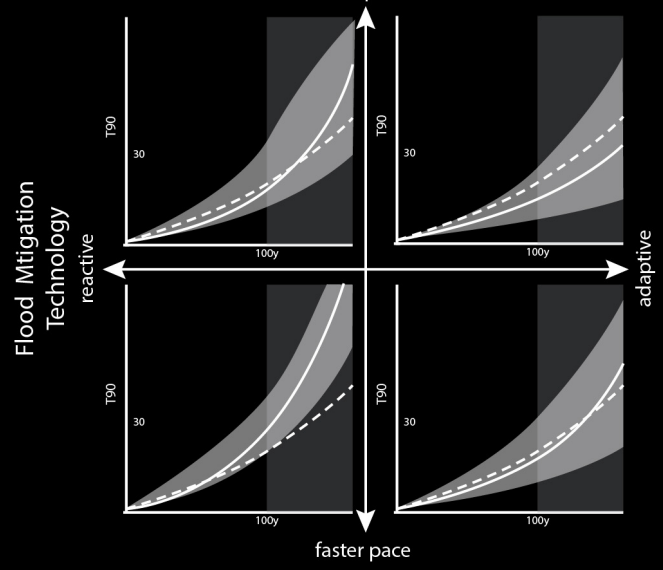
single driver

Sea Level Rise

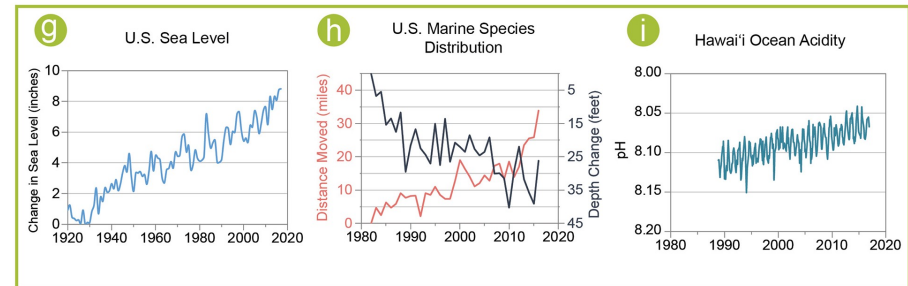
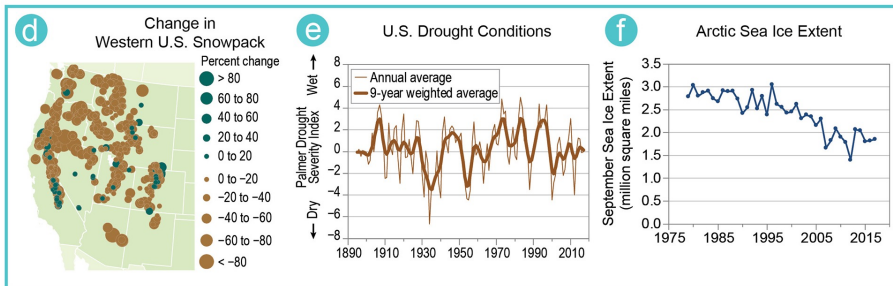
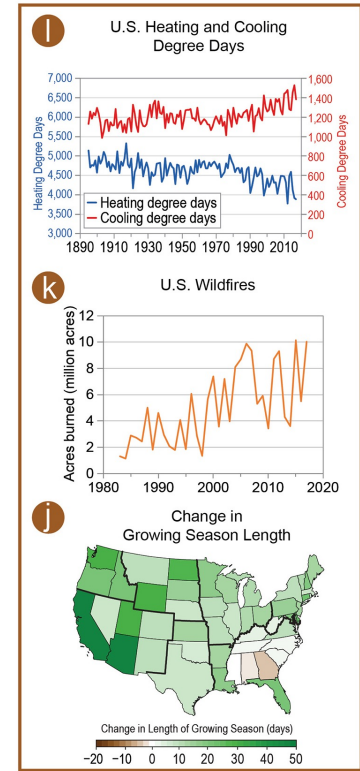
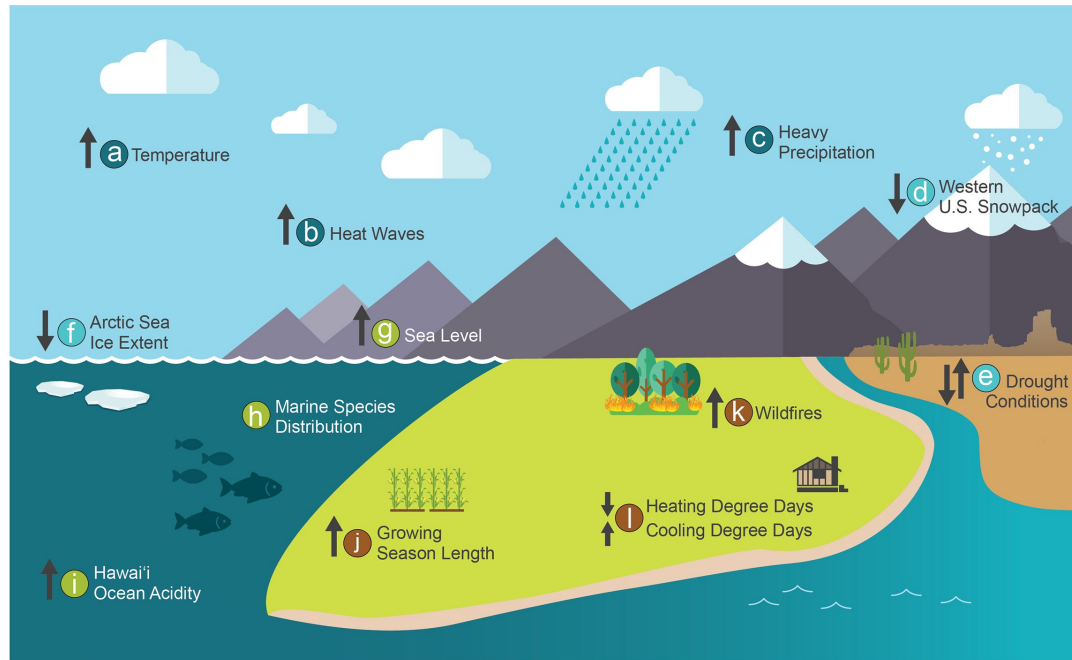
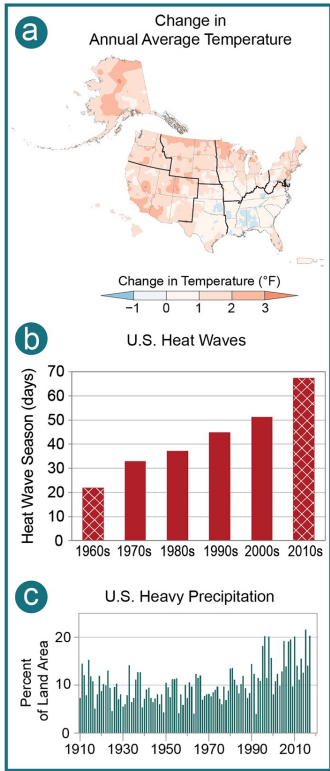


multiple drivers

Sea Level Rise

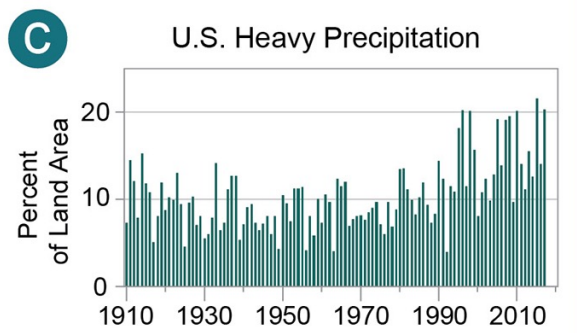
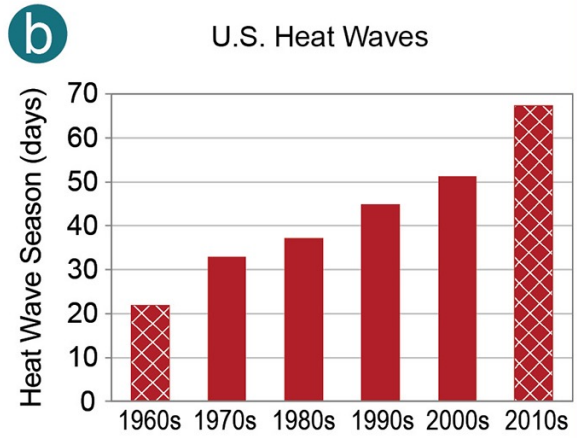
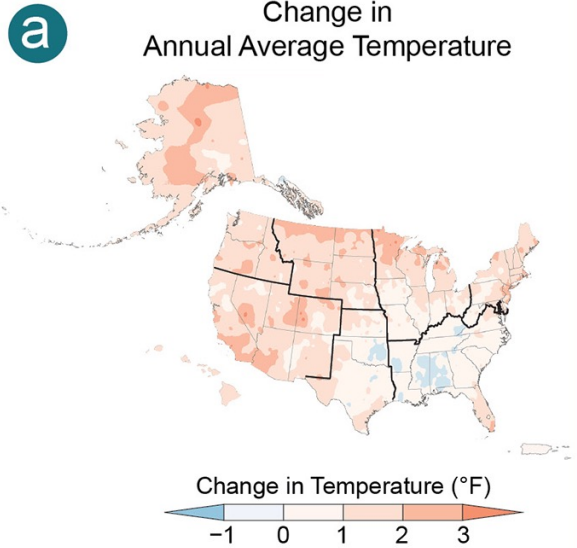


Observed Climate Change Trends in the US 1900-2018



Observed Climate Change Trends (US)

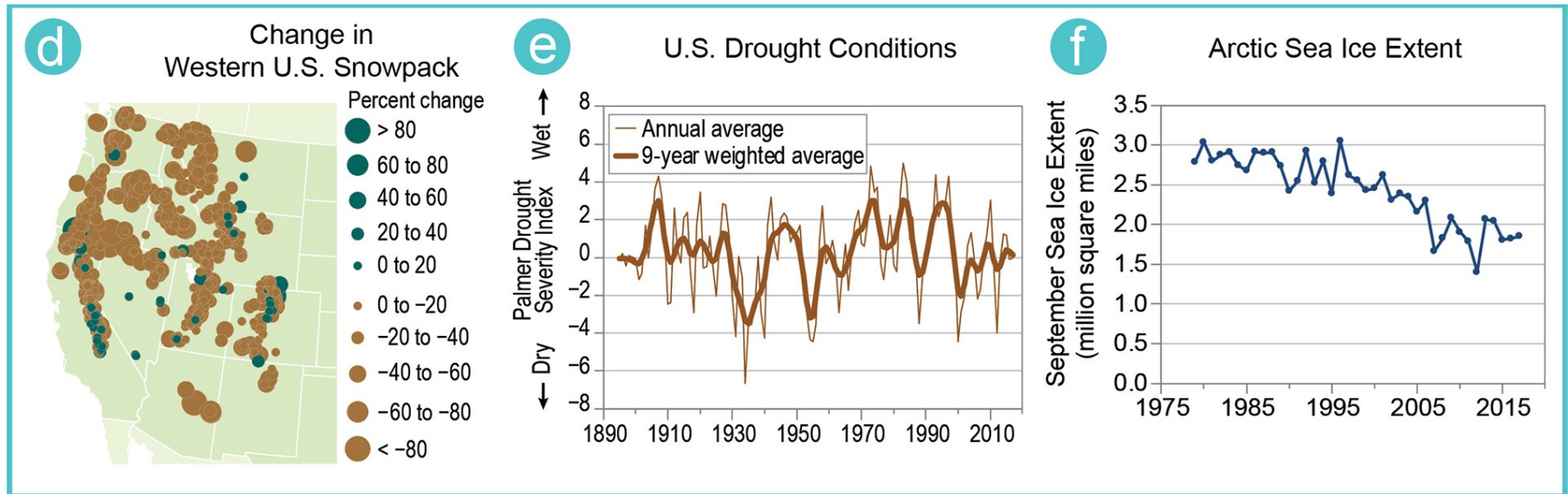
- Annual average temperatures have increased by 1.8°F across the contiguous United States since the beginning of the 20th century



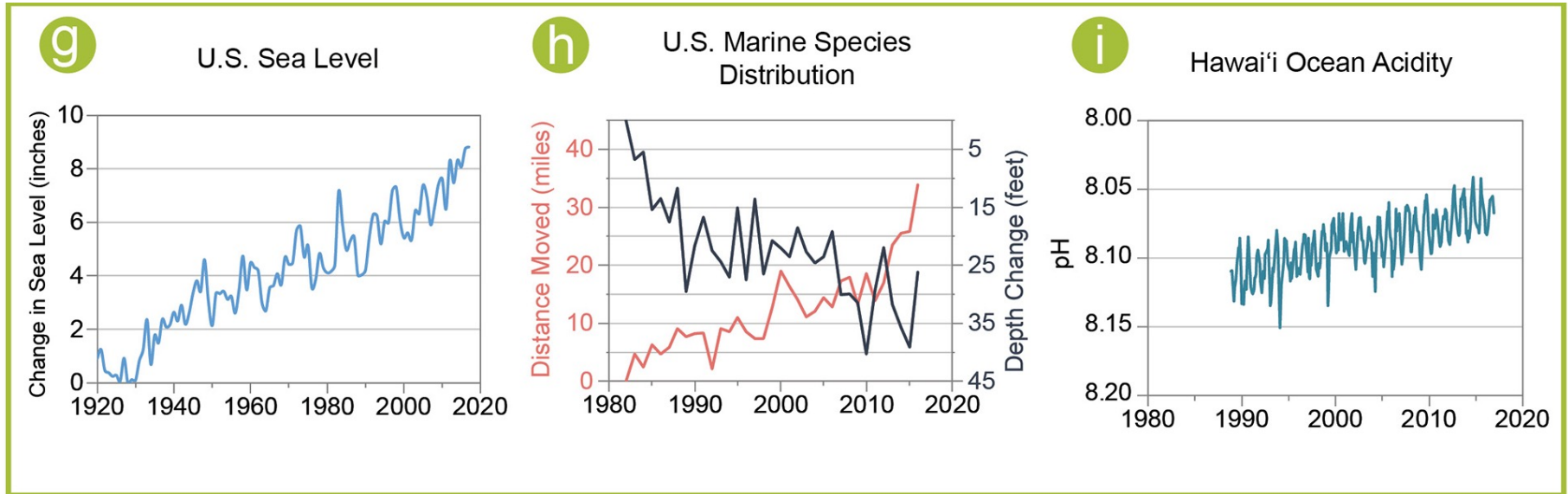
- The season length of heat waves in many U.S. cities has increased > 40 days since the 1960s
- relative amount of annual rainfall (single-day intense events) have increased since 1910

Observed Climate Change Trends in the US 1900-2018

- Large declines in snowpack in the western United States occurred from 1955 to 2016
- There is currently no detectable change in long-term U.S droughts, rather it varies across regions.
- Oceans are absorbing more than a quarter of the CO2 increasing their acidity

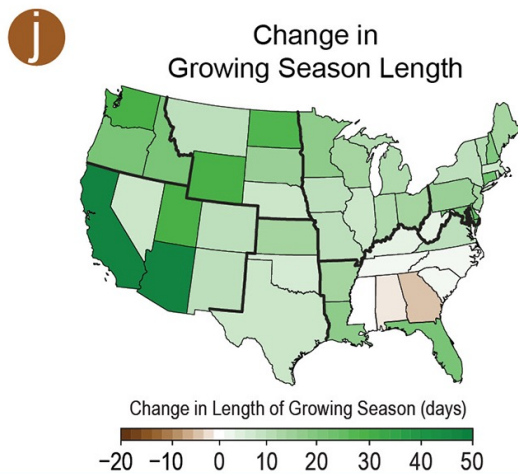
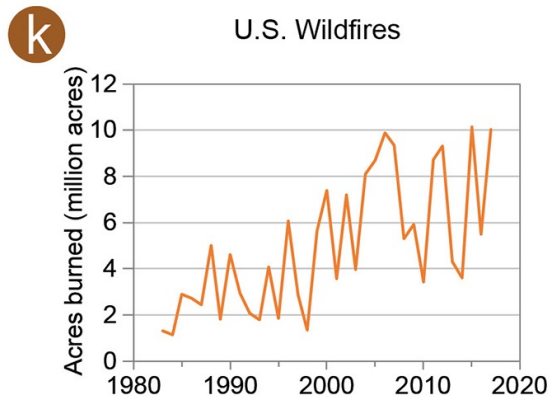
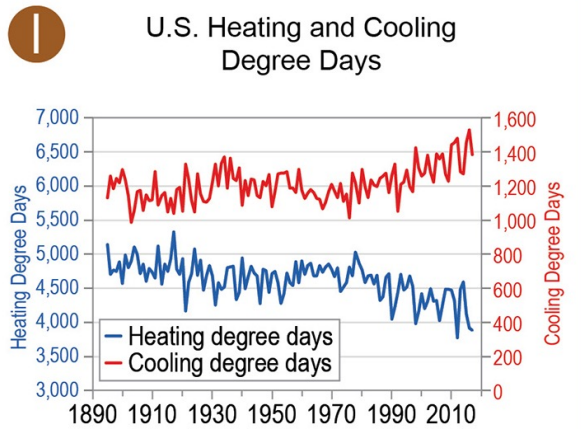


Observed Climate Change Trends in the US 1900-2018



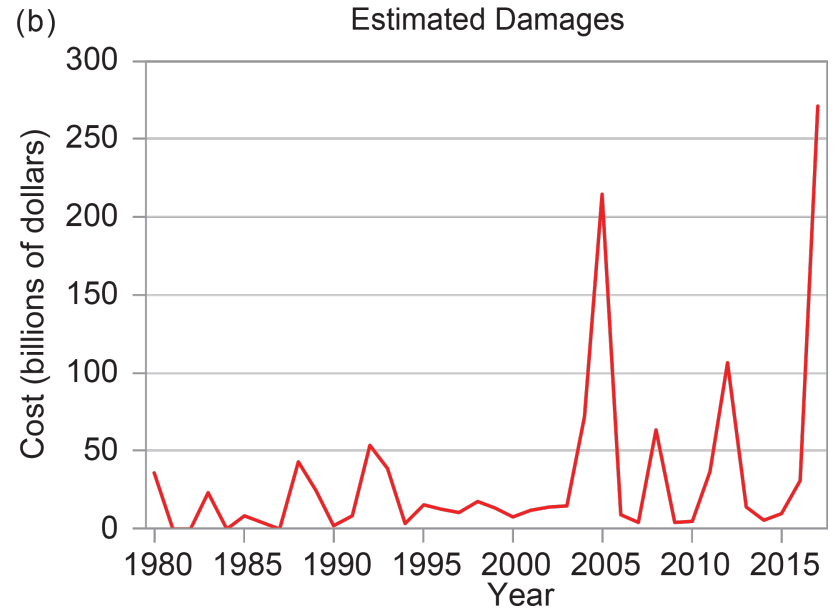
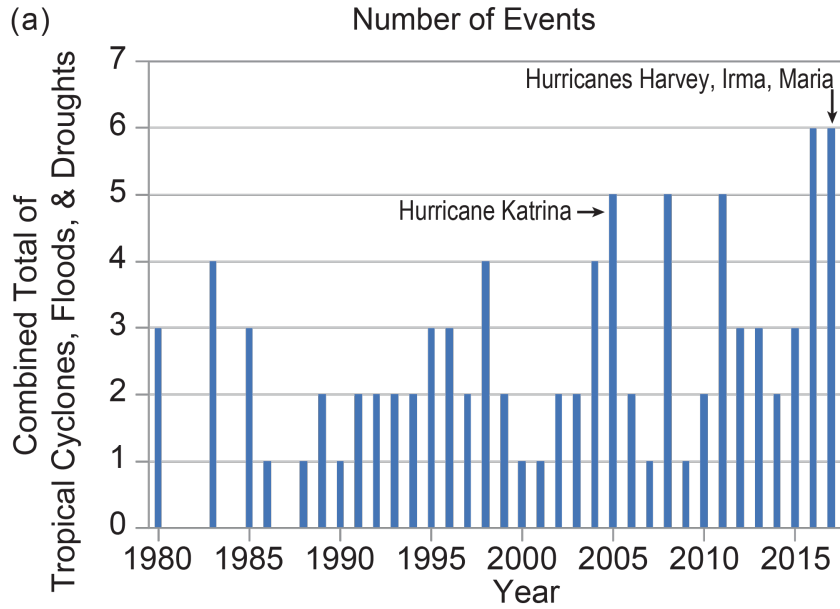
- Annual median sea level has increased by about 9 inches since the early 20th century
- Fish, shellfish, and other marine species along the Northeast coast, on average, moved northward since the early 1980s
- Oceans are absorbing more than a quarter of the CO₂ increasing their acidity

Observed Climate Change Trends (US)

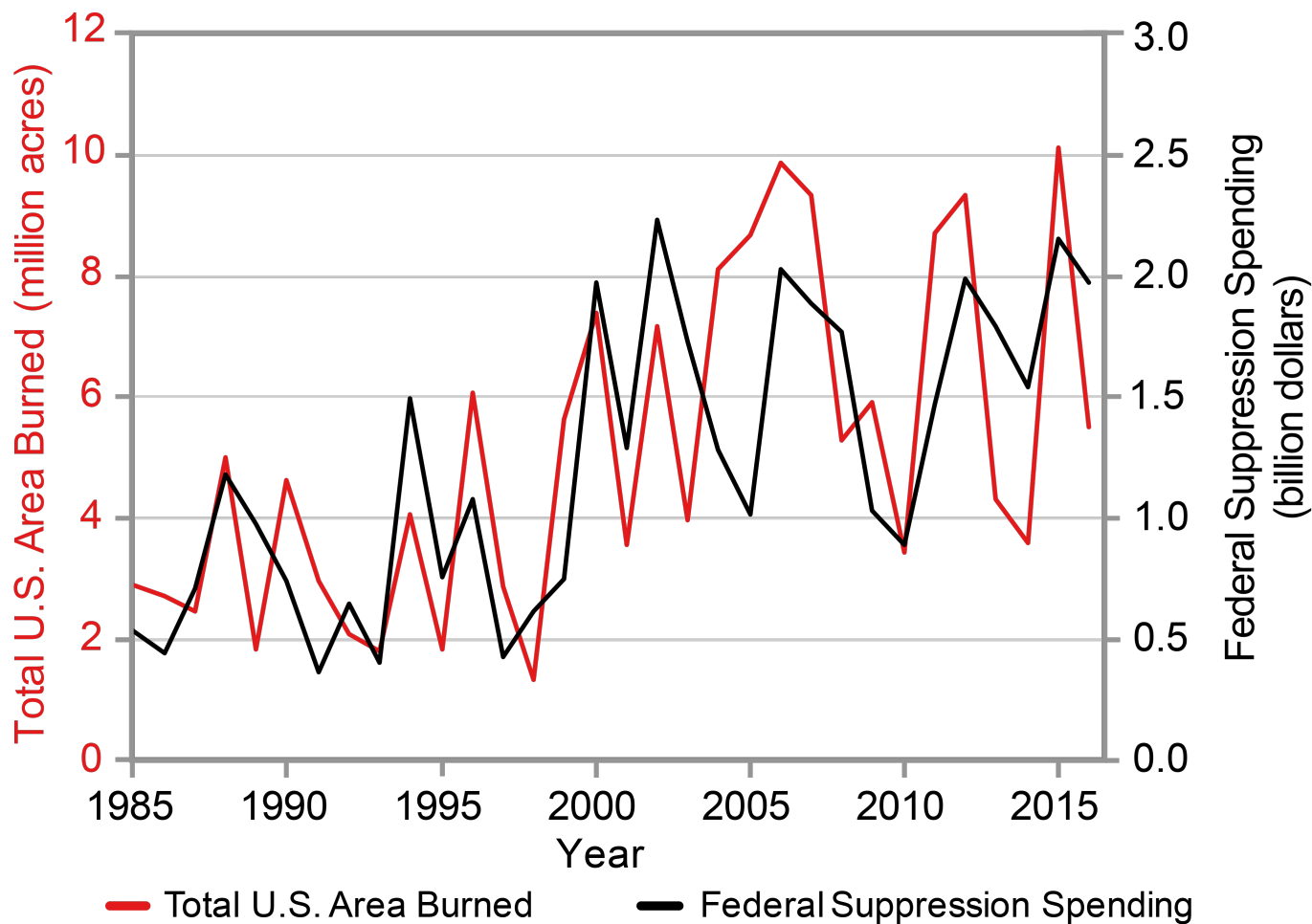


- Cooling degree days (defined as the number of degrees by which the average daily temperature is higher than 65°F) have increased and heating degree days (lower than 65°F) have decreased
- Warmer and drier conditions have contributed to an increase in large forest fires in the western United States
- The average length of the growing season has increased across the contiguous United States

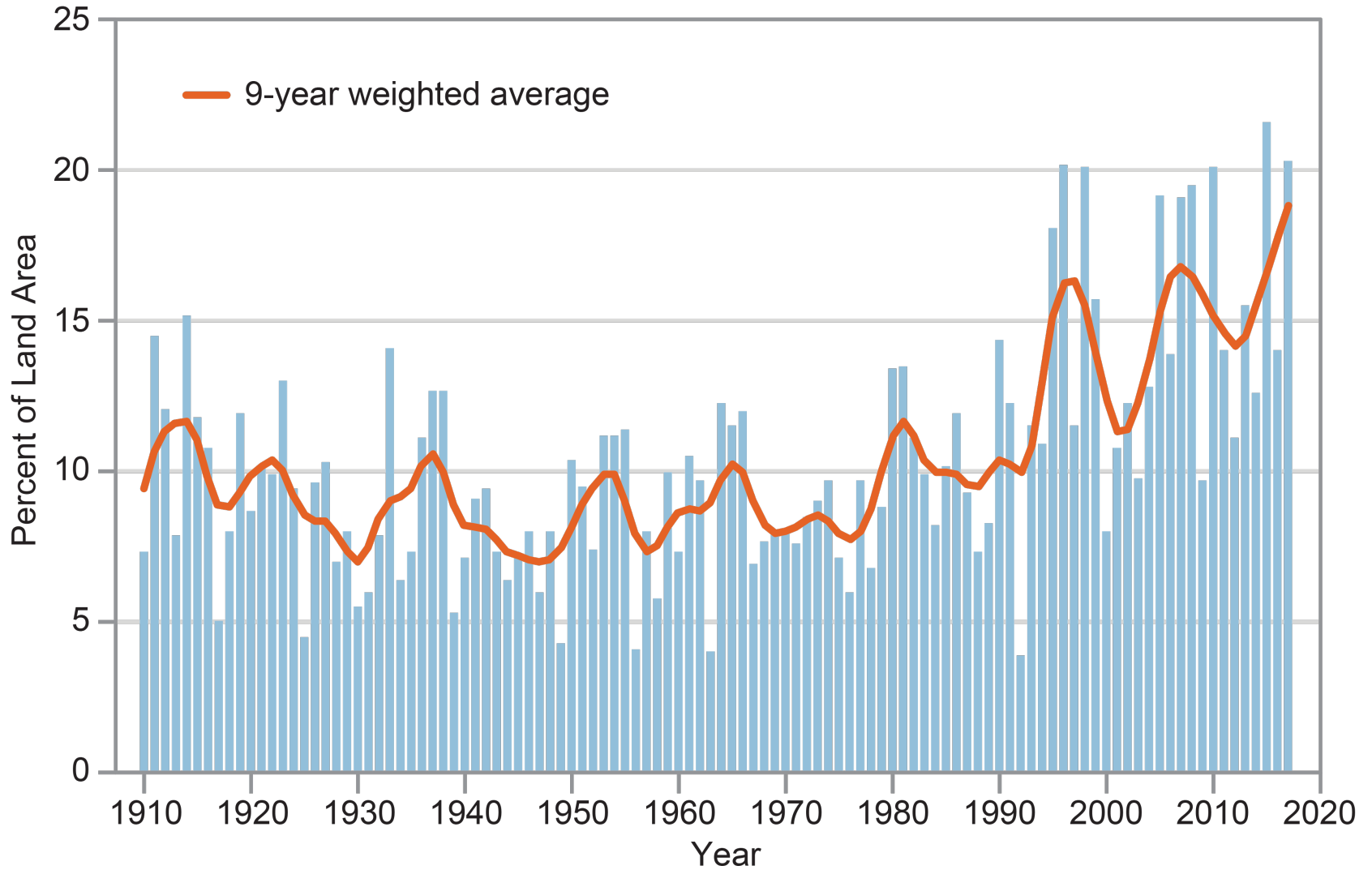
Billion-Dollar Weather and Climate Disaster Events in the United States



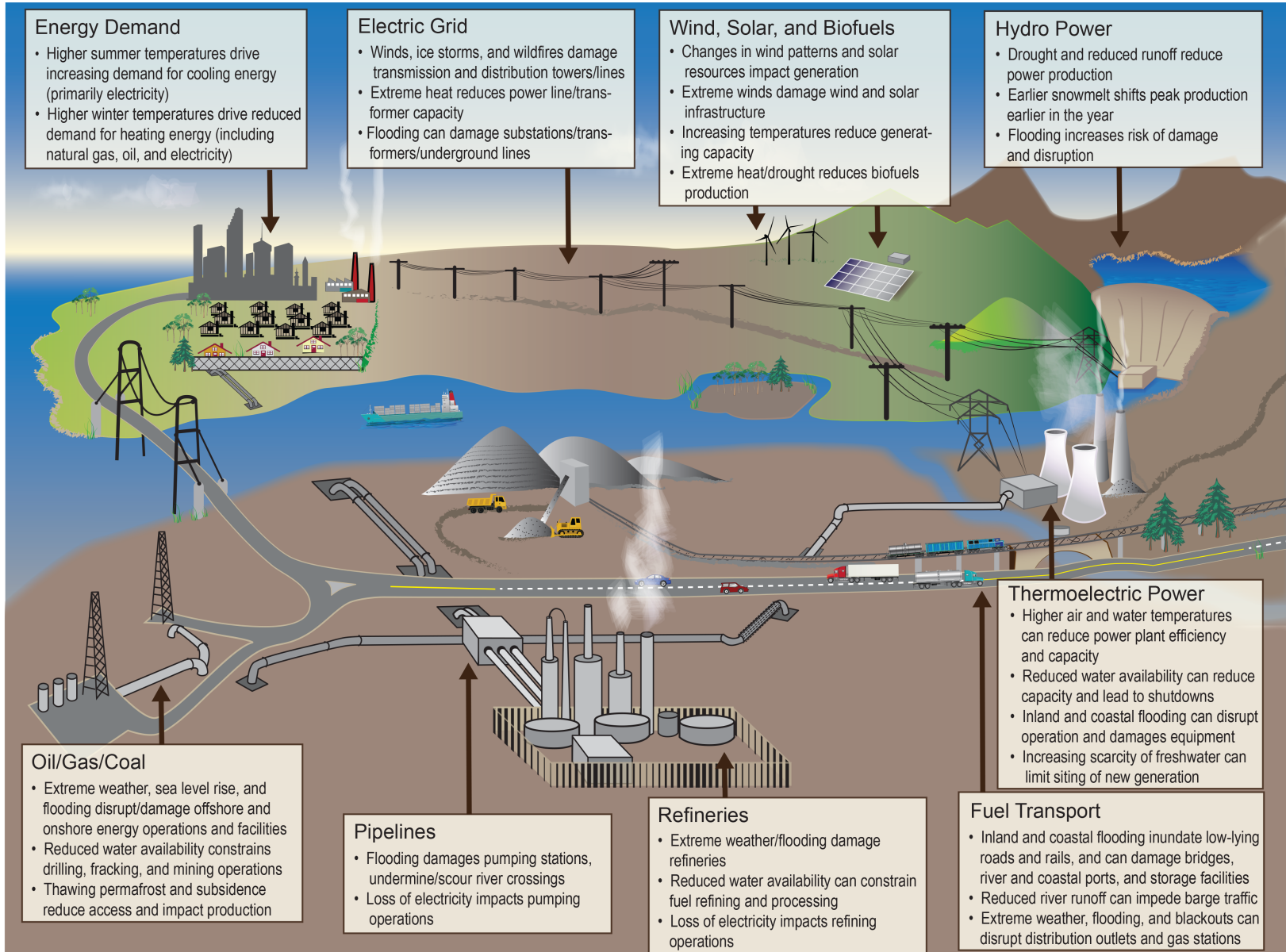
Wildfires—Changes in Area Burned and Cost



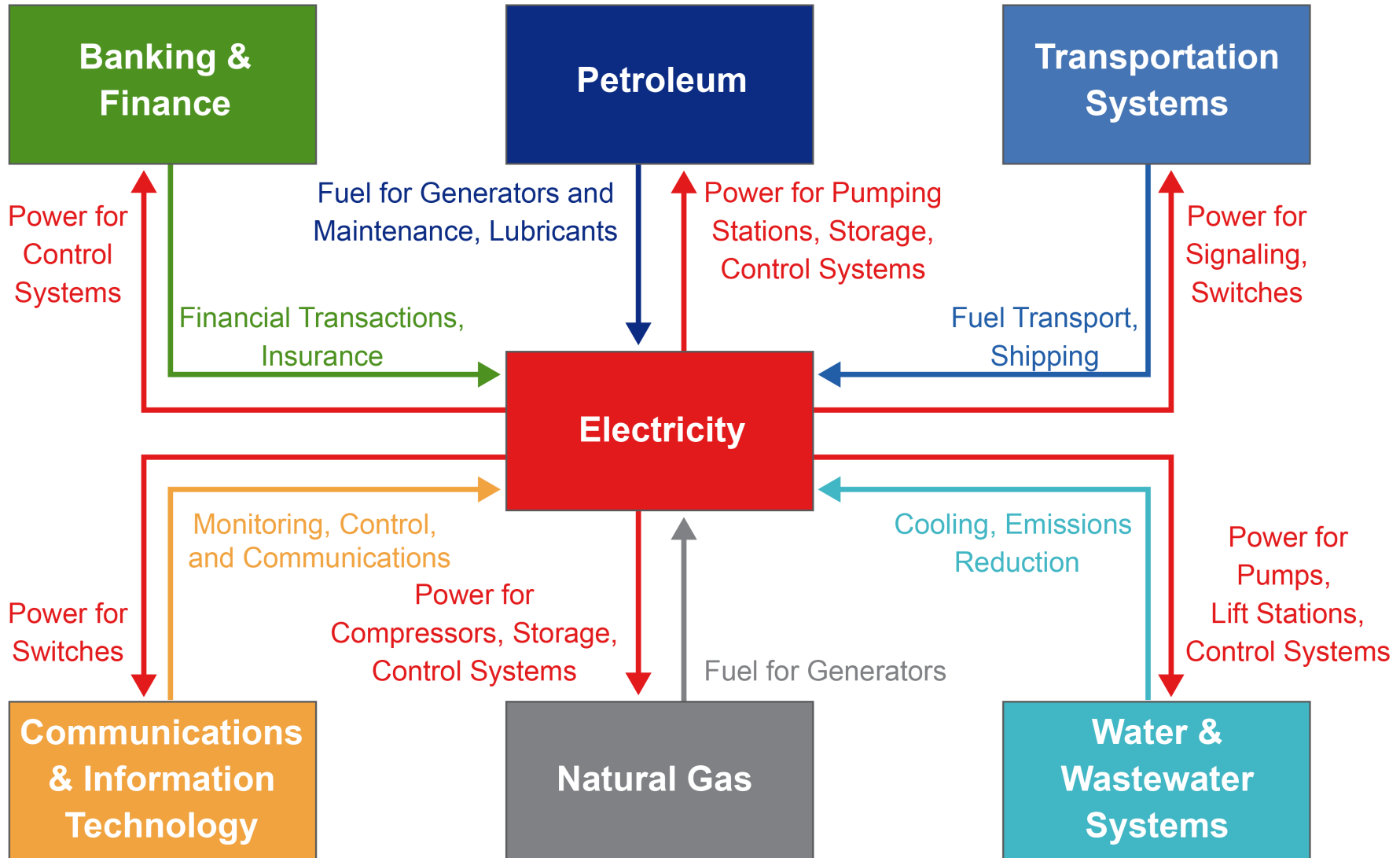
Land Area and Extreme Precipitation



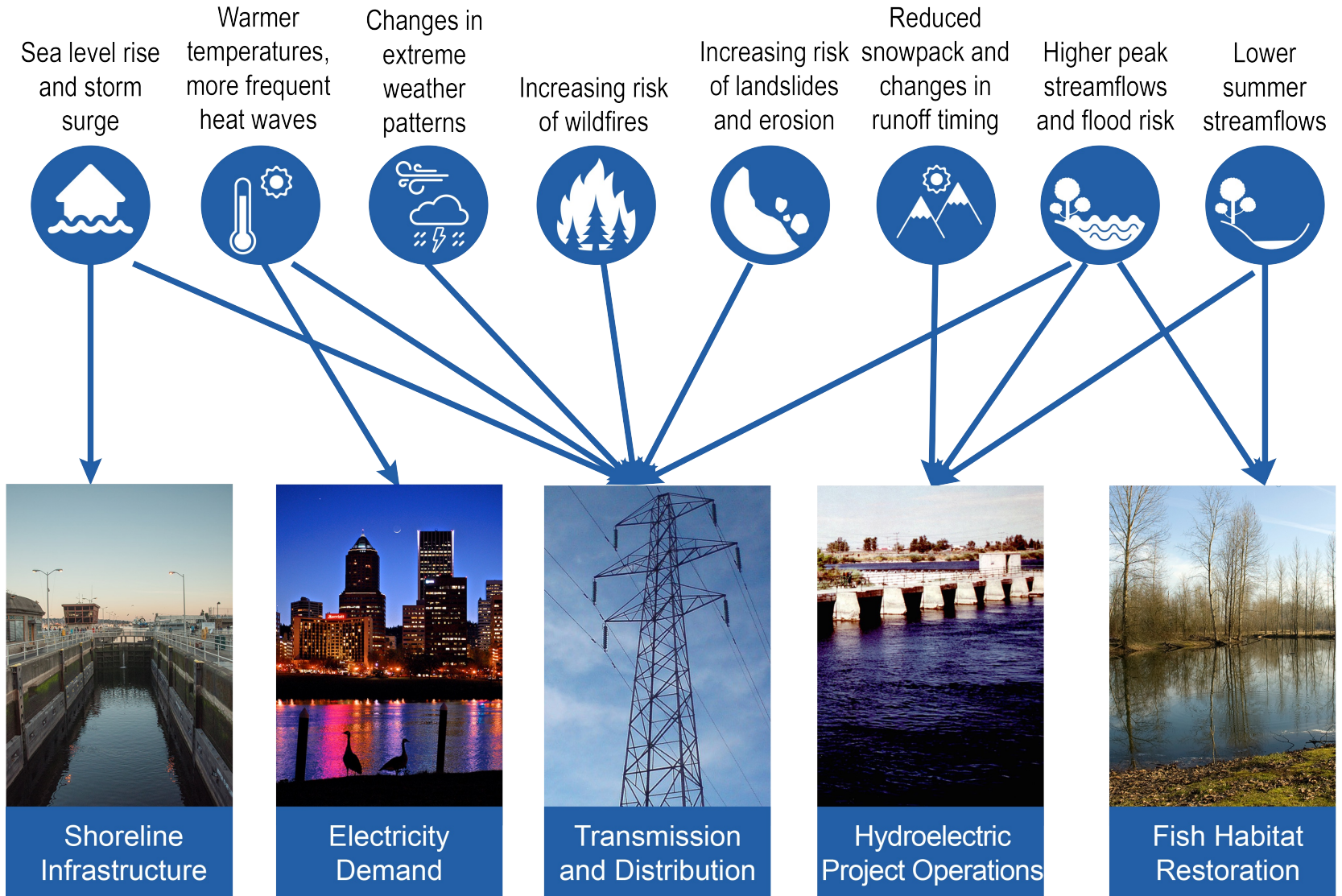
Potential Impacts from Extreme Weather and Climate Change on the Energy Systems



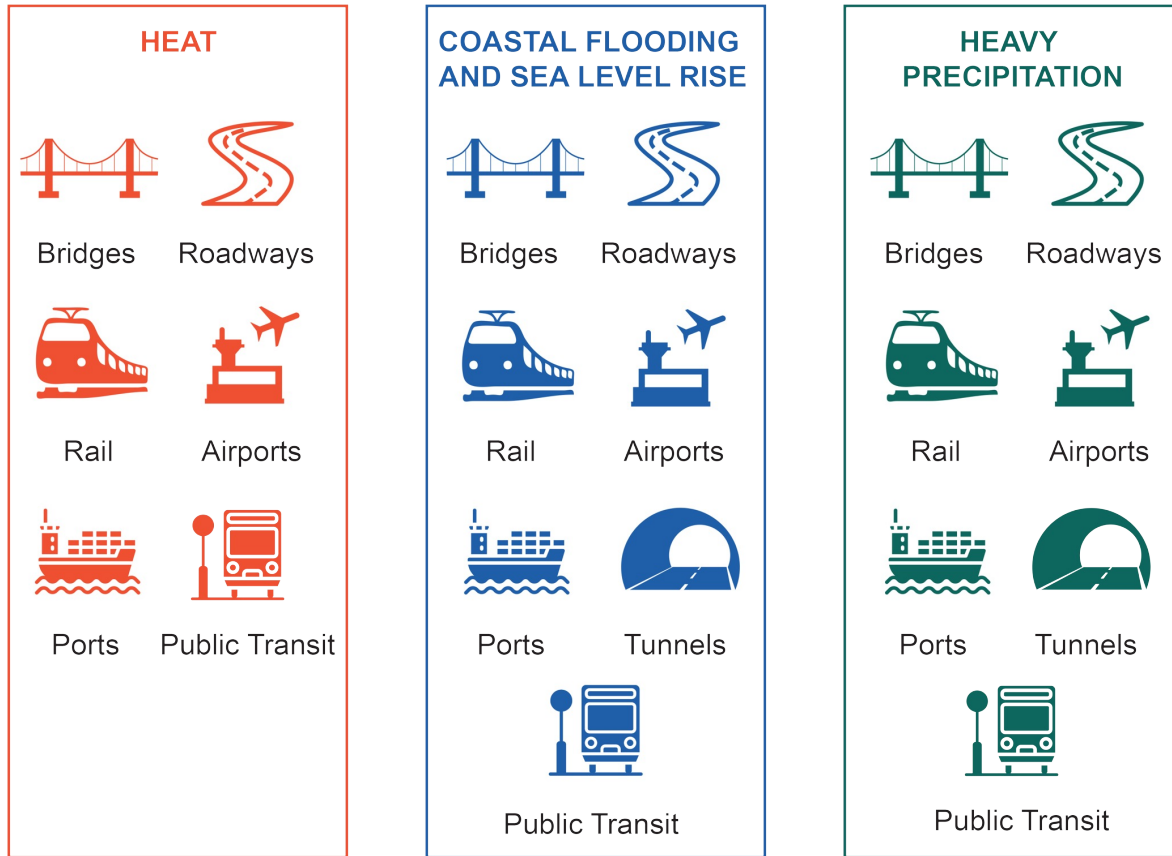
Critical Infrastructure Interdependencies



Multiple Climate Stressors Affect Vulnerable Infrastructure



Climate Change and Notable Vulnerabilities of Transportation Assets



National Performance Goals at Risk



Reduced Project Delivery Delays



Safety



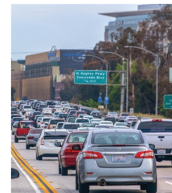
Environmental Sustainability



Freight Movement & Economic Vitality



Infrastructure Condition



Congestion Reduction



System Reliability