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Why the United States Is Becoming More Vulnerable to Natural Disasters

The United States is becoming more vulnerable to natural hazards mostly because of changes in population and national wealth density—more people and more societal infrastructure have become concentrated in disaster-prone areas. For most of the 20th century, the United States has been largely spared the expense of a catastrophic natural disaster. A great earthquake (magnitude 8 or larger) has not struck a major metropolitan area since the 1906 San Francisco earthquake. An extreme or catastrophic hurricane (Class 4 or 5) has not struck directly a major urban area since the one that hit Miami, Florida, in 1926. Yet even without such disasters, which might create losses well over $100 billion, the overall costs of natural hazards, such as extreme weather, drought, and wildfires, are estimated at $54 billion per year for the past 5 years, or approximately $1 billion per week [*National Science and Technology Council*, 1997].

Total cost estimates for natural disasters are highly speculative and depend on (1) what financial consequences are included in the assessment, (2) what phenomena are considered to constitute natural disasters, and (3) the sporadic occurrence of large events such as Hurricane Andrew in 1992, the 1993 Midwest floods, and the 1994 Northridge earthquake. In addition, costs are absorbed through a spectrum of financial vehicles ranging from insurance, federal programs, and disaster relief bills to tax deductions, higher prices, and personal loss. Because of all these uncertainties, we have used the direct costs of structural replacement and repair to compare yearly totals and identify trends. Although such direct costs are less than one half the total, they appear proportional and provide a consistent measure.

In the United States, the direct costs for damage repair average about $20 billion per year, of which over $15 billion is due to earthquakes, tornadoes, hurricanes, and floods (Figure 1). The percentage of national wealth spent on homeowners' and property/casualty insurance has remained approximately constant with respect to the gross national product [*Council of Economic Advisors, 1994; U.S. Census Bureau*, 1997a]. Accordingly, we infer that the increase in cost is not simply an artifact of more insured losses being reported, but rather represents a real increase in property loss from natural hazards.

Over the last decade, improvements in forecasting, warning systems, and building codes have greatly reduced the number of fatalities from natural disasters. As shown in Figure 1, however, economic losses have increased several fold. Our mitigation efforts have succeeded in reducing the loss of life from natural disasters, but not their costs.

Frequency and Severity of Events

The rise in sea level, global climate change, and weather patterns associated with such phenomena as the El Niño Southern Oscillation are all processes that influence the impact and occurrence of hurricanes, floods, and tornadoes. Changes in plate motion and strain accumulation can similarly alter the pattern of earthquakes. Could an explanation for the increase in costs of natural disasters be a corresponding increase in the frequency or severity of natural events, or both?

Figure 2 is a plot of the number of landfalling hurricanes along with the sea surface temperature anomaly that serves as an indicator of El Niño. During an El Niño phase, the sea surface

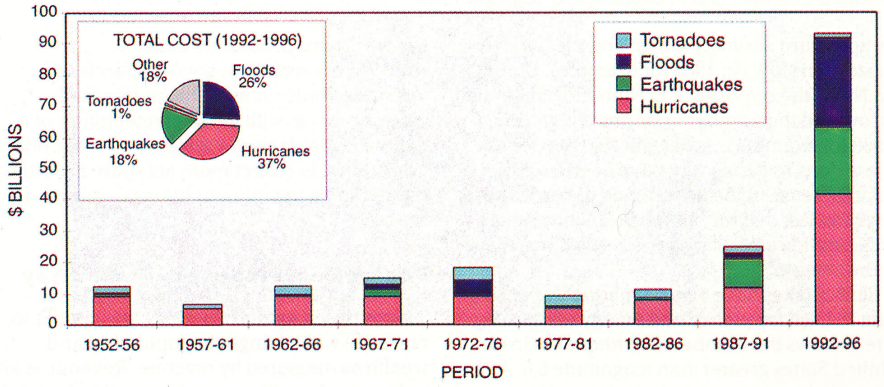

Fig. 1. Five-year costs of natural disasters.

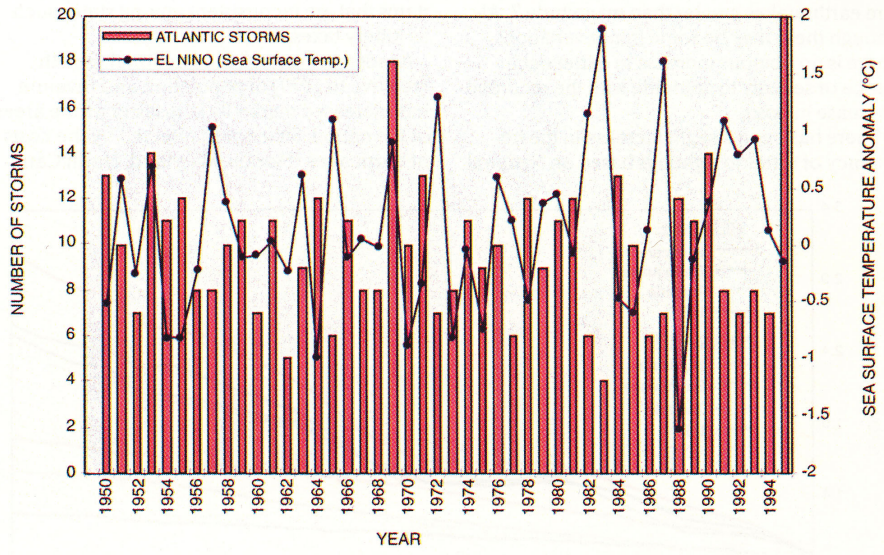

Fig. 2. Atlantic named and subtropical storms plotted against the El Niño Southern Oscillation as shown by the average May-June Sea Surface Temperature anomaly. Data from Bermuda Biological Station for Research [1997]; NOAA Atlantic Oceanographic and Meteorological Laboratory (http://www.aoml.noaa.gov/hrd/tcfaq/tcfaqHED.html); and NOAA Climate Prediction Center (http:nic.fb4.noaa.gov:80/data/).

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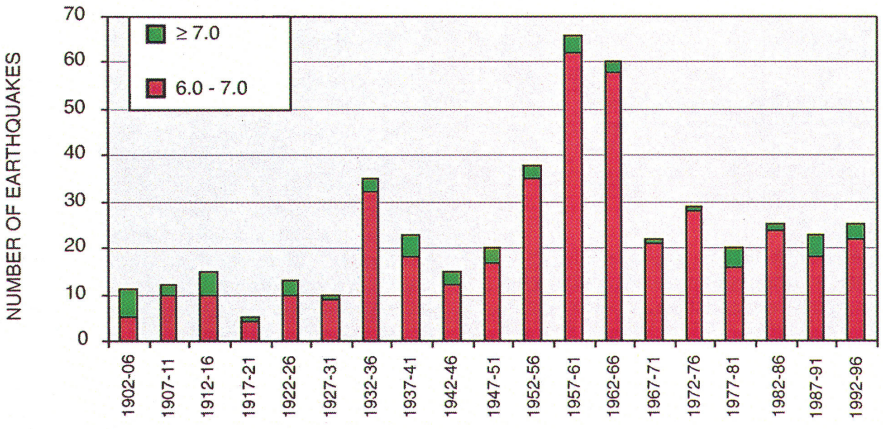

Fig. 3. U.S. earthquakes with Richter magnitude 6.0 and above. Data from National Earthquake Information Center (http://www.neic.cr.usgs.gov).

temperature anomaly is high and the number of storms is low (in 1983 for example). During La Niña (the opposite of El Niño), the anomaly is low and the number of storms is high (in 1988 for example). As seen in the time series, there does not appear to have been a significant increase in the occurrence of hurricanes over the last decade, although El Niño and La Niña provide an explanation for which years have more or fewer.

Earthquakes have also been roughly consistent in both frequency and energy release. Figure 3 shows the number of earthquakes in the United States greater than magnitude 6.0. As expected, there are approximately ten times as many magnitude 6 to 7 earthquakes as there are earthquakes greater than magnitude 7. Although there may be some minor variations, there is no obvious increase in either occurrence or severity to coincide with the recorded increase in costs.

There has been a slight increase in the frequency of tornado sightings based on National Severe Storms Laboratory data (http://www.nssl.noaa.gov/~spc/archive/tornadoes/index.html). The increase coincides, however, with the implementation of a national Doppler radar system and is therefore considered to reflect more accurate reporting rather than a meaningful increase in occurrence.

Placing More Property in Harm's Way

Increases in natural disaster costs appear to correlate with changes in population and wealth as measured by revenue. Revenue is an indicator of wealth for the region. It is the total common tax revenue in the state, excluding items that are inconsistent among states such as lottery taxes.

As seen in Figure 4, the fractional growth (relative to 1970) of population and revenue has increased markedly in disaster-prone areas of the nation. States most affected by the costs of hurricanes (Florida, Maryland, North Carolina, and Texas) and earthquakes (California and Washington) show the largest increase in both population and revenue. More people are moving into coastal areas that are vulnerable to natural hazards—particularly earthquakes on the west coast and hurricanes on the east coast. Furthermore, the effect is amplified because the people who are moving into these coastal areas represent the higher wealth segment of our society, plus their wealth has been increasing.

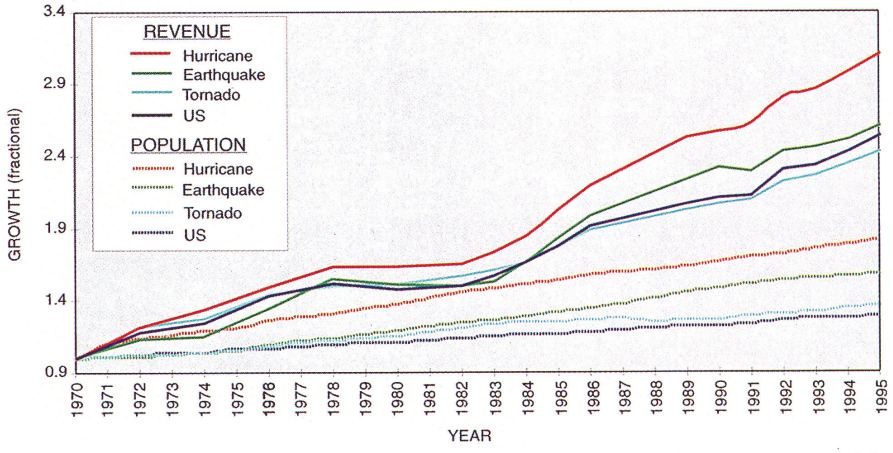

Fig. 4. Fractional growth (relative to 1970) of population and revenue in disaster-prone areas of the United States [U.S. Census Bureau, 1997b].

The costs of tornadoes are increasing at the slowest rate. Correspondingly, the population in areas most prone to tornadoes (the midwest) is growing at the slowest rate, and the wealth in those regions is increasing at the slowest rate. The fractional growth for the United States as a whole is consistent with the trend in costs for floods. For the purpose of Figure 4, we consider the U.S. trend to represent that of flood regions, as floods occur throughout the country.

Developing a More Resilient Society

Although global phenomena such as climate change, sea-level rise, and the El Niño Southern Oscillation amplify the impact of certain disasters, such as hurricanes, floods, and tornadoes, they do not explain the large increase in U.S. costs over the last decade. We are becoming more vulnerable to natural disasters because of the trends of our society rather than those of nature. In other words, we are placing more property in harm's way.

In many ways, the trends seem paradoxical. After all, most natural disasters occur in areas of known high risk such as barrier islands, flood plains, and fault zones. Over time, one would expect that the costs of natural disasters would create economic pressures to encourage responsible land use in such areas.

The long-term economic impact of low-probability, high-cost events such as earthquakes and hurricanes are not being incorporated into the planning and development of our societal infrastructure. Economic incentives for responsible land use have been stifled by legislated insurance rates and federal aid programs that effectively subsidize development in hazard-prone areas. And while there will always be great political pressure to provide economic relief after a disaster, there has been little political interest in requiring predisaster mitigation.

To create political and economic pressures that are supportive of responsible land-use, we need to begin with accurate projections of hazard vulnerability. Such projections will require the integration and assessment of data in many different formats, and expertise that cuts across organizational, professional, and disciplinary boundaries. With an improved understanding of hazard vulnerability, we can create

(1) public awareness that most natural disasters are not random acts, but rather the direct and predictable consequence of inappropriate land use, and (2) broad recognition of the enormous long-term costs to the general taxpayer for inappropriate land use. If we can develop a society more resilient to earthquakes, hurricanes, and floods, perhaps then we will learn to view such events not as random acts that destroy our property and threaten our lives, but rather as the natural processes that build our landscape and shape our environment.

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