DAMAGE THAT RESULTS FROM HURRICANES

Three major kinds of damage from hurricanes are (1) direct damage from winds and rain (building collapse and flying debris), (2) direct damage from the storm surge (flooding), and (3) secondary damage during the cleanup, such as electrocution, exposure to hazardous materials, burns, and to a limited extent contagious disease.

The distribution of damage caused by a hurricane is uneven. The most intense hurricanes (Simpson scale 3-5) cause 83% of damage but are only about 20% of all hurricanes. A common notion is that hurricanes are getting more severe and more costly. This is not accurate if the damage from hurricanes is adjusted to the same year dollar value. If 1992 is used as a value base, the greatest damage occurred in Alabama in 1926, followed by the entire southeastern coast between 1940 and 1960, and again in the 1990s. However, the latter is primarily attributed to damage caused by Hurricane Andrew, a single incident.

Wind Damage

Hurricane winds, which can be sustained at over 100 mph, are capable of causing considerable damage. Most of the wind damage, however, is caused by many small vortices in the wall of the storm's eye. Although their speeds may not be great (30 mph), when they rotate in the same direction as the hurricane, the wind speeds are additive to those of the hurricane. Therefore a hurricane with sustained winds of 75 mph will have wind gusts of over 100 mph. This explains the sometimes patchy distribution of damage, such as completely destroyed property right beside property that appears to be untouched. Many hurricanes also produce tornadoes, which can reach wind speeds of more than 200 mph.

Storm Surge

The storm surge is responsible for 90% of all hurricane-related deaths in the United States. The height of the storm surge of a hurricane is the difference between the measured height of the ocean and the predicted tide level. The damage is usually worst when the storm surge coincides with a high tide because the height of the water is then highest, even though the storm surge alone may not be relatively high.

Table 6-5 Saffir/Simpson hurricane scale ranges

Scale (category)	Barometric pressure		Wind speed (mph)	Storm surge (ft)	Potential damage
	mbar	in			
1	≥980	≥28.94	74-95	4-5	Minimal
2	965-979	28.5-28.91	96-110	6-8	Moderate
3	945-964	27.91-28.47	111-130	9-12	Extensive
4	920-944	27.17-27.88	131-155	13-18	Extreme
5	<920	<27.17	>155	>18	Catastrophic

From Federal Emergency Management Agency: *Multi-hazard identification and risk assessment: a cornerstone of the national mitigation strategy,* Washington, DC, 1997, FEMA.

Table 6-6 Top damaging hurricanes (1925-1995)*

Rank	Hurricane	Year	Category	Damage (U.S. $ billions)
1	Southeast Florida/Alabama	1926	4	72.303
2	Andrew (Fla., La.)	1992	4	33.094
3	Southwest Florida	1944	3	16.864
4	New England	1938	3	16.629
5	Southeast Florida/Lake Okeechobee	1928	4	13.795
6	Betsy (Fla., La.)	1965	3	12.434
7	Donna (Fla., eastern U.S.)	1960	4	12.048
8	Camille (Miss., La., Va.)	1969	5	10.965
9	Agnes (Fla., northeast U.S.)	1972	1	10.705
10	Diane (northeast-US)	1955	1	10.232
11	Hugo (S.C.)	1989	4	9.380

From Pielke RA, Landsea CW: *Normalized hurricane damages in the United States: 1925-95*, paper presented at 22nd Conference on Hurricanes and Tropical Meteorology, Fort Collins, Colo, May 22, 1997.
*Figures adjusted to reflect cost in 1995 U.S. dollars, personal property value, and coastal county population.

Table 6-7 Saffir/Simpson hurricane scale and examples of typical damage

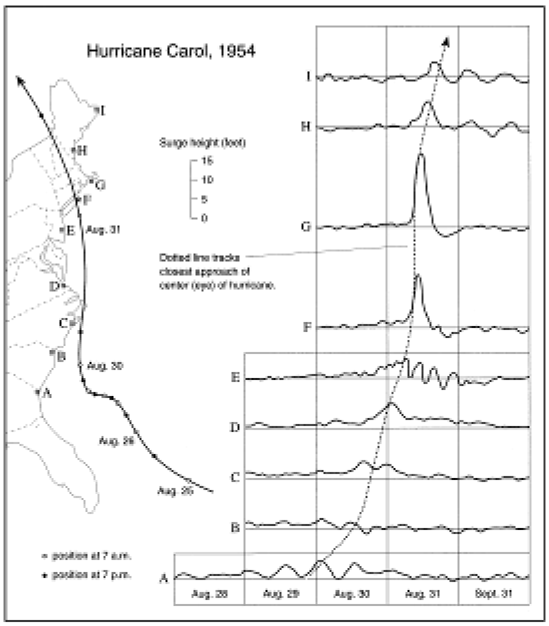
Category	Effects of winds	Effects of storm surge	Examples
1	Winds 74-95 mph; damage primarily to shrubbery, trees, foliage, and unanchored mobile homes; no damage to other structures; some damage to poorly constructed signs.	Storm surge 4-5 feet above normal; low-lying coastal roads inundated, minor pier damage, some small craft in exposed anchorage torn from moorings	Florence, 1988, La. Charley, 1988, N.C.
2	Winds 96-110 mph; considerable damage to shrubbery and tree foliage, some trees blown down; major damage to exposed mobile homes; extensive damage to poorly constructed signs; some damage to roof materials; some window and door damage	Storm surge 6-8 feet above normal; coastal roads and low-lying escape routes inland cut by rising water 2-4 hours before arrival of hurricane center; considerable damage to piers; marinas flooded; small craft in unprotected anchorages torn from moorings; evacuation of some shoreline residences and low-lying island areas required	Kate, 1985, Fla. Bob, 1991, R.I.
3	Winds 111-130 mph; foliage torn from trees, large trees blown down; practically all poorly constructed signs blown down; some damage to roof materials; some window and door damage; some structural damage to small buildings; mobile homes destroyed	Storm surge 9-12 feet above normal; serious flooding at coast, and many smaller structures near coast destroyed; larger structures near coast damaged by battering waves and floating debris; low-lying escape routes inland cut by rising water 3-5 hours before hurricane center arrives; flat terrain 5 feet or less above sea level flooded inland 8 miles or more; evacuation of low-lying residences within several blocks of shoreline possibly required	Alicia, 1983, Tex. Emily, 1993, N.C.
4	Winds 131-155 mph; shrubs and trees blown down; all signs down; extensive damage to roof materials, windows, and doors; roof destruction on many small residences; complete destruction of mobile homes	Storm surge 13-18 feet above normal; flat terrain 10 feet or less above sea level flooded inland as far as 6 miles; major damage to lower floors of structures near shore caused by flooding and battering by waves and floating debris; low-lying escape routes inland cut by rising water 3-5 hours before hurricane center arrives; major erosion of beaches; massive evacuation of all residences within 500 yards of shore and of single-story residences on low ground within 2 miles of shore possibly required	Andrew, 1992, Fla., La. Hugo, 1989, N.C.
5	Winds greater than 155 mph; shrubs and trees blown down; considerable roof damage; all signs down; extensive damage to windows and doors; complete roof destruction on many residences and industrial buildings; extensive shattering of glass in windows and doors; some complete building failures; small buildings overturned or blown away; complete destruction of mobile homes	Storm surge greater than 18 feet above normal; major damage to lower floors of all structures less than 15 feet above sea level within 500 yards of shore; low-lying escape routes inland cut by rising water 3-5 hours before hurricane center arrives; massive evacuation of residential areas on low ground within 5-10 miles of shore possibly required	Camille, 1969, Miss. 1935, Florida Keys

From Malilay J: Tropical cyclones. In Noji EK: *The public health consequences of disasters*, New York, 1997, Oxford University Press.

Two forces make up the storm surge: (1) the low barometric pressure that literally sucks water into the center of the hurricane, and (2) the pileup of this excess water against the shoreline as the storm moves westward. The drop in barometric pressure will raise 1 foot of water per 1-inch drop in barometric pressure. This effect usually accounts for about 2 feet of the height of the storm surge. As this dome of water is pressed into the shoreline by the winds that move the hurricane westward, the water backs up and rises typically another 2 to 10 feet. Storm surges are greatest when they coincide with high tides. Huge surges have been recorded. Hurricane storm surges can be as high as 25 feet above normal and affect hundreds of miles of coastline. Storm surges cause considerable damage by coastline erosion and inland backwater surges. Examples of high storm surges are Hurricane Camille at 30 feet and Hurricane Hugo at 17 feet.

Other

Damage and safety are determined by the degree to which evacuations can be conducted and building codes be enacted and enforced for property in hurricane-susceptible areas. Safety through evacuation is based on the accuracy of the weather forecast, adequacy of landfall warning, transportation, and sheltering. Building construction codes greatly affect the amount of damage. For example, two comparable hurricanes, Alicia in Texas in 1983 and Diana in North Carolina in 1984, affected similar towns, which distinguished themselves primarily in their building codes. Whereas communities in Texas suffered damage to 70% of the homes, North Carolina suffered damage to only about 3% of the homes.



Storm track and surge charts for Hurricane Carol, August 28 to September 1, 1954. (From Monmonier M: Cartographies of danger: mapping dangers in America, Chicago, 1997, University of Chicago Press.)