Hurricane Sandy and Selected Transportation Issues

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NIST Developing a Community-Centered Approach to Disaster Resilience

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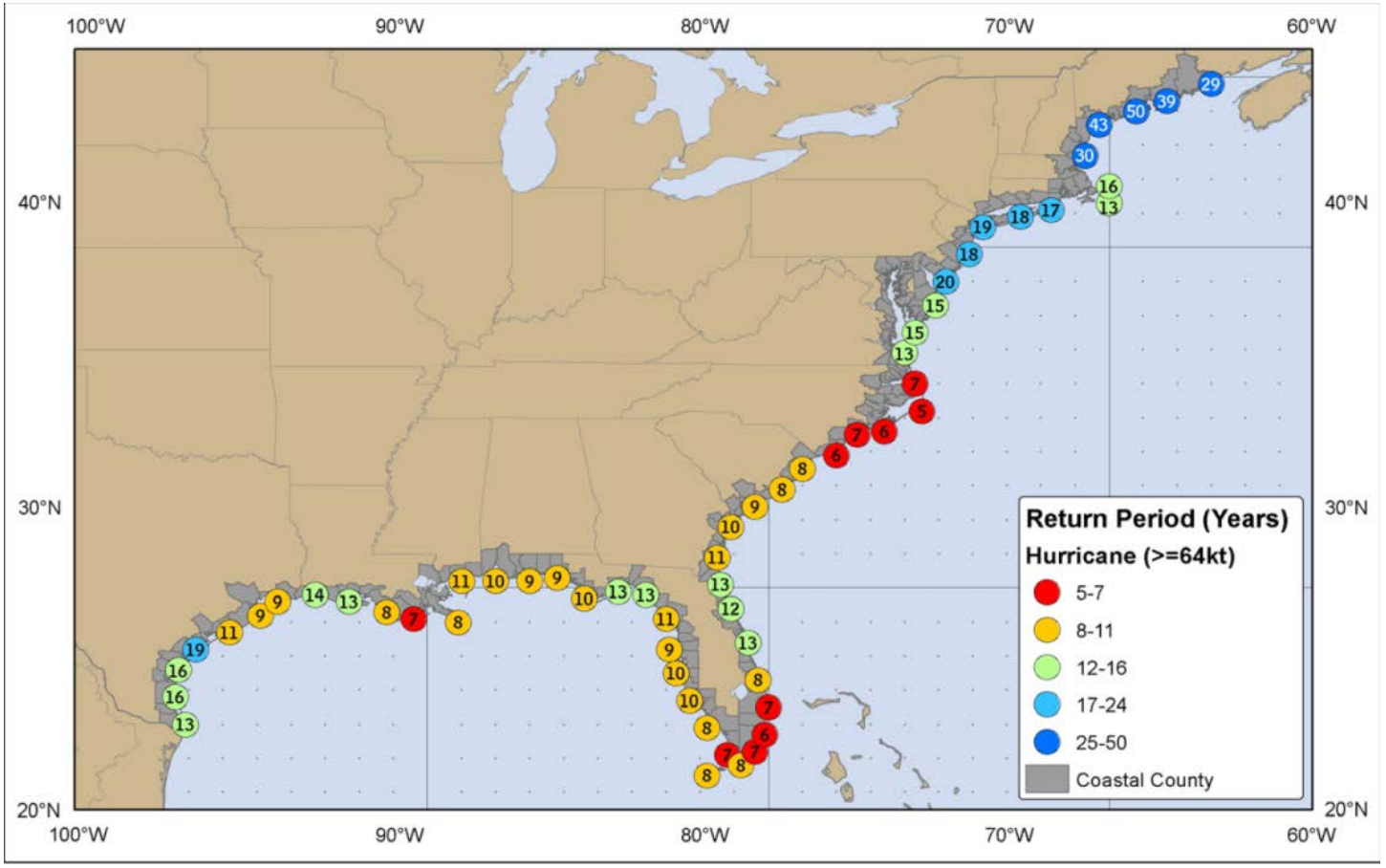
Tropical Cyclone Return Periods in Years

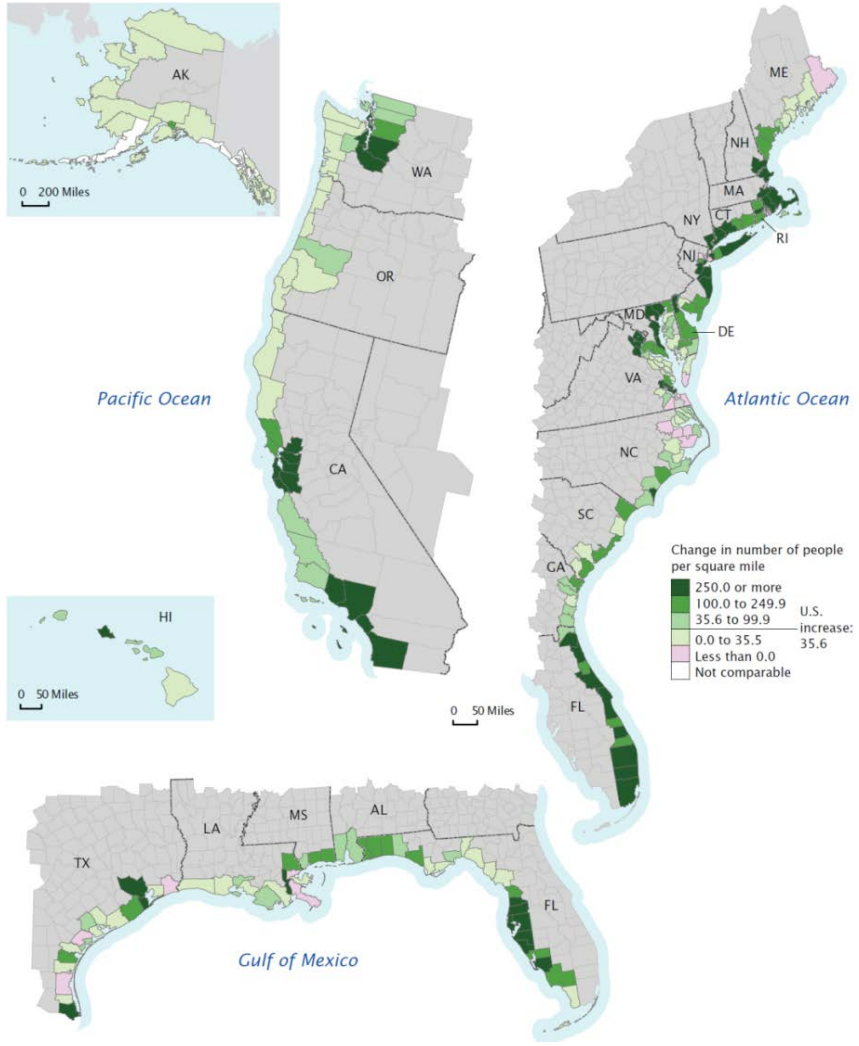


Source: Blake, E.S., Landsea, C.W., and Gibney, E.J. (August 2011) The Deadliest, Costliest, and Most Intense United States Tropical Cyclones from 1851 to 2010 (and other frequently requested hurricane facts), NOAA Technical Memorandum NWS NHC-6, p. 25, http://www.nhc.noaa.gov/pdf/nws-nhc-6.pdf. Intensity defined as pressure when it made landfall. Hurricanes passing within 50 n miles of location indicated. Numbers correspond to tables in report. Kt refers to wind speed. 1kt = 1.15 mph.

Land Use Patterns as Vulnerability Drivers

Changes in Population Density, U.S. Coastal Counties, 1960-2008*

According to the U.S. Bureau of the Census, four of the five New York City counties rank the highest among U.S. coastal counties.**



Source: *Compiled from Stephen G. Wilson and Thomas R. Fischetti (May 2010) Coastal population trends in the U.S.: 1960-2008, *p. 13; **p. 12. http://www.census.gov/prod/2010pubs/p25-1139.pdf

Increased Infrastructure Use with Limited Capacity Adjustment

- Energy Usage and Production: Based on EIA data, consumption increases until about 2007 (with the recession contributing to a decline) but energy production continues to increase (Source of figure and findings: EIA, Monthly Energy Review, 2013)

- Transportation: According to FHWA data, Vehicle Miles of Travel continue to increase and fuel consumption continues to increase in spite of fuel economy (Source of figure and findings: U.S. DOT, FHWA (April 2013) Highway Statistics 2011)

Transit Usage in the New York – New Jersey – Connecticut Metropolitan Area

- The tri-State urbanized area had 4.18 billion passenger trips in 2012, more than six times the next largest urbanized area in population
- This ridership accounted for 22 billion passenger miles

Source: American Public Transportation Association (May 2014) 2014 Public Transportation Fact Book. Appendix B: Transit Agency and Urbanized Area Operating Statistics, Washington, DC: American Public Transportation Association, p. 244.

Underlying Transportation Condition Potentially Affecting Vulnerability: ASCE Transportation Condition and Needs Estimates, U.S., 2013

Aviation	**D**	(D, D+)
Bridges	**C+**	(C, C)
Ports	**C**	(-, -)
Rail	**C+**	(C-, C-)
Roads	**D**	(D-, D)
Transit	**D**	(D, D+)

Note: Grades for previous years are in parenthesis (2009 (left) and 2005 (right))

America's Infrastructure GPA D+ (up from D in 2009 and 2005)

Total investment needs: $3.6 trillion by 2020 (up from $2.2 trillion in 2009 and $1.6 trillion in 2005) (estimated 5 year investment need)

Sources: ASCE (2013) 2013 Report Card for America's Infrastructure, http://www.infrastructurereportcard.org/
http://www.infrastructurereportcard.org/a/#p/grade-sheet/previous-grades
ASCE (2009) "2009 Report Card for America's Infrastructure." www.asce.org/reportcard
ASCE (2005) "2005 Report Card for America's Infrastructure," Online. Available at: <http://www.asce.org/reportcard/2005/index.cfm> (accessed November 7, 2005).

Condition and Operations of New Facilities: Example of Bridge Collapses and Age

Some observations

- About a couple of dozen bridges have collapsed in the U.S. as reported by the National Transportation Safety Board since the mid-1960s
- Bridges that have collapsed have generally been younger in age than the overall bridges in the US even though bridge condition generally declines with age (National Bridge Inventory); for example, while 30% of bridges that collapsed were under 20 years old, only 20% of all bridges were in that category (R. Zimmerman (2012) Transport, the Environment and Security, Cheltenham, UK and Northampton, MA: Edward Elgar Publishing, p. 199)

- A combination of causes usually contributes to bridge collapses, though there may be a single initiating event.

- Non-redundant design, common in the mid-20th century can contribute to the severity of consequences of bridge collapses.

Hurricanes and Transit: Damage to Transit, Hurricane Sandy, 2012, NYC

Source: MTA. (November 2, 2012) Water in Cranberry Tube on AC Line.

Source: MTA. Debris from Jamaica Bay fills Tracks Inside Broad Channel A Station on November 1, 2012.

Transit Restoration Following Hurricane Sandy

- In the couple of weeks following Hurricane Sandy, about eighty percent of the transit lines fully recovered along their entire lengths, and the rest allowed for partial coverage of routes.
- Compared with the same period in the previous year in the second week of 2012 following Hurricane Sandy, overall system ridership decline averaged 14-16 percent.

Source: R. Zimmerman, RAPID/Collaborative Research: Collection of Perishable Hurricane Sandy Data on Weather-Related Damage to Urban Power and Transit Infrastructure," National Science Foundation, the U. of Washington (lead), Louisiana State University, and New York University; R. Zimmerman (2014 forthcoming), "Planning Restoration of Vital Infrastructure Services Following Hurricane Sandy: Lessons Learned for Energy and Transportation," J. of Extreme Events, Vol. 1, No. 1.

Transit Dependencies on Electric Power

- In the 2003 northeast U.S. and Canada blackout, transit took about 1.3 times and traffic signals 2.6 times as long to be restored once electric power returned.*
- The Metro-North railway experienced an outage of more than a week due to the impairment of a large power line.**
- Transformer explosions have impaired transit line, e.g., in NYC on July 29, 2001,and power outages caused closures of San Francisco Bay Area and Chicago transit lines.***

Sources:
*R. Zimmerman and C. E. Restrepo (2006) “The Next Step: Quantifying Infrastructure Interdependencies to Improve Security,” International Journal of Critical Infrastructures, Vol. 2, Nos. 2/3, pp. 215-230; p. 223.
**Matt Flegenheimer (September 25, 2013) Power Failure Disrupts Metro North’s New Haven Line; May Last Days, New York Times http://www.nytimes.com/2013/09/26/nyregion/metro-norths-new-haven-line-suspended-after-power-loss.html
*** R. Zimmerman (2005) “Mass Transit Infrastructure and Urban Health,” J. of Urban Health, 82(1), pp. 21-32; pp.27-28.

Electric Power Solutions

- Hardening by sealing
- Submersion of critical components
- Removable components
- Decentralization of energy systems

Source: Con Ed and Orange & Rockland Utilities (June 20, 2013) Post Sandy Enhancement Plan, p. 33, 34, 39, 40, 46
http://www.coned.com/publicissues/PDF/post_sandy_enhancement_plan.pdf

Green Infrastructure Alternatives for Water Management

New York City Environmental Protection, NYC Green Infrastructure Plan A Sustainable Plan for Clean Waterways, Executive Summary, p. 1.
http://www.nyc.gov/html/dep/pdf/green_infrastructure/NYCGreenInfrastructurePlan_ExecutiveSummary.pdf

Small-Scale Technological Fixes for Water Management

MTA raised subway grates combined with street furniture

Source: Metropolitan Transportation Authority of the State of New York (2008) Greening Mass Transit: The Final Report, p. 53. http://web.mta.info/sustainability/pdf/SustRptFinal.pdf

NYC Elevation and barriers for transit grates to divert water.

Source: Photo by Rae Zimmerman 2012. Not for distribution or use without the permission of the author.

Roadside swale for water diversion, Salt Lake City, Utah

Source: Photo by Rae Zimmerman 2012. Not for distribution or use without the permission of the author.

Adaptation Measures for Independent Energy Generation in Transit Systems: Photovoltaics on NYCT Corona Maintenance Shop Roof

NYC Transit (2010) Corona Maintenance Shop. NYCT First LEED Certification. http://www.pcac.org/wp-content/uploads/2010/08/corona_leed_presentationac2ad_trb_print1.pdf

Flexibility Through Multi-Modal Connections: Bus Connections at Subway Stations, NYC

- Connections with buses does and can continue to provide alternative transportation modes in emergencies
- The New York City subway stations vary in the numbers of buses stopping at the stations from a couple of dozen to none
- Bus connectivity is in part related to the number of train tracks located at each station

Source: Zimmerman, R. et al. (2014 forthcoming), “Promoting Transportation Flexibility in Extreme Events through Multi-Modal Connectivity,” New York, NY: NYU-Wagner. Funded by the U.S. DOT Region 2 University Transportation Research Center (UTRC).

Redesigning Streets and Rail Lines: Innovations for the Future

- Where environment and security becomes a local problem, street planning and management are familiar, local solutions that can work
- Streets and rail corridors are a key platform for change
- Spatial and Temporal Adaptations:
  - Wildlife corridors
  - Streets for temperature and heat control: Cool pavements
  - Green corridors for pedestrian thoroughfares
  - Increasing absorptive capacity of street surfaces
  - Streets for stormwater control (Kuala Lumpur, Malaysia)
  - Streets for waste recycling (glasphalt, plastic bags)
  - Streets for electric power generation
  - Streets as utility corridors
  - Decentralizing streets; Deconstructing large roadways

R. Zimmerman (2012) Transport, the Environment and Security. Making the Connection, Cheltenham, UK and Northampton, MA: Edward Elgar Publishing, Ltd., p. 140-150. http://www.e-elgar.com/bookentry_mainUS.lasso?id=13884

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