

Challenges in Disaster Resilience

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The Americas Are At Risk From Diverse Natural Hazards



Earthquake

Wildfire



Hurricane

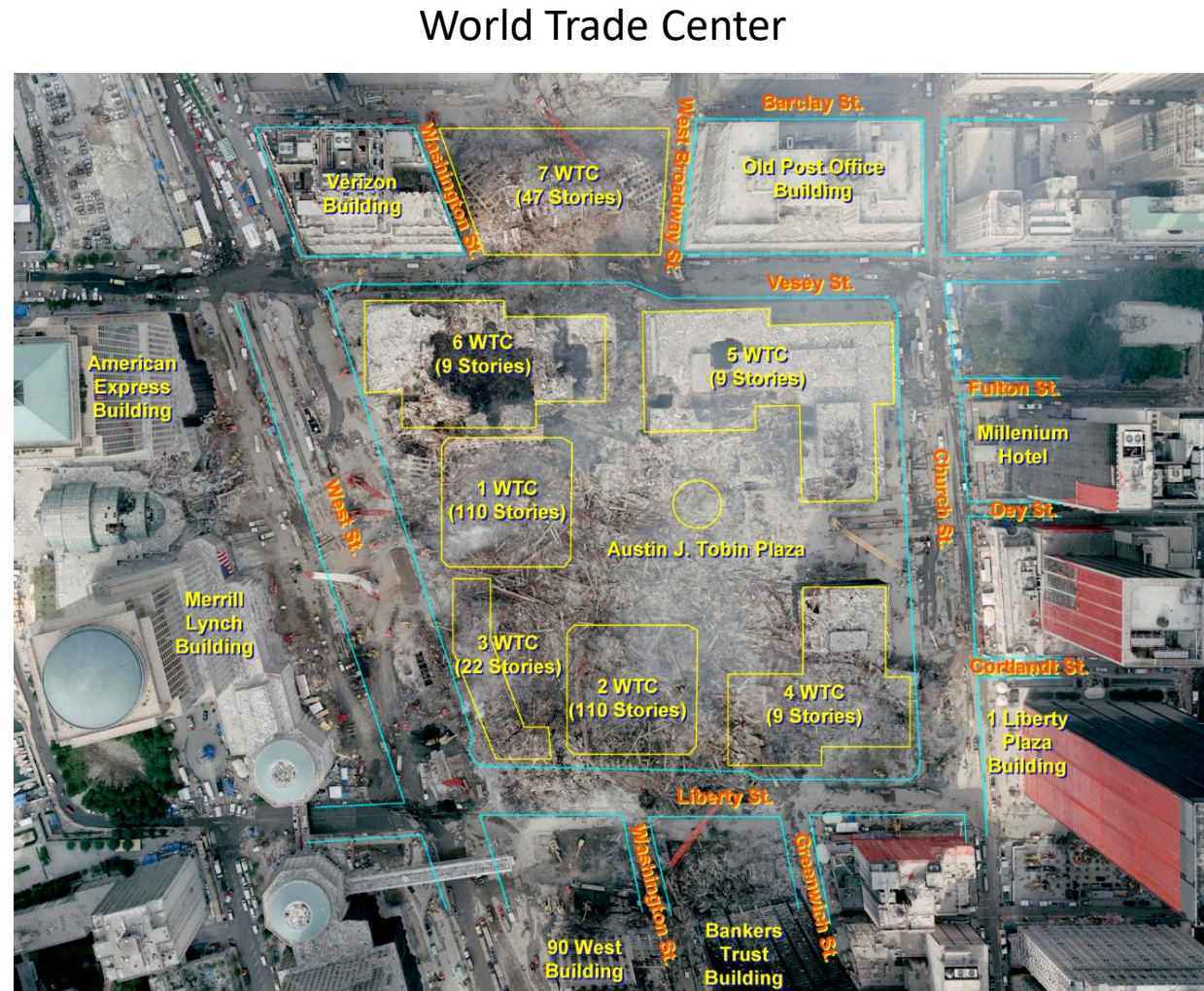


...and From Technological and Manmade Events



By Brocken Inaglory - Own work, CC BY-SA 3.0,
<https://commons.wikimedia.org/w/index.php?curid=11489206>

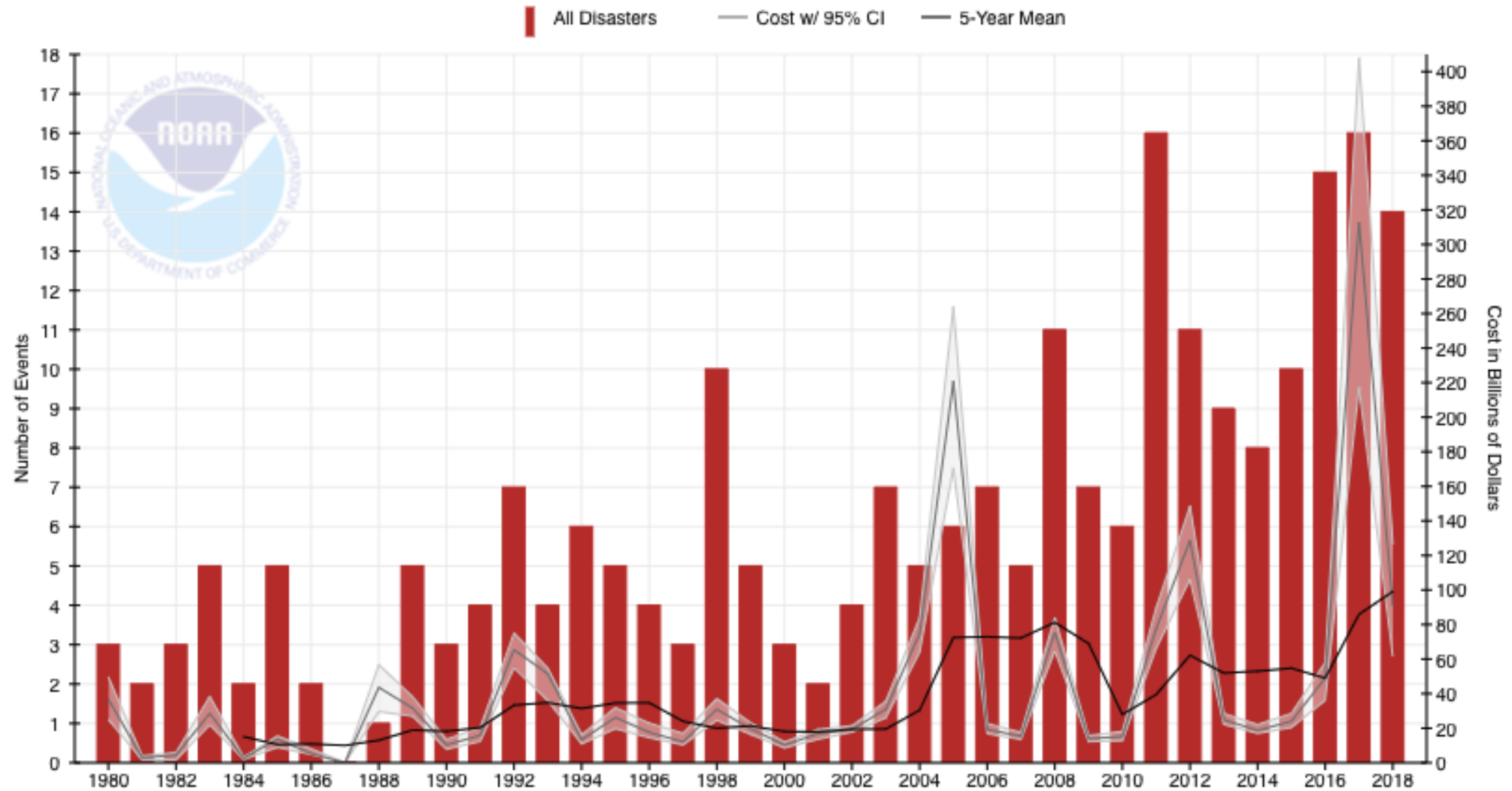
San Bruno, CA Natural Gas Explosion



Credit: NOAA September 23, 2001

Over Time, Event Impacts are Increasing in Number

Billion-Dollar Disaster Event Types by Year (CPI-Adjusted)



Source: Adam Smith NOAA/NCEI

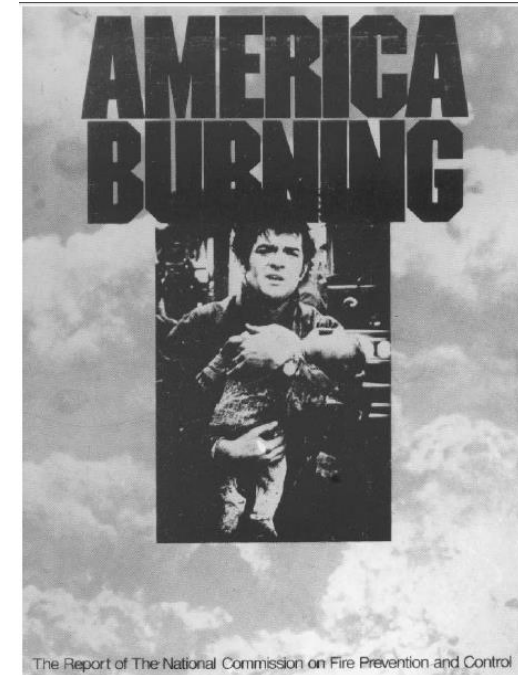
But, Progress IS Possible!

Historical Perspective - Addressing the Urban Fire Problem

America Burning

In 1974, Congress enacted the *Federal Fire Prevention and Control Act*, in part, as a response to the 1973 report by the National Commission on Fire Prevention and Control entitled *America Burning*.

Among other things, this Act created what have become the U.S. Fire Administration and the National Fire Academy. The Act built on existing fire responsibilities at the National Bureau of Standards (NBS) by creating the NBS Center for Fire Research (CFR).



In 1976, the U.S. experienced 2.9 million fires and 8,800 fatalities.

Basic Approach: Understand the Impacts, Understand the Hazard, Improve Resilience

Understand Impacts

- **National Fire Incident Reporting System** – fire fighters report data on structure fires, enabling a basic understanding of parameters from ignition to outcomes

Understand Hazard

- **Heat and Visible Smoke Release Measurements** – enabling fundamental heat release rate measurements worldwide via improved standard test method
- **Fire Dynamics Models** – enabling transformation from prescriptive to performance standards through tools to accurately predict the spread of fire, smoke, and toxic products

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Improve Resilience

- **Fire Fighter Protective Equipment** – enabling safer and more effective fire fighting through performance metrics and standards for thermal imagers and personal alert safety systems and positive-pressure ventilation techniques for fire fighting
- **Automatic Fire Sprinkler Standards** – enabling reductions in loss of life and property due to fire by developing installation and design standard for residential sprinkler systems



The Result - In 30 Years: Major Reductions in Fires, Deaths, and Injuries

In 1976, the U.S. experienced 2.9 million fires and 8,800 fatalities.

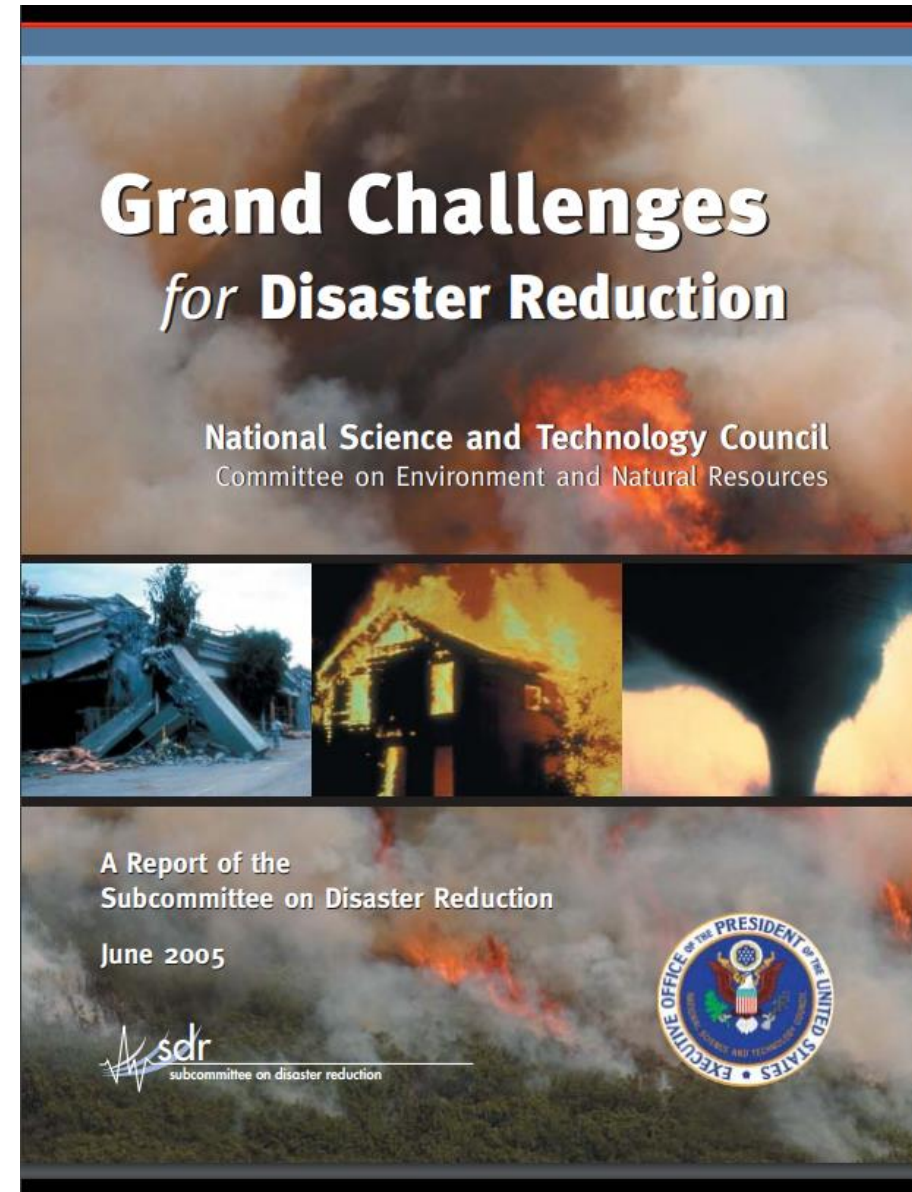
Year	Reported Fires	Civilian Deaths	Civilian Injuries	Firefighter Deaths	Firefighter Injuries
1980	3,000,000	6,505	30,200	138	98,070
1990	2,250,000	5,195	28,600	108	100,300
2000	1,750,000	4,045	22,350	103	84,550
2006	1,638,000	3,245	16,400	89	83,400



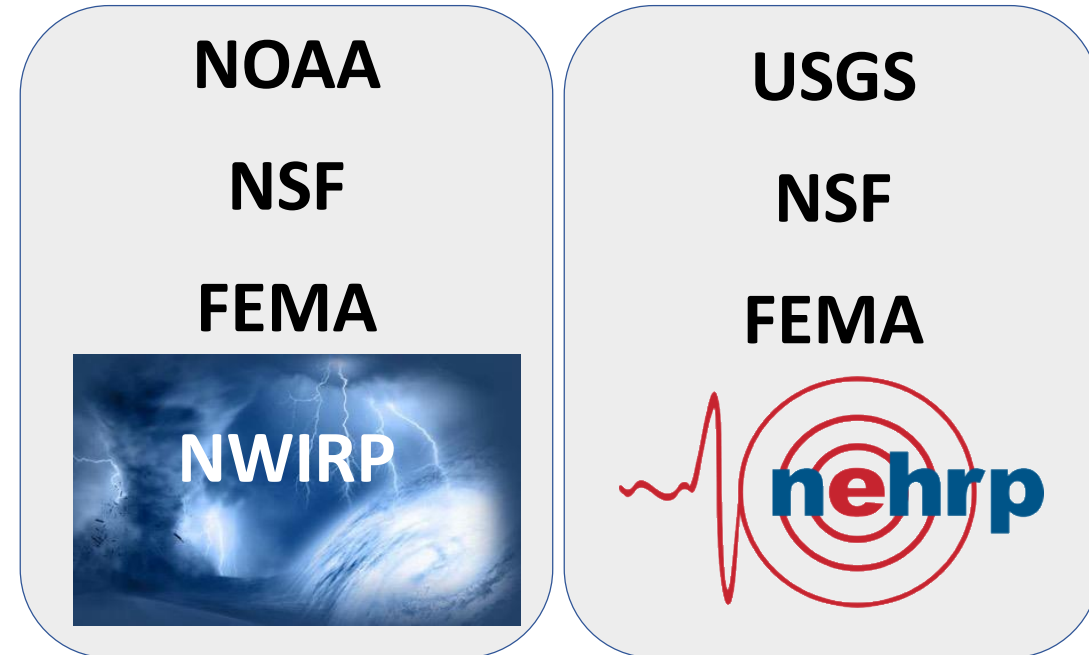
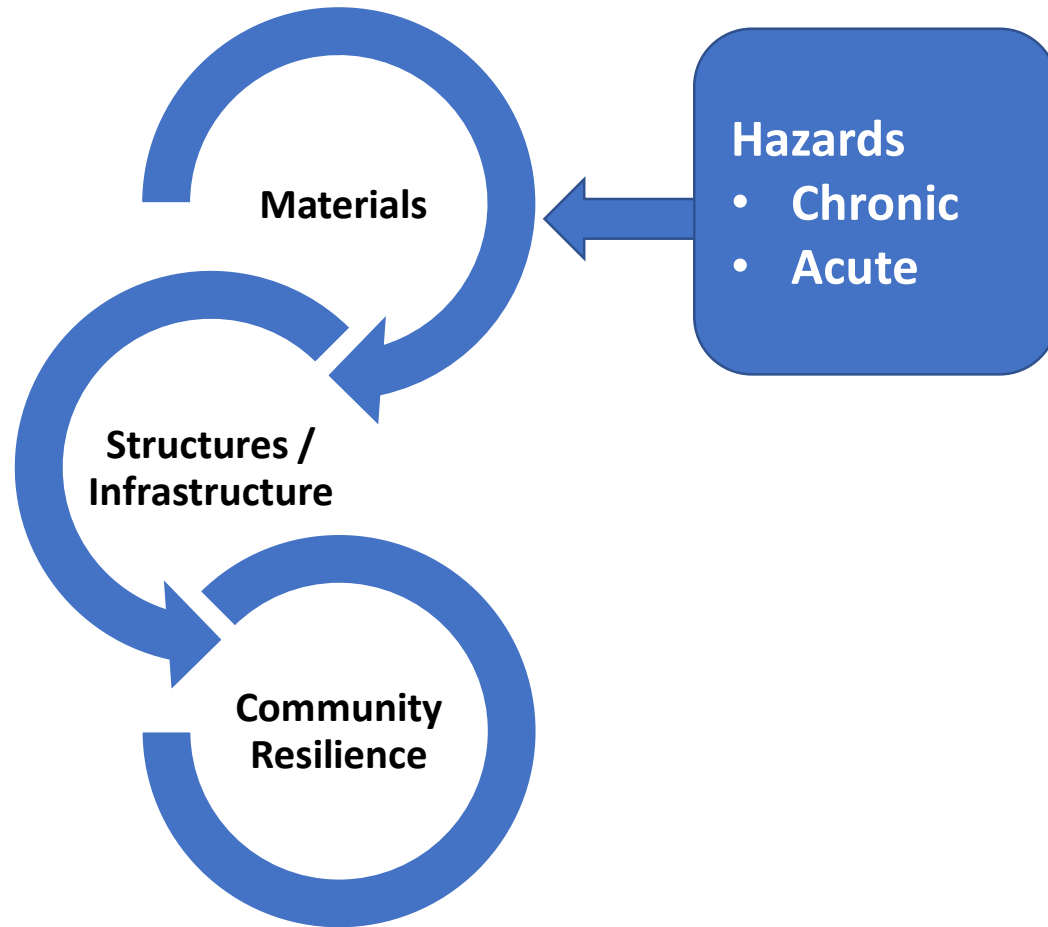
Do We Already have an *America Burning* for Resilience?

2005 the U.S Subcommittee on Disaster Resilience – Grand Challenges

1. Provide hazards information where and when it is needed.
2. Understand the natural processes that produce hazards.
3. Develop hazard mitigation strategies and technologies.
4. Recognize and reduce vulnerability of interdependent critical infrastructure.
5. Assess disaster resilience using standard methods.
6. Promote risk-wise behavior.



NIST Disaster Resilience Program and Our Partners are Working to Achieve Major Measurable Impacts



NIST Research and Investigations

NIST Partners

Part 1: Much Work to be Done: Understand the Impacts

Example: Morbidity and Mortality in Disasters

Studies and Estimates of Morbidity and Mortality in Puerto Rico Vary Based on Methodology and Scope

- Puerto Rico's Department of Public Safety certified **64*** deaths related to the storm*, but later updated this estimate to **1,427**** on June 13, 2018 and to **2,975***** on August 28, 2018.
- The New York Times and other news organizations estimate that the actual death toll could be **over 1,000***, based on analysis of daily mortality data from Puerto Rico's Vital Statistics Record Office.
- Letter to the Editor of JAMA provides an estimate of **1,139****** excess deaths through December 2017, using death counts from vital statistics records and updating a previous estimate.
- Harvard School of Public Health conducted a population-based survey and estimated **4,645******* deaths.
- George Washington University conducted a study of excess mortality, and estimate that there were **2,975******* excess deaths in Puerto Rico from September 2017 through the end of February 2018.

*Robles, F., Davis, K., Fink, S, Almukhtar, S., 2017. "Official Toll in Puerto Rico: 64. Actual Deaths May Be 1,052." *The New York Times*. December 9, 2017.

** Puerto Rican Government, 2018. "Transformation and Innovation in the Wake of Devastation: An Economic and Disaster Recovery Plan for Puerto Rico," a preliminary report dated July 9, 2018 and released for public comment.

***Darrah, N., 2018. "Puerto Rico governor raises Hurricane Maria death toll from 64 to 2,975." *Fox News*. August 28, 2018.

****Santos-Lozada AR, Howard JT, 2018. "Use of Death Counts from Vital Statistics to Calculate Excess Deaths in Puerto Rico Following Hurricane Maria," *JAMA*. Aug. 2, 2018: doi:10.1001/jama.2018.10929.

***** Kishore N, Marques D, et al., 2018. "Mortality in Puerto Rico after Hurricane Maria," *NEJM* 2018, 379:162-170.

*****George Washington University, in collaboration with the University of Puerto Rico Graduate School of Puerto Rico, 2018 "Ascertainment of the Estimated Excess Mortality from Hurricane Maria in Puerto Rico," a Project Report for the Governor of Puerto Rico, August 28, 2018.

Draft NIST/COE Metrics for Resilient Communities Following a Disaster

- Population stability
 - % people in their homes
 - population count
- Economic stability
 - Household income
 - Employment rate
 - Earnings by sector
- Social Services stability
 - % staffed hospital beds / wait time
 - % attendance per school
 - Availability of social institutions
- Physical Services stability
 - % customers served utilities (electric power, telecom, water, wastewater)
 - % buildings functional
 - % transportation network functionality

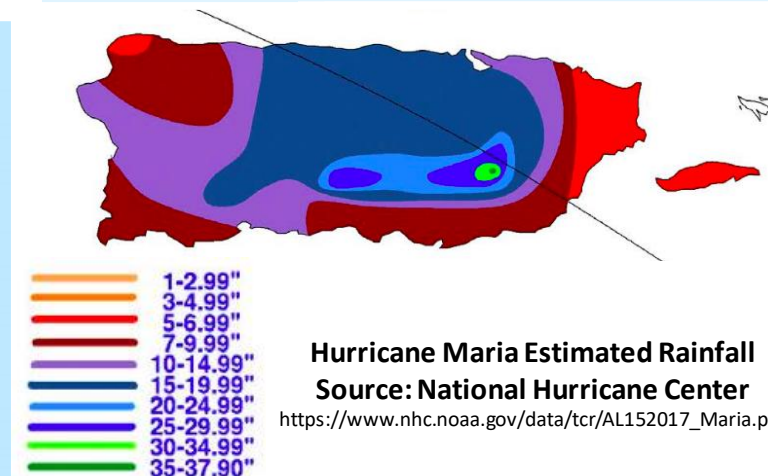
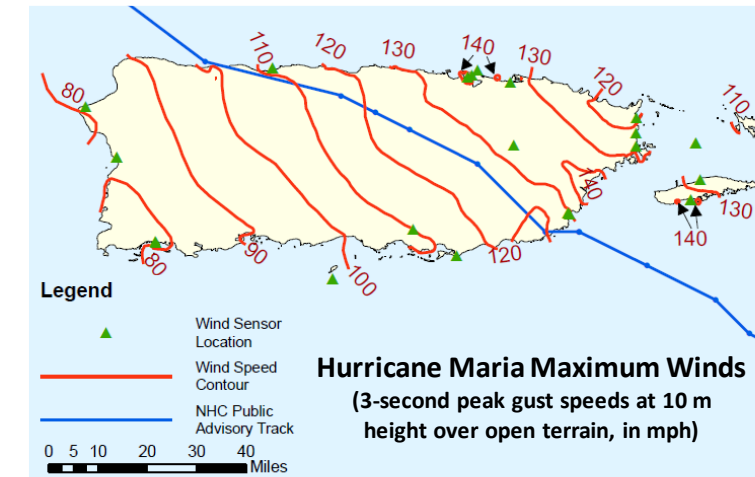
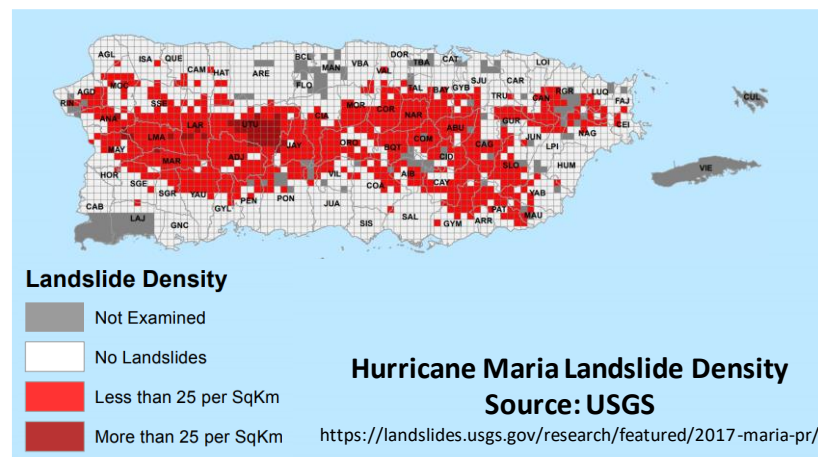
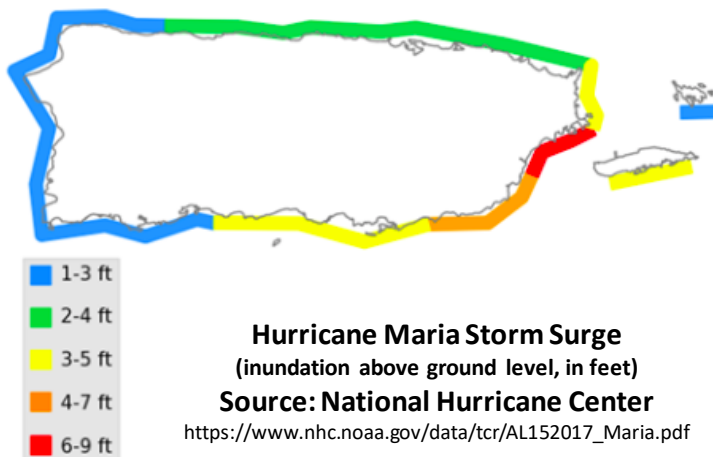


Part 2: Much Work to be Done: Understand the Hazard

Hazard Measurement Science

Hurricane Maria subjected Puerto Rico to Multiple Hazards:

- High winds: peak gusts > 140 mph
- Storm surge: peak coastal inundation > 6 ft
- Rainfall, flooding: total rainfall of 5 - 40 inches
- Landslides: many hundreds occurred

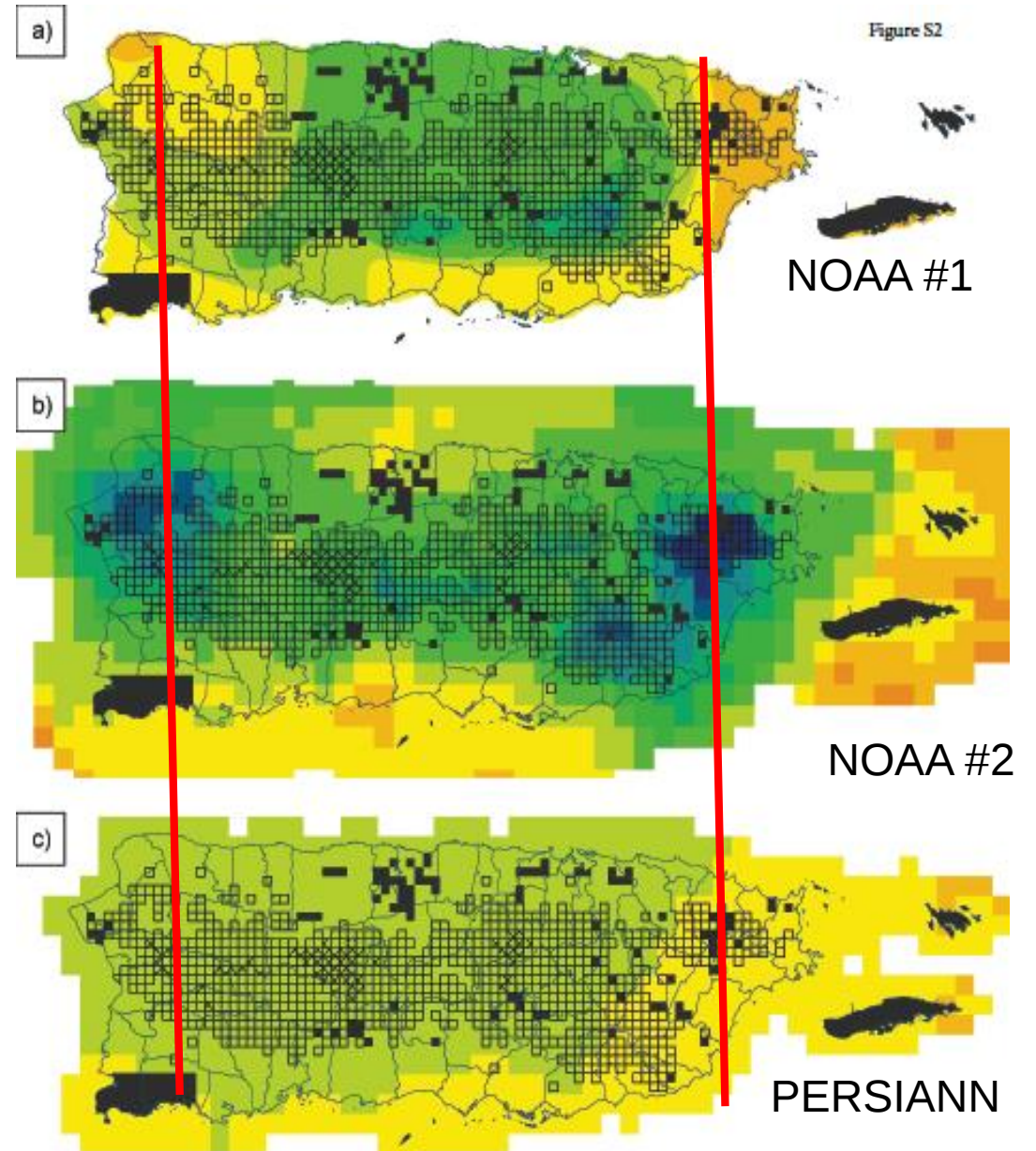


Hurricane Maria - Rainfall Hazard Measurement

In addition to station reporting issues, NWS Radar suffered complete structural failure just prior to landfall

Disparity in rainfall measurements dependent on choice of sensor and/or methodology – varied as much as 60 cm.

These measurements are a critical component of NWIRP post windstorm investigations



Source: Bessette-Kinton et al, 2019 (With Permission)

Actual Wind Measurement Complicated by Enhanced Fujita Tornado Scale Using Damage Indicators, Not Direct Wind Speed Measurements

- No direct measurements of tornadic wind speeds near the ground.
- While *reported* as a range of wind speeds, the EF scale is a damage indicator.
- 28 damage indicators (targets) are indicative of wind strength based general observations.
- Biases in database:
 - Awareness / population bias
 - Target Damage
 - Can be based on single record
 - ...

EF Rating	Wind Speed (3-sec gust)
0	63-85 mph
1	86-110 mph
2	111-135 mph
3	136-165 mph
4	166-200 mph
5	Over 200 mph



Metrology in the Wildland-Urban Interface

- Post-fire study findings
 - Embers are a major cause of ignition
 - Witch Creek/Guejito Fire (California 2007)
 - 65% of structures ignited by embers
 - Waldo Canyon Fire (Colorado 2012)
 - 50 % of structures ignited by embers
 - Embers can be lofted for more than 20 km
 - Exposure 1-2 hours occurs ahead of fireline
 - Vegetative and Structural firebrands
- Metrology Need
 - Emberometer –
 - Needed to measure ember flux
 - Number & Mass



2007 California Fire

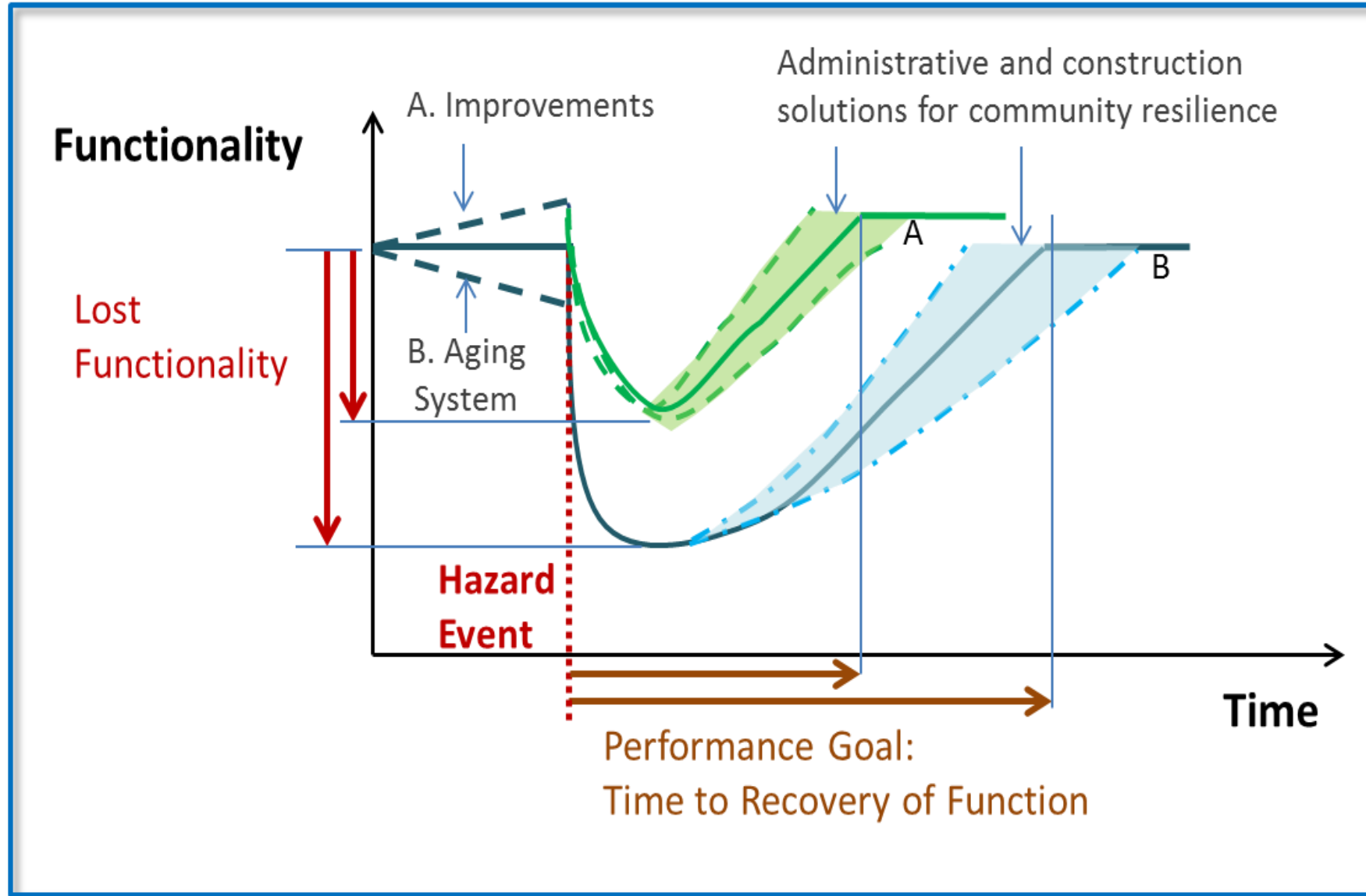


2012 Colorado Fire

Step 3: Much Work to be Done: Improve Resilience

Tools and Methods

Adoption and Enforcement



Sometimes, we know what works.



Photo Credit: Google



NIST Investigations Can Lead to Changes in Codes/Standards

- **World Trade Center (2001 – 2005/2008)**

U.S. model building codes changes adopted for fire proofing; fire resistance rating; structural integrity; occupant evacuation & fire service access elevators; active fire protection systems; emergency responder communications.

- **Station Nightclub Fire (2003 - 2005)**

Requirements on automatic sprinklers, restricted festival seating in new and existing buildings, crowd managers for existing and new assembly occupancies, and egress inspection recordkeeping adopted in NFPA 101 (Life safety Code)

- **Joplin Tornado (2011 – 2014)***

Recommendations for standard/code requirements for tornado-resistant design for buildings, code requirements for tornado shelters in many more buildings, and standards and codes for clear, consistent, and accurate emergency communications

Sometimes, we don't know what works

“WUI” Fire Codes are not providing adequate protection –

- Focused on thermal radiation and flame contact
 - Firebrands-50% of the ignitions addressed only through ignition and fire spread resistance
- Firebrand exposure and penetration not adequately addressed
 - Igniting wood crib on roof does not adequately represent wind-driven firebrand exposure
 - Vegetative vs structural firebrands
- Weather – wind and wind-driven fire and firebrands are not addressed
 - Need to Understand Wind in Fire Severity Zones
 - Or else, Difficult to improve building design and materials



NIST Community Resilience Planning Guide Helps Communities Achieve Resilience



[English](#)

[Espanol](#)

FORT COLLINS

STAKEHOLDER QUOTE

"Actions to improve resilience can offer immediate dividends beyond resiliency. That's why we are planning now and moving forward in ways that reflect our community's priorities. The NIST Guide is a very helpful tool for doing just that."

- Gerry Horak,
Ft. Collins Mayor Pro Tem

NASHUA

STAKEHOLDER QUOTE

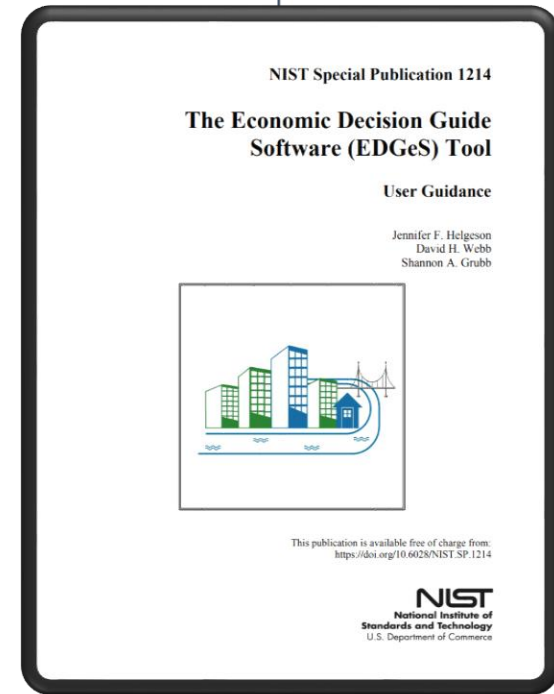
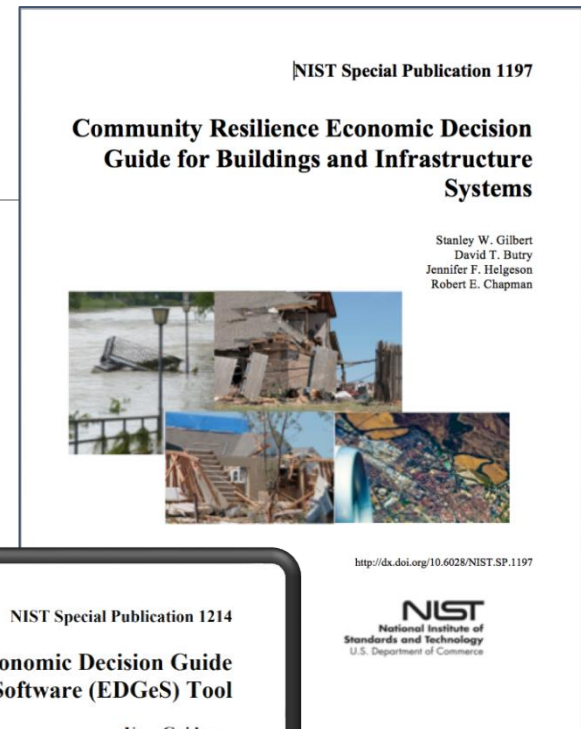
"The performance goals were the number one thing we got out of using the NIST Guide. They kept conversations anchored."

- Justin Kates, Director of
Emergency Management,
City of Nashua



Economics Always Matters! – The NIST Economic Decision Guide

- Standard methodology for evaluating investment decisions to improve a community's resilience
- Compliments the NIST Community Resilience Planning Guide– but can be used alone
 - Mechanism to evaluate and prioritize efficiency of resilience actions and to prioritize them
- Step-by-Step User Guide with example community resilience planning scenarios
<http://nvlpubs.nist.gov/nistpubs/SpecialPublications/NIST.SP.1214.pdf>
- Tool now publicly available (beta version):
<https://www.nist.gov/services-resources/software/edge-economic-decision-guide-software-tool>



How to Join Us at NIST

Summer Undergraduate Research Fellowship (SURF):

<https://www.nist.gov/surf>

* **NIST Pathways Program** for currently enrolled students (high school through post-grad): <https://www.nist.gov/ohrm/student-and-other-opportunities>

* NIST NRC Postdoc Fellowship:

<https://www.nist.gov/iaao/nist-nrc-postdoctoral-research-associateships-program>

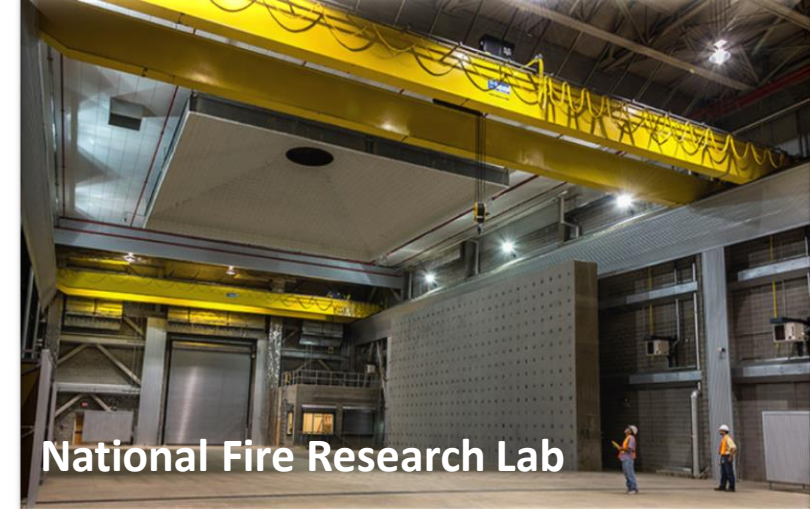
PREP (Professional Research Experience Program):

<https://www.nist.gov/iaao/academic-affairs-office/nist-professional-research-experience-program-prep>

Guest Researchers, and Sabbaticals

* **Term Appointments and many others!**

* *US citizens only*



Back - up

