



Building Housing Resilience:

Lessons Learned from Post-Disaster Reconnaissance and Convergence Research

Tracy Kijewski-Correa



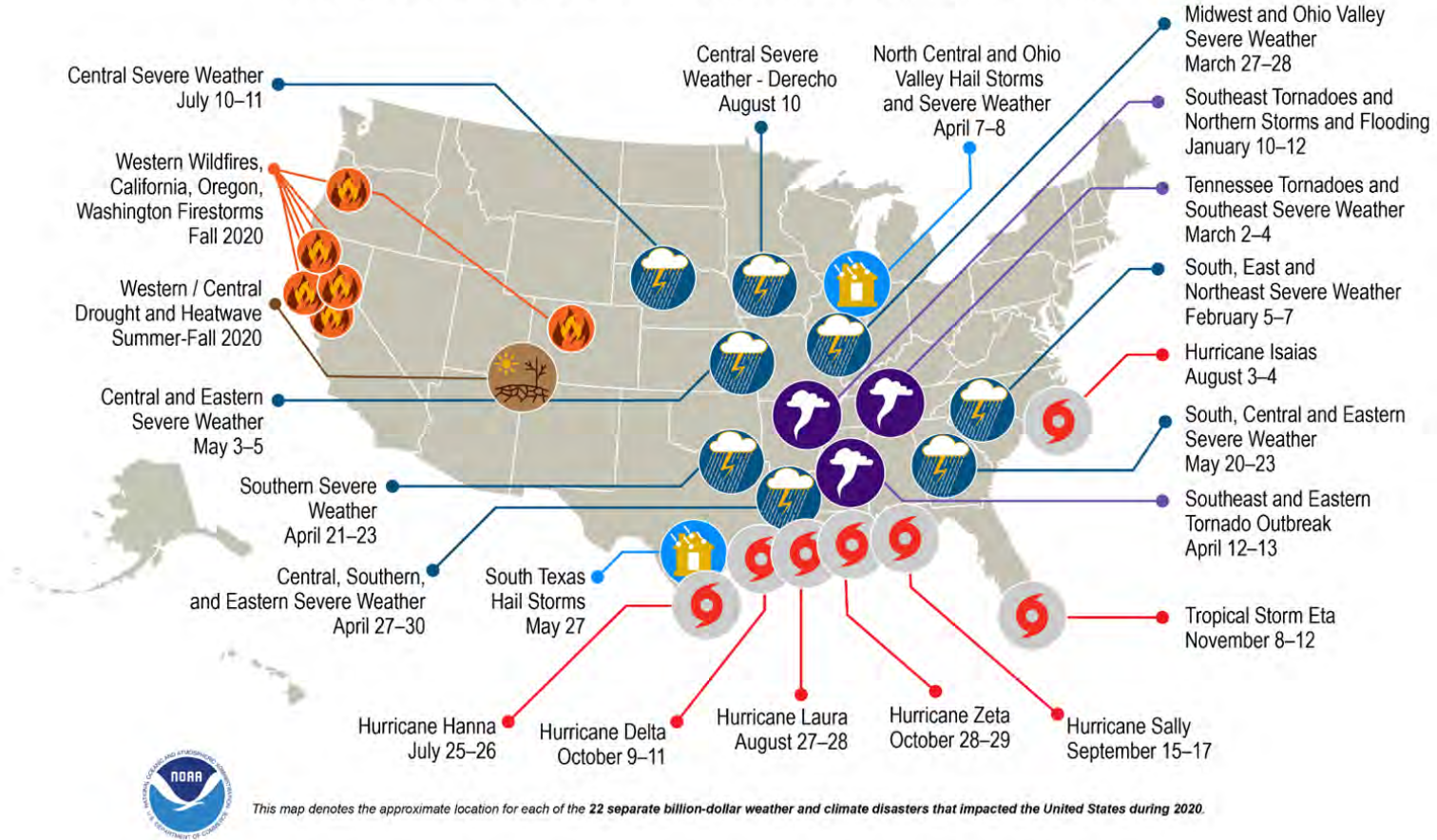


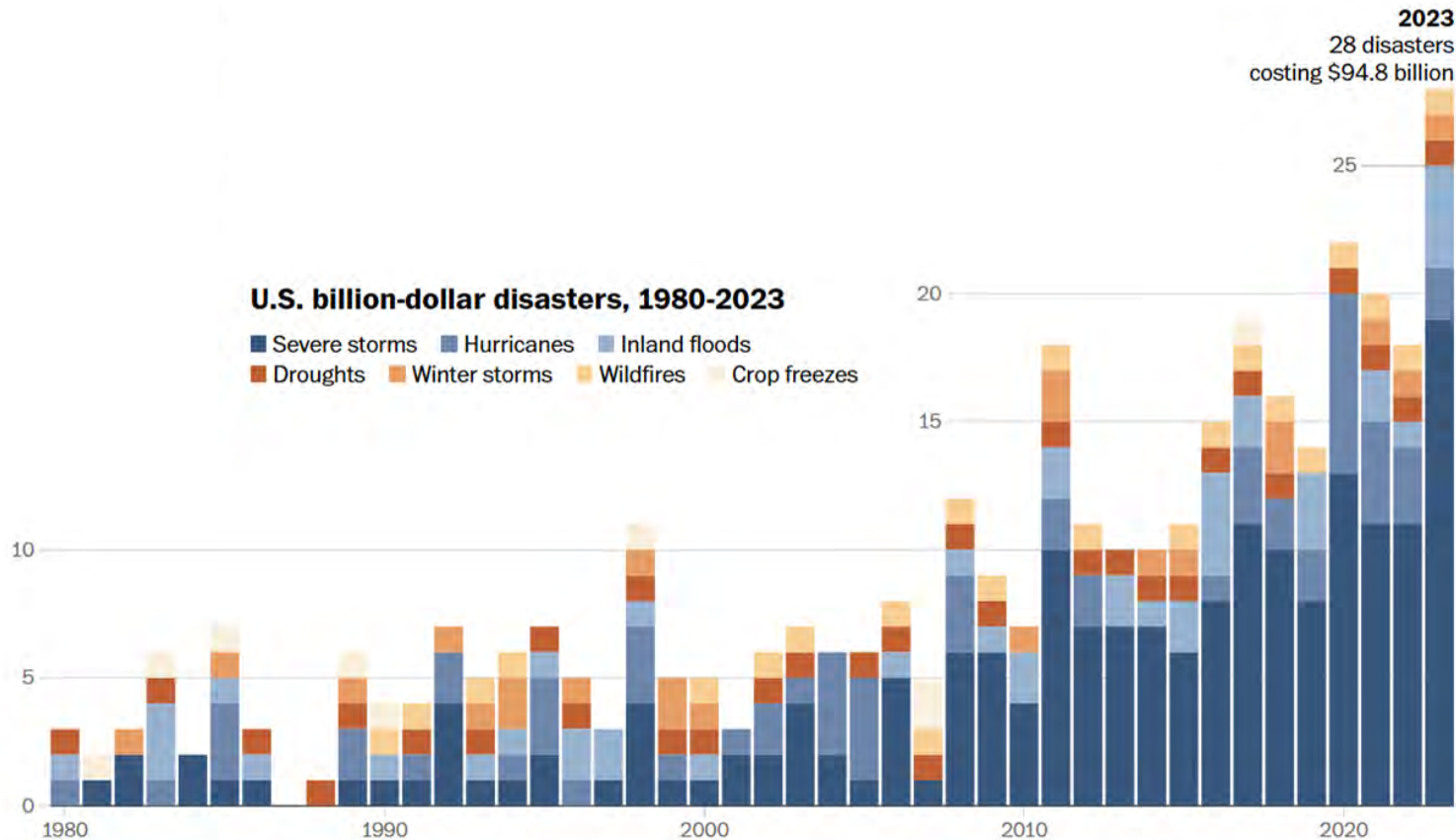
HURRICANE MICHAEL (2018)



How did we get here?

U.S. 2020 Billion-Dollar Weather and Climate Disasters





Source: [National Oceanic and Atmospheric Administration](#). Chart does not include 20 events from 2024 because the year is incomplete.

Source: Washington Post





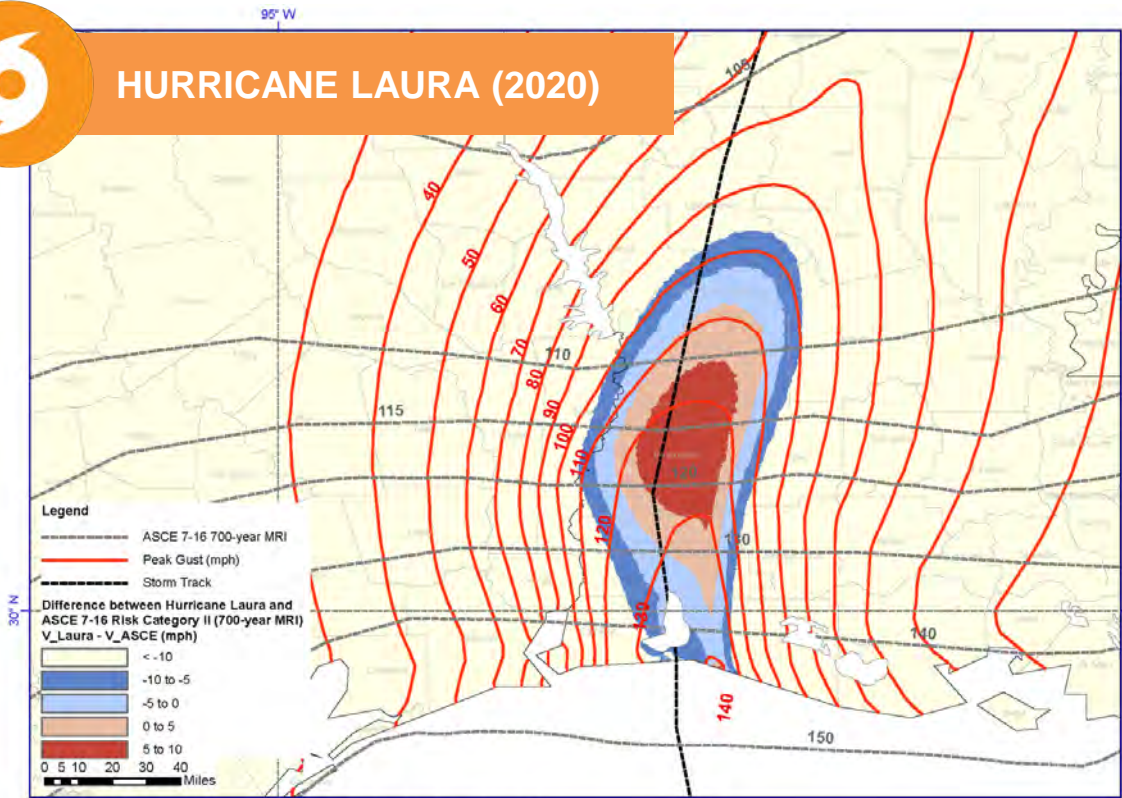
HAZARD

- Since 1980, frequency of landfalling hurricanes has increased
- Intensifying hazards (heavy rainfall)
- Storms slowing and stalling (heavy rains, storm surge)
- Rapid intensification (inland strong winds)



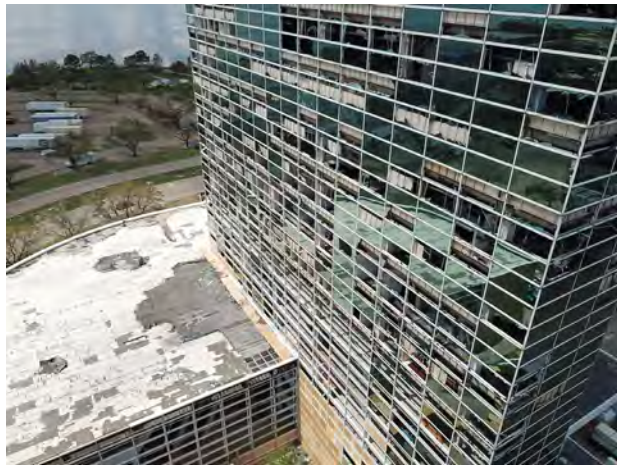


HURRICANE LAURA (2020)



Hurricane Laura (2020): Preliminary Peak Wind Gust (mph)

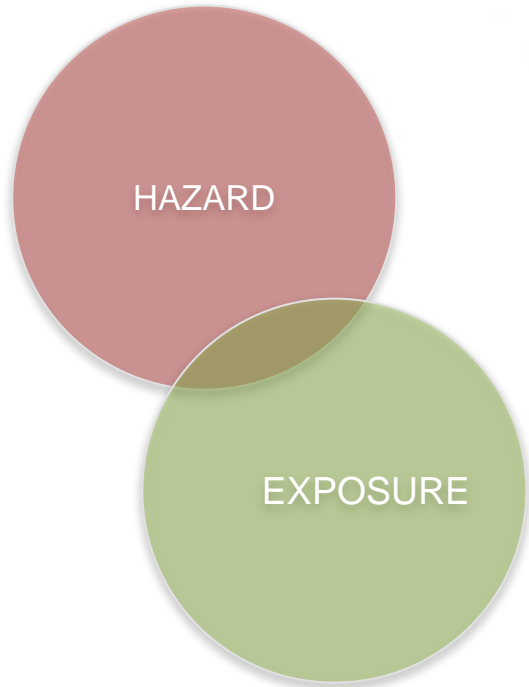
Estimated 3-second gust wind speeds (mph) at 10m above ground over flat open terrain from ARA model fit to surface level observations using storm track and central pressure data from NHC through Forecast Advisory Number 33 and observations through 1200 UTC on 8/28/2020. The values of peak gust winds in mph are shown after station names. Values have been adjusted for anemometer height and terrain; "a" means station failed before the arrival of the peak wind; "b" indicates a potentially anomalous value. The maps have been produced for the National Institute of Standards and Technology under Contract 1333ND19PNB730060. Maps are subject to change. Created on: 9/4/2020 (Version 47)



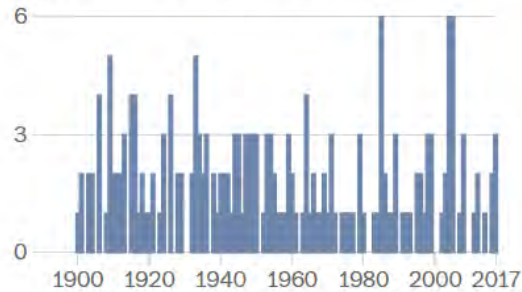
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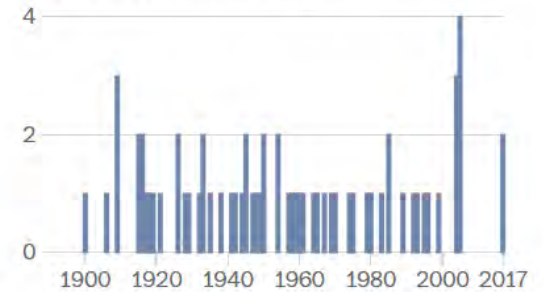
Factors influencing U.S. hurricane damage, 1900-2017



Hurricanes making landfall

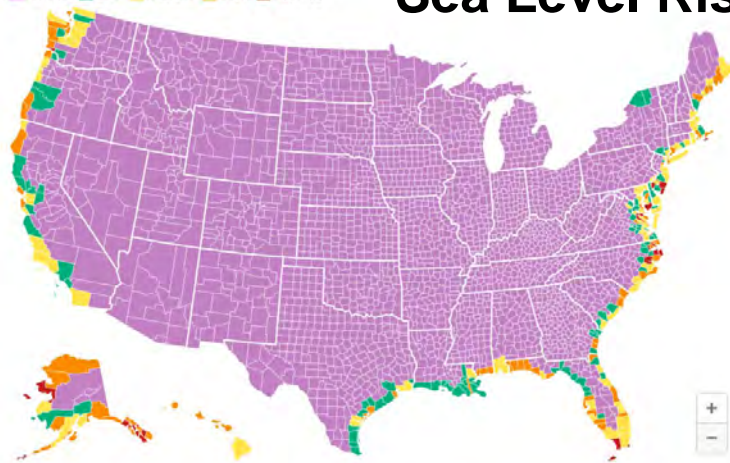


Major hurricanes making landfall



Risk Threshold
No Risk Low Medium High Red Flag

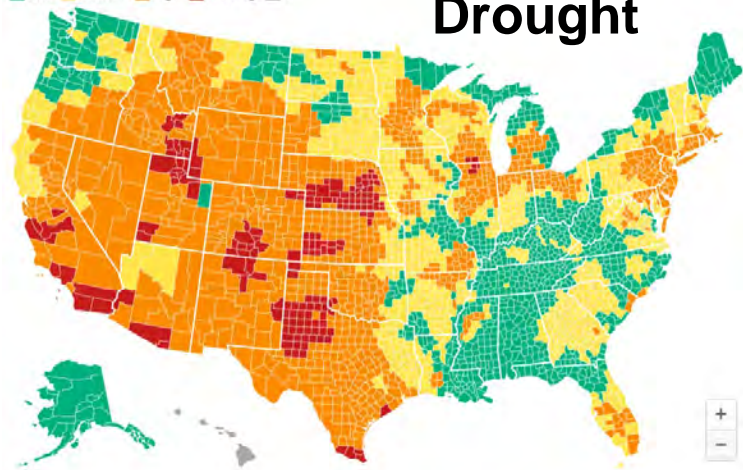
Sea Level Rise



Map: American Communities Project • Source: Climate risk data from Four Twenty Seven • Created with Datawrapper

Risk Threshold
Low Medium High Red Flag 0

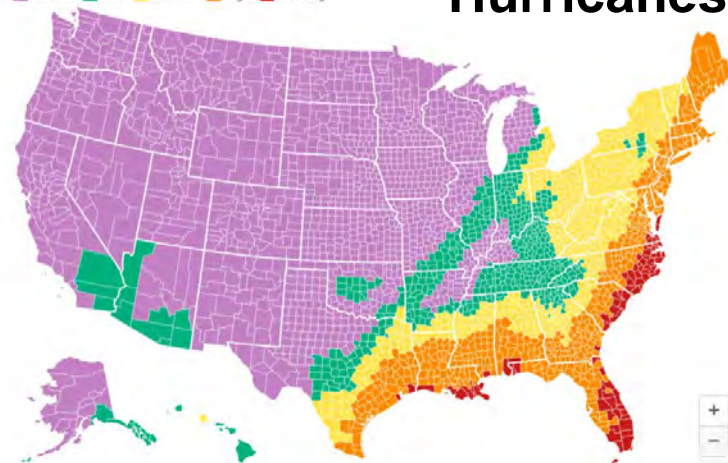
Drought



Map: American Communities Project • Source: Climate risk data from Four Twenty Seven • Created with Datawrapper

Risk Threshold
No Risk Low Medium High Red Flag

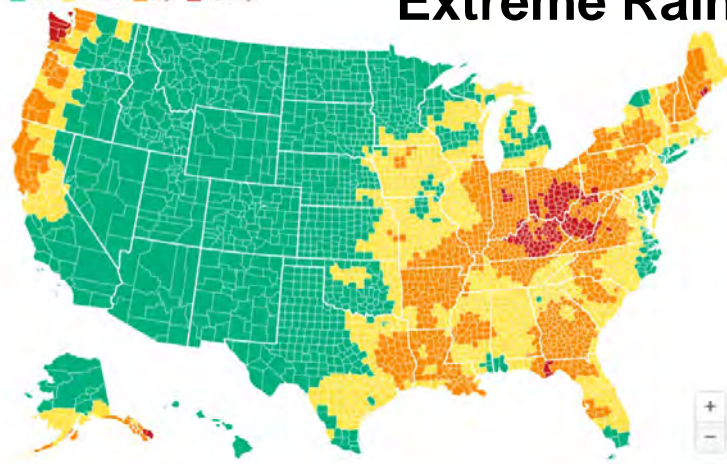
Hurricanes



Map: American Communities Project • Source: Climate risk data from Four Twenty Seven • Created with Datawrapper

Risk Threshold
Low Medium High Red Flag

Extreme Rain



Map: American Communities Project • Source: Climate risk data from Four Twenty Seven • Created with Datawrapper

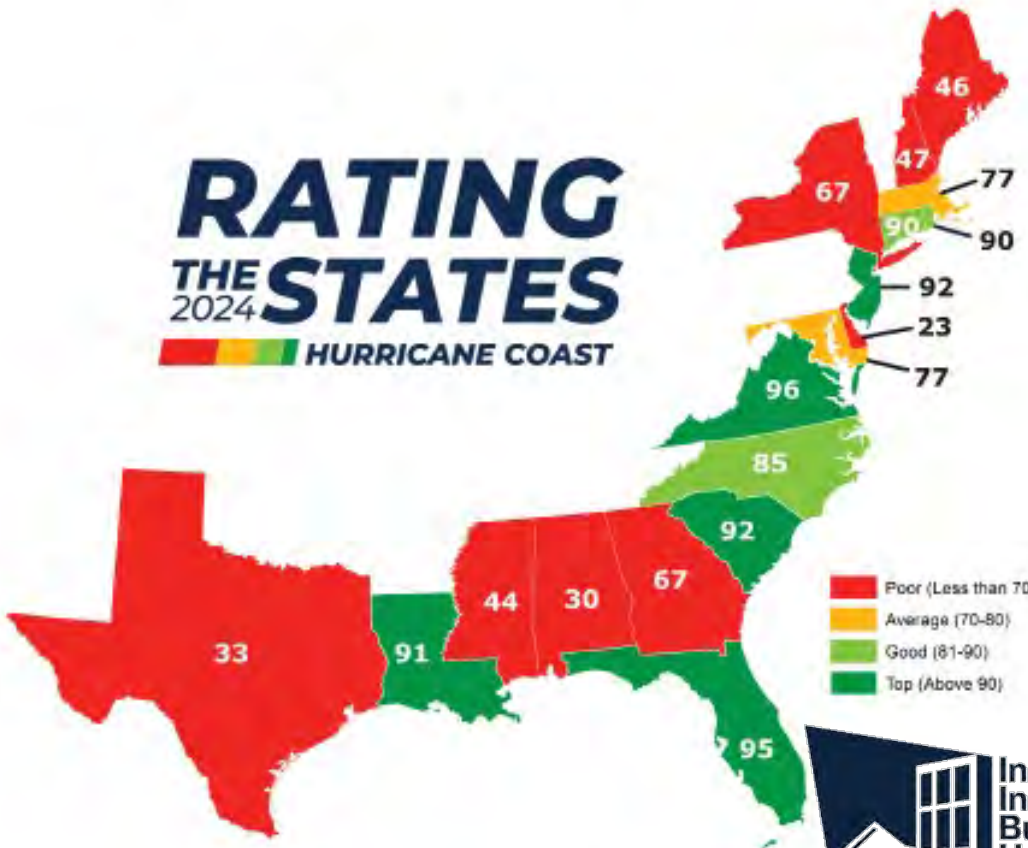


American Communities Project



RATING THE STATES 2024

HURRICANE COAST



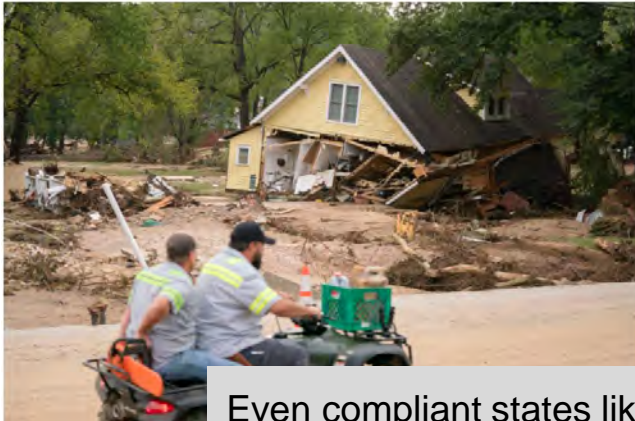
- Red: Poor (Less than 70)
- Yellow: Average (70-80)
- Light Green: Good (81-90)
- Dark Green: Top (Above 90)



Building codes led North Carolina to lose out on \$70M in disaster prep funds, state says

Western North Carolina towns denied \$18M in flood resilience grants in part due to state standards

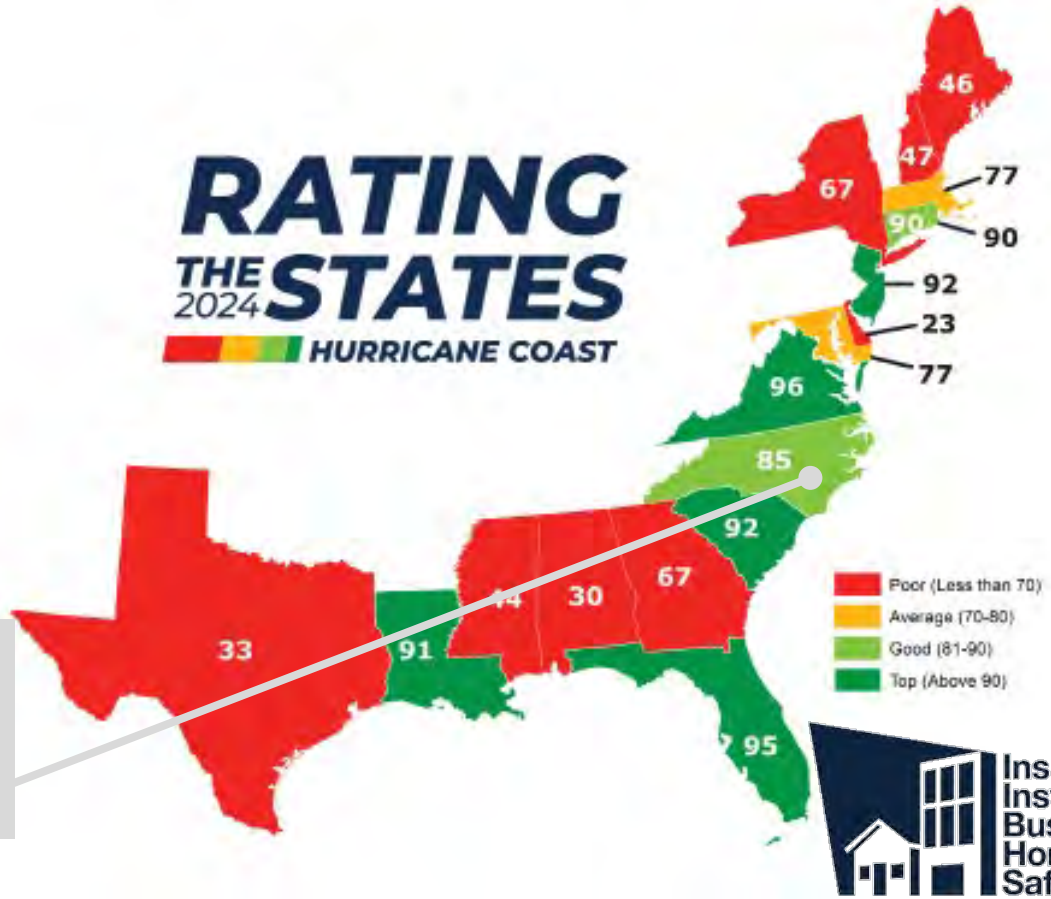
BY: BRANDON KINGDOLLAR - OCTOBER 16, 2024 5:45 AM

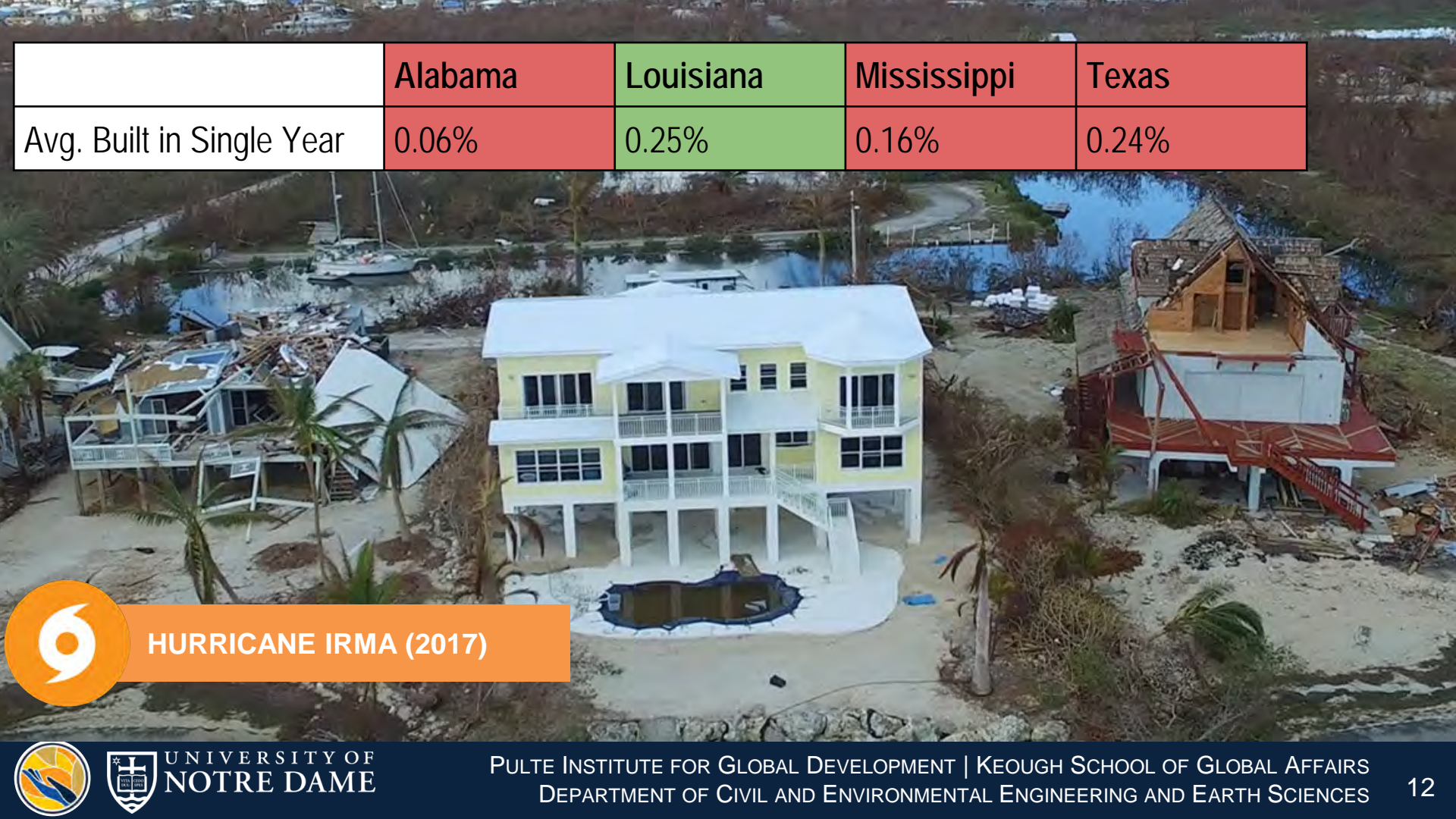


Even compliant states like North Carolina are 1-2 cycles behind the latest national model codes

RATING THE STATES 2024

HURRICANE COAST





	Alabama	Louisiana	Mississippi	Texas
Avg. Built in Single Year	0.06%	0.25%	0.16%	0.24%

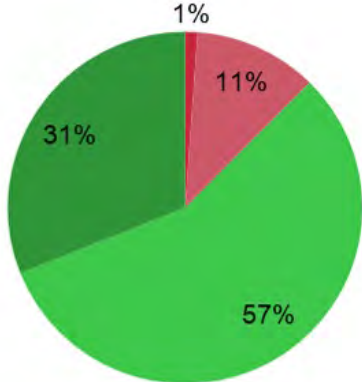
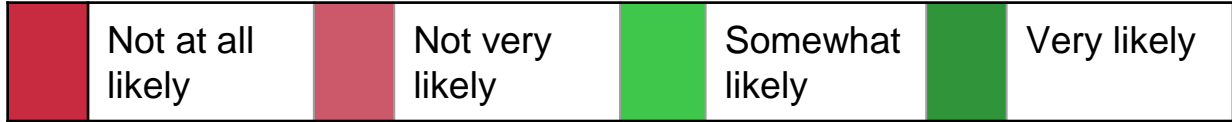
 HURRICANE IRMA (2017)



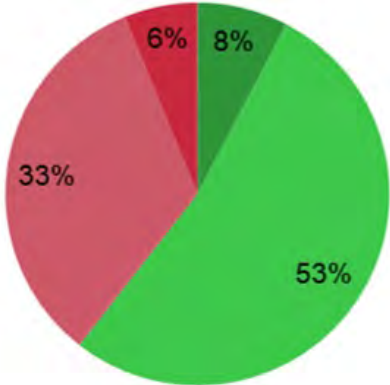
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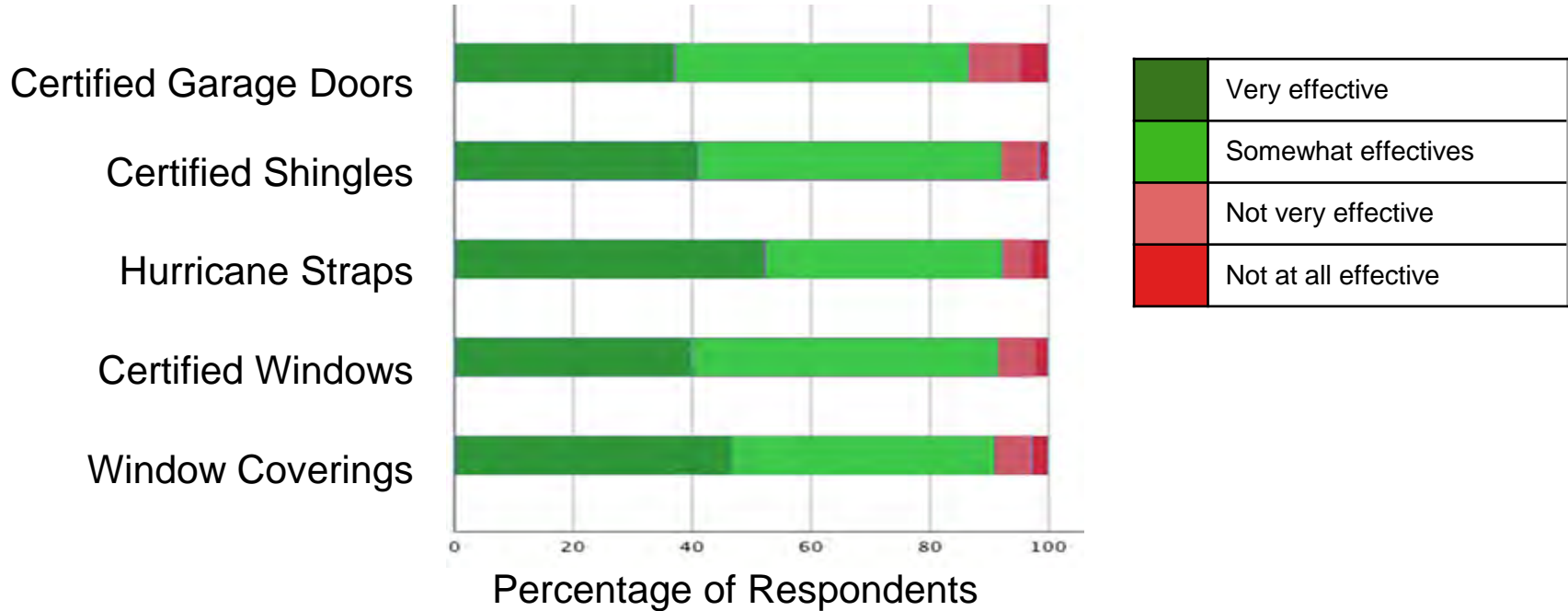
Q61b. What is the chance of a strong hurricane hitting your home in the next five hurricane seasons (2017-2021)?



Q82. How worried are you about hurricanes hitting your area?



Q76. How effective do you think the following home upgrades or repairs are in reducing the risk of damage to your home in strong hurricanes?



PERCEIVED
THREAT

PERCEIVED
EFFECTIVENESS

PERCEIVED
AFFORDABILITY

PERCEIVED
VULNERABILITY

Q75. For you personally, how affordable is each action?

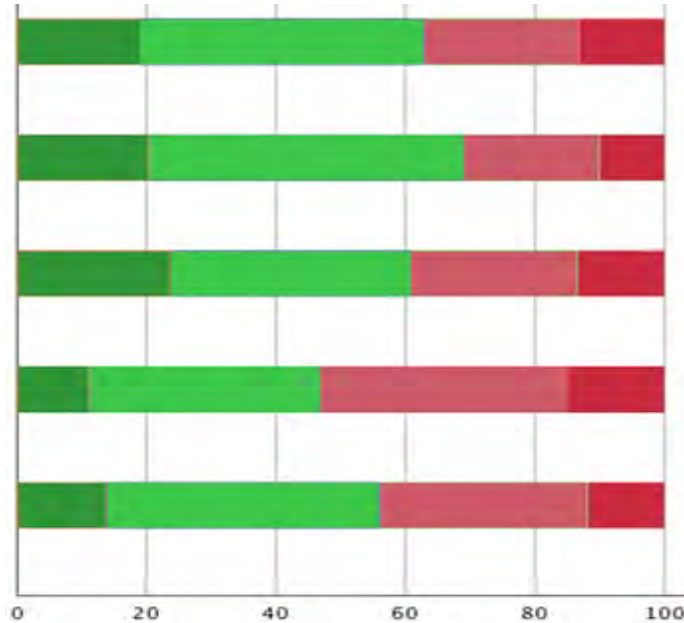
Certified Garage Doors

Certified Shingles





Hurricane Straps

Certified Windows

Window Coverings



Percentage of Respondents

	Very affordable
	Somewhat affordable
	Not very affordable
	Not at all affordable



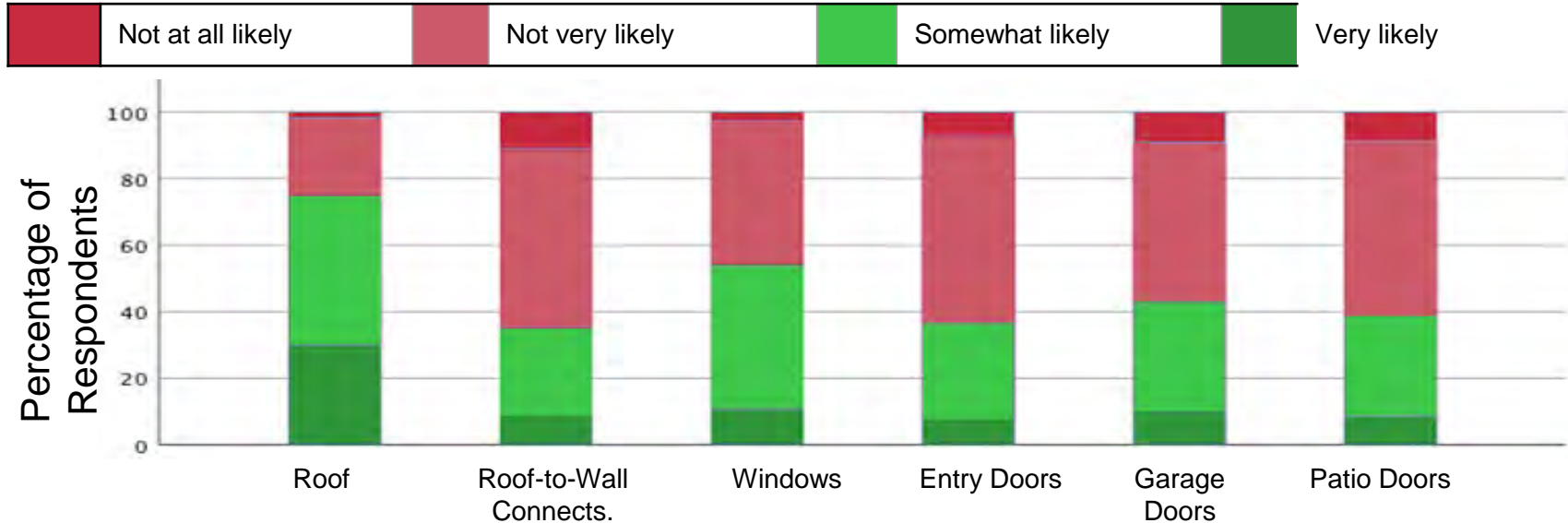
PERCEIVED
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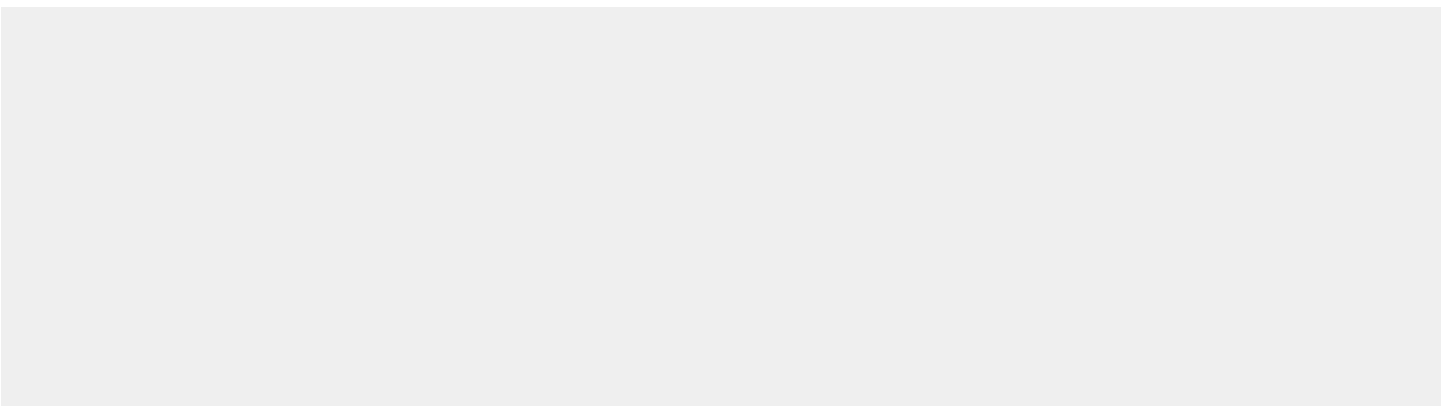
Q69. If a strong hurricane hit your home, how likely are the following parts to sustain significant damage?



CHALLENGE: Building codes create the impression that buildings are not as vulnerable as they are.



IMPLICATIONS OF THE LIFE-SAFETY APPROACH



1990	1995	2000	2005	2010	2015	2020
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*Hartwig, R.P., & Wilkinson, C. (2016). Residual Market Property Plans: From Markets of Last Resort to Markets of First Choice. Insurance Information Institute, May. Available at: https://www.iii.org/sites/default/files/docs/pdf/residual_markets_wp_051616.pdf.

MOVING BEYOND LIFE-SAFETY



	ADOPT CODE	ABOVE CODE	BUILDING RETROFIT	LIFELINE RETROFIT	FEDERAL GRANTS
Overall Benefit-Cost Ratio	11:1	4:1	4:1	4:1	6:1
Cost (\$ billion)	\$1/year	\$4/year	\$520	\$0.6	\$27
Benefit (\$ billion)	\$13/year	\$16/year	\$2200	\$2.5	\$160

Riverine Flood	6:1	5:1	6:1	8:1	7:1
Hurricane Surge	not applicable	7:1	not applicable	not applicable	not applicable
Wind	10:1	5:1	6:1	7:1	5:1
Earthquake	12:1	4:1	13:1	3:1	3:1
Wildland-Urban Interface Fire	not applicable	4:1	2:1	not applicable	3:1

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WHERE ARE OUR POINTS OF INFLUENCE?



What can we learn?



**Affected
Communities**



*Network
Coordination*



Recon Equipment



**Technology
Translation**



**Field
Observations**



*Response
Coordination*



Cyberinfrastructure



**Research &
Development**



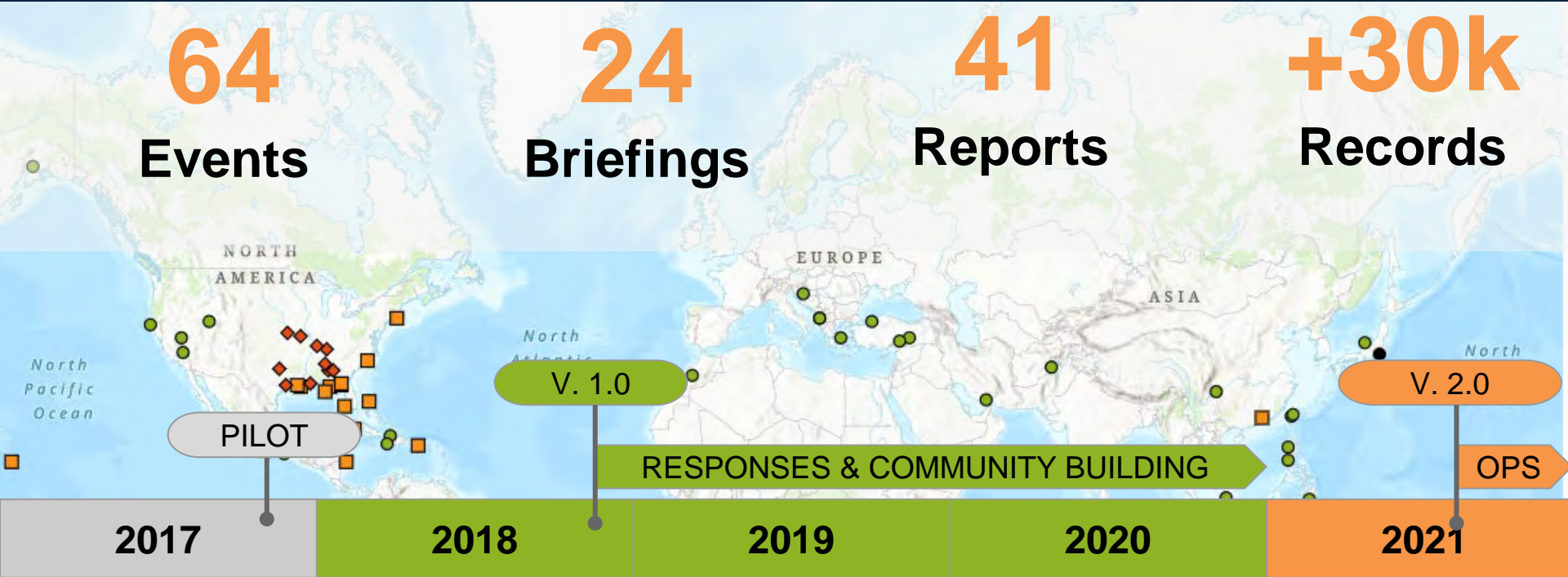
StEER
**STRUCTURAL
EXTREME EVENTS
RECONNAISSANCE**

*Computational
Infrastructure*



*Experimental
Facilities*

CHRONOLOGY & GEOGRAPHIC COVERAGE



EARTHQUAKE



TORNADO



HURRICANE

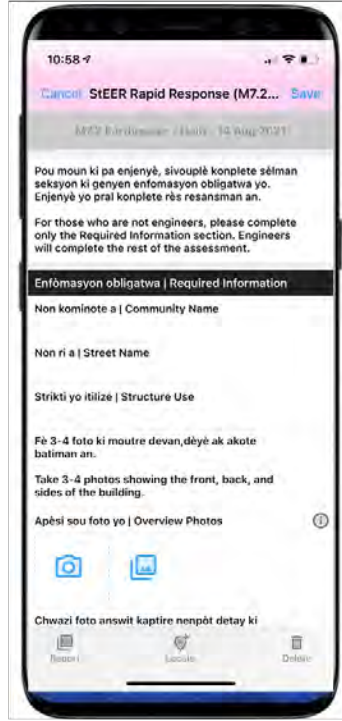


TSUNAMI

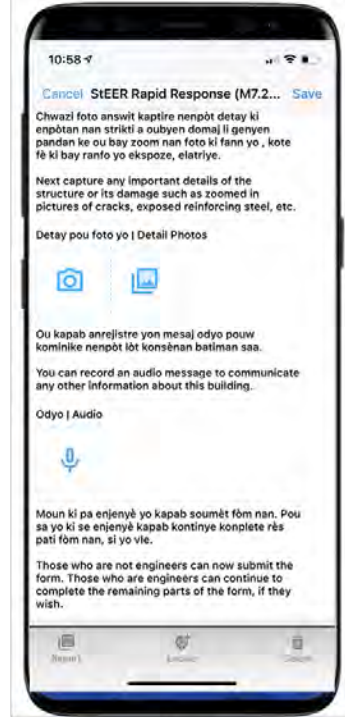
MOBILE PHONES FOR SCALABLE DATA COLLECTION



Geolocation:
directionality on Open
Street Maps



General Information:
Usage and overview
photos



Detail & Context: Detail
photos & audio context



MINING DATA FOR BRIGHT SPOTS



NIPPES EARTHQUAKE (2021)

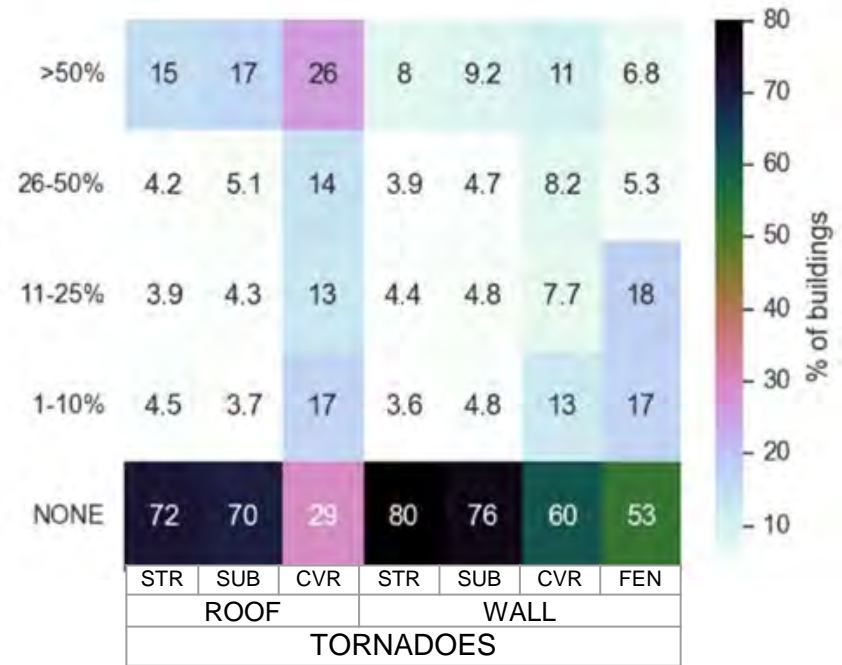
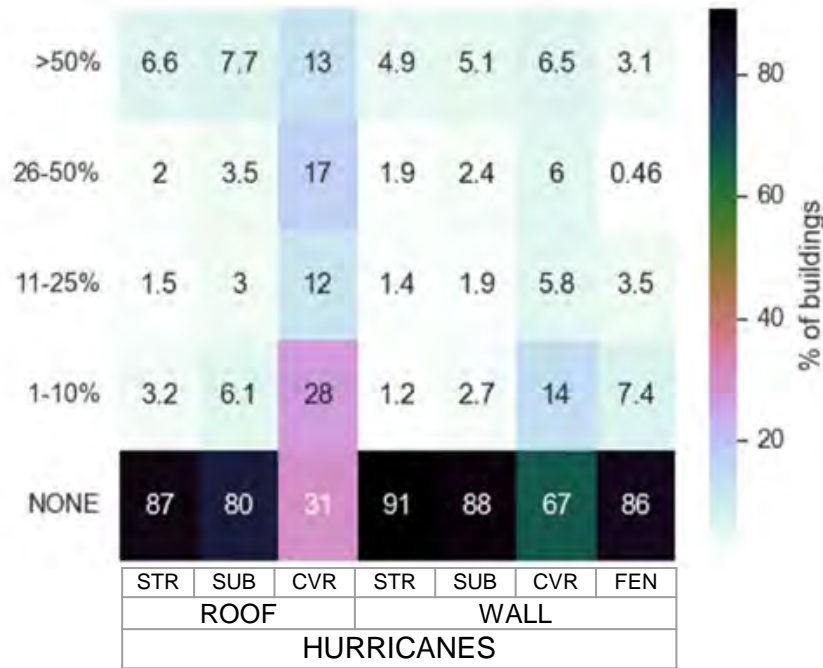
Kijewski-Correa, T., Canales, E., Hamburger, R., Lochhead, M., Mbabazi, A., Presuma, L. (2024), "A Hybrid Model for Post-Earthquake Performance Assessments in Challenging Contexts," *Bulletin of Earthquake Engineering*, <https://doi.org/10.1007/s10518-024-01927-8>



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UNIFIED WINDSTORM RESIDENTIAL DATABASE



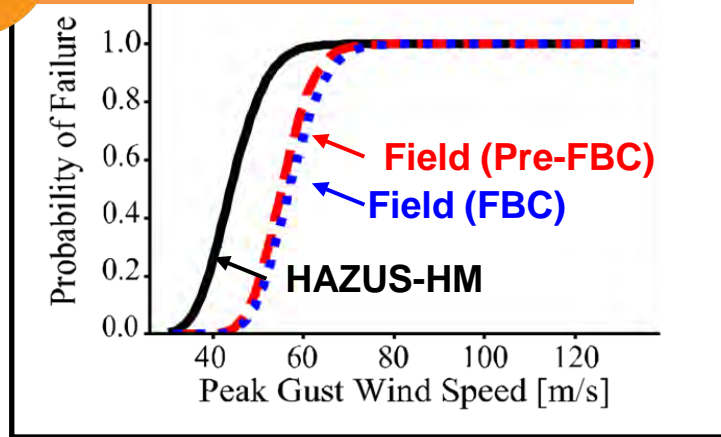
Roueche, D.B., Nakayama, J.O., **Kijewski-Correa, T.**, Prevatt, D.O. (2023) "Unified Multievent Windstorm Performance Testbed for Single-Family Residential Buildings," *Natural Hazards Review*, 25(2), <https://doi.org/10.1061/NHREFO.NHENG-1796>



IMPROVED LOSS MODELING



HURRICANE MICHAEL (2018)









Location	Total Expected Losses (Sum of Loss Ratios)		
	IBC/IRC	FBC (no retrofits)	FBC (retrofits)
Mexico Beach	122.33	115.22	113.64
Panama City Beach	383.81	366.80	354.70

Angeles, K. and Kijewski-Correa, T. (2022) "Bayesian Data Integration Framework for the Development of Component-level Fragilities Derived from Multiple Post-Disaster Datasets," *Structural Safety*, 99, <https://doi.org/10.1016/j.strusafe.2022.102260>



What can we do?

Lesson 1: Message today's benefits, not tomorrow's consequences

 National Institute of BUILDING SCIENCES™		ADOPT CODE	ABOVE CODE	BUILDING RETROFIT	LIFELINE RETROFIT	FEDERAL GRANTS
Overall Benefit-Cost Ratio		11:1	4:1	4:1	4:1	6:1
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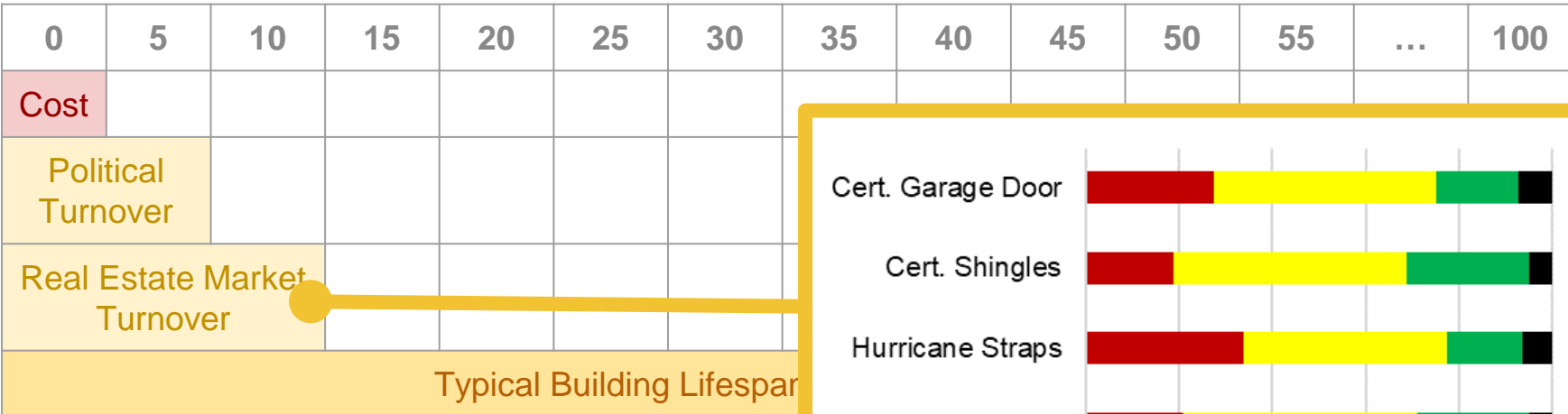
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Lesson 1: Message today's benefits, not tomorrow's consequences

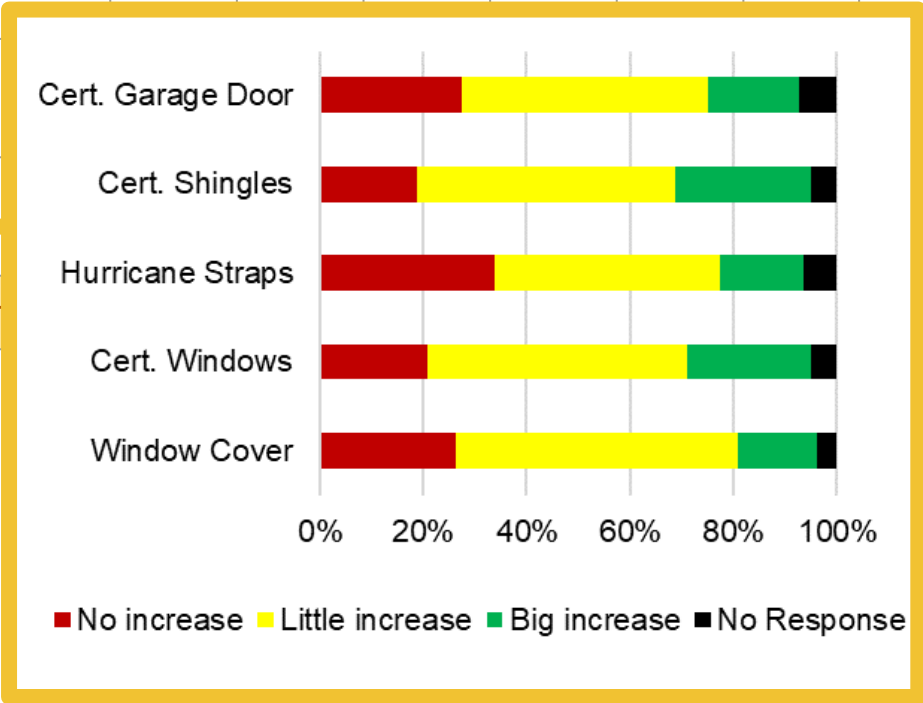
	0	5	10	15	20	25	30	35	40	45	50	55	...	100
Cost														
Political Turnover														
Real Estate Market Turnover														
Typical Building Lifespan														



Lesson 1: Message today's benefits, not tomorrow's consequences



- **Affordability** is not the primary barrier to action, nor is income
- Owner's don't take action to avoid future losses
- Property values need to **reward resilience**, insurance credits too slow

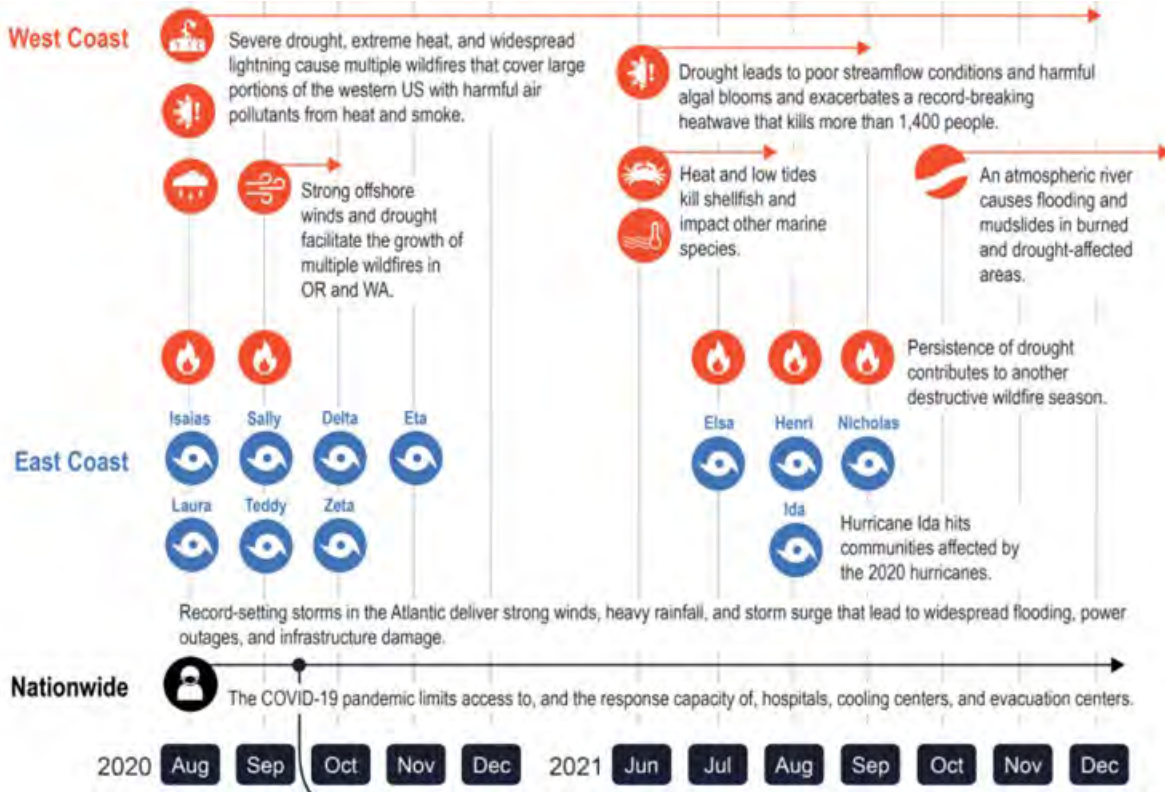


Lesson 2: ~~Build Back Better.~~ Build Better Before.

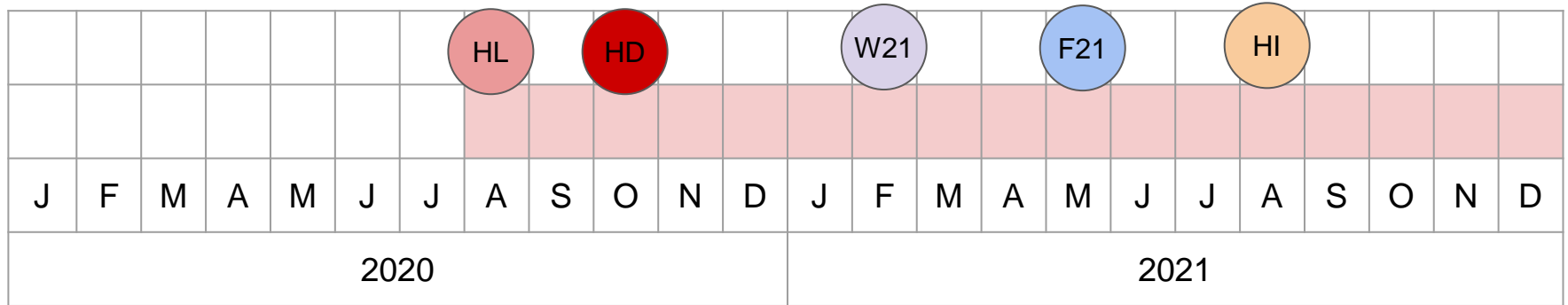


HURRICANE LAURA (2020)





Case Study in Compounding Disaster: Lake Charles, Louisiana




HL	H Laura (8/2020)		W21	Winter Storm Uri (2/2021)	
HS	H Sally (9/2020)		F21	Louisiana Flooding (5/2021)	
HD	H Delta (10/2020)		HI	H Ida (8/2021)	
HZ	H Zeta (10/2020)		TSN	TS Nicholas (9/2021)	



Lesson 3: Design with nature, not against it



 HURRICANE IAN (2022)

Lesson 3: Design with nature, not against it



 HURRICANE MATTHEW (2016)

Lesson 4: A Minimum is a minimum



MIDWEST TORNADO OUTBREAK (2021)



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Lesson 4: A Minimum is a minimum



MIDWEST TORNADO OUTBREAK (2021)



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Lesson 5: Know when it is time to hide, and when it is time to run

DeBary, Florida
Hurricane Preparedness
Hurricane season lasts from June 1st through November 30th and there are a lot of things you can do to prepare

BEFORE

STAY INFORMED

- Check Volusia.org/PIN for up-to-date and accurate information
- Download the [Volusia FL EM app](#) for updates and emergency assistance
- Buy a weather radio to stay informed during power outages

MAKE A KIT

- Keep important documents in a zip-lock bag
- Store non-perishable food and flashlights in a sealed container (suggested 7-day of food for every person in your family)

KNOW YOUR ZONE, KNOW YOUR HOME

Do you plan on evacuating when it is time? DeBary is NOT in a surge zone, so if you live in a secure and stable home, and do not require any electronic medical equipment, it is recommended that you shelter in place.

- If you choose to evacuate know where you are going (friends, family, hotel/motel, public shelter).

DURING

KEEP INFORMED

- Keep the television and/or radio on and nearby for any weather updates and follow emergency orders closely.
- Visit Volusia.org/PIN

STAY INSIDE

- Stay inside and away from any windows or doors, interior rooms, hallways, or closets on the lower level are the safest option.



SHELTER IN PLACE

BABCOCK RANCH



TAKEAWAYS

- **Losses are mounting globally**
 - Hazards, exposure and vulnerability are all contributing
 - Driven by our policies, our behaviors, our design philosophies
- Fundamentally **rethink how and where we build**
- **Understand (perverse) incentives and human behavior**
 - Need to change how we message → **co-benefits today**
 - New era: **compounding losses** → **Build Better Before**
 - **Design with nature** to reduce costs
 - Remember a code minimum is a minimum (occupant vulnerability and functional recovery objectives)
 - Are we prepared to advise communities regarding when it is time to **hide or retreat?**



ACKNOWLEDGEMENTS

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Data Collectors: StEER Network of volunteer engineers, participating households

Any opinions, findings, conclusions, or recommendations expressed in this material are those of the author and do not necessarily reflect the views of NSF or these partners.



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