Building Codes Save: A Nationwide Study

Losses Avoided As a Result of Adopting Hazard-Resistant Building Codes

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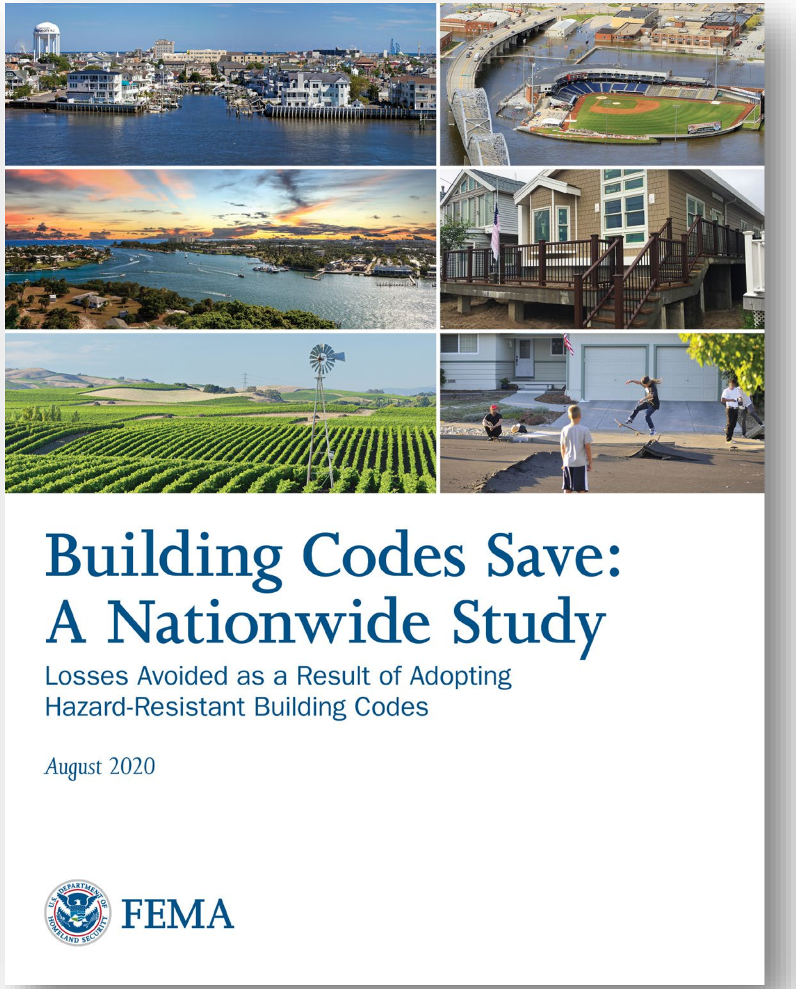
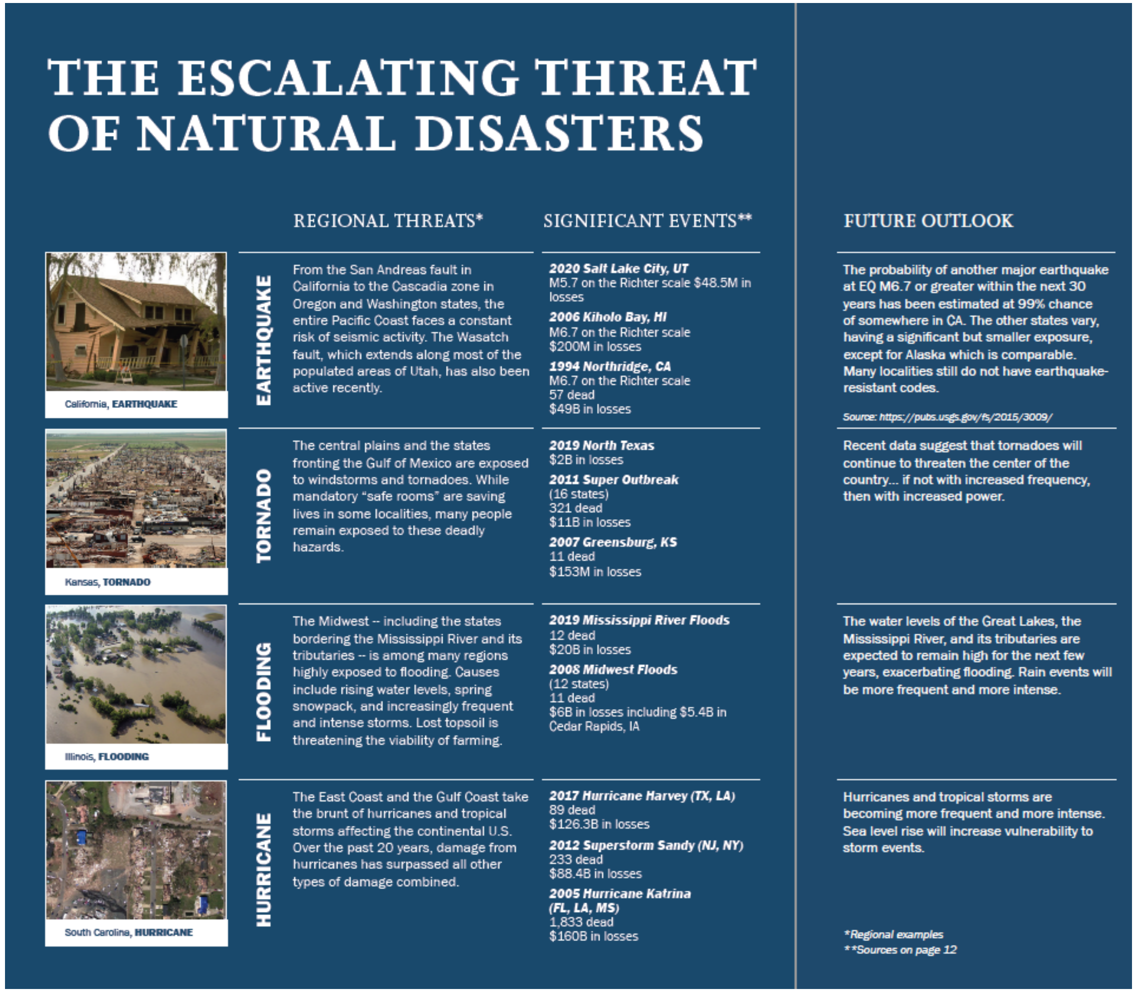
Presentation Agenda

- Introduction
- Methodology
- Data Collection and Filtering
- Analysis and Findings by Hazard
- Nationwide Findings
- Study Brochure



Building Codes Save (BCS) Study Goals

- Demonstrate the monetary benefit of adopting hazard resistant building codes
- Quantify the effect of building codes in lowering disaster risk for new construction
- Use results to incentivize code adoption, determine opportunities for risk reduction, and engage public officials



THE ESCALATING THREAT OF NATURAL DISASTERS

		REGIONAL THREATS*	SIGNIFICANT EVENTS**	FUTURE OUTLOOK
California, EARTHQUAKE	EARTHQUAKE	From the San Andreas fault in California to the Cascadia zone in Oregon and Washington states, the entire Pacific Coast faces a constant risk of seismic activity. The Wasatch fault, which extends along most of the populated areas of Utah, has also been active recently.	***2020 Salt Lake City, UT*** M5.7 on the Richter scale $48.5M in losses ***2006 Kiholo Bay, HI*** M6.7 on the Richter scale $200M in losses ***1994 Northridge, CA*** M6.7 on the Richter scale 57 dead $49B in losses	The probability of another major earthquake at EQ M6.7 or greater within the next 30 years has been estimated at 99% chance of somewhere in CA. The other states vary, having a significant but smaller exposure, except for Alaska which is comparable. Many localities still do not have earthquake-resistant codes. *Source: https://pubs.usgs.gov/fs/2015/3009/*
Kansas, TORNADO	TORNADO	The central plains and the states fronting the Gulf of Mexico are exposed to windstorms and tornadoes. While mandatory "safe rooms" are saving lives in some localities, many people remain exposed to these deadly hazards.	***2019 North Texas*** $2B in losses ***2011 Super Outbreak*** (16 states) 321 dead $11B in losses ***2007 Greensburg, KS*** 11 dead $153M in losses	Recent data suggest that tornadoes will continue to threaten the center of the country... if not with increased frequency, then with increased power.
Illinois, FLOODING	FLOODING	The Midwest – including the states bordering the Mississippi River and its tributaries – is among many regions highly exposed to flooding. Causes include rising water levels, spring snowpack, and increasingly frequent and intense storms. Lost topsoil is threatening the viability of farming.	***2019 Mississippi River Floods*** 12 dead $20B in losses ***2008 Midwest Floods*** (12 states) 11 dead $6B in losses including $5.4B in Cedar Rapids, IA	The water levels of the Great Lakes, the Mississippi River, and its tributaries are expected to remain high for the next few years, exacerbating flooding. Rain events will be more frequent and more intense.
South Carolina, HURRICANE	HURRICANE	The East Coast and the Gulf Coast take the brunt of hurricanes and tropical storms affecting the continental U.S. Over the past 20 years, damage from hurricanes has surpassed all other types of damage combined.	***2017 Hurricane Harvey (TX, LA)*** 89 dead $126.3B in losses ***2012 Superstorm Sandy (NJ, NY)*** 233 dead $88.4B in losses ***2005 Hurricane Katrina (FL, LA, MS)*** 1,833 dead $160B in losses	Hurricanes and tropical storms are becoming more frequent and more intense. Sea level rise will increase vulnerability to storm events.

**Regional examples*
***Sources on page 12*

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BCS Study Summary

How much are the hazard-resistant codes that have been adopted since 2000 saving counties, states, and the nation?

$1.6 billion*

*Average annualized savings as of 2018

Key Highlights

- First time engineering-based parcel analysis using Big Data (18.1 million post-2000 structures)
- Hazards: flood, hurricane wind, seismic
- Hazard risk and code adoption varies
- $32 Billion saved over 20 years
- $132 Billion in savings possible by 2040
- Building and Contents damages only, just the tip of the iceberg!

Losses Avoided Definitions

Average Annual Loss (AAL)	Estimated long-term value of losses in any single year in a specified geographic area
Average Annual Losses Avoided (AALA)	Comparison of the baseline pre-I-Code AAL with the AAL for the building code in place at the time of construction
No/low losses avoided	Due to nearly identical pre-I-Code and I-Code parameters and hazard maps
Negative losses avoided	Minimal occurrence, locations where map updates show a lower hazard

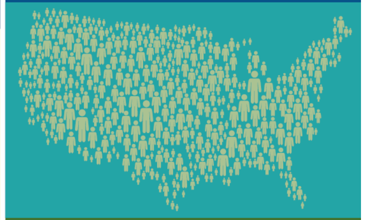
BCS Methodology

PHASE 1
Concept test in Charleston, SC, and Salt Lake City, UT
PILOT STUDY

PHASE 2
FEMA Region IV demonstration study
REGIONAL STUDY

PHASE 3
Development of national dataset and methodology
NATIONAL METHODOLOGY

PHASE 4
Building Codes SAVE



NATIONWIDE STUDY

Step 1: Collect and filter data

Step 2: Adapt and assign damage curves

Step 3: Input data into Hazus

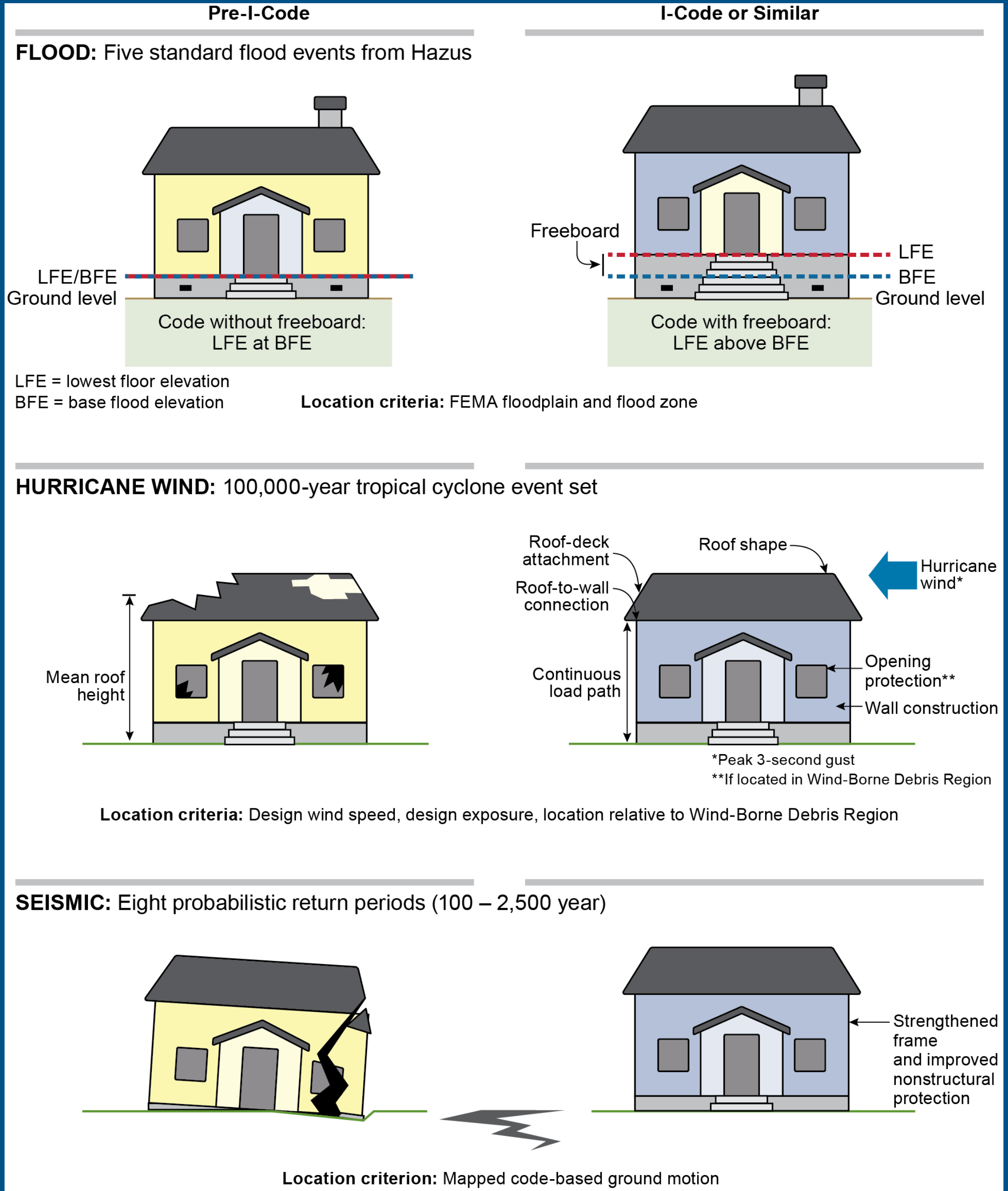
Step 4: Compute and analyze damage and losses/losses avoided

Step 5: Evaluate losses avoided findings

Step 6: Perform quality assurance

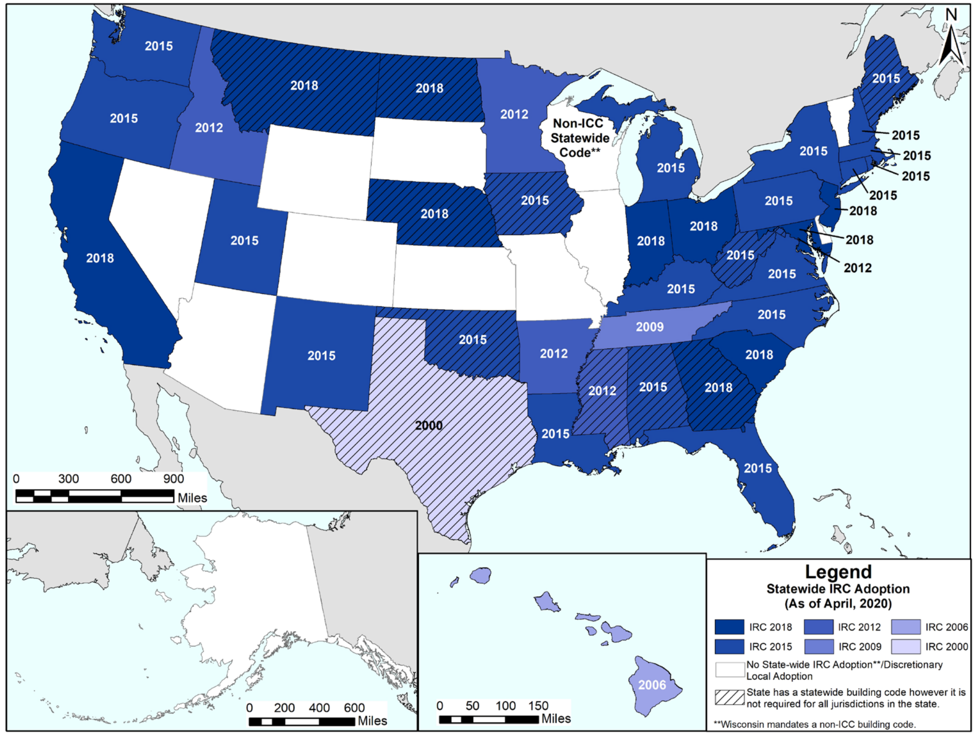
Losses Avoided Computations

- Hazus simulations
- Direct property damage (building and contents)
- Compare pre-I-Code provisions to I-Code or similar provisions



Data Collection

- CoreLogic and Microsoft Bing parcel-level data
- Building code adoption data
  - National data sources (ICC, BCEGS, FEMA CRS)
  - State/local provisions and modifications
  - Adoption date with one-year lag
- Hazard-specific maps
  - National Flood Hazard Layer, Flood Insurance Rate Maps, CoreLogic flood layer
  - ASCE 7 wind maps/NOAA coastline
  - USGS probabilistic ground motion data



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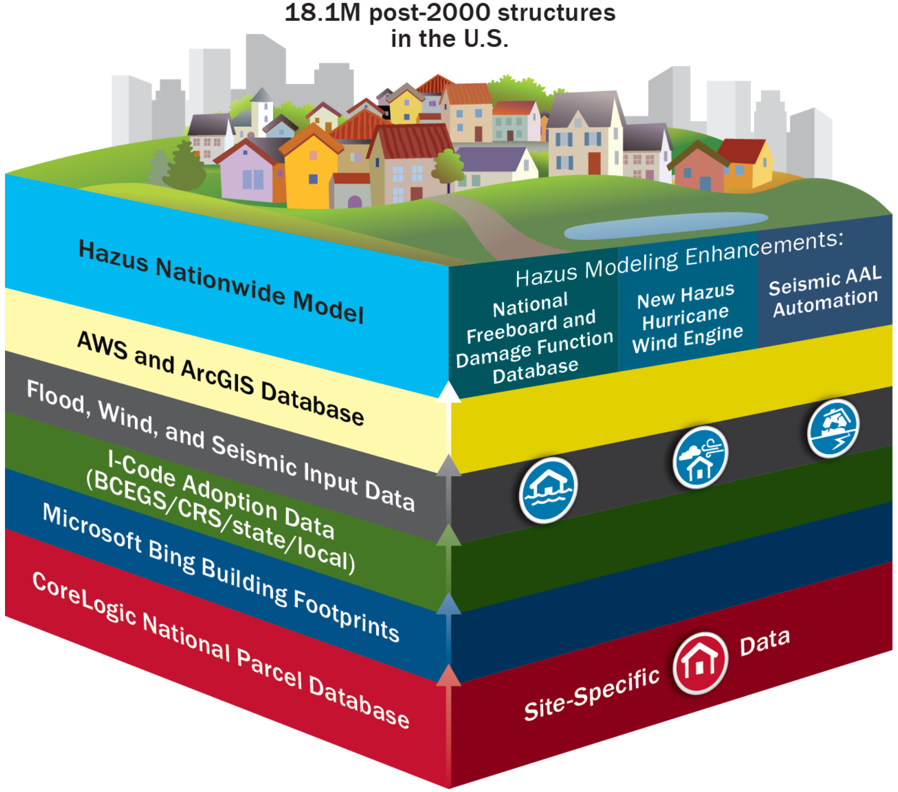
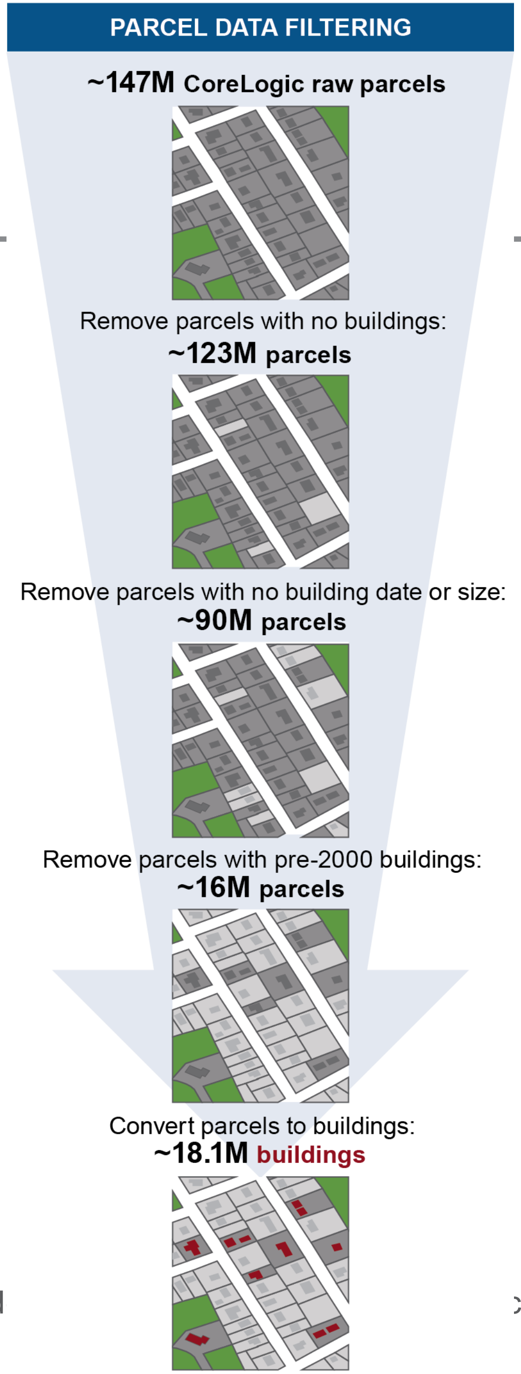
Data Processing





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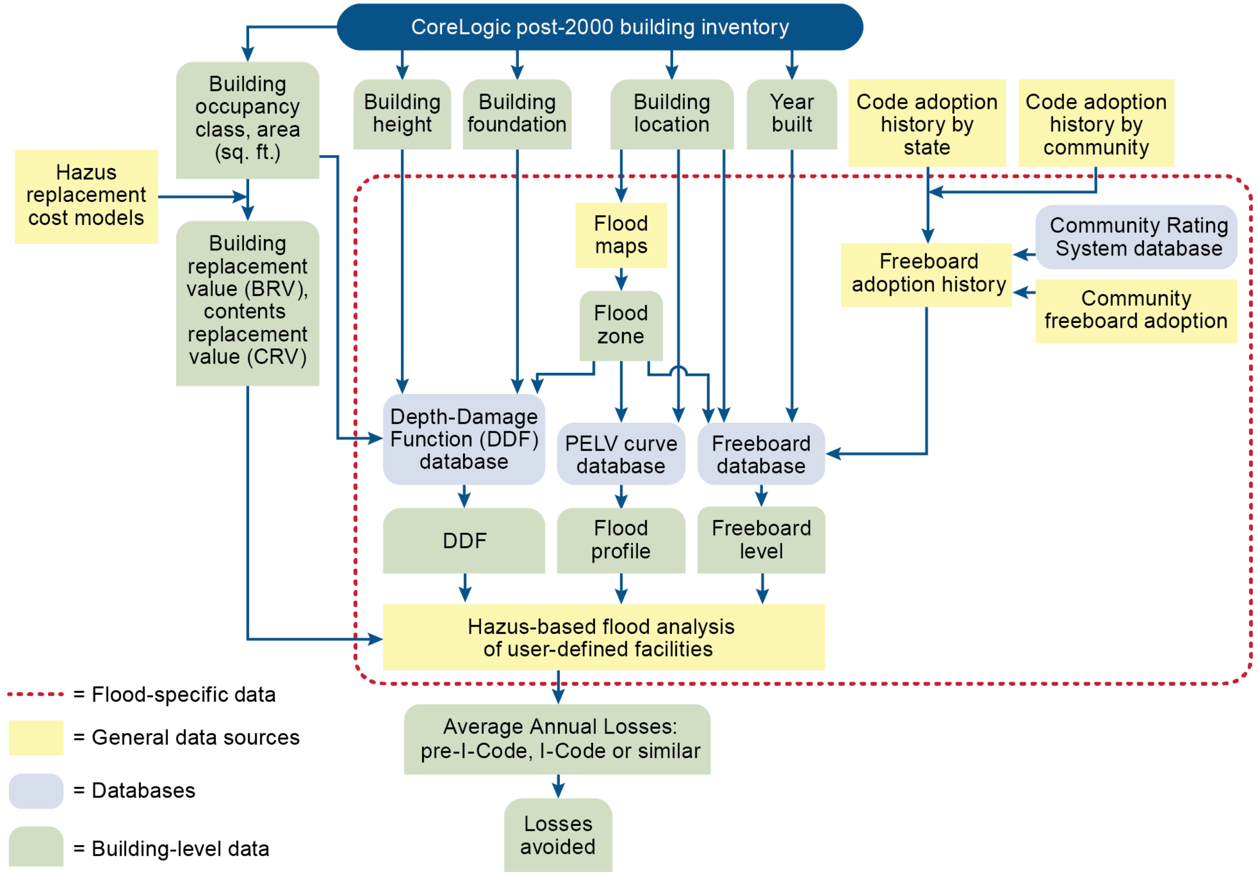
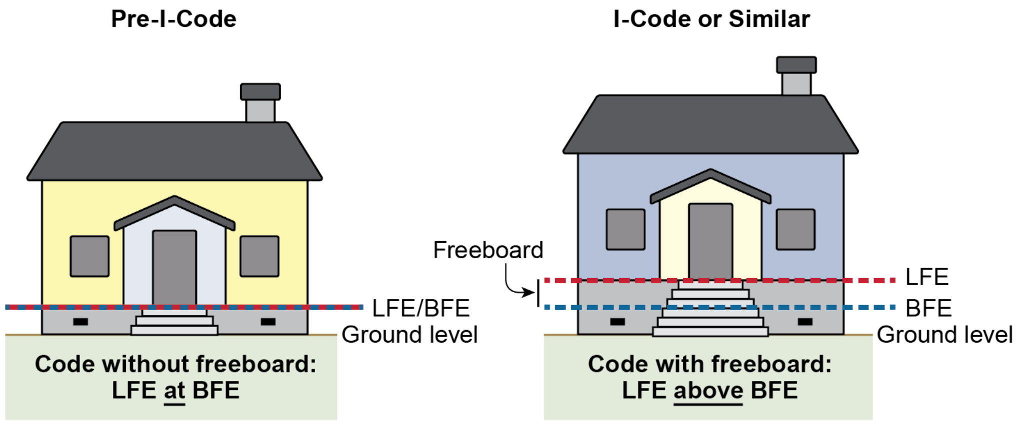
Flood Analysis

- Assign Freeboard Values
- Assign representative flood profile
- Assign Depth Damage Functions
- Calculate flood loss

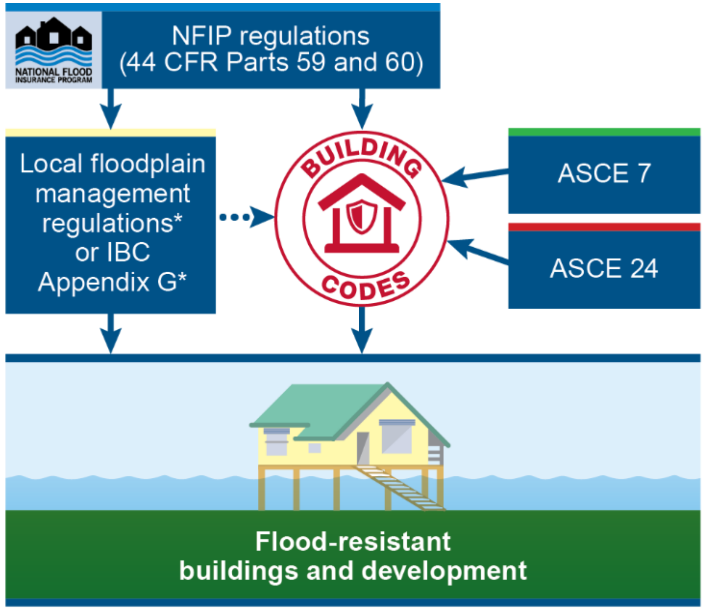


Flood Code: Freeboard Adoption

- I-Code adoption: State and local
- Other statewide and local codes/regulations
- Sources: State, CRS, local (including BCEGS)

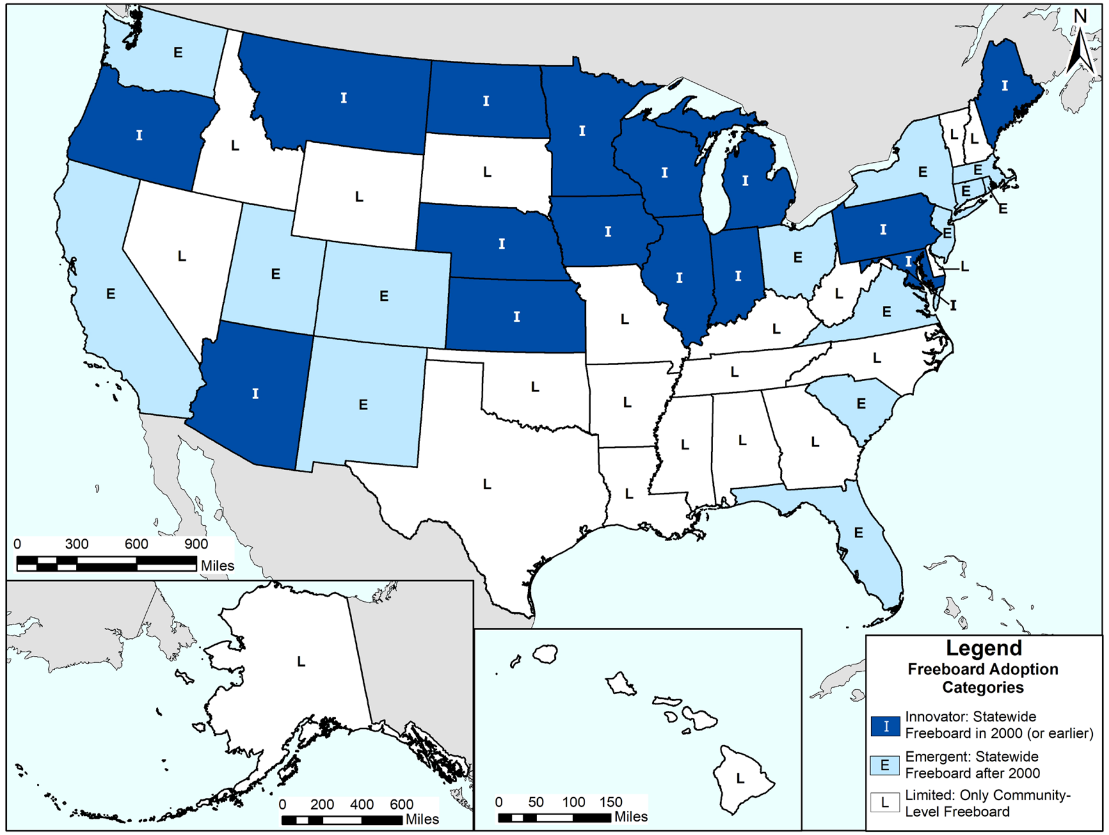


LFE = lowest floor elevation   BFE = base flood elevation



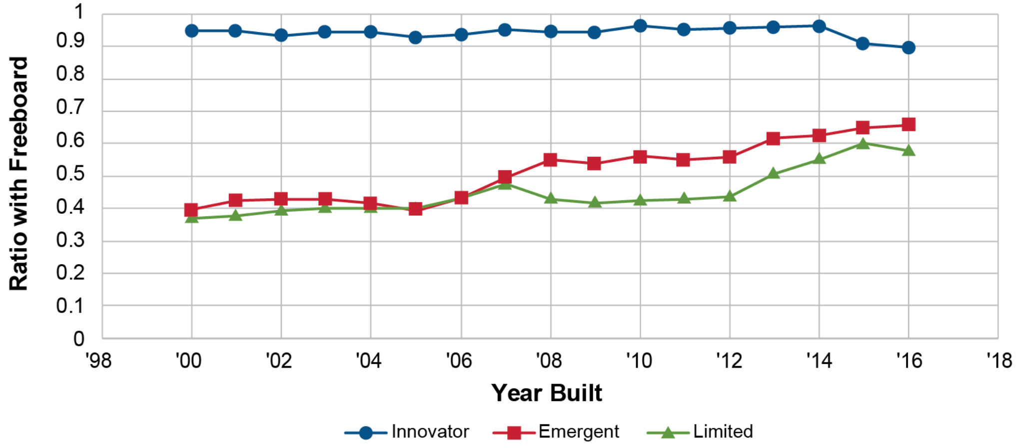
* NFIP-consistent administrative provisions, community-specific adoption of FISs and maps, and technical requirements for development outside the scope of the building code (and higher standards in some communities)

Flood Code: Freeboard Adoption



Freeboard Adoption Categories by State

- Innovator: Statewide freeboard in 2000 or earlier
- Emergent: Statewide freeboard after 2000
- Limited: Only community-level freeboard



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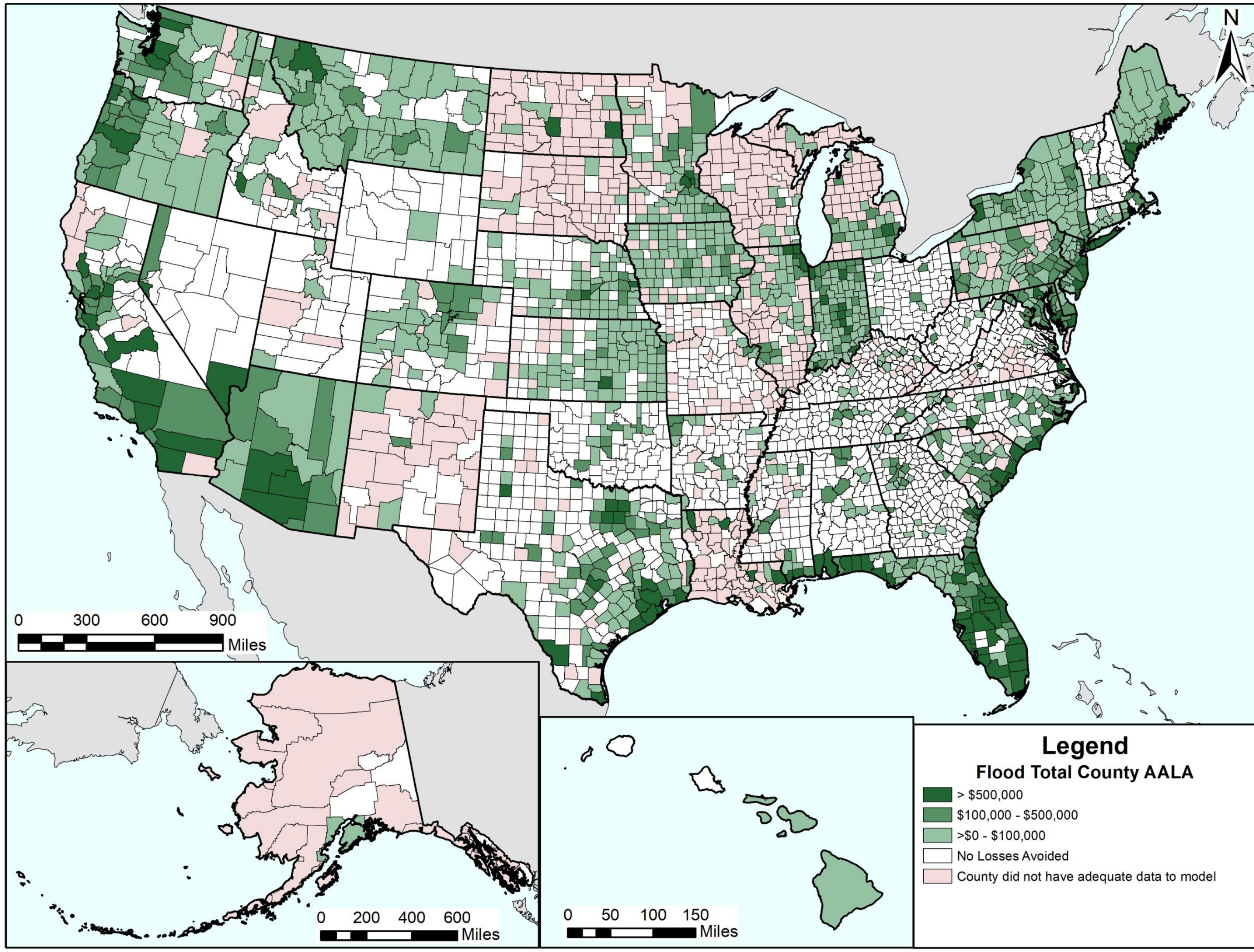
Flood Results Summary

Top Ten States for Flood AALA

State	Building Count (modeled/freeboard)	Total AALA
Florida	310,963 / 150,173	$169 million
Texas	95,287 / 59,035	$63 million
California	44,611 / 24,853	$47 million
New York	12,182 / 6,281	$24 million
New Jersey	36,932 / 22,476	$20 million
South Carolina	38,363 / 20,163	$18 million
Arizona	11,355 / 11,350	$18 million
Louisiana	19,517 / 11,504	$17 million
Indiana	9,574 / 9,462	$16 million
North Carolina	25,902 / 10,229	$10 million
Total	**786,473 / 400,498**	**$484 million**



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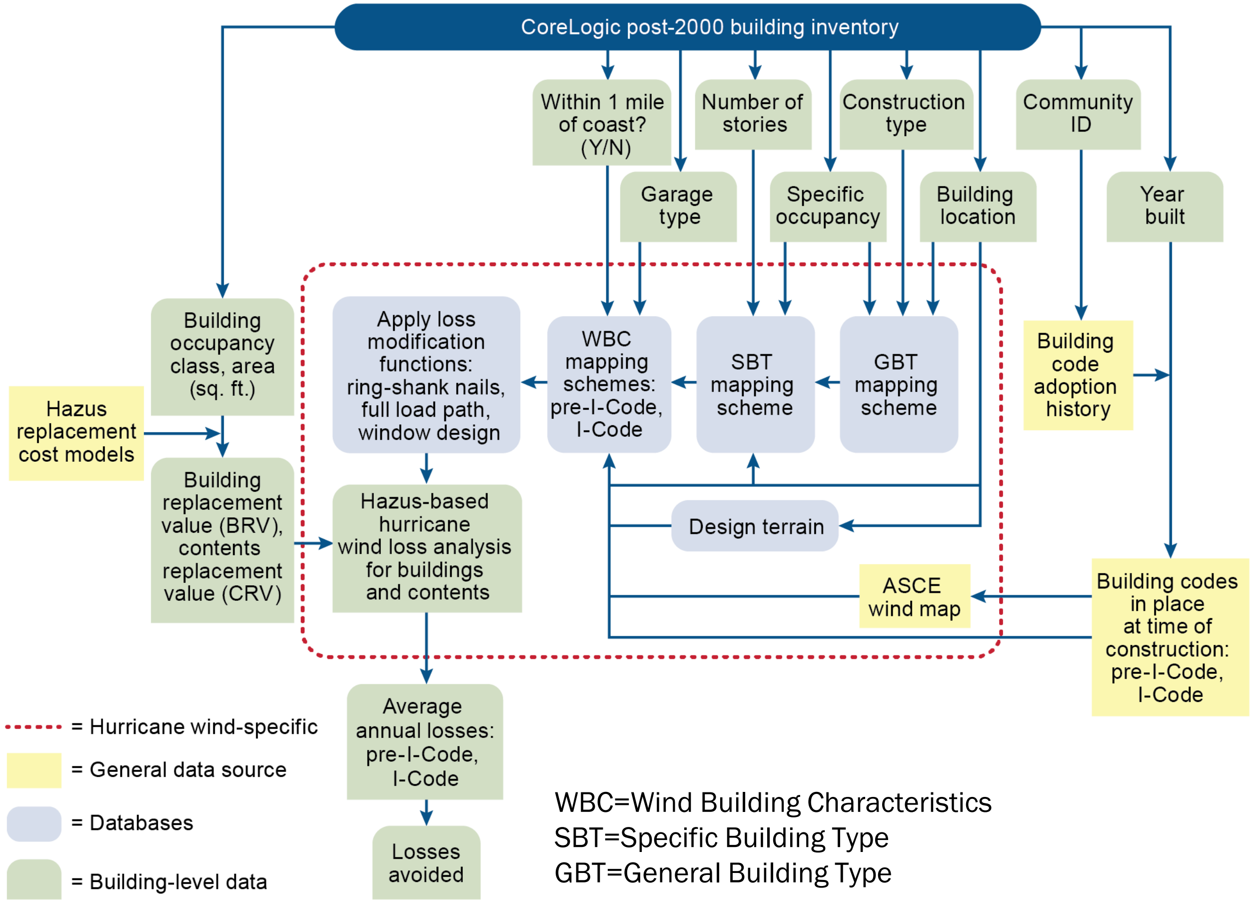
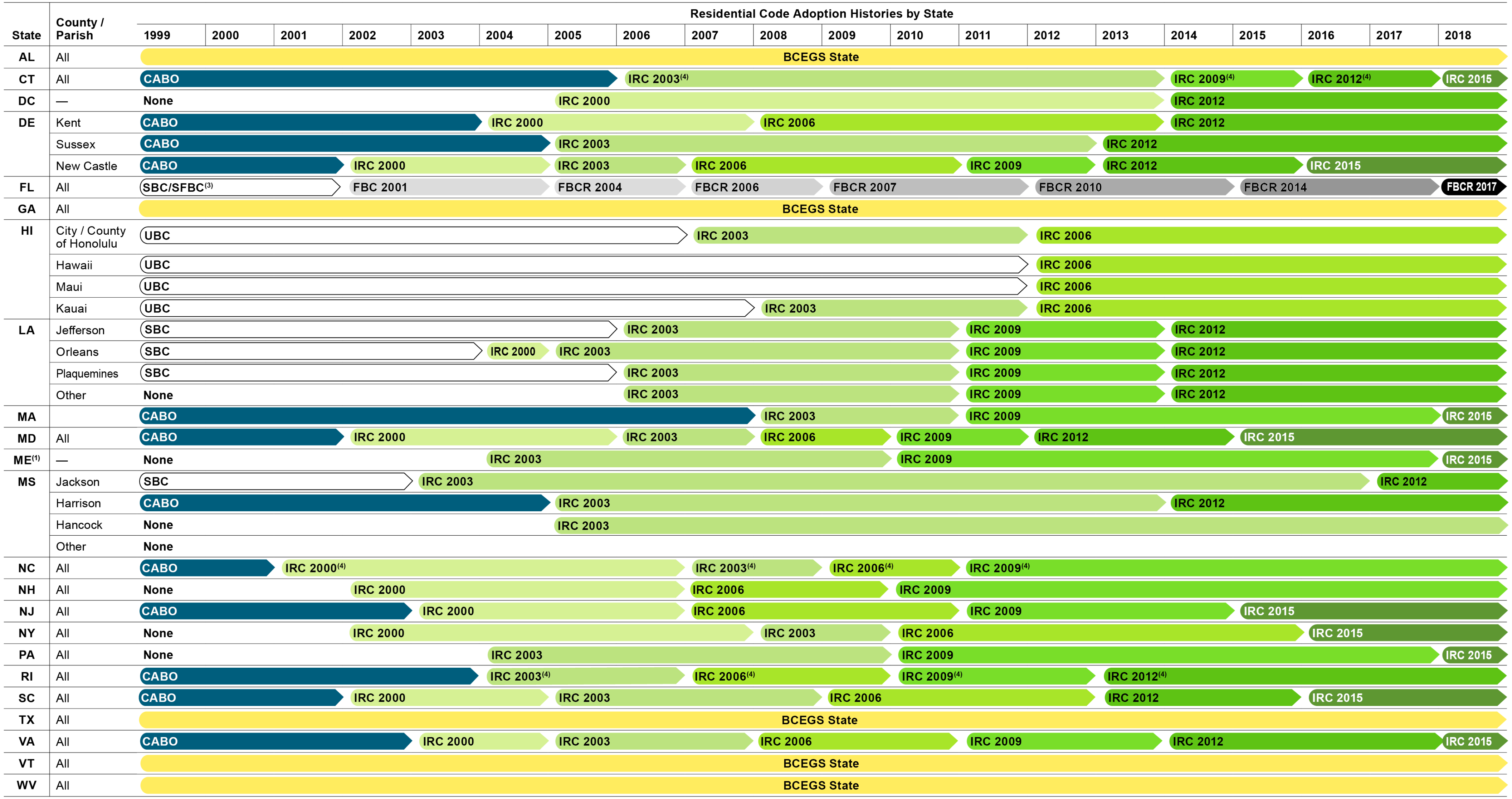
Hurricane Wind Analysis

- Supplement CoreLogic inventory with Hazus Replacement Cost Models and building code history
- Assign building types and wind-specific building characteristics
- Apply loss modification functions based on building code requirements
- Calculate hurricane wind loss



Hurricane Wind Code Adoption



CABO = Council of American Building Officials

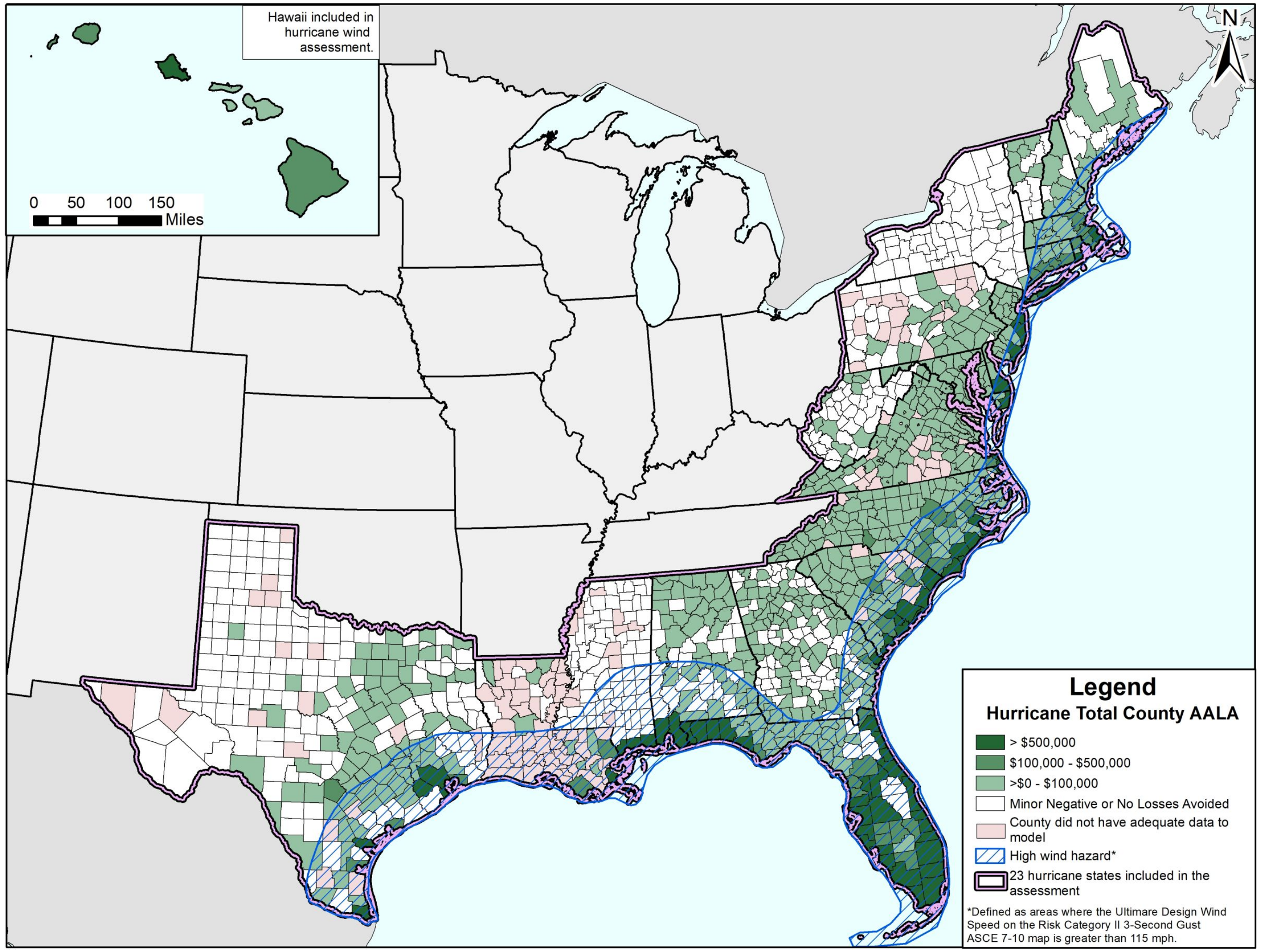
IRC = International Residential Code

BCEGS State = Partial building code adoption histories at jurisdictional level obtained from a BCEGS (Building Code Effectiveness Grading Schedule) database.

Hurricane Wind Results Summary

Top 11 States for Hurricane Wind AALA

State	Building Count Modeled	Total AALA
Florida	1,666,348	$857 million
South Carolina	415,686	$68 million
North Carolina	870,586	$34 million
Alabama	351,452	$31 million
Texas	2,445,030	$29 million
Mississippi	218,613	$15 million
New Jersey	244,001	$7.4 million
New York	296,846	$5.6 million
Massachusetts	149,853	$5.2 million
Virginia	463,801	$1.6 million
Hawaii	54,402	$1.6 million
Total	**9,200,267**	**$1,055 million**



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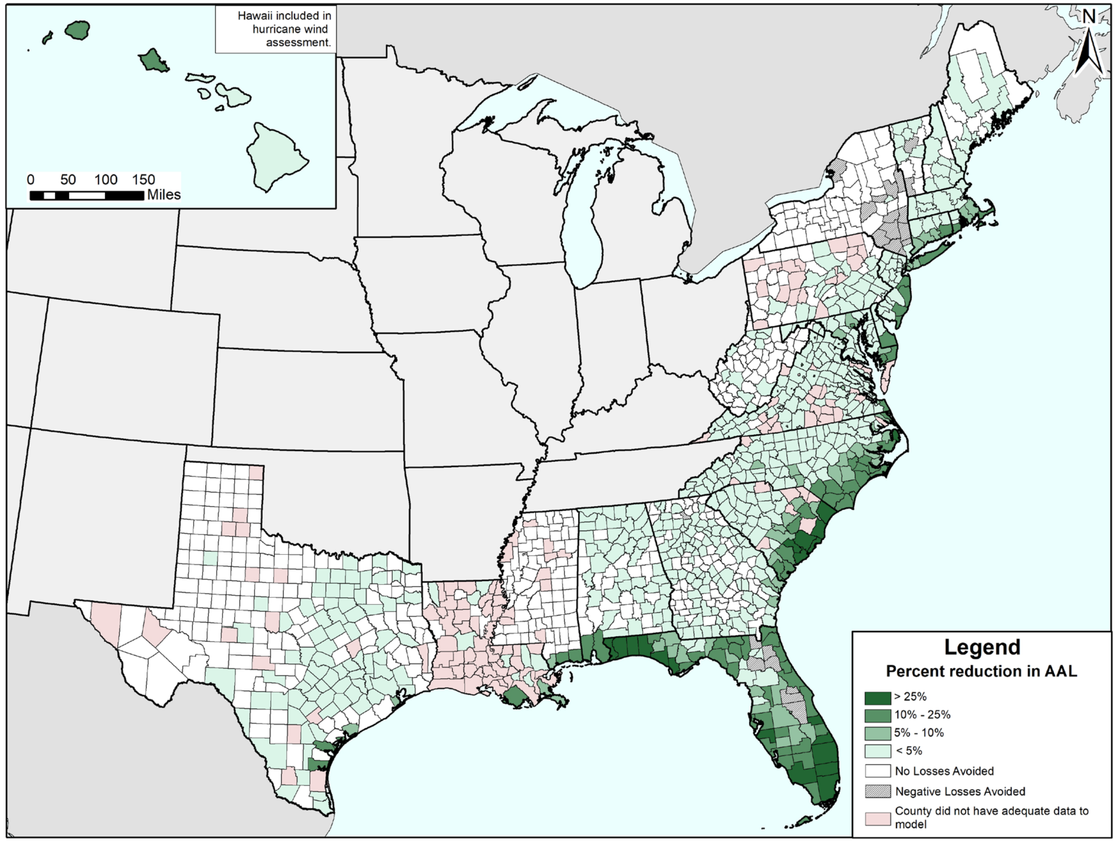
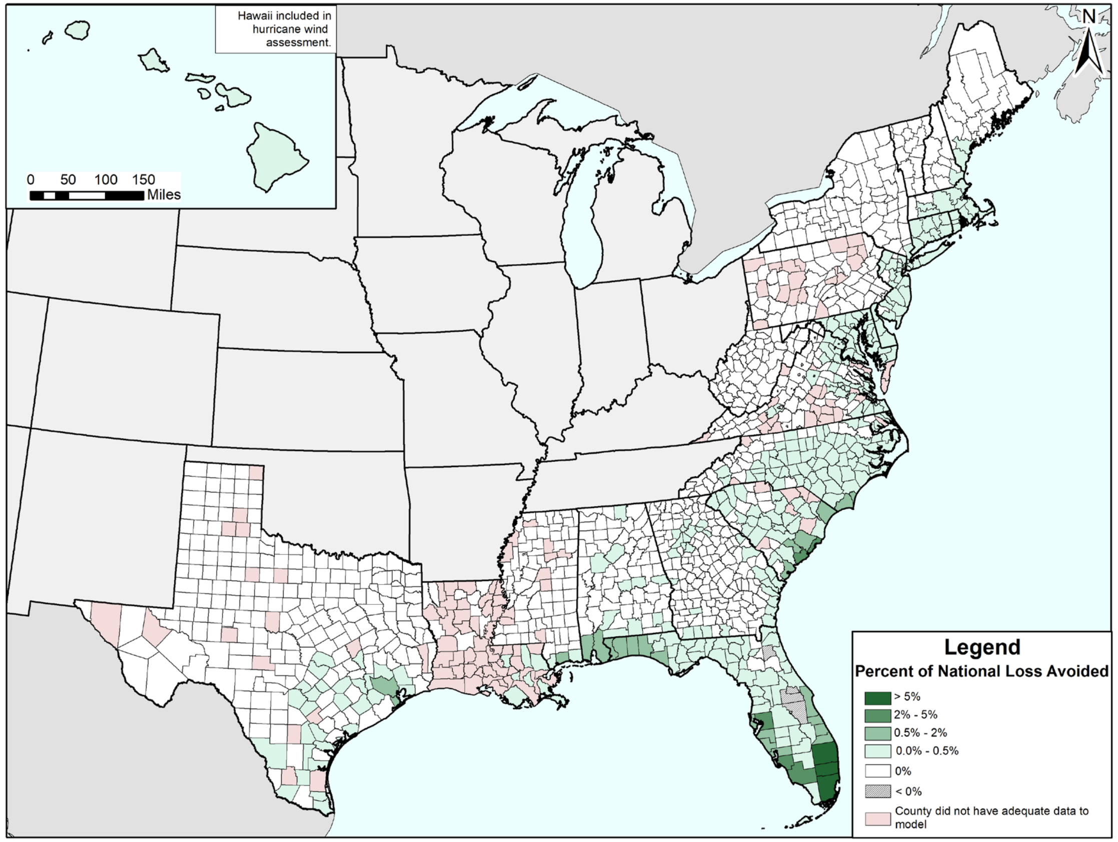
Hurricane Wind Results

Percent Reduction in AAL



Percent of National Losses Avoided



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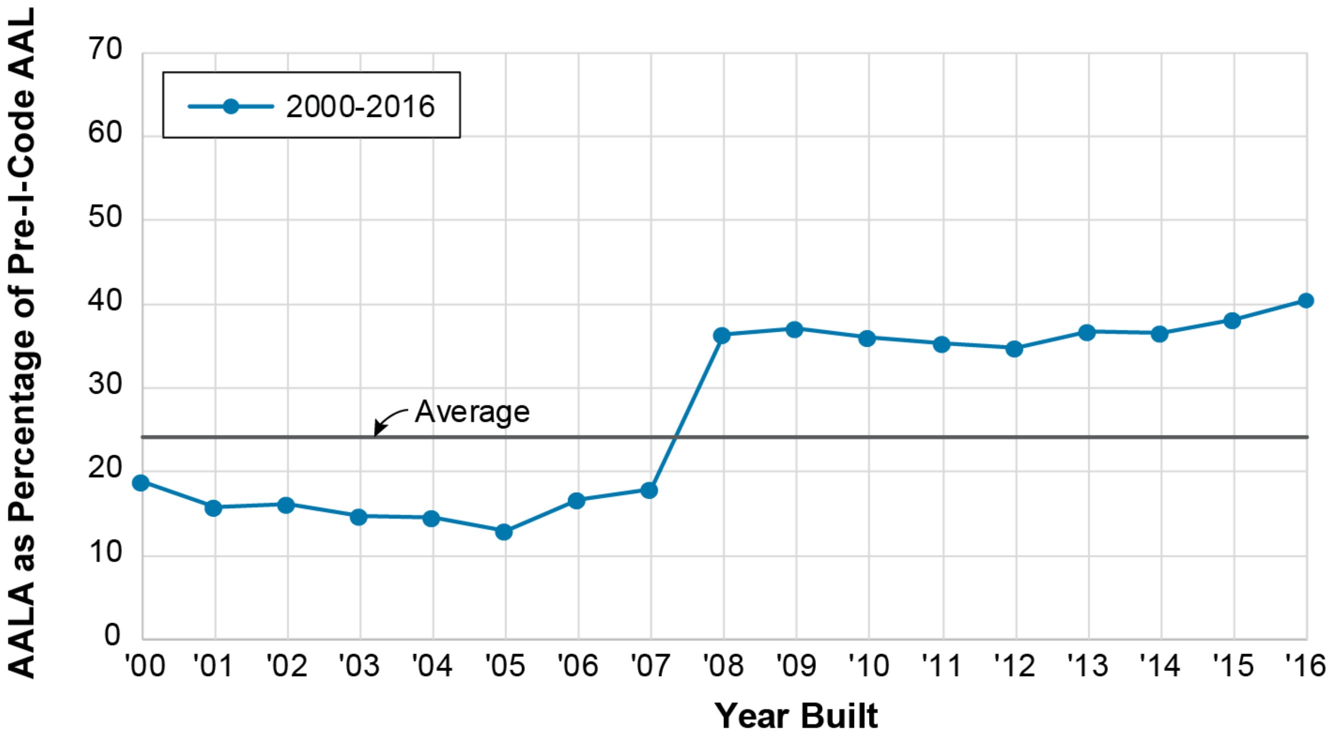
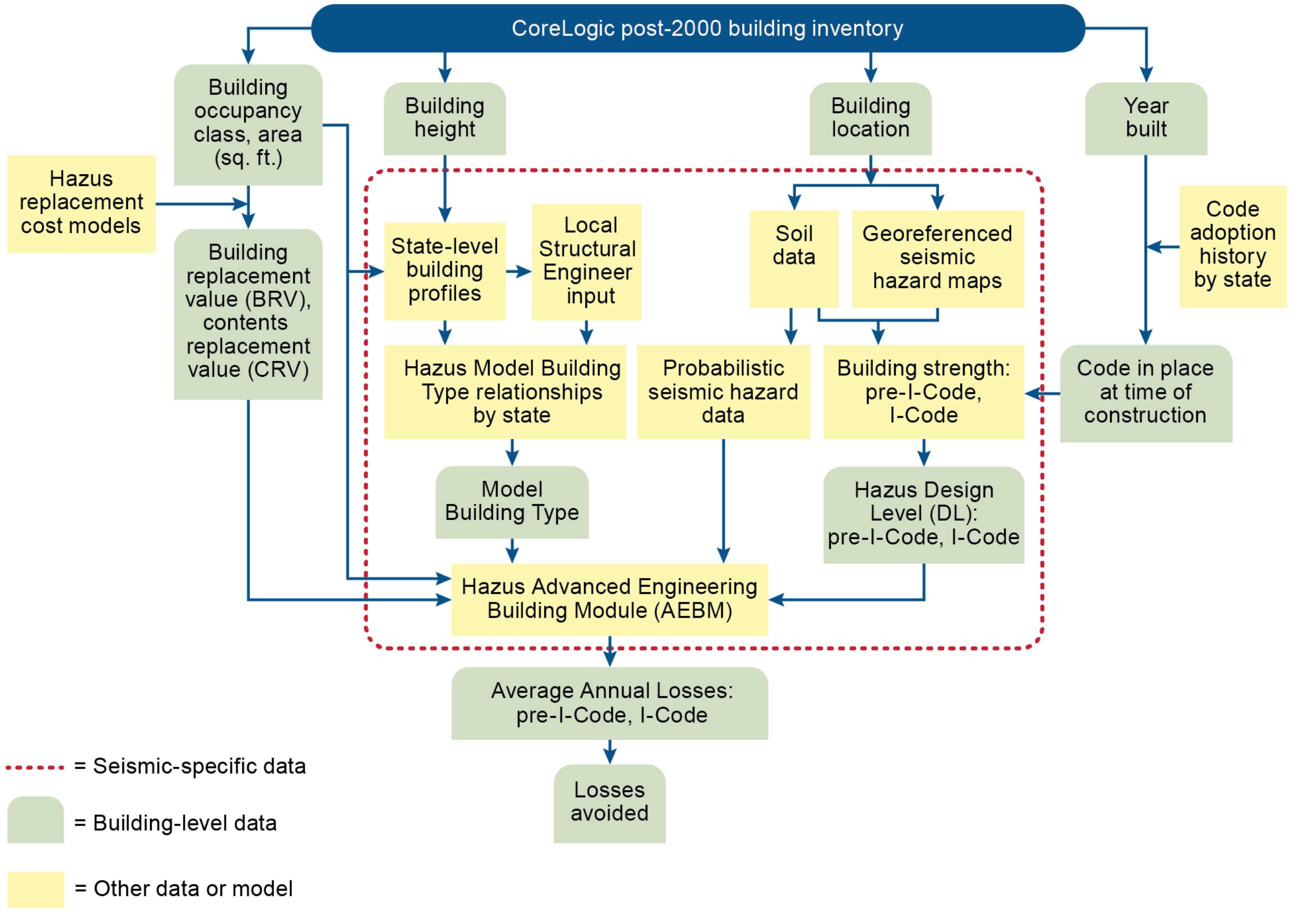
Hurricane Wind Results

- **2000-2008:** Early codes post-Andrew
- **2008:** 2006 IBC and 2006/2007 amendments to 2004 FBC after 2004 hurricane season
- **2008-2016:** additional jurisdictions adopting I-Codes



Seismic Analysis

- Develop state-level model building type (MBT) profiles to assign individual MBTs
- Identify code in place at time of construction
- Develop census-tract Design Levels
- Calculate losses



Seismic Code Adoption

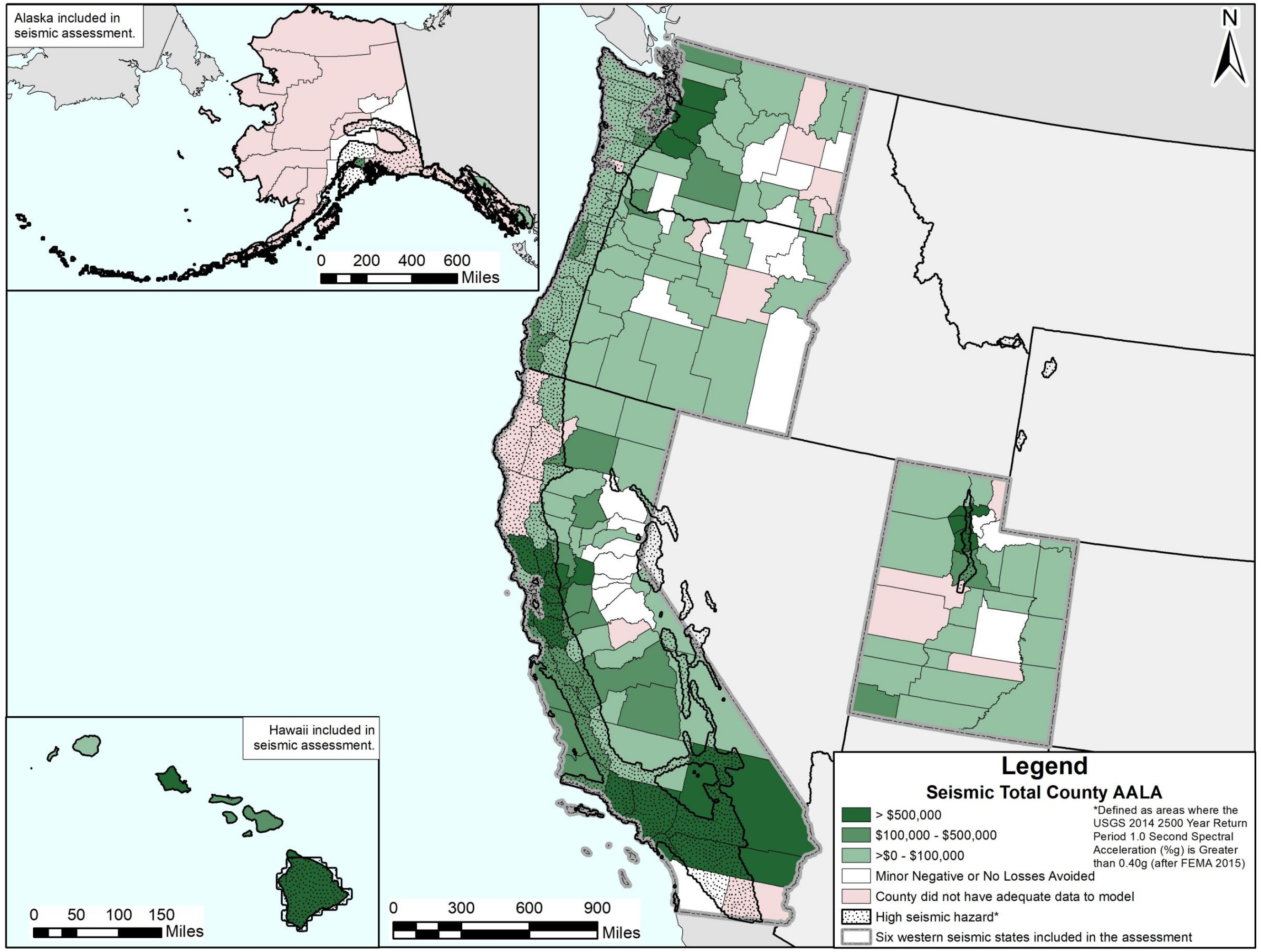
State	County / Borough	City	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
			Commercial Code Adoption Histories by State																			
AK	All	All	UBC 1997		IBC 2000				IBC 2003		IBC 2006					IBC 2009					IBC 2012	
	Fairbanks North Star	Fairbanks	UBC 1997			IBC 2000			IBC 2003			IBC 2006			IBC 2009					IBC 2015		
	Kenai Peninsula	Kenai	UBC 1997				IBC 2000		IBC 2003			IBC 2006					IBC 2009					
	Ketchikan Gateway	Ketchikan	UBC 1994	UBC 1997					IBC 2003					IBC 2006			IBC 2012					
	Matanuska-Susitna	Palmer	UBC 1997							IBC 2003		IBC 2006			IBC 2009						IBC 2015	
	Anchorage	Anchorage inside BSSA	UBC 1997				IBC 2000		IBC 2003			IBC 2006			IBC 2009					IBC 2012		
	Juneau	Juneau	UBC 1997					IBC 2003					IBC 2006					IBC 2009			IBC 2012	
CA	All	All	UBC 1997									IBC 2006			IBC 2009			IBC 2012			IBC 2015	
HI	All	All	None											IBC 2006								IBC 2012
	City / County of Honolulu	All	UBC 1994	UBC 1997							IBC 2003					IBC 2006						
	Hawaii	All	UBC 1991 w/Zone 4[1]													IBC 2006						
	Maui	All	UBC 1994	UBC 1997												IBC 2006						
	Kauai	All	UBC 1991		UBC 1997							IBC 2003				IBC 2006						
OR	All	All	UBC 1997					IBC 2003			IBC 2006			IBC 2009				IBC 2012				
UT	All	All	UBC 1997			IBC 2000		IBC 2003			IBC 2006			IBC 2009			IBC 2012			IBC 2015		
WA	All	All	UBC 1997					IBC 2003			IBC 2006			IBC 2009			IBC 2012			IBC 2015		

(1) UBC 1991 and UBC 1991 w/ Zone 4 are assumed equivalent to UBC 1994 (pre-I-Code)
BSSA = Building Safety Service Area
IBC = International Building Code
UBC = Uniform Building Code

Seismic Results Summary

States Ranked by Seismic AALA

State	Building Count Modeled	Total LA
California	1,337,104	$41 million
Washington	507,453	$11 million
Utah	252,990	$3.2 million
Hawaii	54,162	$3.0 million
Oregon	249,149	$1.3 million
Alaska	41,055	$0.2 million
Total	**2,441,923**	**$60 million**



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Seismic Results: Hawaii Post and Pier Construction

- Buildings elevated on post and pier construction vulnerable to damage
- After 2000, code required improvements in place
- Used custom Hazus fragility curves
- Higher than average losses avoided for this building type
- >20% losses avoided as percentage of pre-I-Code loss (compared to 8% overall)

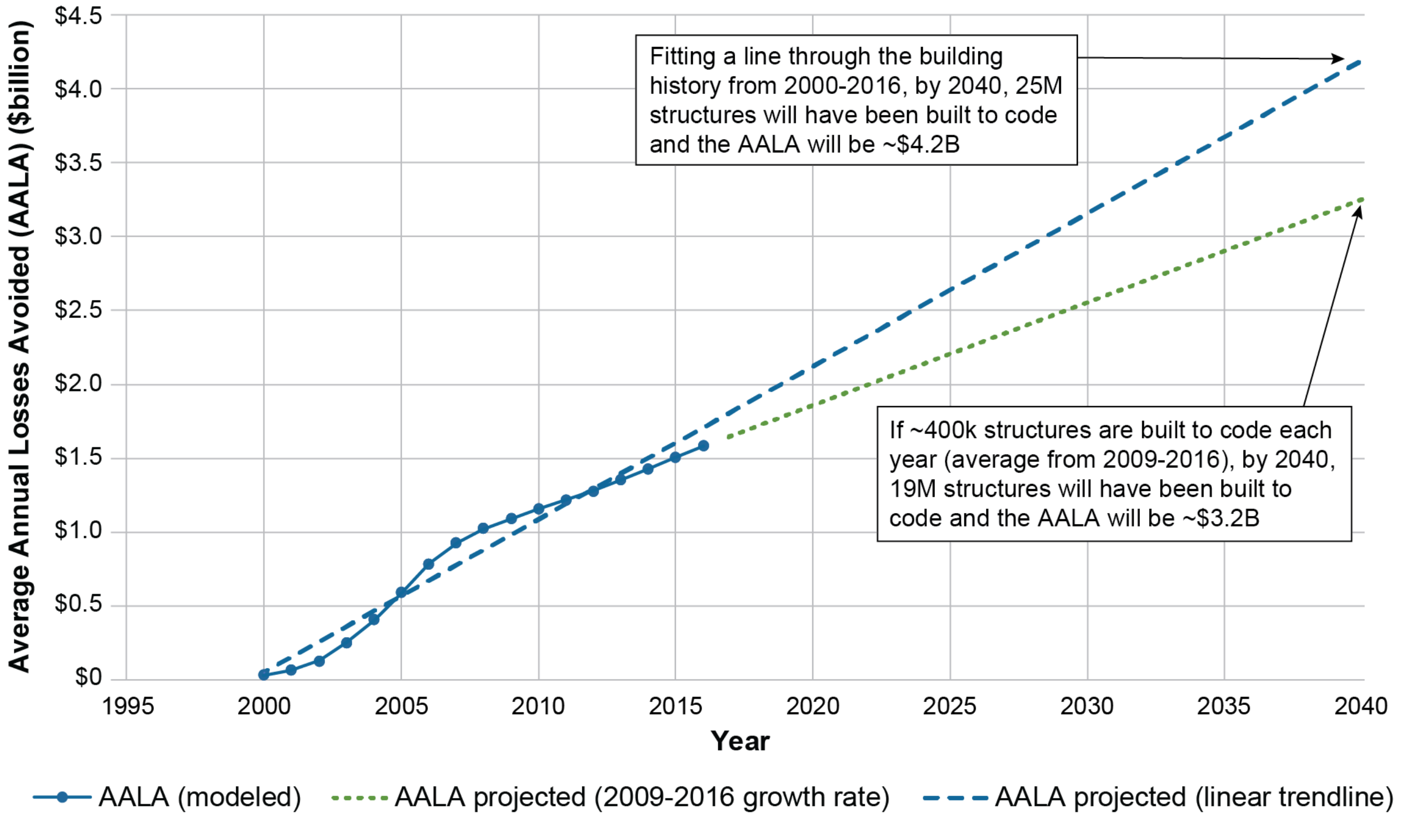
Findings

Hazard	Building Count Modeled	Total LA
Flood	786,473	$484 million
Hurricane Wind	9,200,267	$1.1 billion
Seismic	2,441,923	$60 million
Total		**$1.6 billion**

- Florida, Texas, California, and South Carolina account for 80% of the total AALA
- Areas of high growth and high hazard provide a starting point for improvement
- Residential dwellings make up 85% of building inventory

Extrapolating Compounding Results

- $3.2-4.2 billion AALA by 2040
- $133-171 billion cumulative from 2000–2040
- Other “what-if” scenarios



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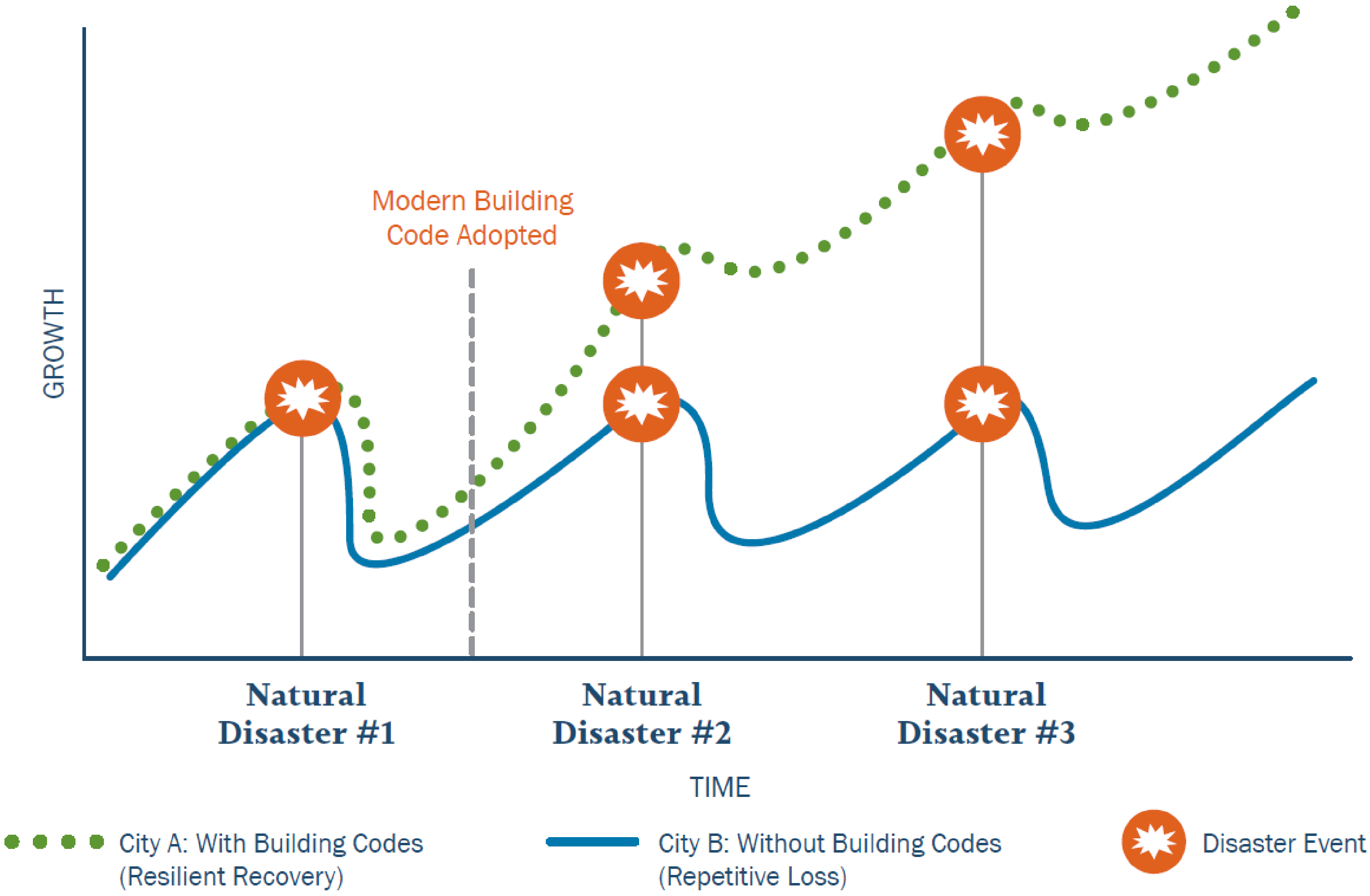
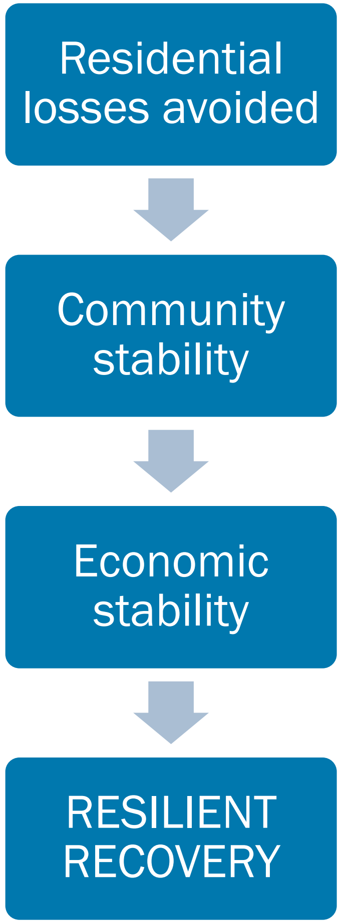
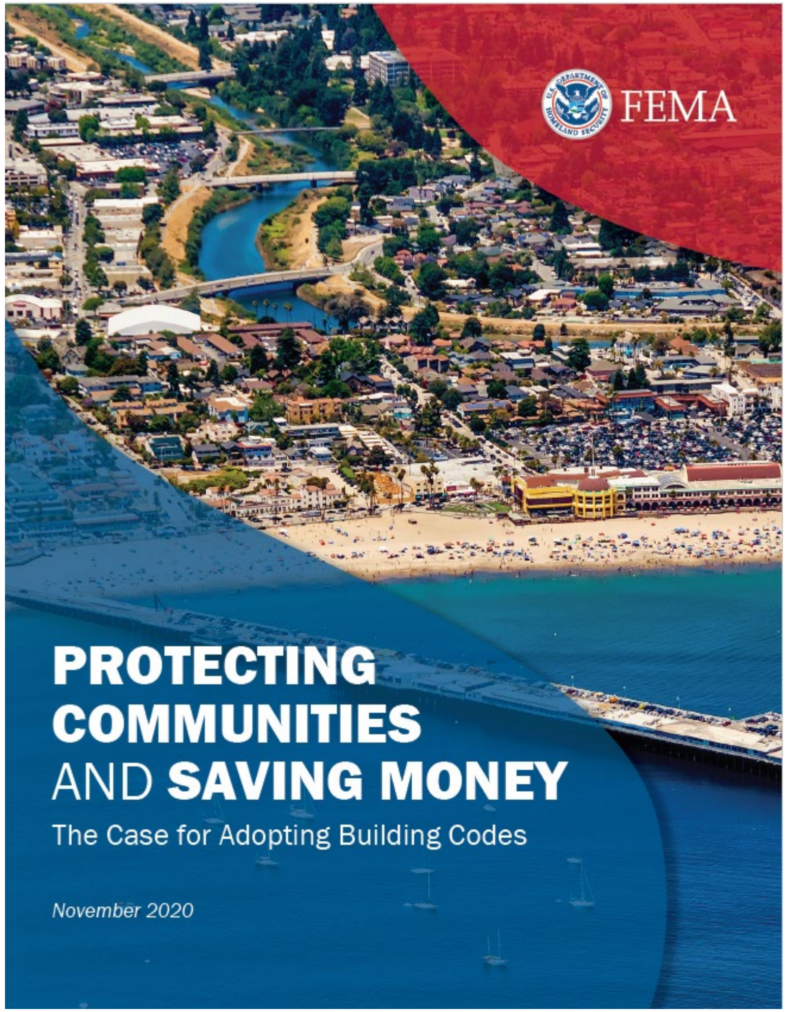
Advancing Community Benefits







BREAKING THE CHAIN OF DESTRUCTION

Some states have broken the chain of destruction by adopting modern building codes that protect property during natural disasters. Florida and California, pioneers in this field, have had modern hazard-resistant building codes in place since the 1990s. Other states such as Virginia, New York, and Montana have followed suit, putting in place state-wide building codes that local jurisdictions are required to adopt.

Other states have broken the chain from the bottom up; that is, local jurisdictions have pushed the envelope with the adoption of hazard-resistant building codes and raised the bar on their home states to do the same. For example, Miami-Dade County, Florida raised the standards for roof construction and mandated the use of impact-resistant windows. The state incorporated these requirements into its mandatory state-wide code. Similarly, the City of San Antonio blazed a new trail in the state of Texas with the regular adoption of modern code updates, most recently the ICC 2018 International Building Code. Other local jurisdictions in Texas can provide a higher level of protection to their citizens and adopt modern building codes, too.

Many states still lack a state-wide modern building code that local jurisdictions are required to adopt. This includes many tornado-prone states in the southern/central part of the country and some other flood-prone states in the northern midwest. These areas represent some of the greatest or best opportunities to strengthen U.S. communities in the face of natural disasters.

$1.8 BILLION

Estimated reduction in property losses over 20 years associated with California's modern building codes during earthquake and flood events

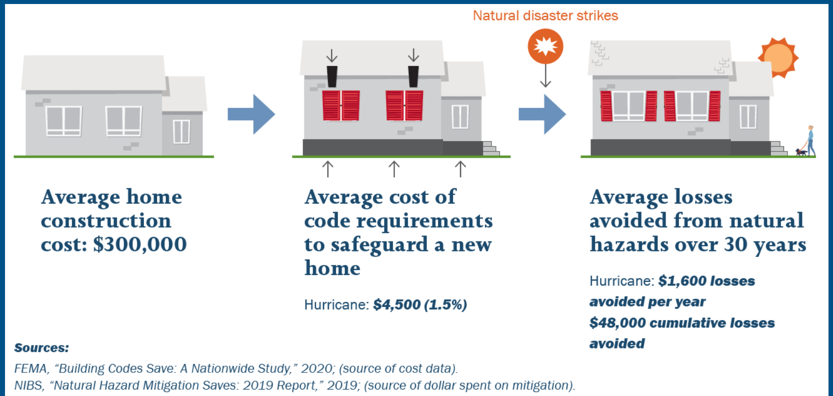
This map shows the varying levels of building code adoption by states and their counties. Code adoption is uneven.

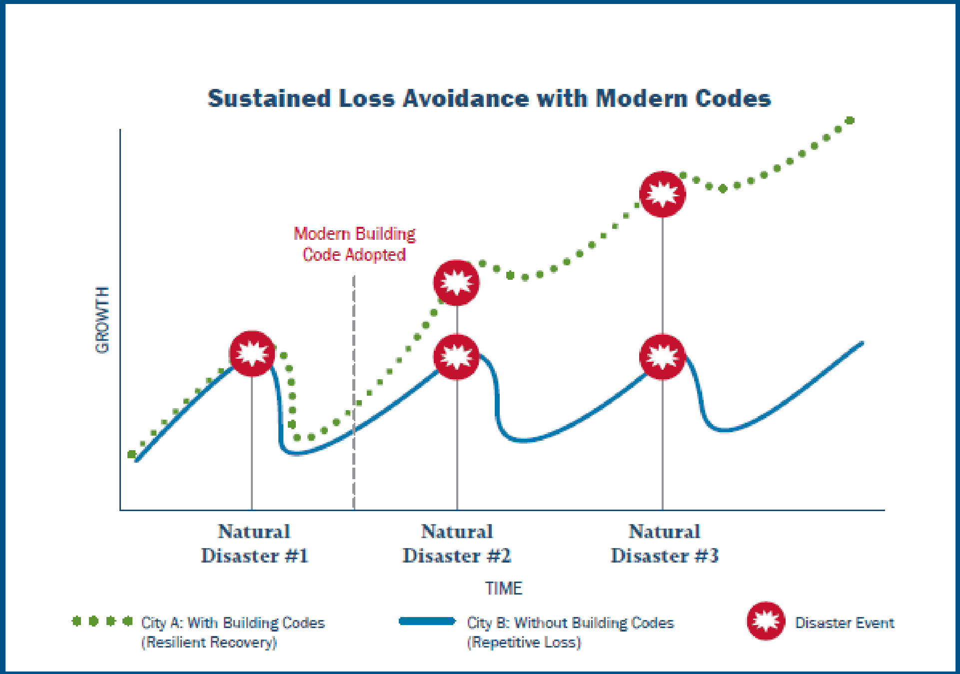
- ALL COUNTIES HAVE HAZARD-RESISTANT CODES
- SOME COUNTIES HAVE HAZARD-RESISTANT CODES
- NO COUNTIES HAVE HAZARD-RESISTANT CODES

Based on BCEGS data provided by Insurance Services Office (December 21, 2018)

6 PROTECTING COMMUNITIES & SAVING MONEY

65% of counties, cities, and towns across the U.S. today still have not adopted modern building codes





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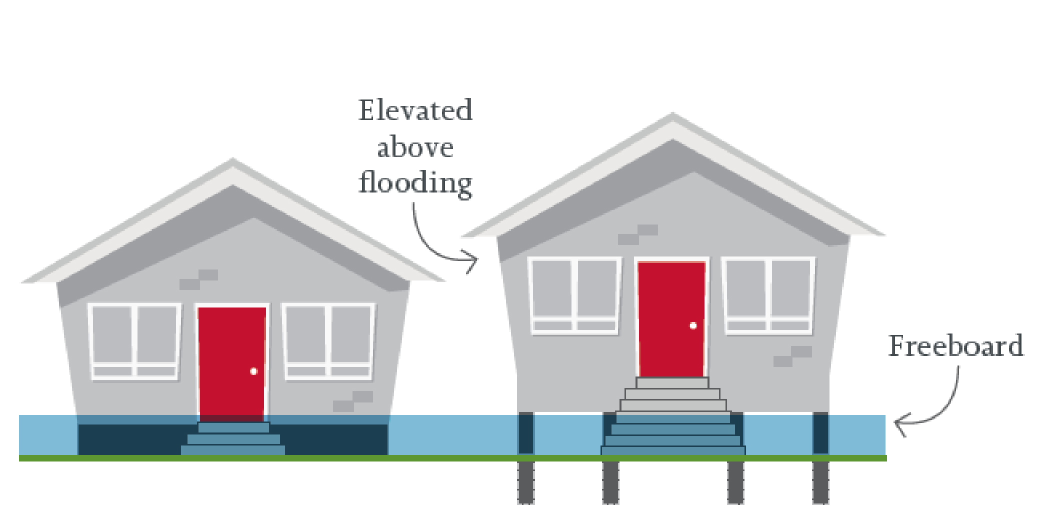
Breaking the Chain of Destruction

- Pioneers:
  - FL and CA have had hazard-resistant codes since the 1990s
  - CA has avoided $1.8 billion in losses over 20 years
- Trailblazers:
  - San Antonio, TX regularly adopts modern code updates
  - Miami-Dade County, FL: higher standards incorporated into FL Building Code
- Opportunities:
  - States that lack a statewide modern building code
  - South, central, and northern midwest regions

Spotlight: Cedar Rapids, Iowa

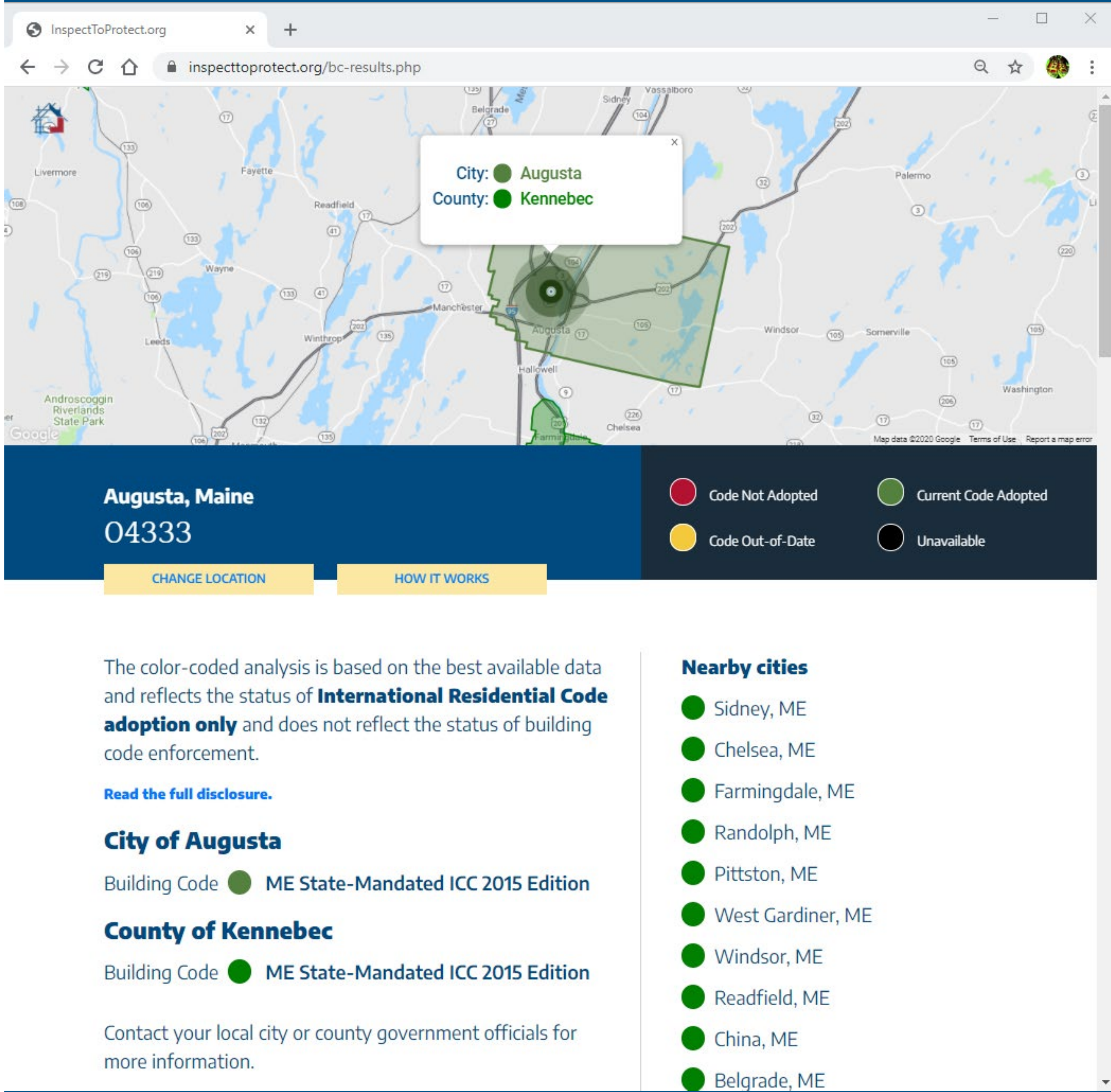
After 2008 floods: Implemented flood mitigation measures, including modern building codes

2016 floods: 2nd highest flood on record, but less damage than in 2008



Portfolio of Supporting Elements and Programs and Partnerships

- Mitigation Investment Strategy Goal 3
- FEMA Strategic Plan
- BRIC, DRRA 1206, HMA, MT Planning
- No Code. No Confidence. (InspectToProtect.org) by FLASH
- Natural Hazard Mitigation Saves by NIBS
- US Code Adoption Database by ICC



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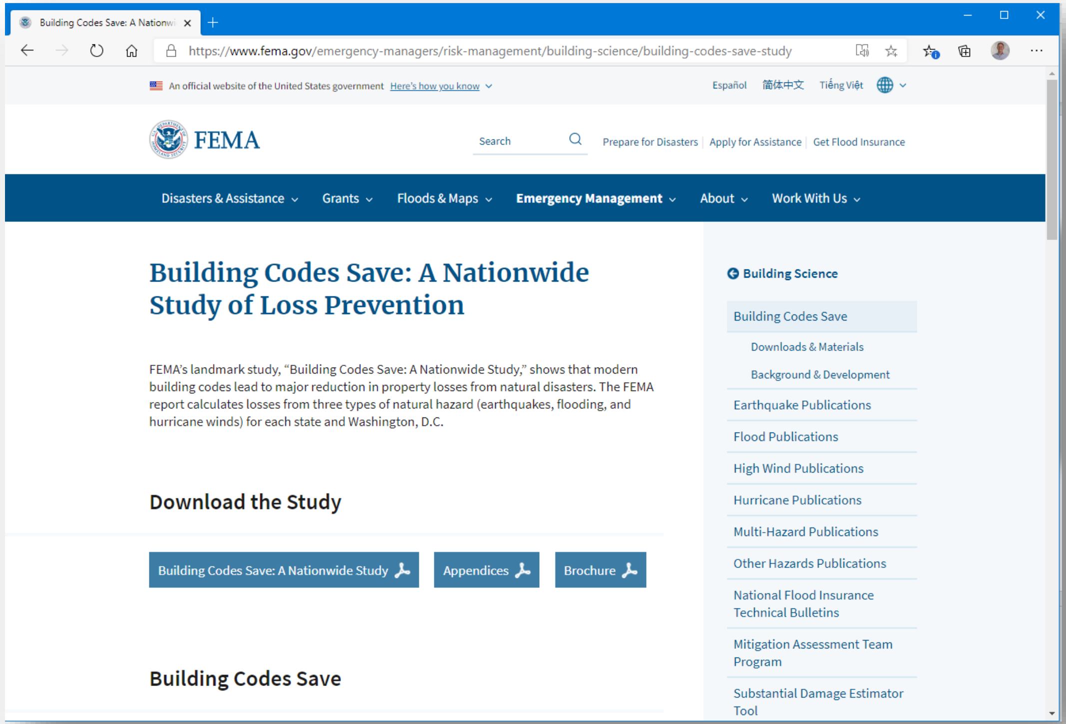
Conclusions

- Adopting and continuing to adopt modern hazard-resistant codes benefits states and communities across the country, avoiding billions of dollars in annual losses
- Communities with multiple hazards benefit significantly, and those in low/moderate hazards benefit from combination of multi-hazard savings and generally stronger buildings
- Modeling real buildings at the parcel level is an effective tool for communities and the nation

Next Steps

- Launched Study on 11/20 in coordination with EA, FLASH, ICC, and IBHS
- Marketing Strategy, website, brochure and companion resources
- Coordination with partners on extended outreach campaigns
- Future BCS Studies
- Inspire Building Code Advocates!



https://www.fema.gov/emergency-managers/risk-management/building-science/building-codes-save-study

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Or visit the FEMA Building Science Branch website at:
https://www.fema.gov/emergency-managers/risk-management/building-science

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