THE UNIVERSITY
of NORTH CAROLINA
at CHAPEL HILL

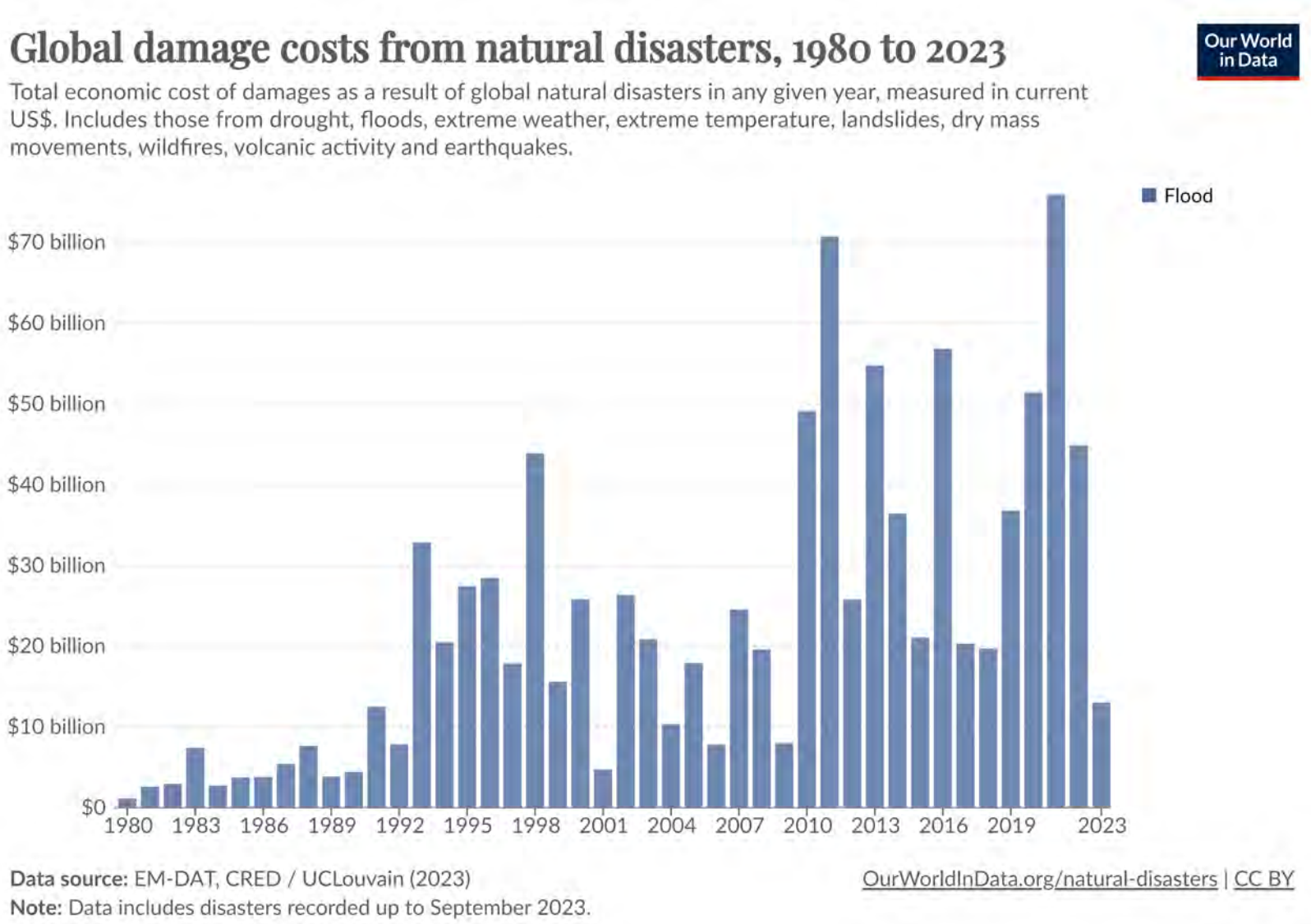
Assessing, Pricing, and Mitigating the Risk of Floods and Other Natural Hazards II

Leveraging Numerical Models and Data-driven Methods to Understand Systemic Flood Risks

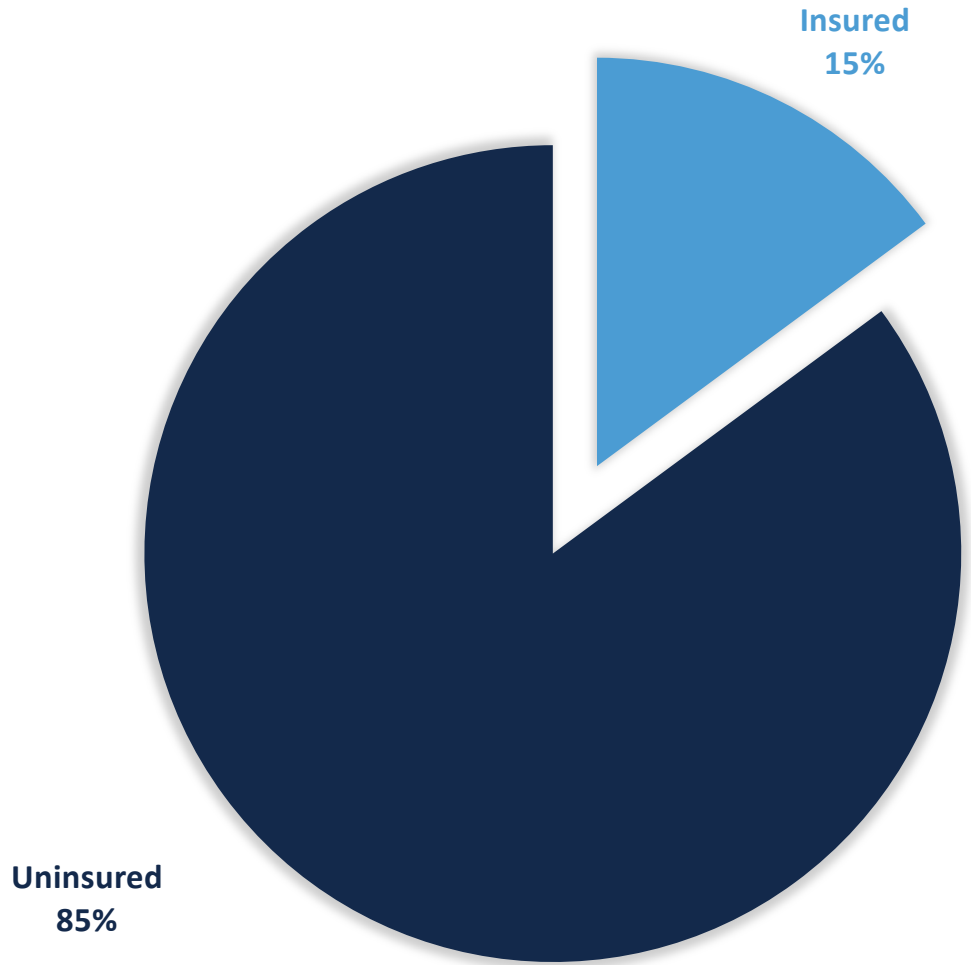
Dr. Antonia Sebastian, Assistant Professor

Department of Earth, Marine and Environmental Sciences | College of Arts and Sciences
Energy, Ecology and the Environment Program (E3P) | Department of Environmental Science and Engineering

Despite investments in mitigation, the costs of flooding are increasing



A large portion of these damages are uninsured



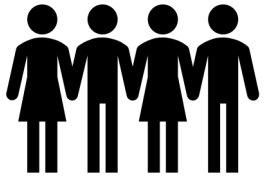
Global flood losses were estimated to be $299 billion USD from 2018-2022 (Munich Re 2023).

Global flood losses are predicted to reach $1 trillion per year by 2050 (Hallegate et al. 2013).

Growing evidence suggests that uninsured flood damages may have cascading social and economic consequences for

Households

Businesses



Communities

POLITICO

How climate change could spark the next home mortgage

Taxpayers are backing more than a trillion dollars in home mortgages, but the agencies buy
neglecting to consider climate risks.

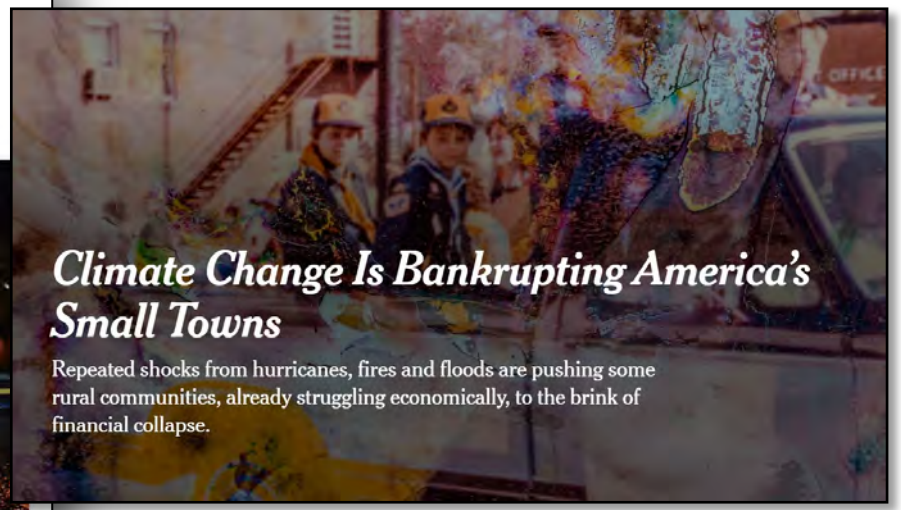
US businesses to lose a collective 3.1 million days of operation from flooding in 2022, report shows

By Rachel Ramirez, CNN

4 minute read · Updated 6:42 AM EST, Mon December 13, 2021

Hurricane Ida caused severe flooding in the Ditmas Park neighborhood in Brooklyn, New York, in September 2021. Stephen Lovekin/Shutterstock

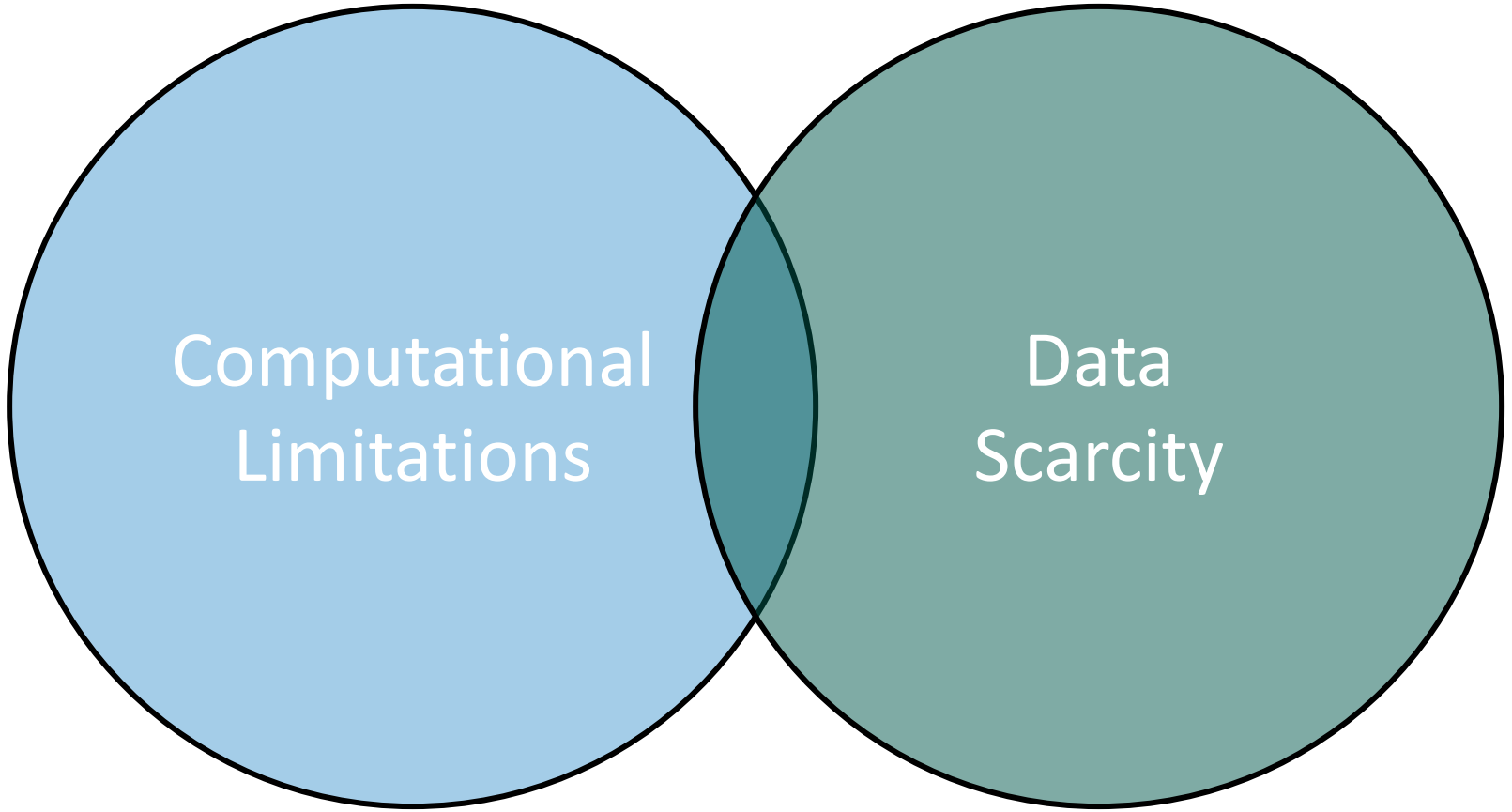
(CNN) — As climate change increases sea level, fuels more extreme rainfall and



Climate Change Is Bankrupting America's Small Towns

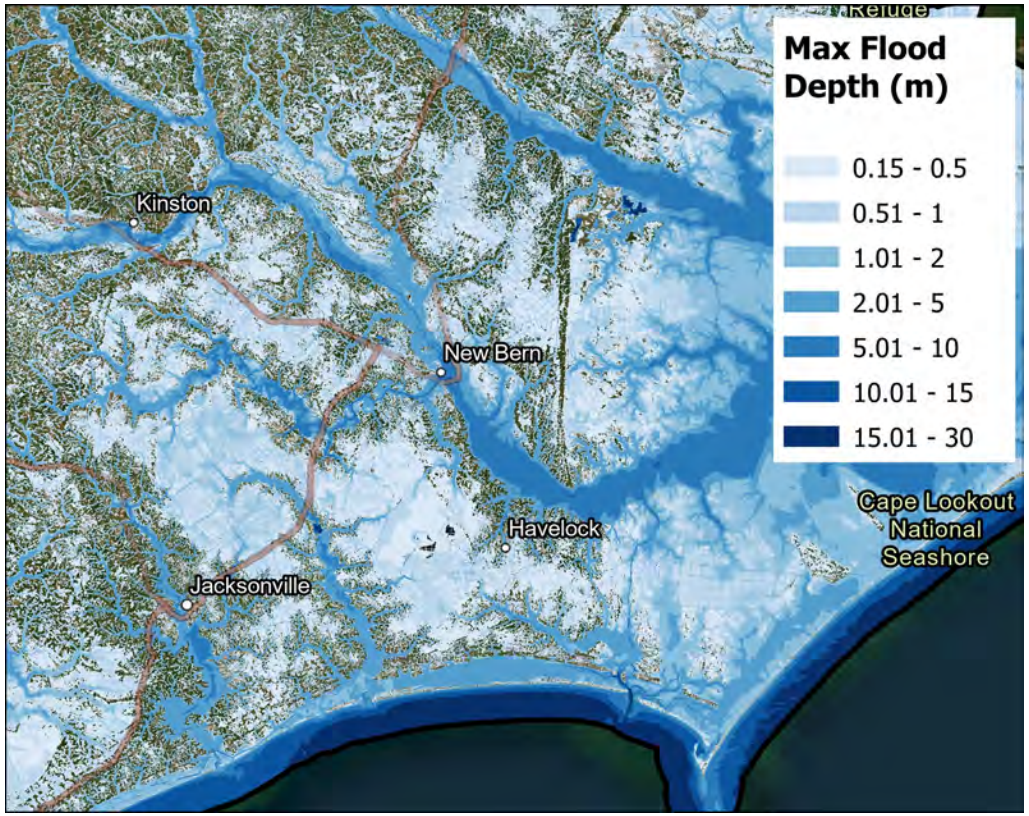
Repeated shocks from hurricanes, fires and floods are pushing some rural communities, already struggling economically, to the brink of financial collapse.

… yet quantification of systemic flood risks has been limited.

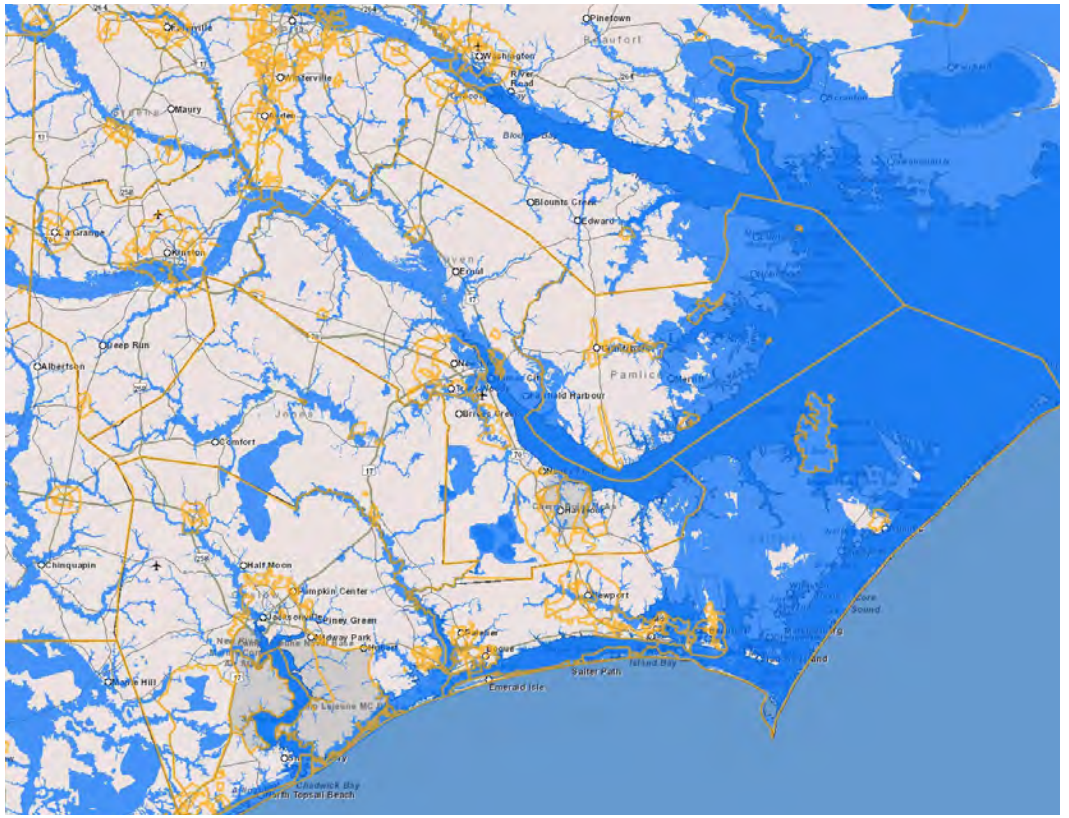


Instead, we typically assess flood exposure to a limited number of severe weather events

The largest storm in the record

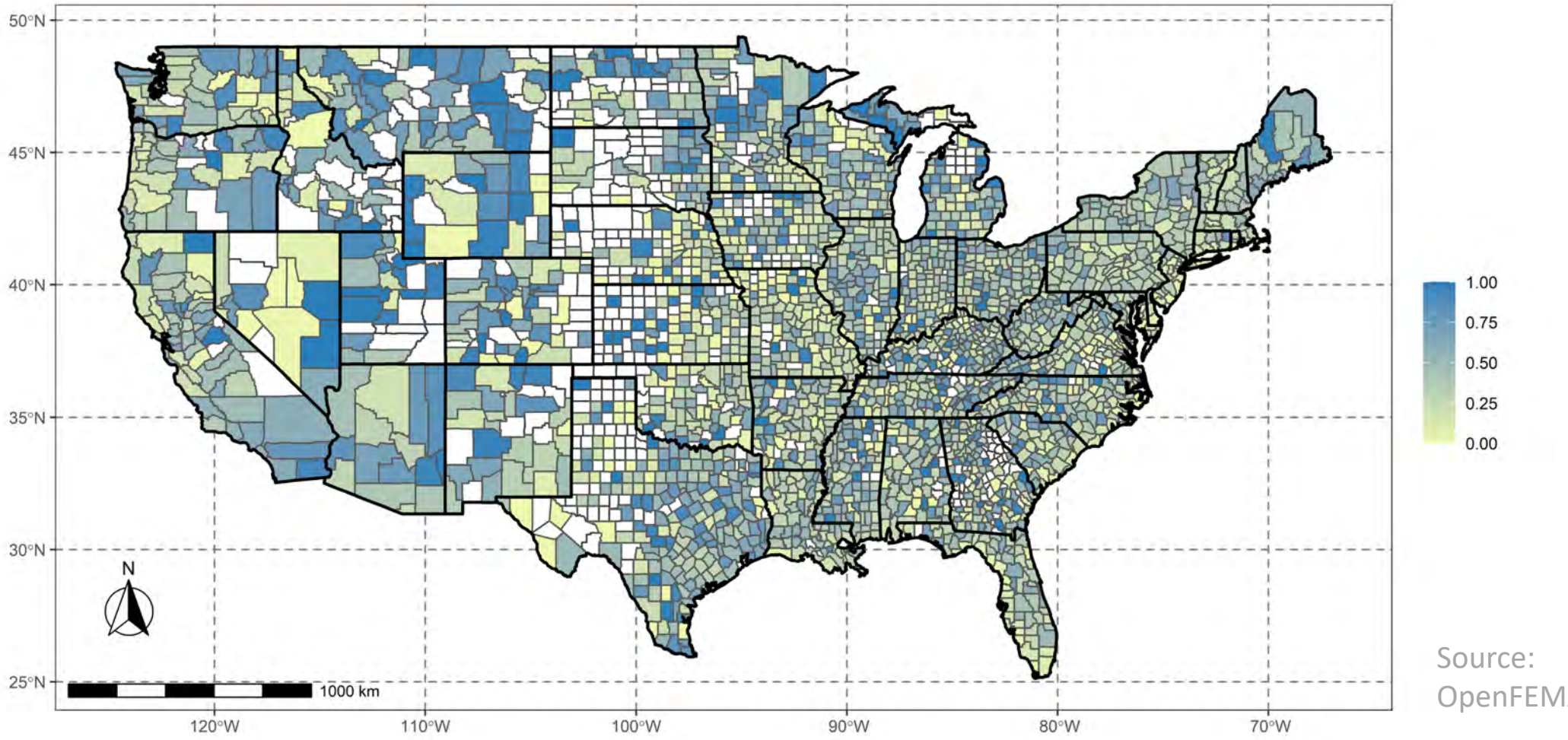


… or a limited number of “design storm events”



… but these serve as a poor proxy for cumulative risk.

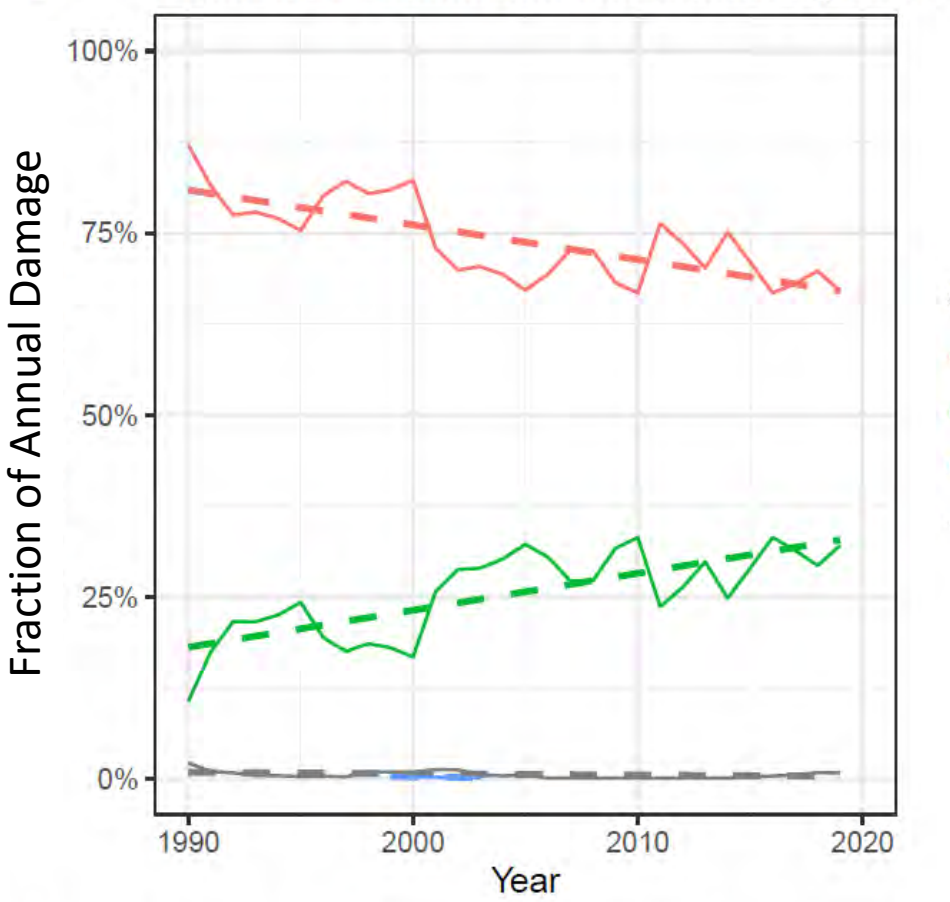
In the U.S., insured damage frequently occurs outside of mapped flood hazard areas

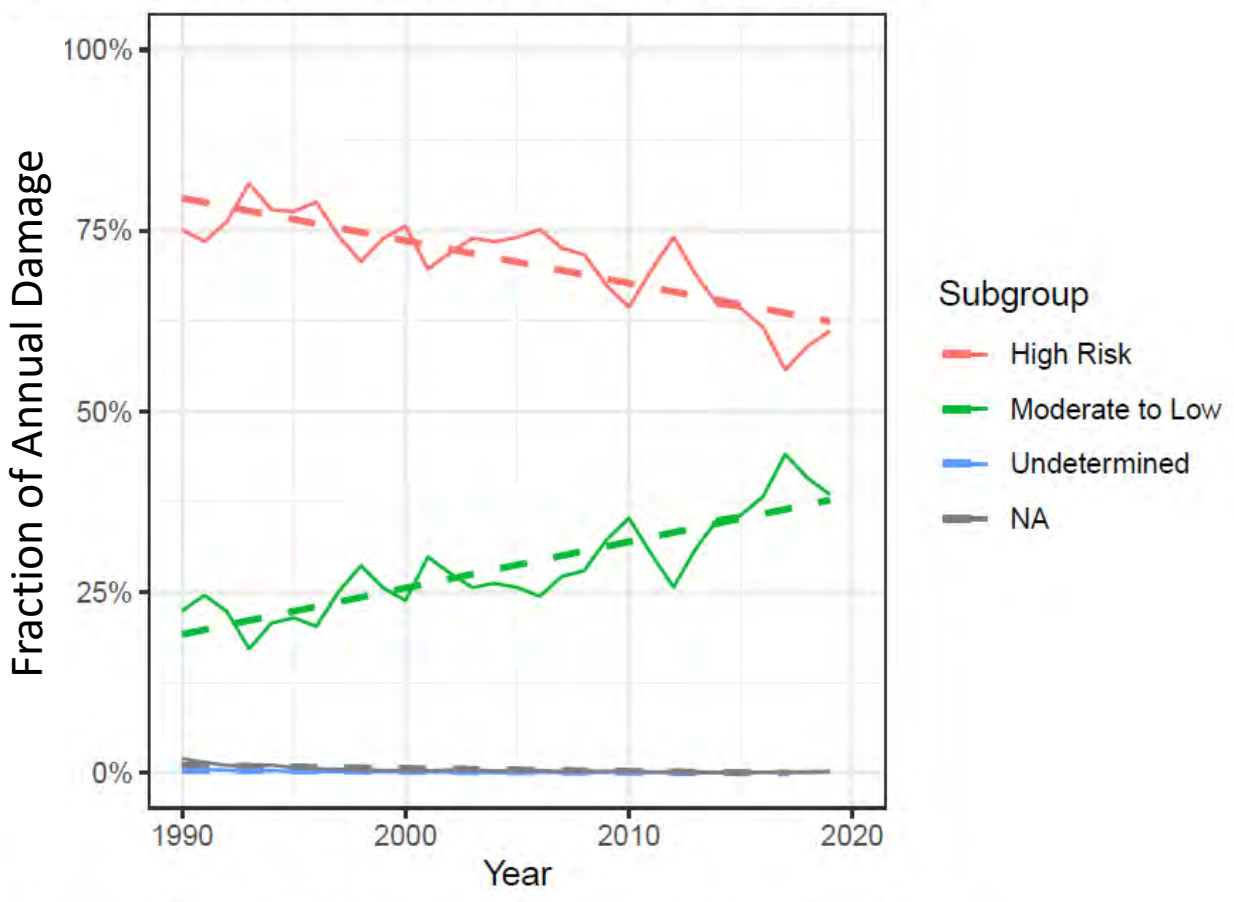


Source: OpenFEMA

Nationwide, about 28% of damages and 33% of insurance claims have occurred outside of FEMA-designated high-risk zones (1968-2021).

And the fraction of damage outside of mapped hazard areas is growing over time...





… especially in coastal areas.

The problem will only grow as the hazard mapping process is costly and burdensome.

100-YEAR FLOODS COULD OCCUR YEARLY BY END OF 21ST CENTURY

SOME FLOODS ARE SO SEVERE THEY RARELY STRIKE MORE THAN ONCE A CENTURY, BUT RISING SEAS COULD THREATEN COASTAL COMMUNITIES WITH YEARLY EXTREME FLOODS.

AGU ADVANCING EARTH AND SPACE SCIENCES

12 September 2023

Old Town Alexandria, Virginia, in May 2016 after high tides in the Potomac River inundated the street. Floods like these will occur more frequently as sea levels inch toward coastal infrastructure.

Credit: NOAA

With Climate Change, Smaller Storms Are Growing More Fearsome, More Often

The Friday storm that produced vast flooding in New York City started out earlier in the week as an unremarkable — if unpredictable — weather system.

Sept. 30, 2023

The New York Times

As Sea Levels Rise, Expect More Floods

A new study unveils the increasing exposure of coastal communities to minor and extreme floods as sea levels rise.

Eos 3 May 2019

Given that we already see increasing trends in insured damages…

1. **How much uninsured flood risk is there? Where is it? Who holds it?**

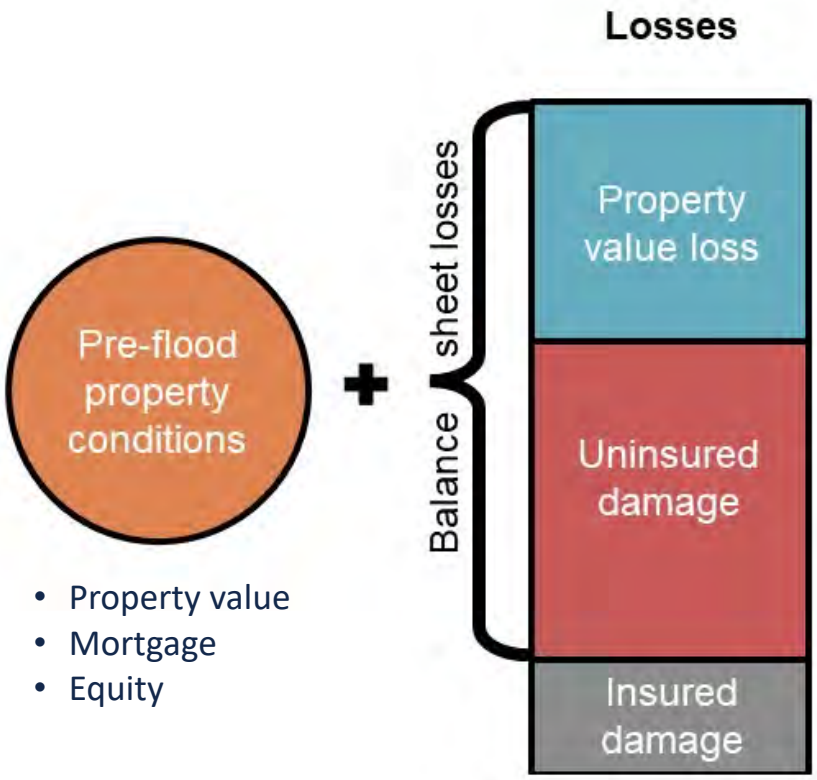
2. **How do uninsured *losses* (e.g., damages, property value declines) occurring across multiple events cascade through the financial system and influence community recovery outcomes?**

UNC Financial Flood Risk Team of Researchers:
H.B. Zeff, H. Thomson, R. Kleiman, H. Garcia, K. Fitzmaurice, M. Lord, A. Sebastian, G. Characklis

Session Law 2019-224 North Carolina General Assembly (NGCA). North Carolina Policy Collaboratory. Strengthening Flood Resilience in Eastern North Carolina (2019-2021).

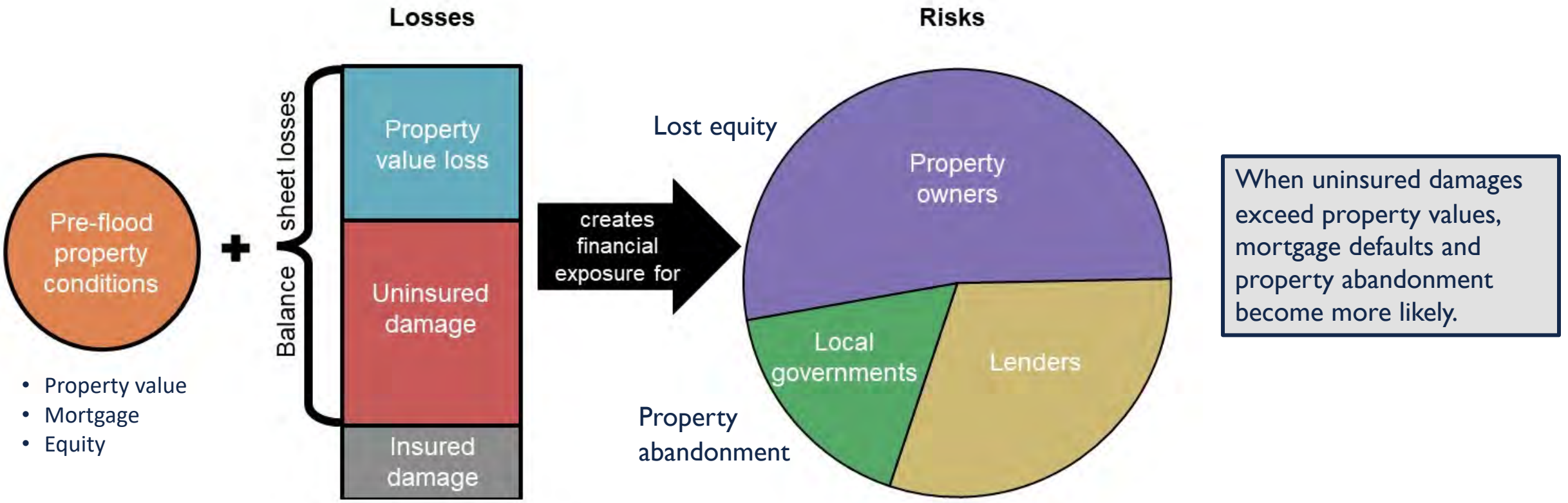
Regional Integrated Sciences and Assessments (RISA) Program. Innovating a Community-based Resilience Model on Climatic and Healthy Equity in the Carolinas (2021-2026).

Flood losses interact with pre-flood financial conditions…



- Property value
- Mortgage
- Equity

…their combination transfers risk (creates financial exposure) to other parties



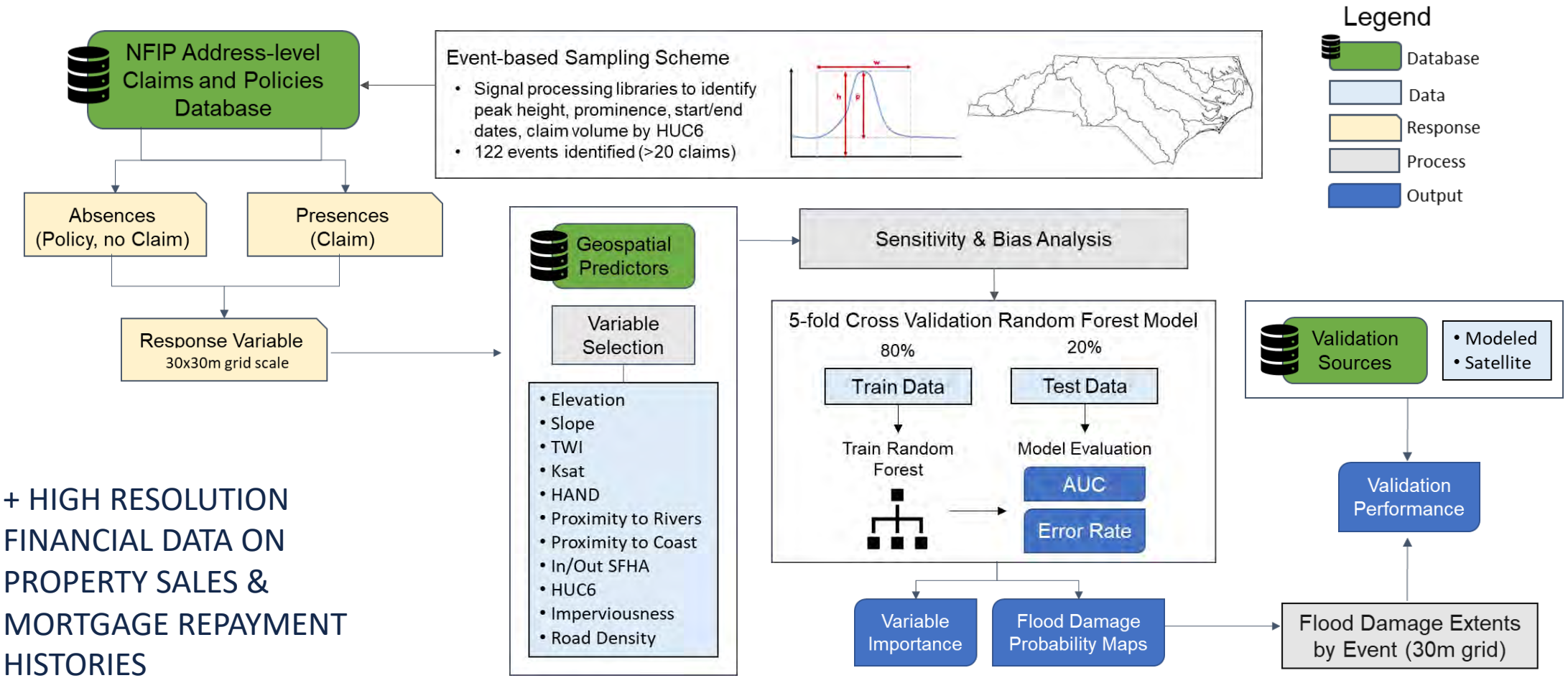
- Property value
- Mortgage
- Equity

When uninsured damages exceed property values, mortgage defaults and property abandonment become more likely.

Systemic Financial Risk Arising From Residential Flood Losses

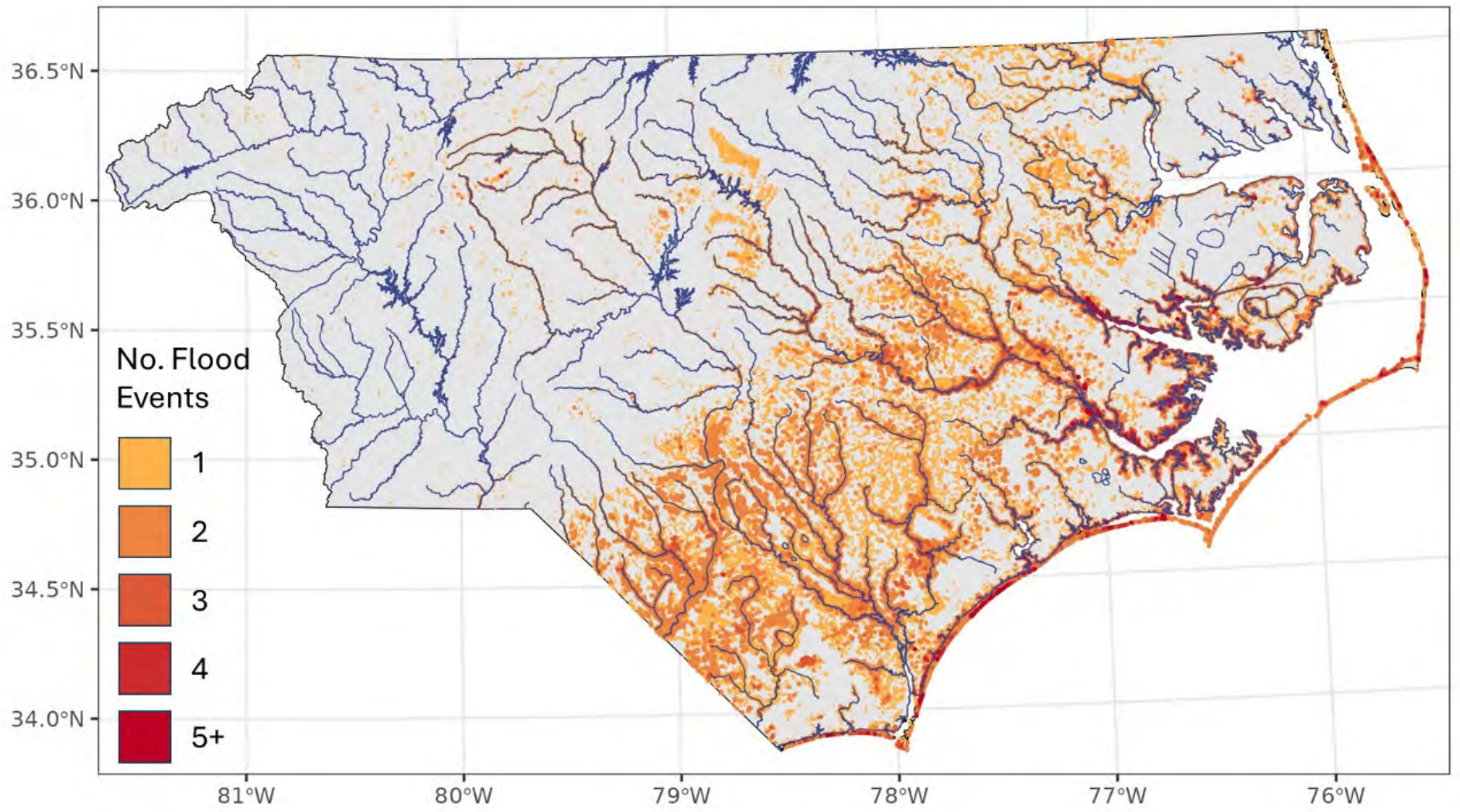
Hope Thomson[1,2], Harrison B. Zeff[1,2], Rachel Kleiman[1,2], Antonia Sebastian[3], and Gregory W. Characklis[1,2]

Using Novel Data Streams to Reconstruct Historical Flood Exposure in Eastern NC

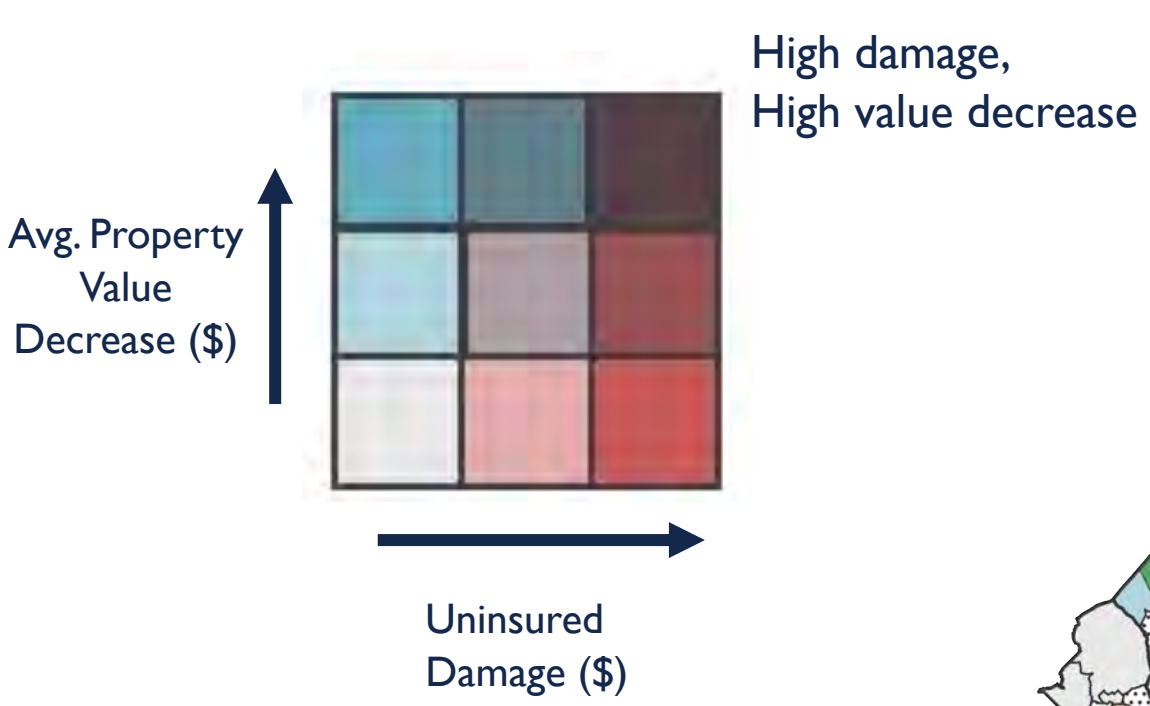


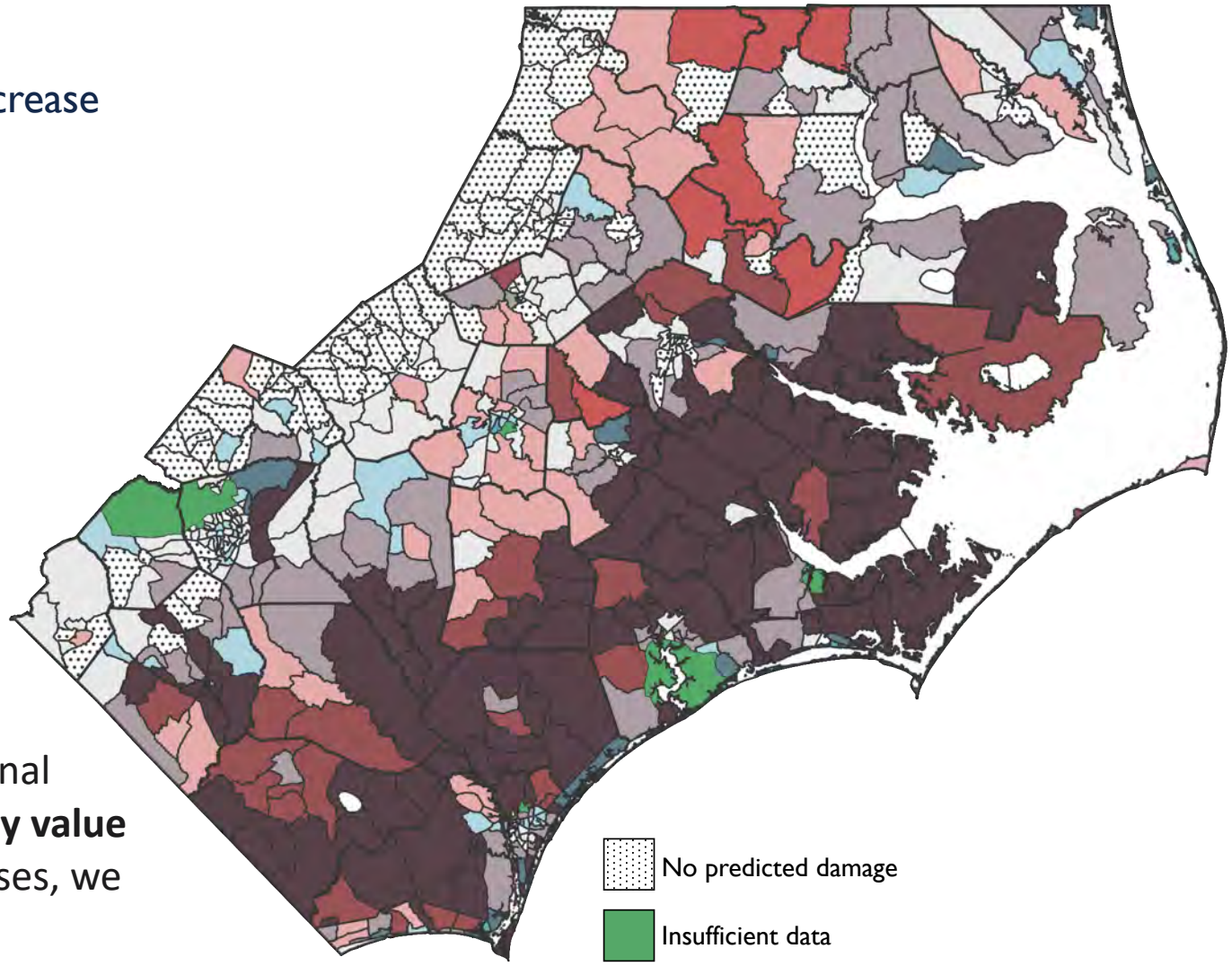
+ HIGH RESOLUTION FINANCIAL DATA ON PROPERTY SALES & MORTGAGE REPAYMENT HISTORIES

Database of Repetitive Flood Exposure across >20 Flood Events (1996-2018)



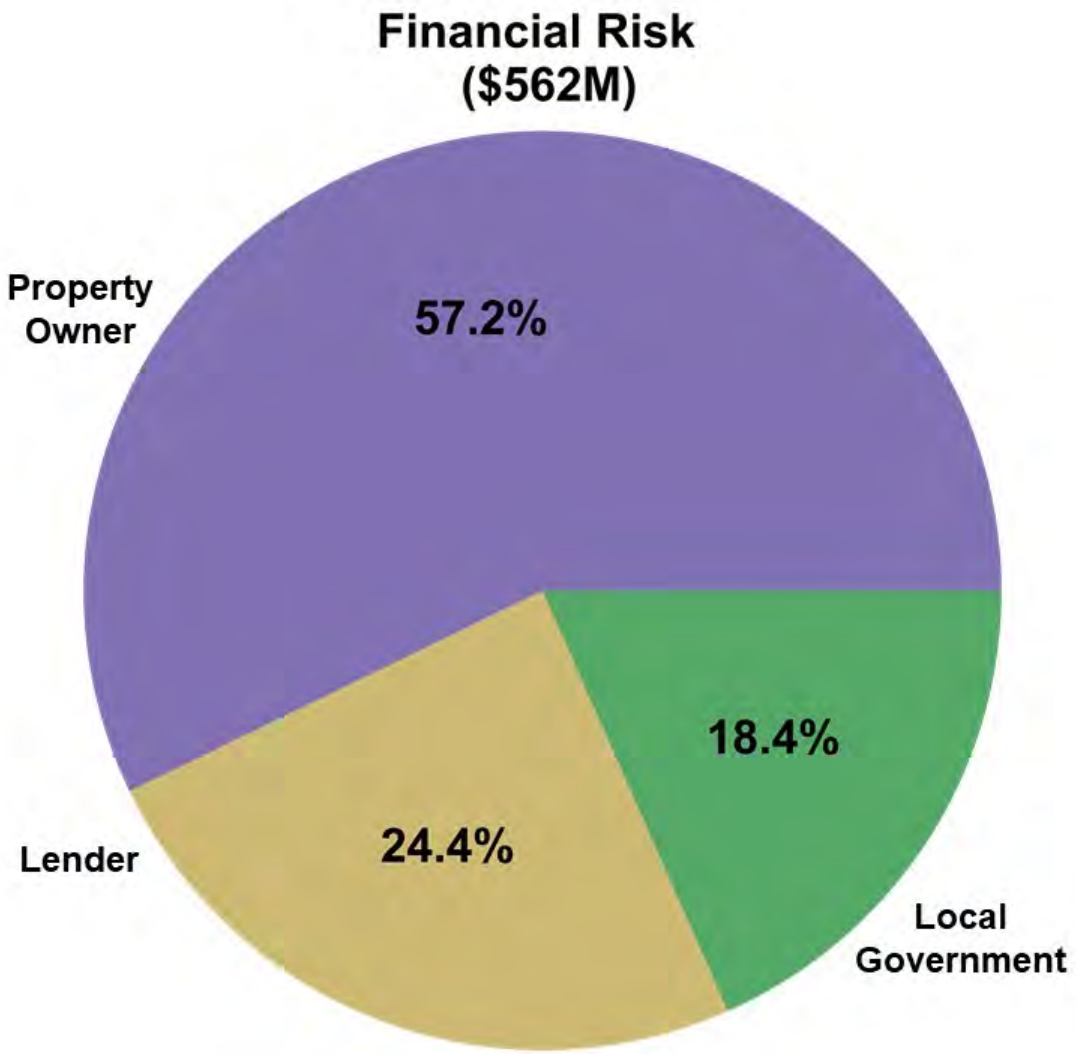
Spatial distribution of balance sheet losses from Hurricane Florence (2018)





In Eastern North Carolina, Hurricane Florence generated **$366M in insured damage** and an additional **$1.77B in combined uninsured damage and property value losses** at residential properties. Of the combined losses, we estimated the **uninsured damage to be ~$1 billion** (Thomson et al. 2023).

Distribution of financial risk due to potential losses cascading from default/abandonment



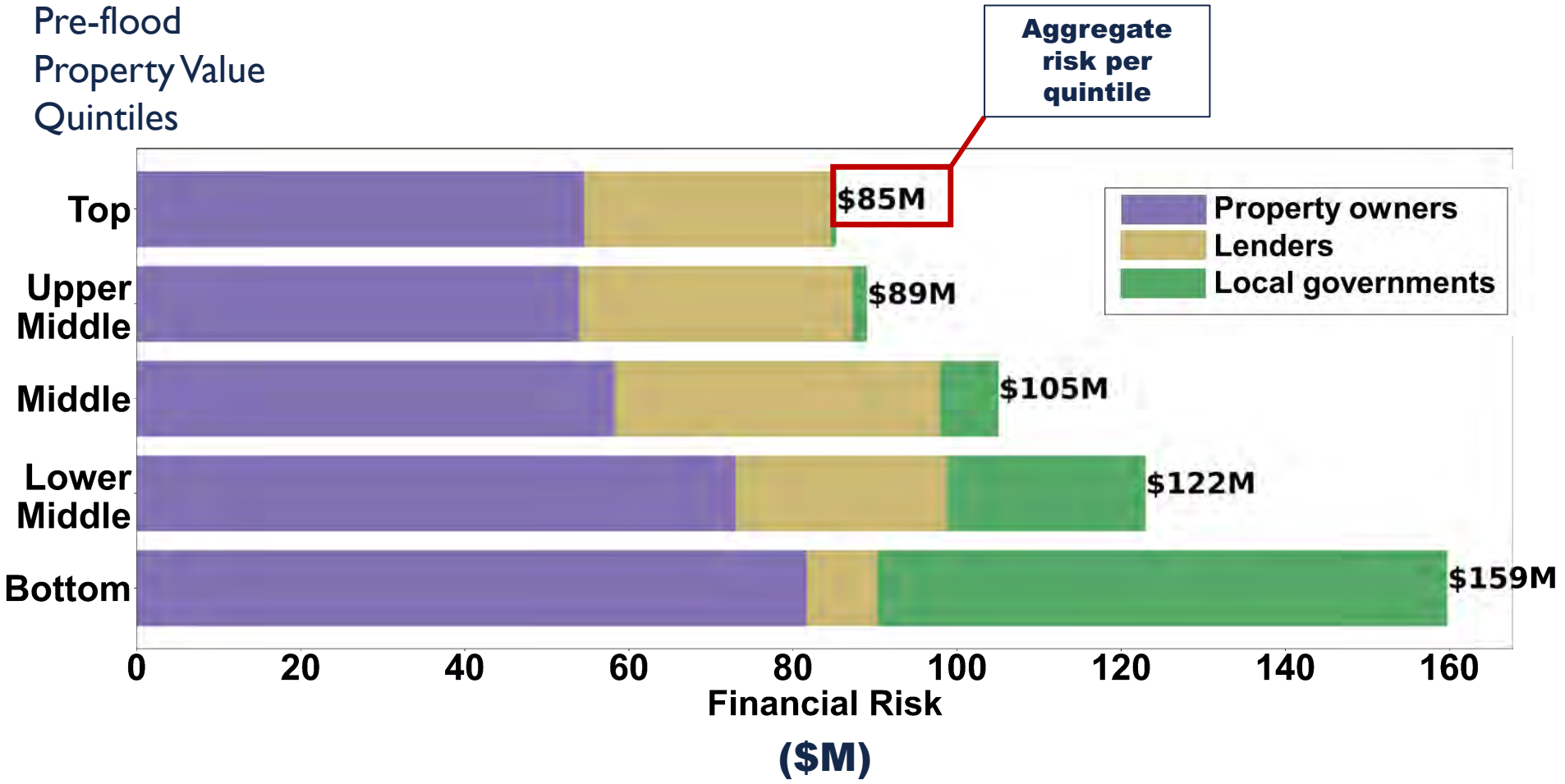
- Property owners are the most exposed across groups
- Lenders and local government have significant exposure, but this varies by governance type and location

(Thomson et al. *Earth's Future* 2023)

Lower value properties generate more risk

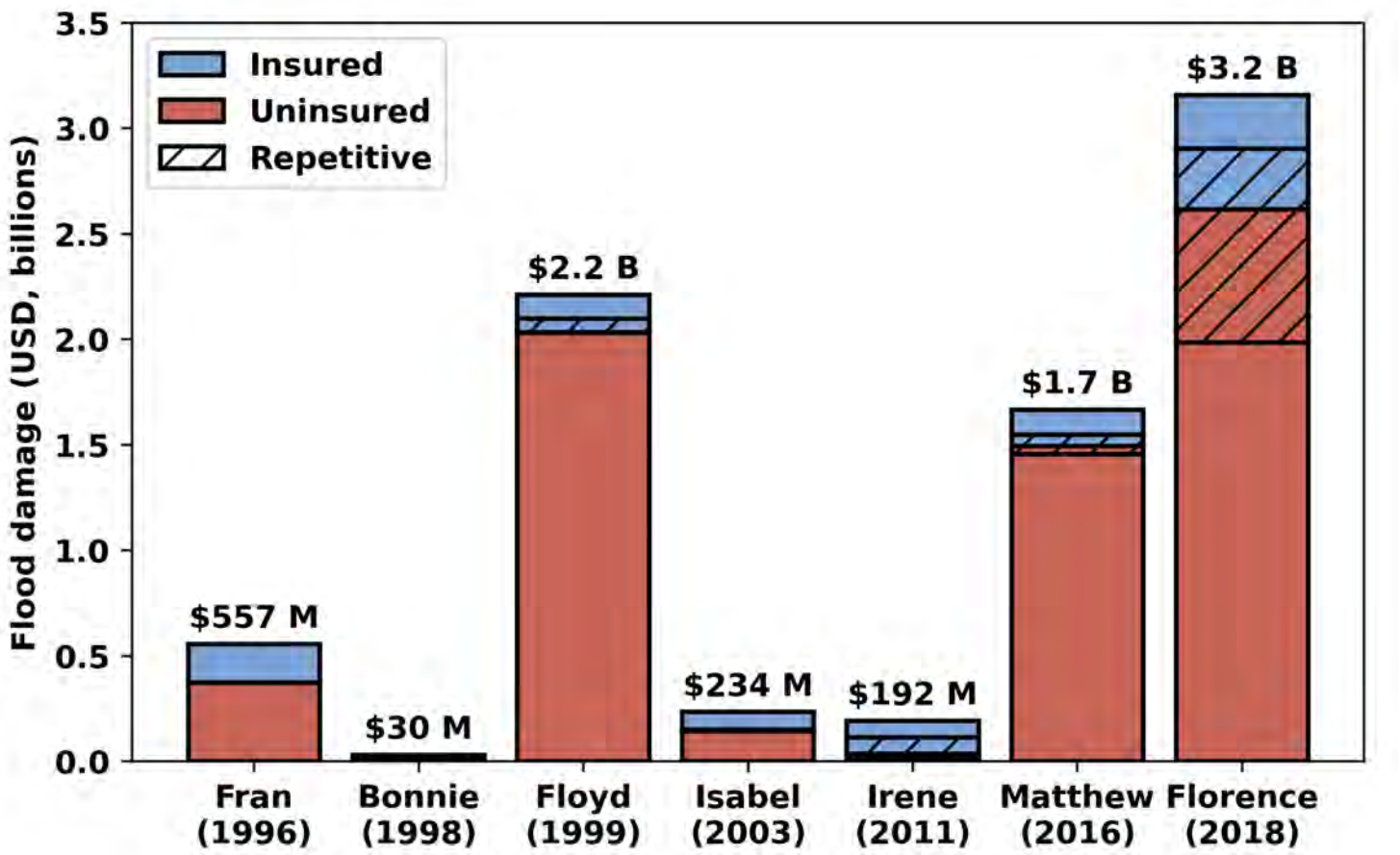
High-value homes pose the greatest risk to lenders.

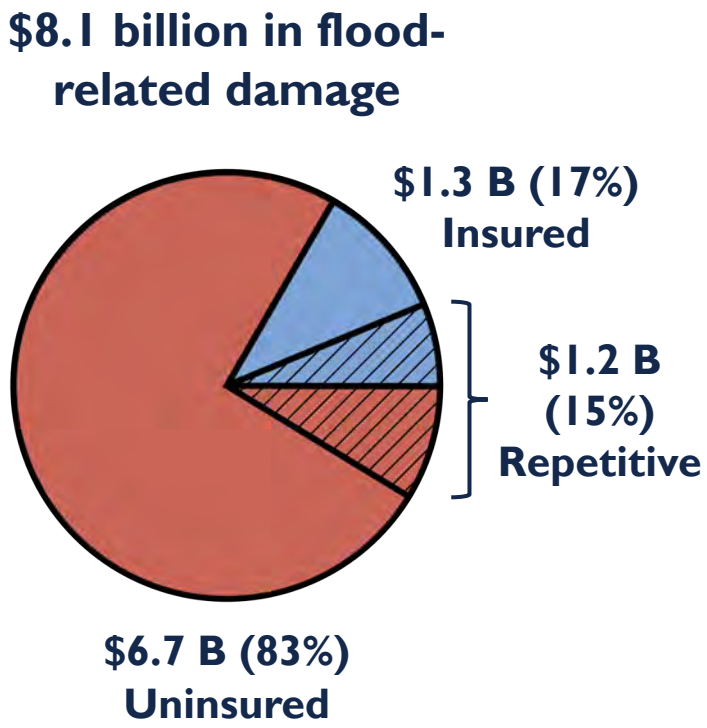
Low-value homes pose the greatest risk to local government.



(Thomson et al. *Earth's Future* 2023)

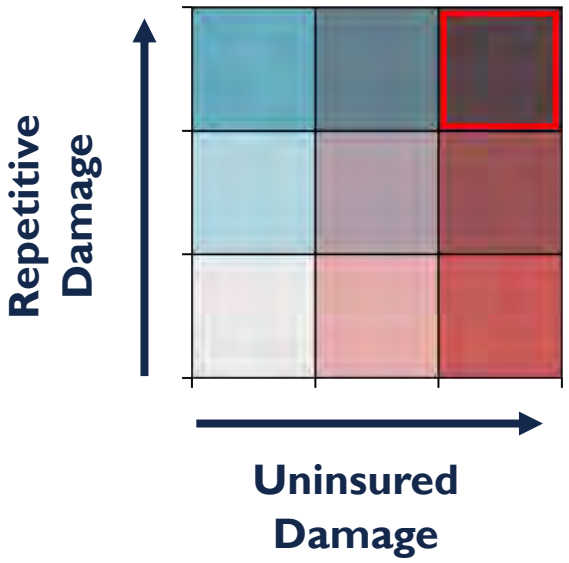
Estimate burden of uninsured and repetitive flood damage for the Largest Flood Events

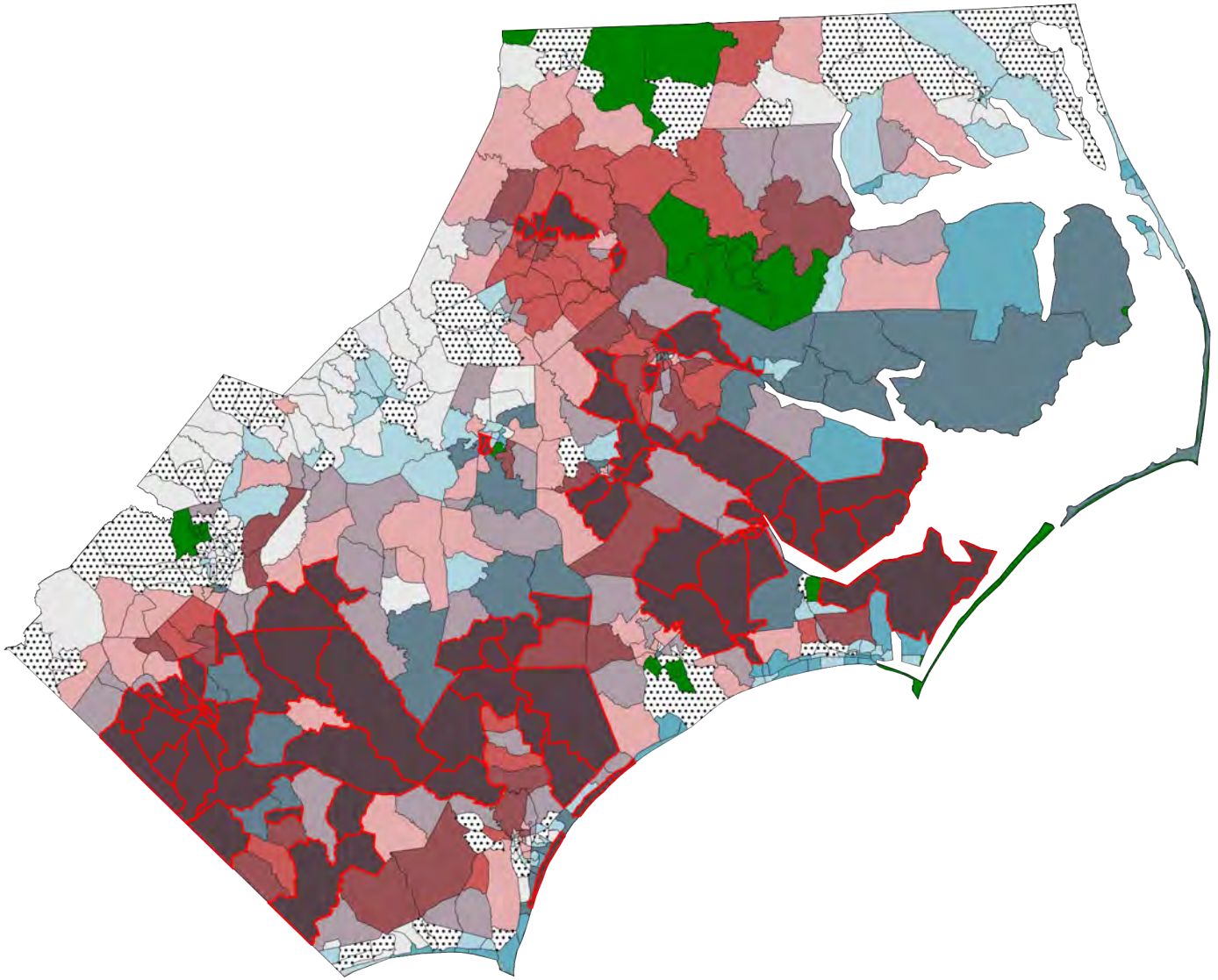




Damages adjusted for inflation and expressed in 2020 USD

Spatial distribution of uninsured and repetitive damage

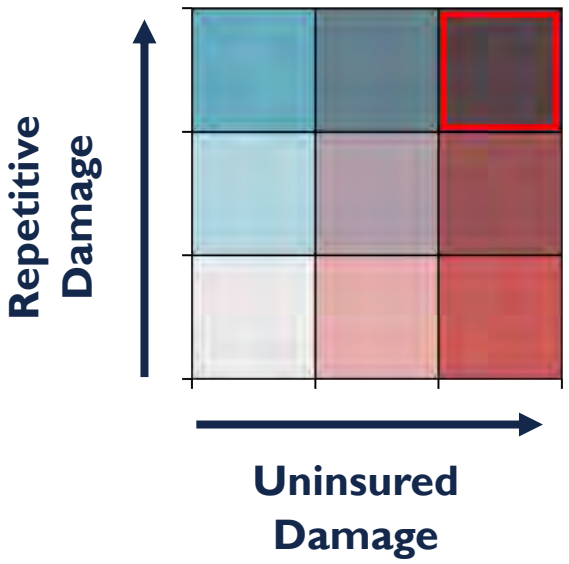


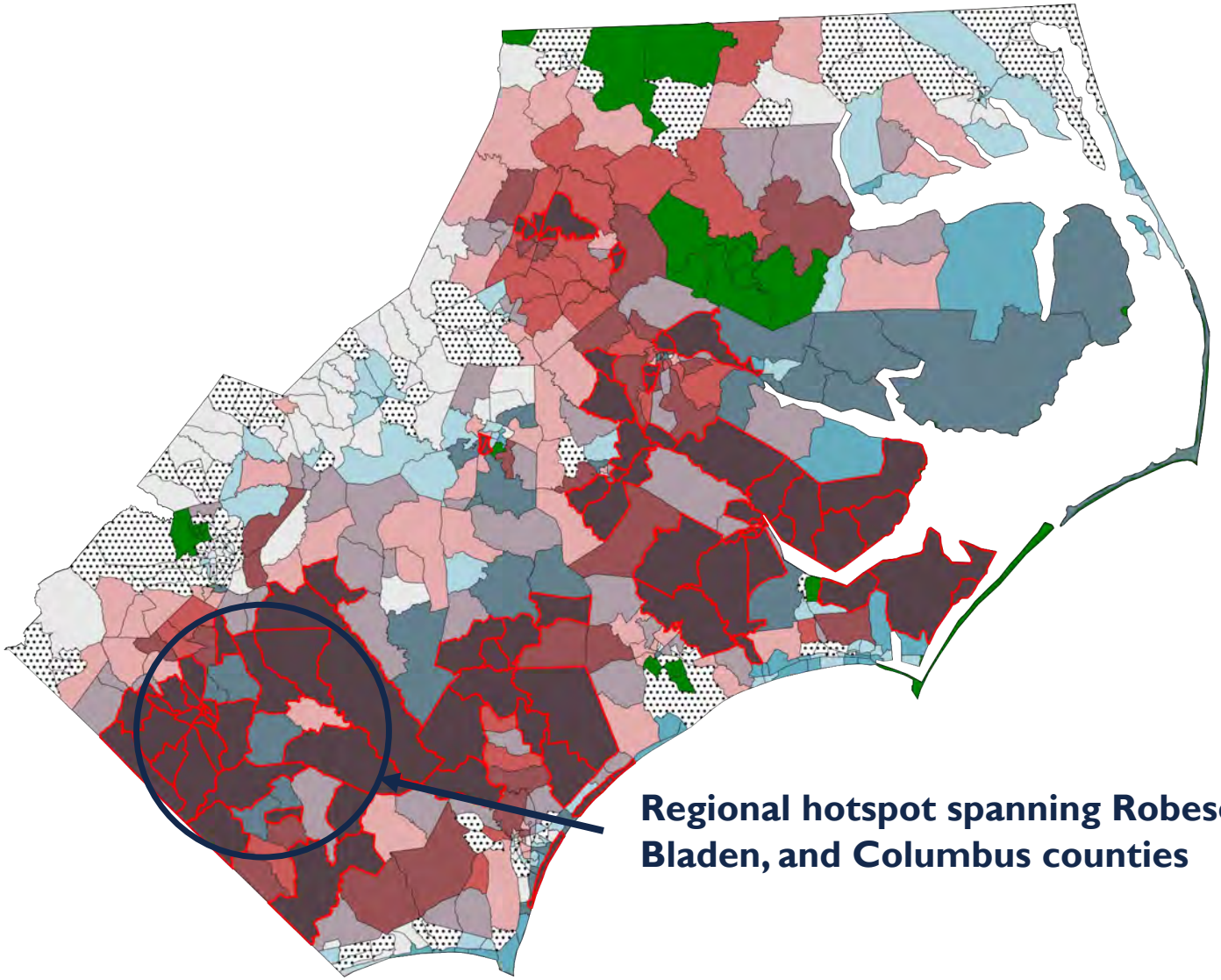


Insufficient data

No predicted damage

Lower-income and economically distressed areas bear a disproportionate burden





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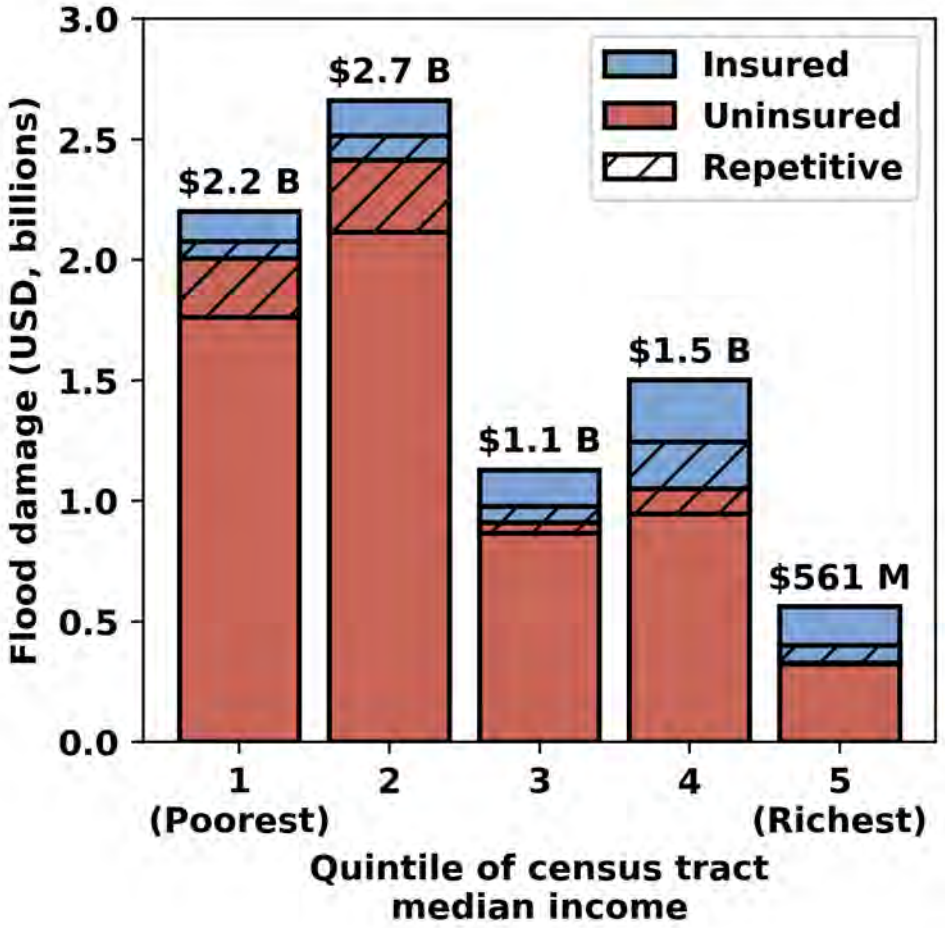
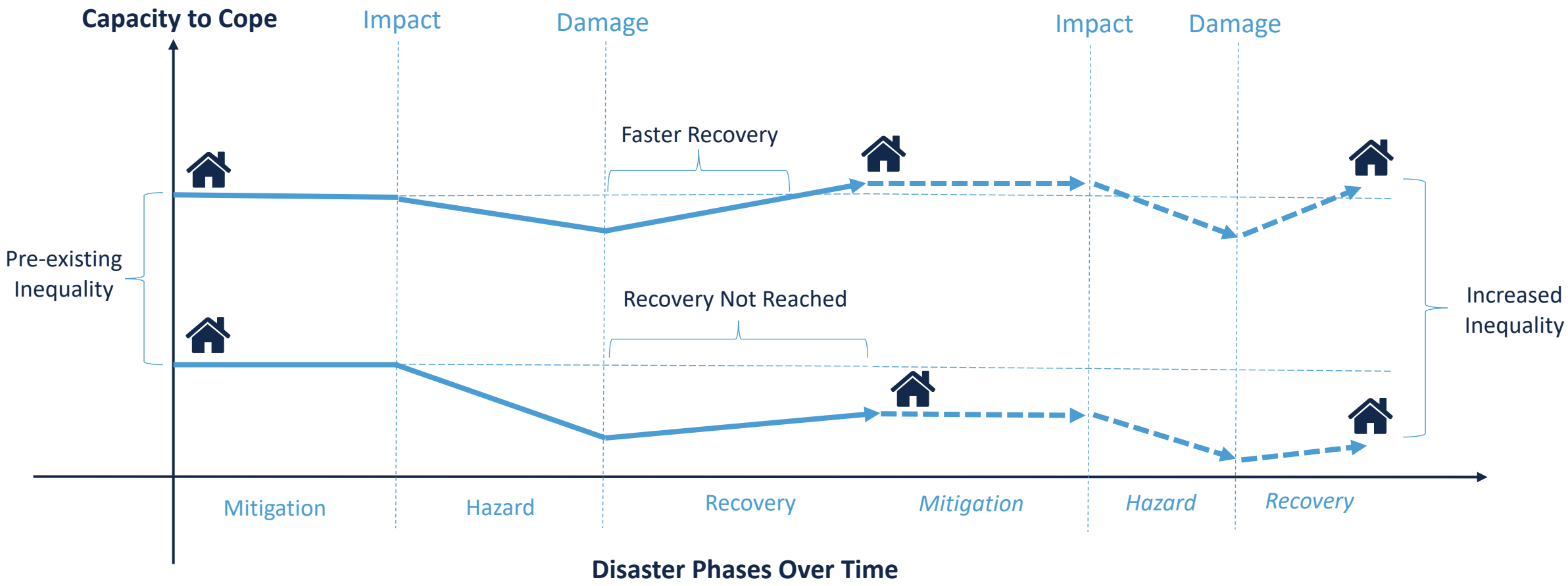


- **Losses in less wealthy areas were driven by uninsured damage**
- **Lower-income households are less able to absorb unexpected budgetary shocks from flooding**
- **These shocks can push homeowners into a state of financial instability**

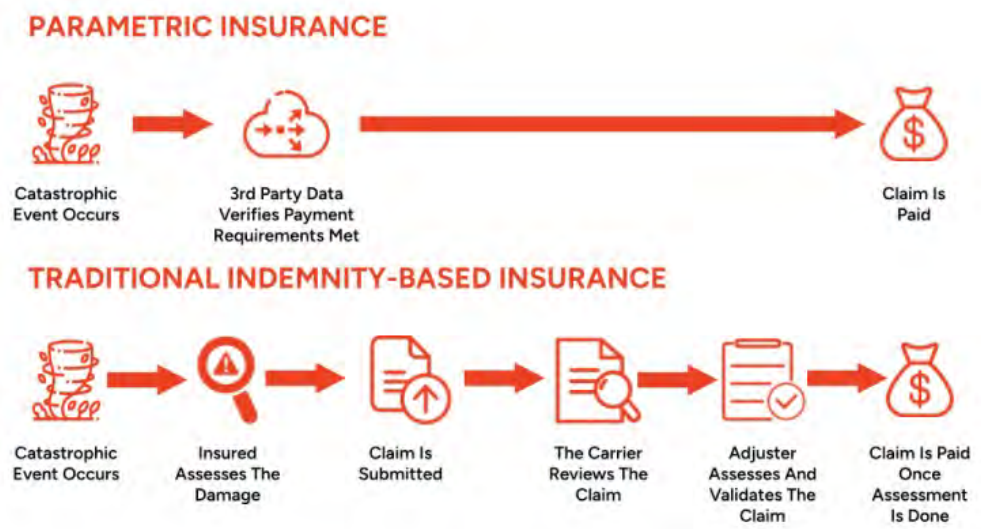
Tracking Recovery: repetitive flood exposure exacerbates existing inequalities

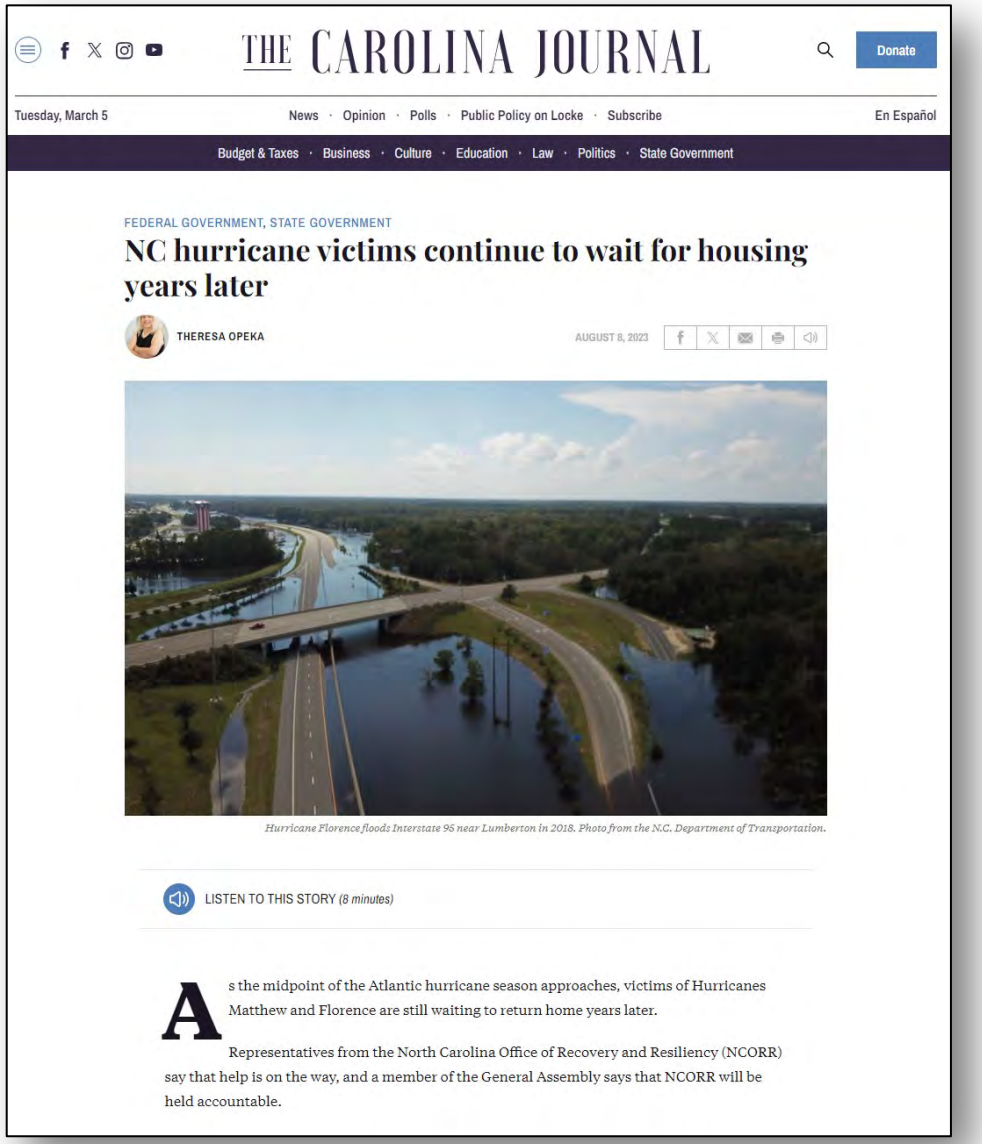


Adapted from Van Zandt 2020

Addressing Flood Resilience & Recovery

- Spatially-targeted investments in flood adaptation to reduce
  - Flood Hazard (e.g., levees, green infrastructure)
  - Building Exposure (e.g., building elevation, buyouts)
  - Financial Vulnerability (e.g., flood insurance subsidies)
- Improving access to mitigation assistance and aiding recovery
  - Who applies/is denied HMA, how much ‘unmet need’ exists
- Designing community-based parametric insurance





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FEDERAL GOVERNMENT, STATE GOVERNMENT

NC hurricane victims continue to wait for housing years later

THERESA OPEKA AUGUST 8, 2023

Hurricane Florence floods Interstate 95 near Lumberton in 2018. Photo from the N.C. Department of Transportation.

LISTEN TO THIS STORY *(8 minutes)*

As the midpoint of the Atlantic hurricane season approaches, victims of Hurricanes Matthew and Florence are still waiting to return home years later.

Representatives from the North Carolina Office of Recovery and Resiliency (NCORR) say that help is on the way, and a member of the General Assembly says that NCORR will be held accountable.

Thank you!

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H.B. Zeff, H. Thomson, R. Kleiman, H. Garcia, K. Fitzmaurice, M. Lord, A. Sebastian, G. Characklis

This work has been funded by:

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NOAA-OAR-CPO-2021-2006677 Regional Integrated Sciences and Assessments (RISA) Program. Innovating a Community-based Resilience Model on Climatic and Healthy Equity in the Carolinas (2021-2026).

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