UNC RESEARCH

UNIVERSITY Research WEEK

Lunch & Learn

Flooding and Our Future

Presented by the Office of the Vice Chancellor for Research, the UNC Institute for the Environment & North Carolina Collaboratory

Lunch & Learn

Flooding and Our Future Panel

Panel Emcee: Greer Arthur

Research Director, North Carolina Collaboratory

Antonia Sebastian

Assistant Professor, Department of Earth, Marine and Environmental Sciences and Environment, Ecology and Energy Program

Greg Characklis

William R. Kenan Jr. Distinguished Professor, Department of Environmental Sciences and Engineering; Director, Center on Financial Risk in Environmental Systems

Mike Piehler

Professor and Director, UNC Institute for the Environment; Chief Sustainability Officer and Special Assistant to the the Chancellor, Sustainability

University Research Week

UNC Research

Lunch & Learn

Antonia Sebastian

Assistant Professor, Department of Earth, Marine and Environmental Sciences and Environment, Ecology and Energy Program

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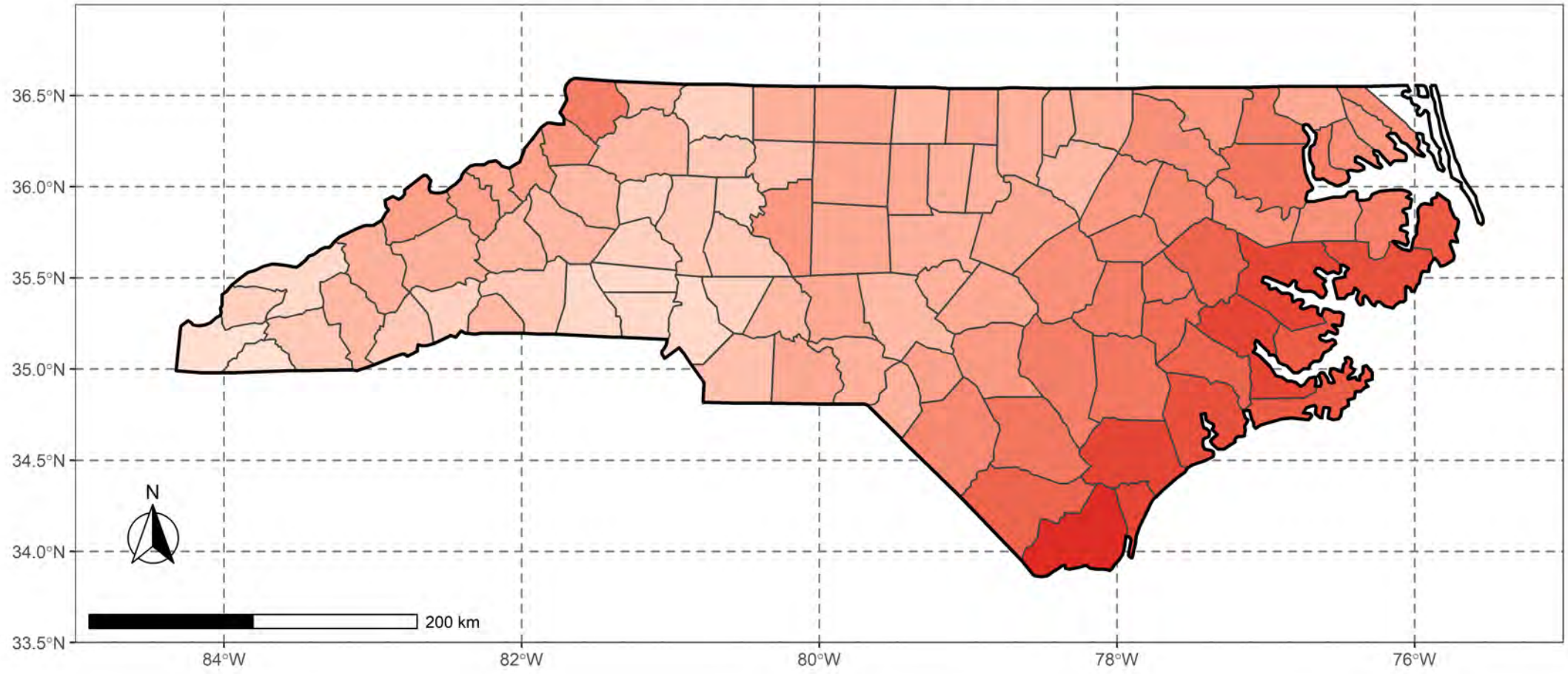
North Carolina is no stranger to devastating flood events



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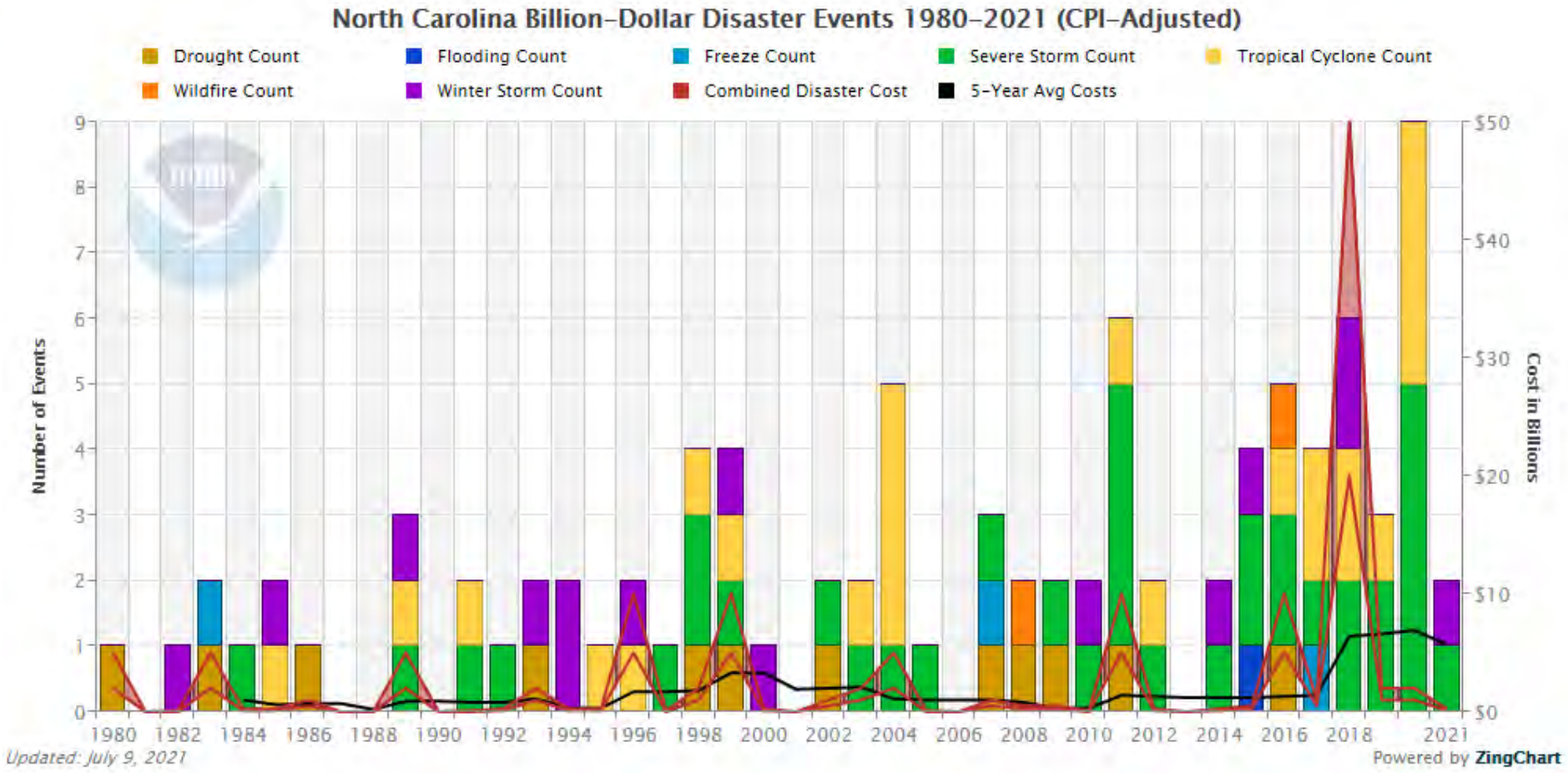
Damages from extreme events are increasing across NC, but why?



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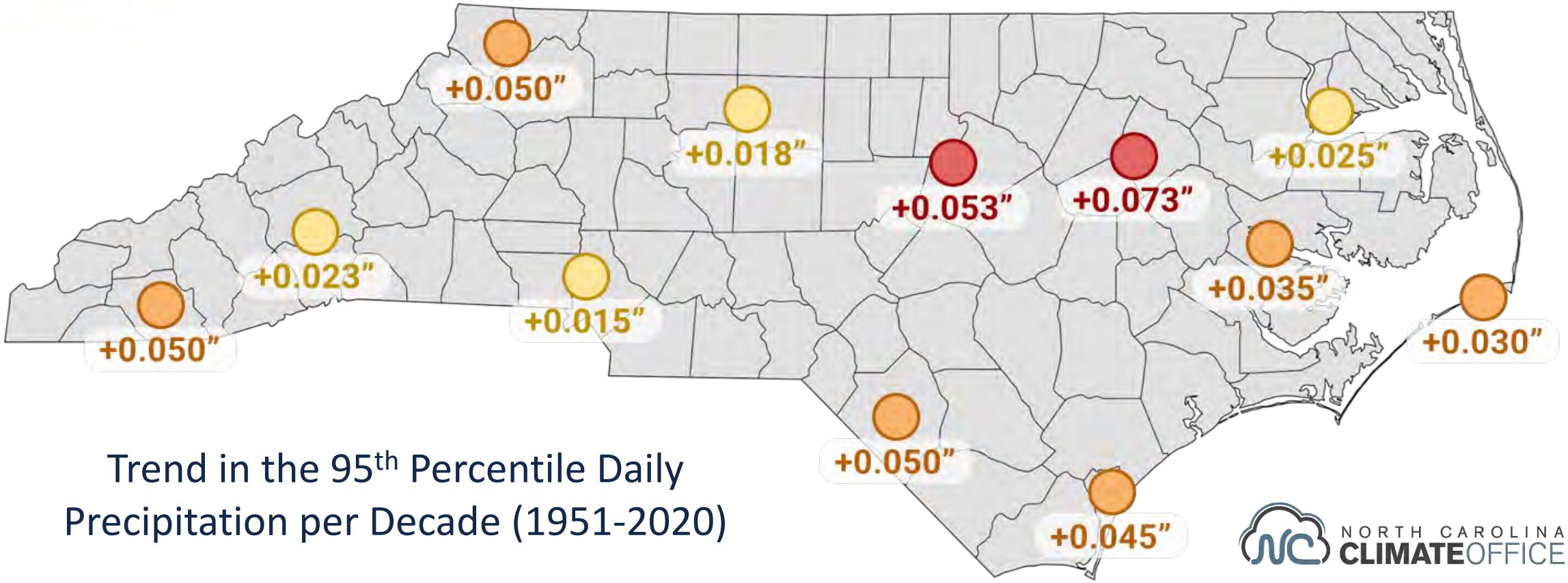
Extreme rainfall volumes are increasing at many locations



Trend in the 95th Percentile Daily Precipitation per Decade (1951-2020)

NORTH CAROLINA CLIMATEOFFICE

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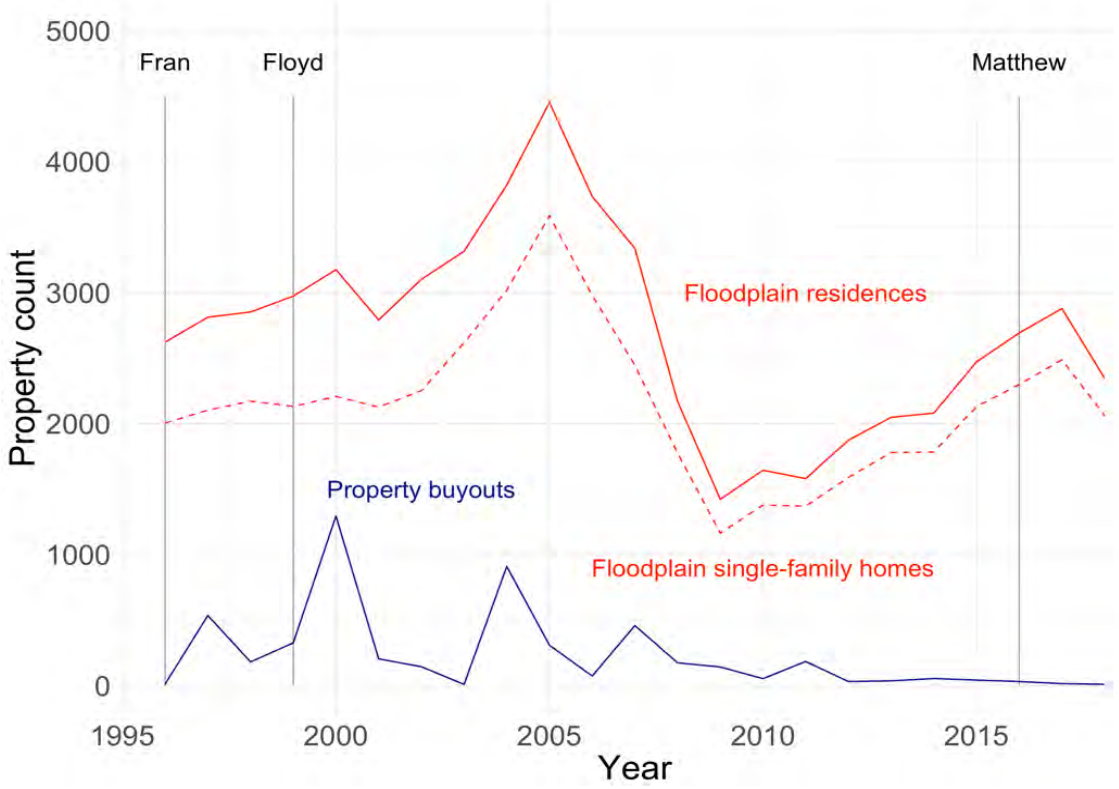
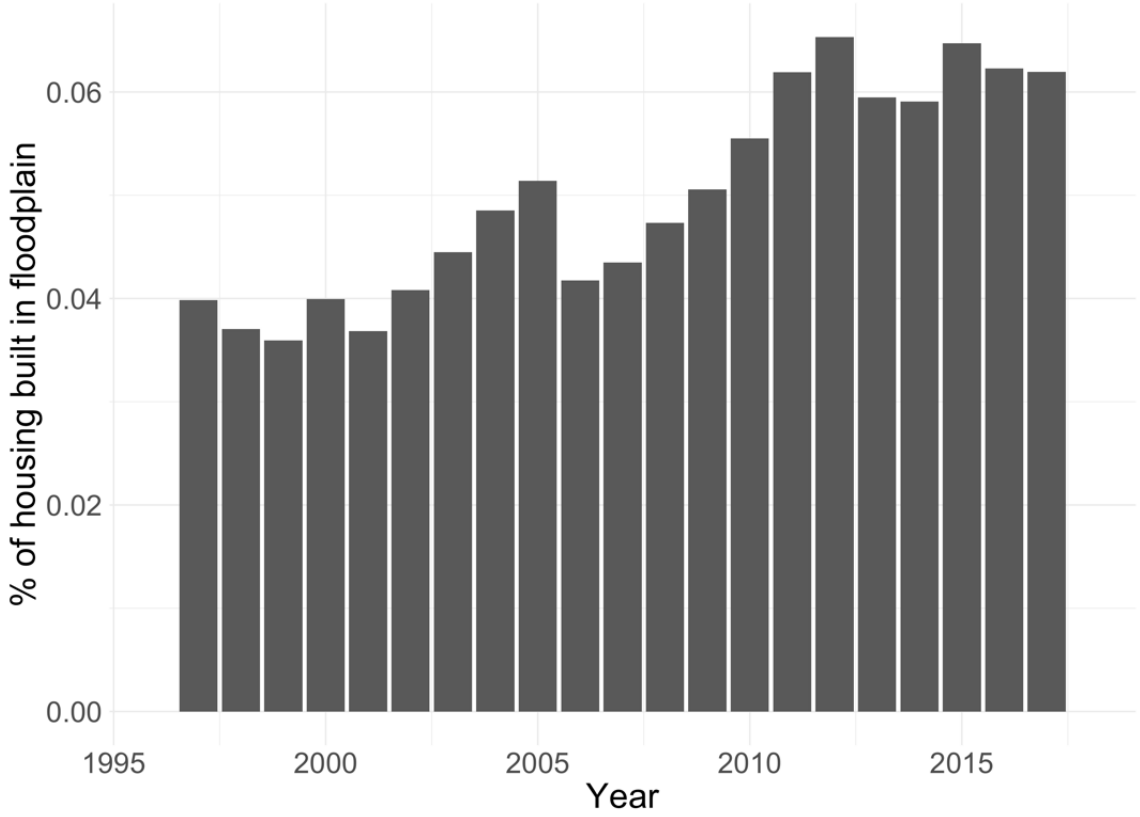
… and we continue to live and build in flood-prone places.

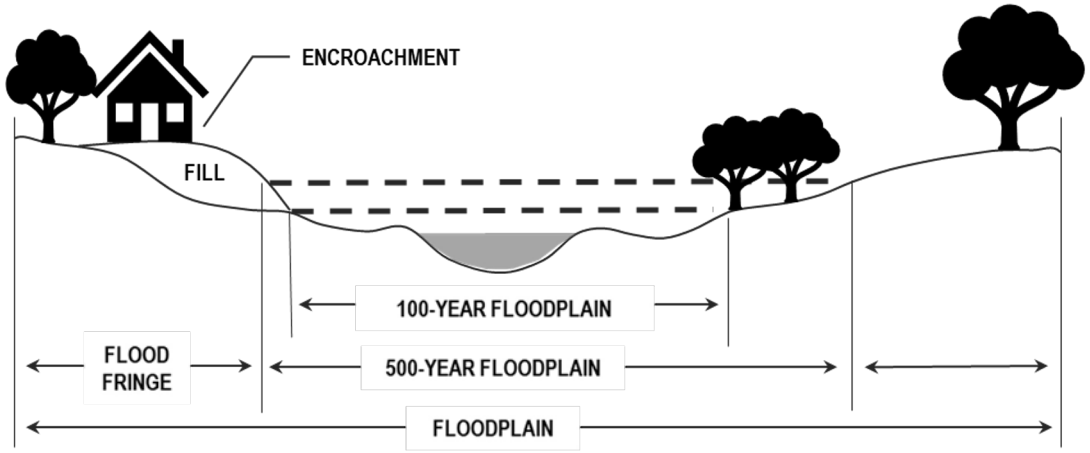




There are 10 new residences built in the 100-year floodplain for every 1 structure bought out (Hino et al. 2023).

The FEMA floodplain is the primary marker of risk and an important planning tool, but it is poorly understood.

The area with >1% chance of being inundated by a **river** or **coastal flood** in any given year.



It is *not* the area that will only flood once in 100 years. In fact, a home in a floodplain has a **26% chance of flooding** during a 30-year mortgage.

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The FEMA maps also don't show potential flooding from other sources, undermining community preparedness.

Pluvial Flooding:

Extreme Precipitation

Storm Sewer or Groundwater Surcharge

Photo: David Pfeiffer CC BY 2.0

Compound Flooding:

Storm Surge

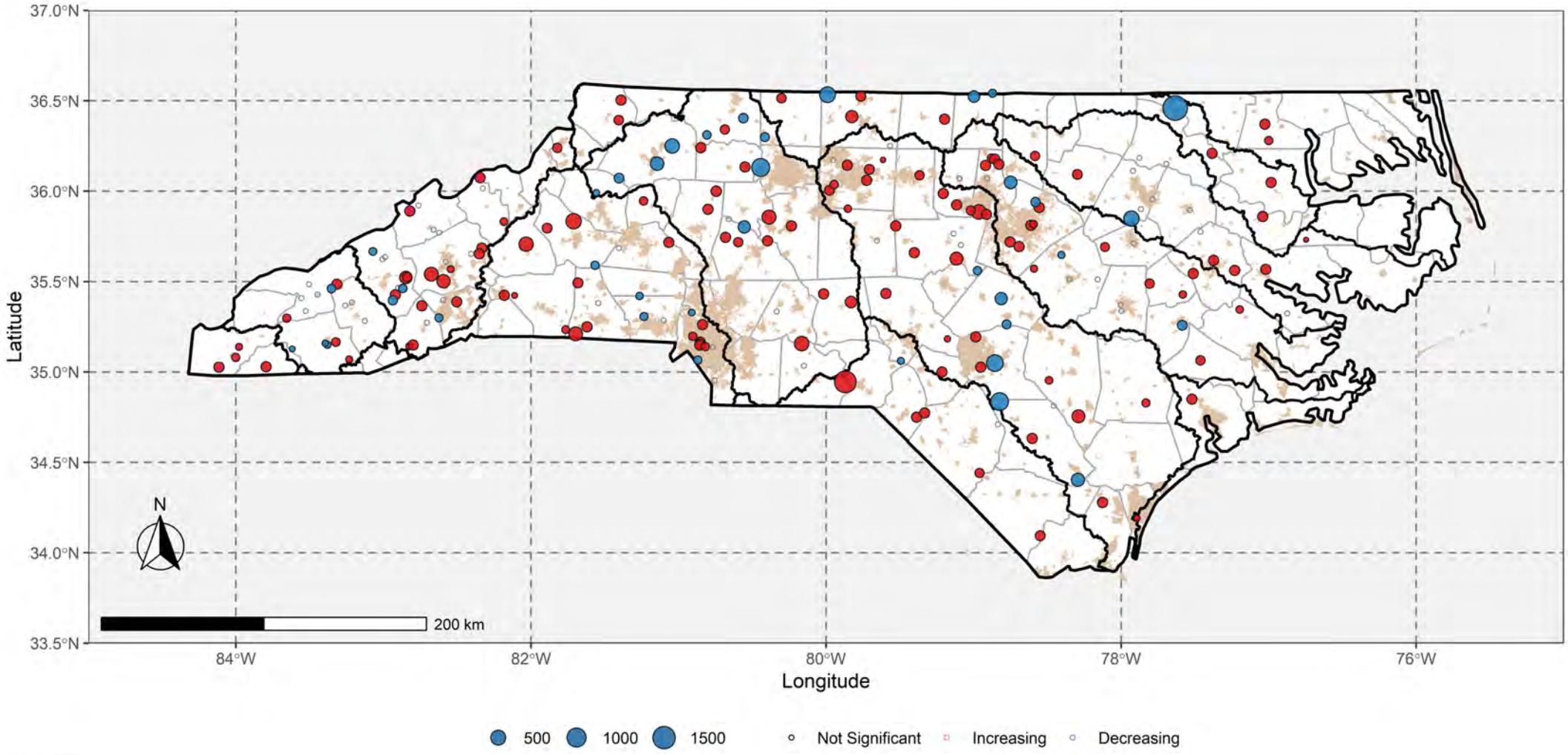
Extreme Precipitation

Storm Sewer or Groundwater Surcharge

Photo: AP Photo/Steve Helber

Inland Flood Wave

Moreover, the 100-year flood is not stationary, and many maps are out of date.



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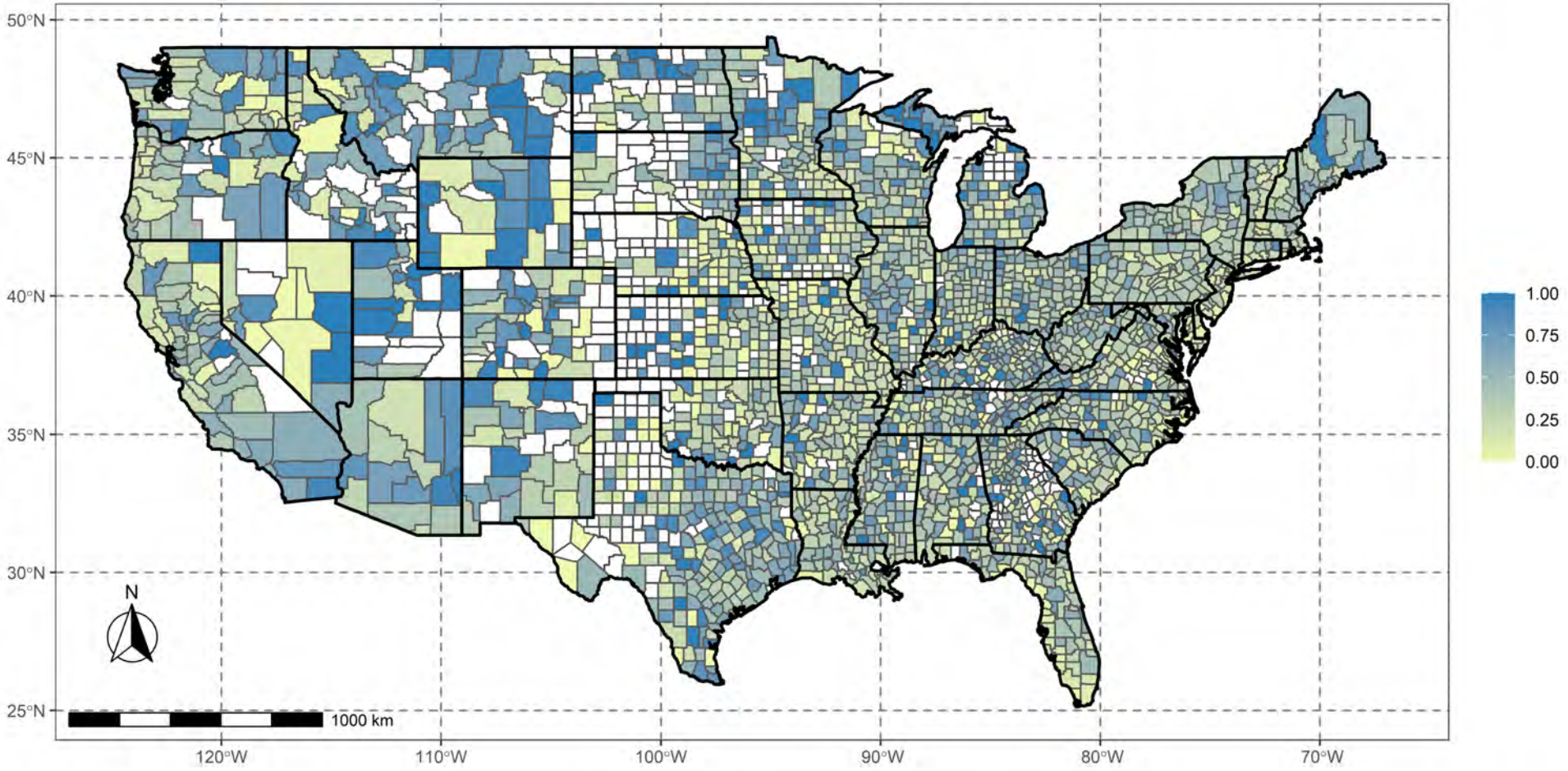
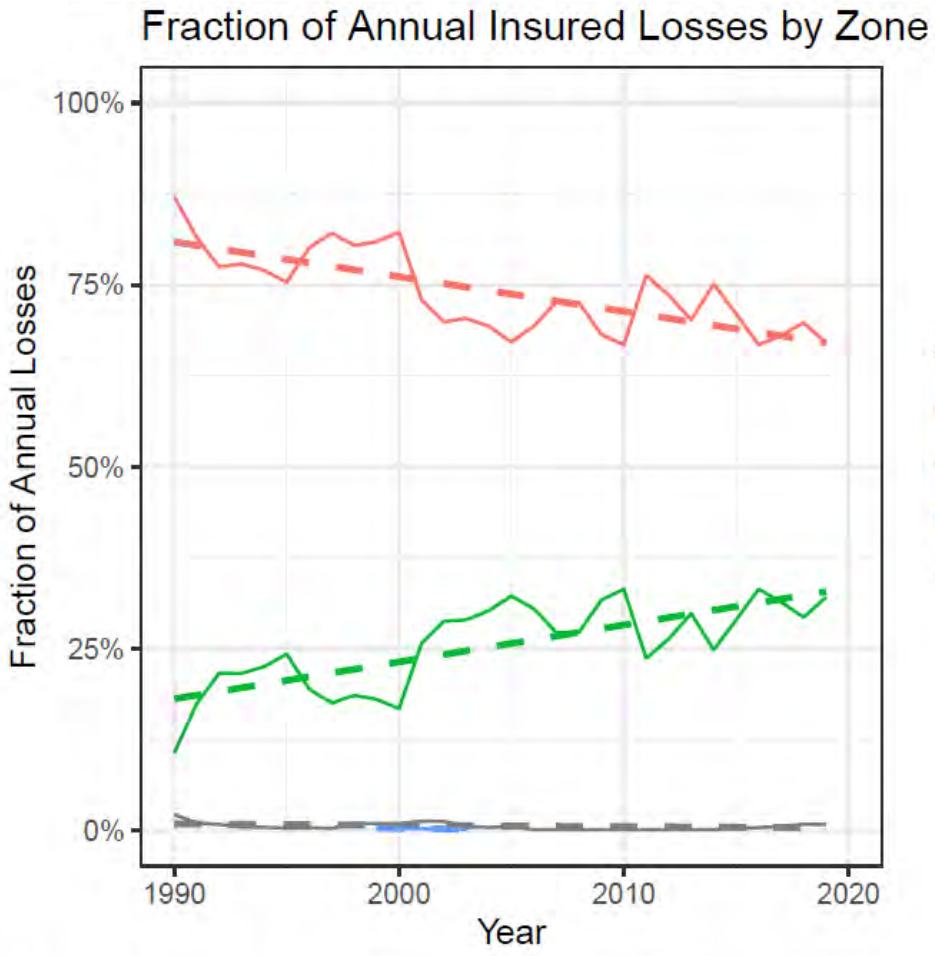
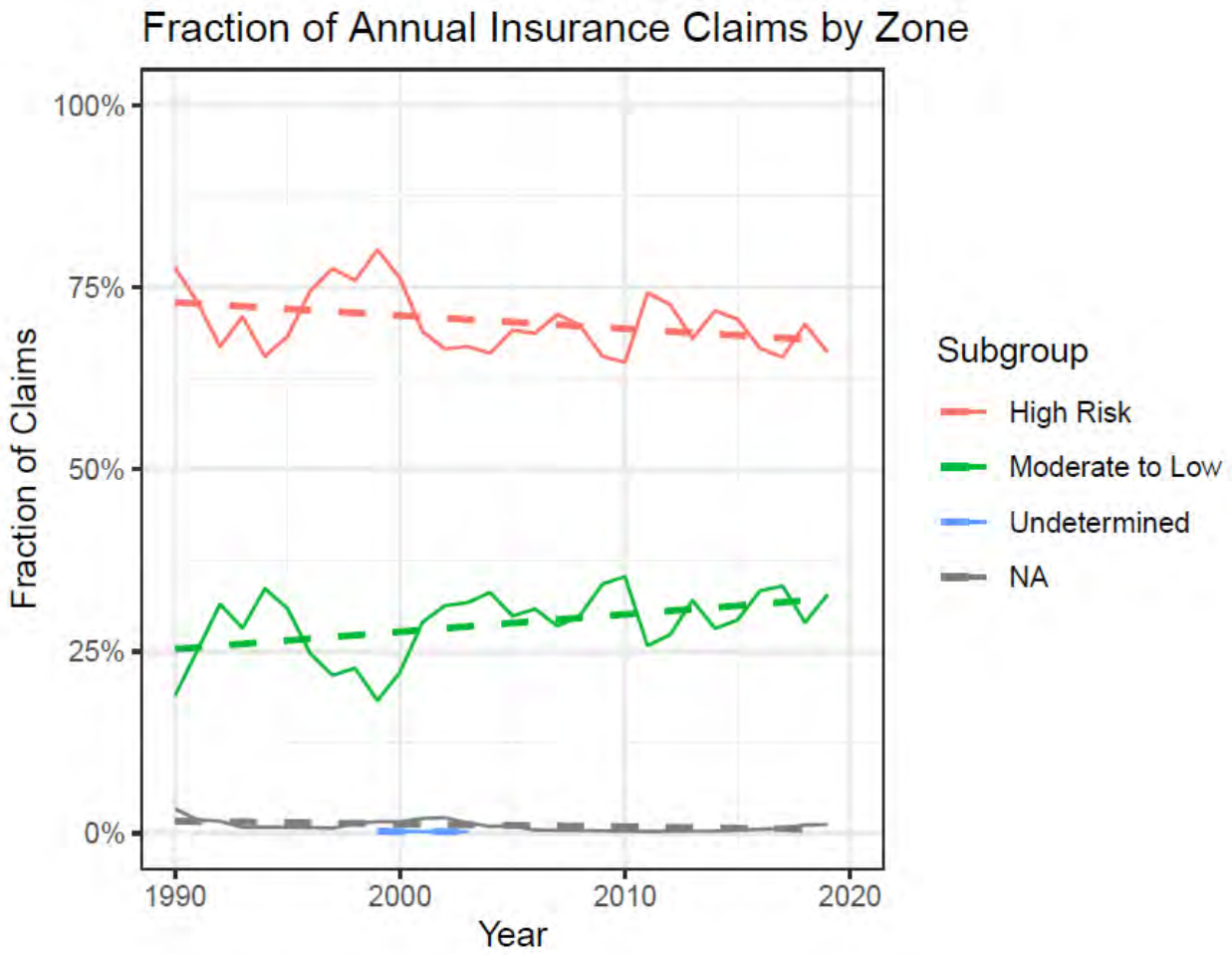
Nationwide, 28% of historical flood damage has occurred outside of mapped FEMA floodplains.



The rate of damage outside of the floodplain is growing…





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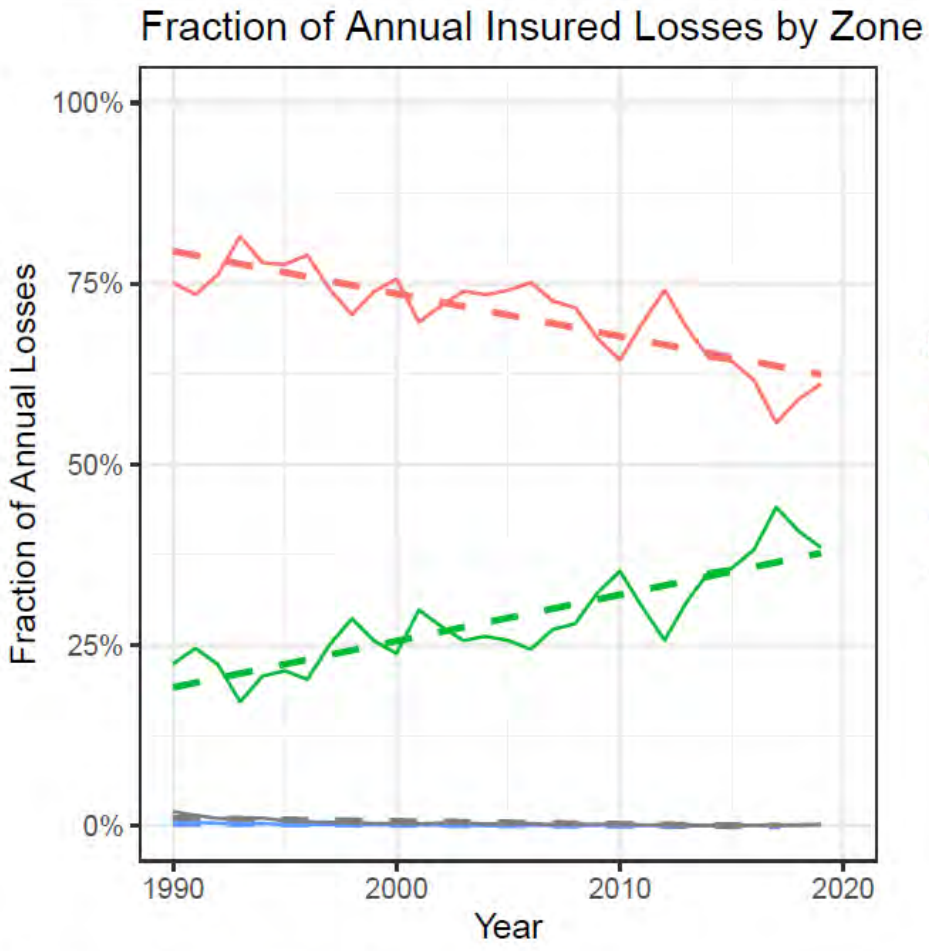
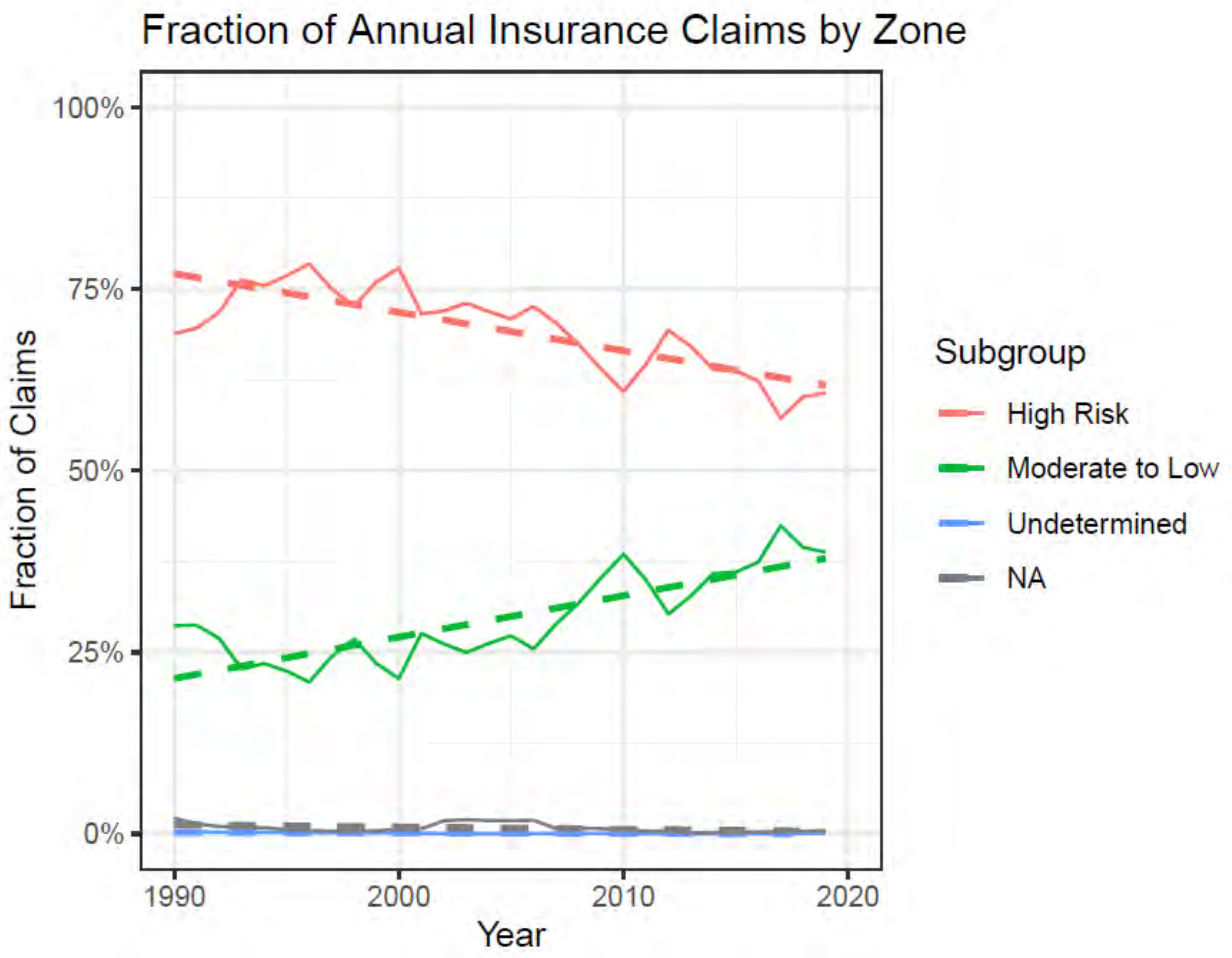
...especially in U.S. Gulf & Atlantic coastal areas.





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So, what is UNC's 'Flood Lab' doing about it…

Our goal is to advance scientific understanding of the dynamic interactions between natural, social, and engineered systems and how they drive the **evolution of flood risk across space and time**. We…

1. Use physics- and statistics-based models to advance flood hazards and exposure mapping at large scales
2. Quantify flood risks to households and communities with a focus on types of risks that have been historically overlooked and, as a result, may be uninsured or unaccounted for
3. Forecast how flood hazards and associated risks may change under future conditions, and how communities may respond, using climate, land use, and detailed population data
4. Support climate adaptation and flood mitigation policy and planning

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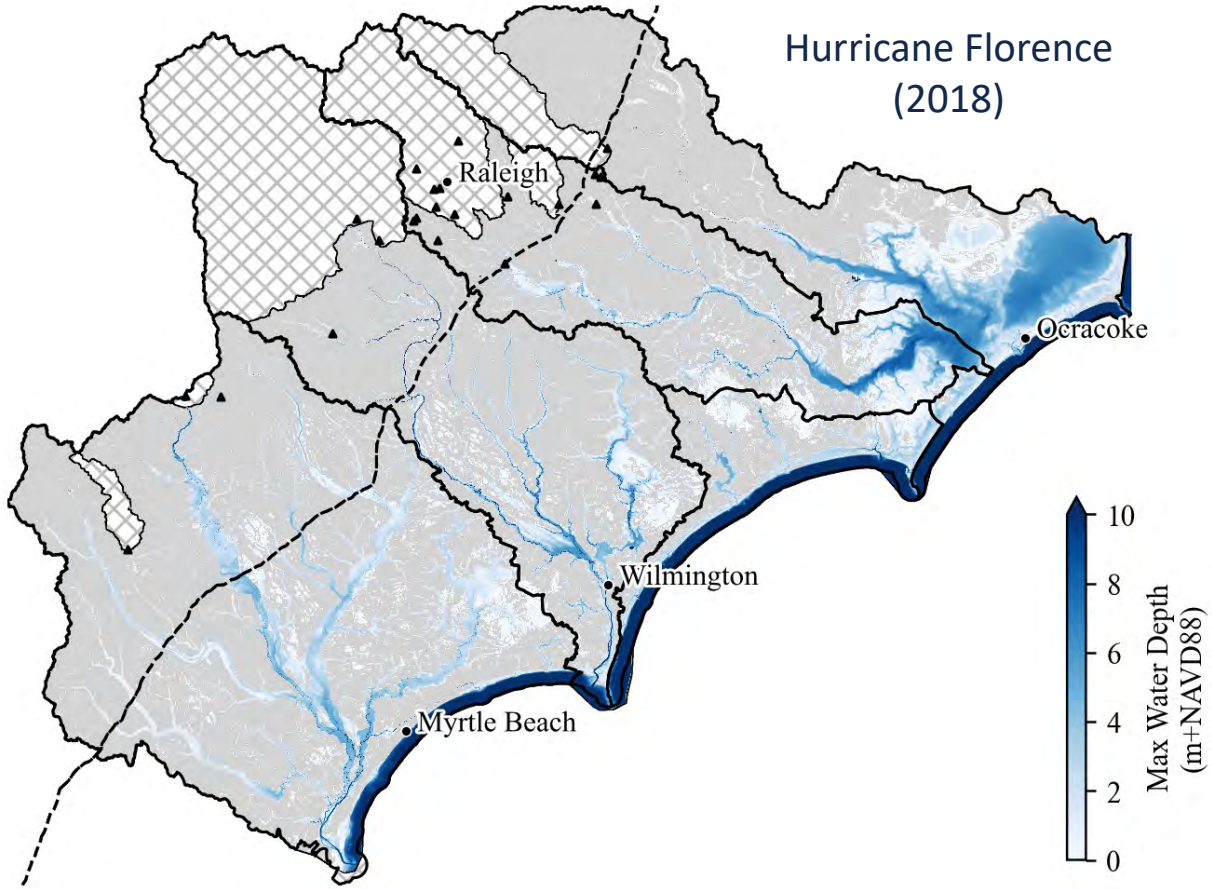
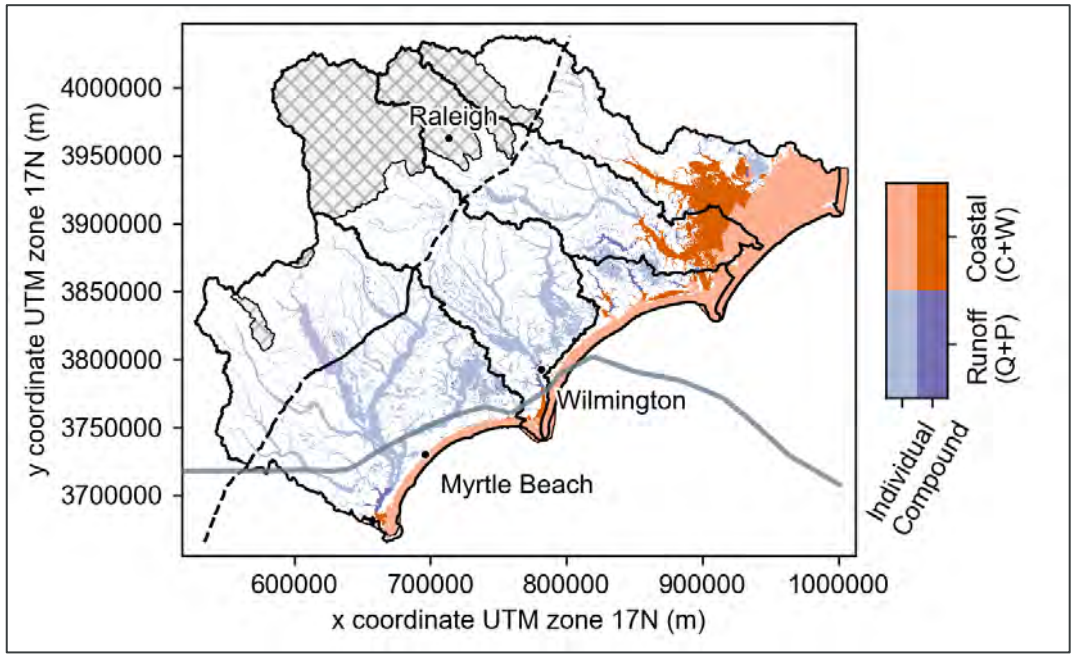
Building physics-based models capable of representing multiple flood drivers

Lauren Grimley,
PhD Student





How are the interactions between compound flood mechanisms changing as a function of anthropogenic processes and what does this mean for future flood risk?

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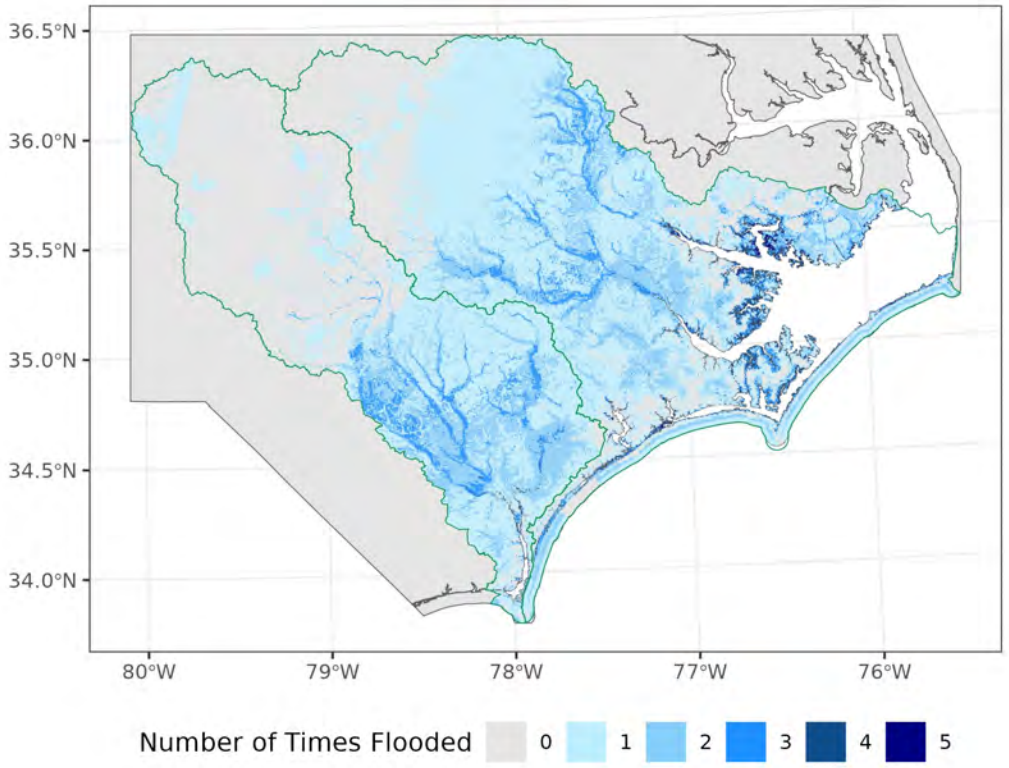
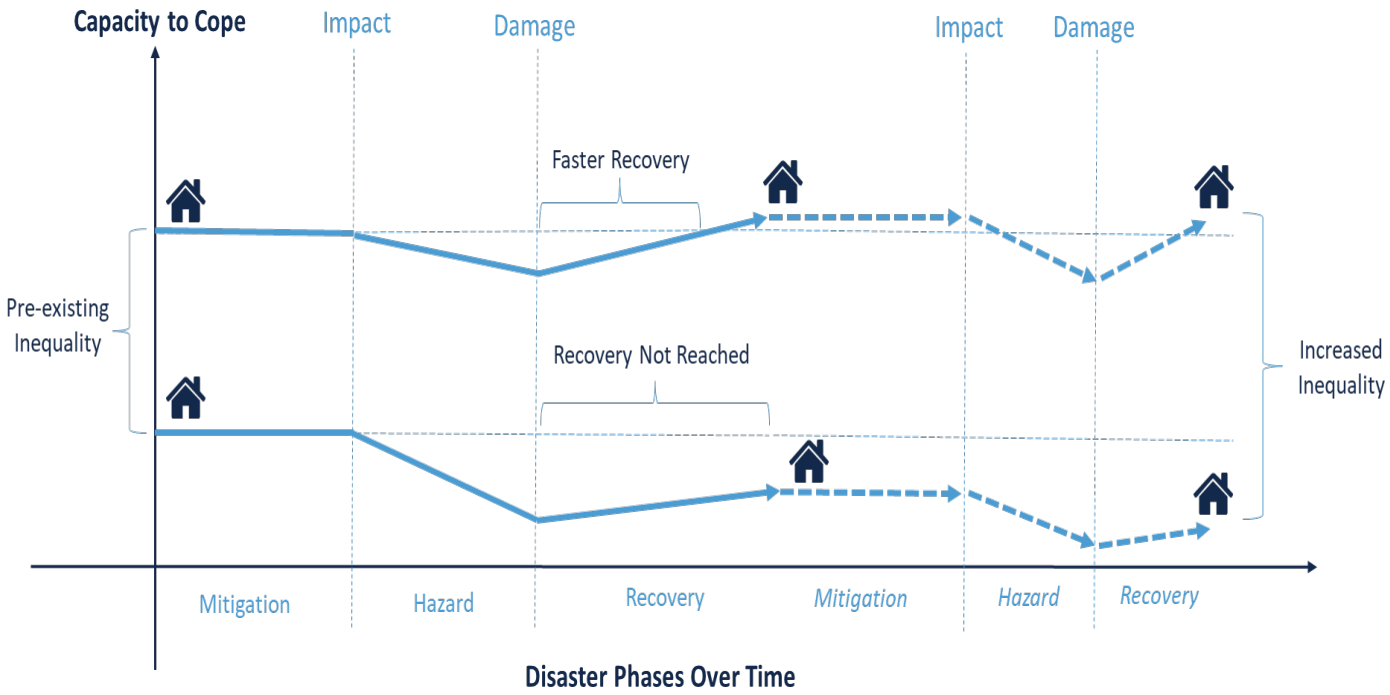
Creating a database of historical flood events across North Carolina to map repeat exposures

Helena Garcia,
PhD Student



Number of times flooded across
10 Tropical Cyclones (1990-2020)



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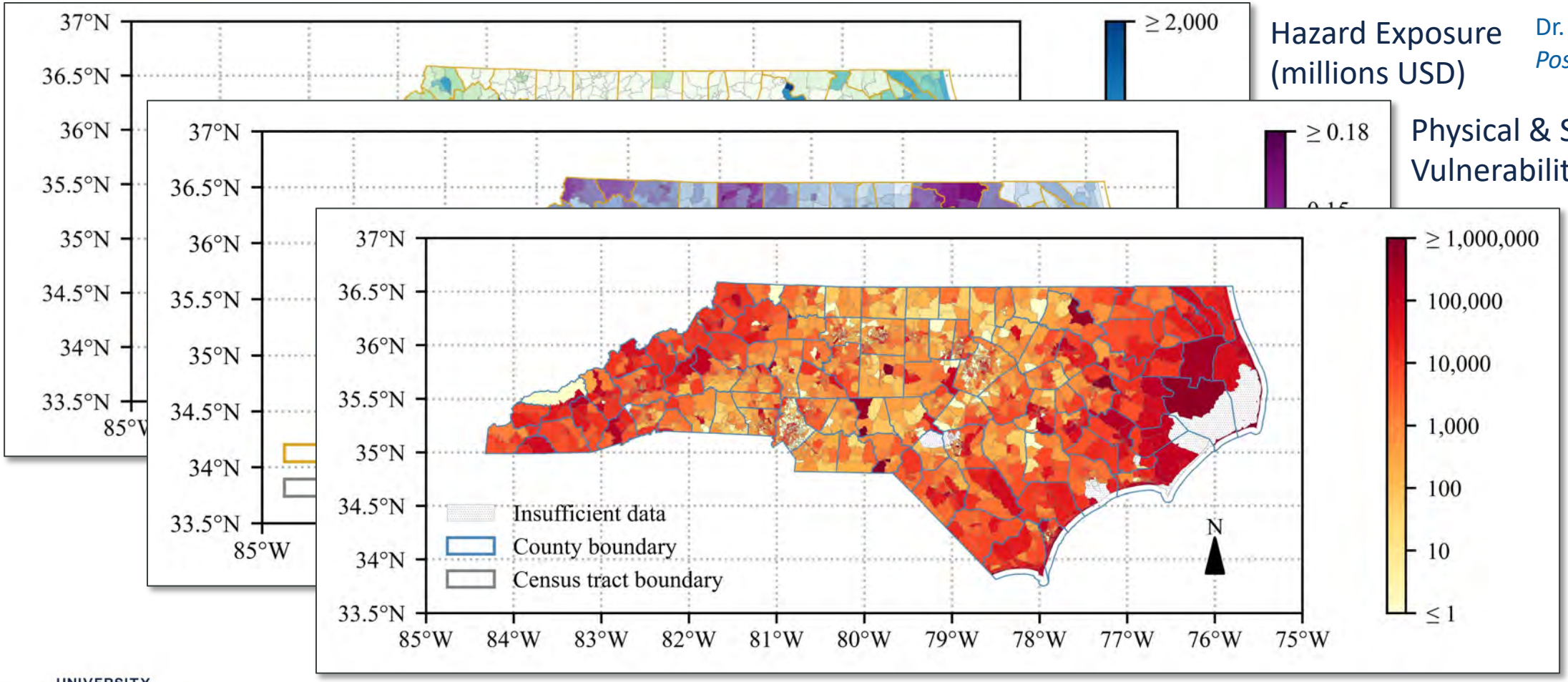
Identifying potential hotspots of uninsured damage

Dr. Victor Wang, *Postdoc*



Wang & Sebastian, *JFRM* 2021

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Thank you!

Contact Antonia Sebastian at asebastian@unc.edu

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Greg Characklis

William R. Kenan Jr. Distinguished Professor, Department of Environmental Sciences and Engineering; Director, Center on Financial Risk in Environmental Systems

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Flooding and Financial Risk

Greg Characklis

W. R. Kenan, Jr. Distinguished Professor

Dept. of Environmental Science and Engineering
&
Center on Financial Risk in Environmental Systems
Gillings School of Global Public Health
UNC Institute for the Environment

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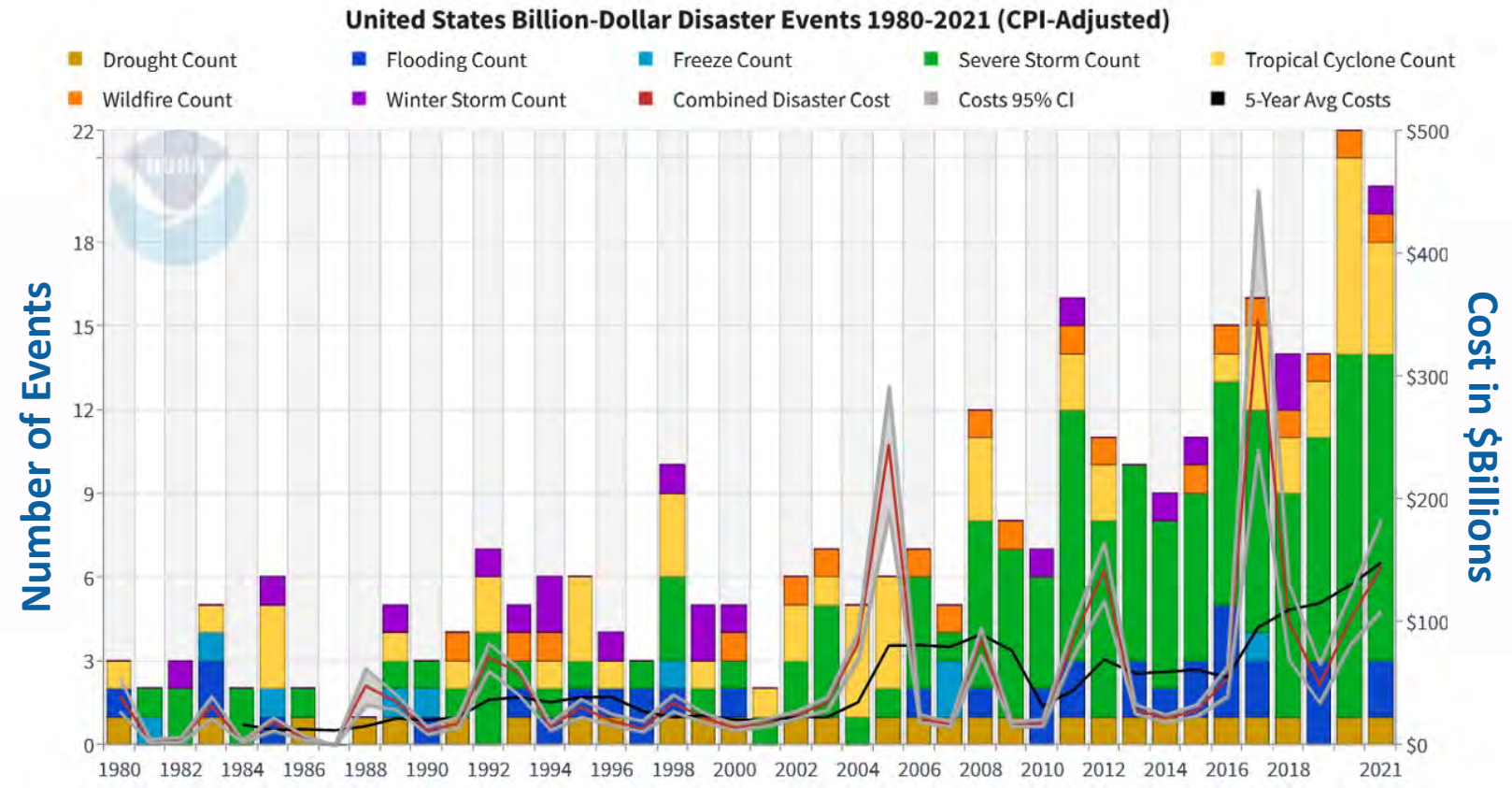
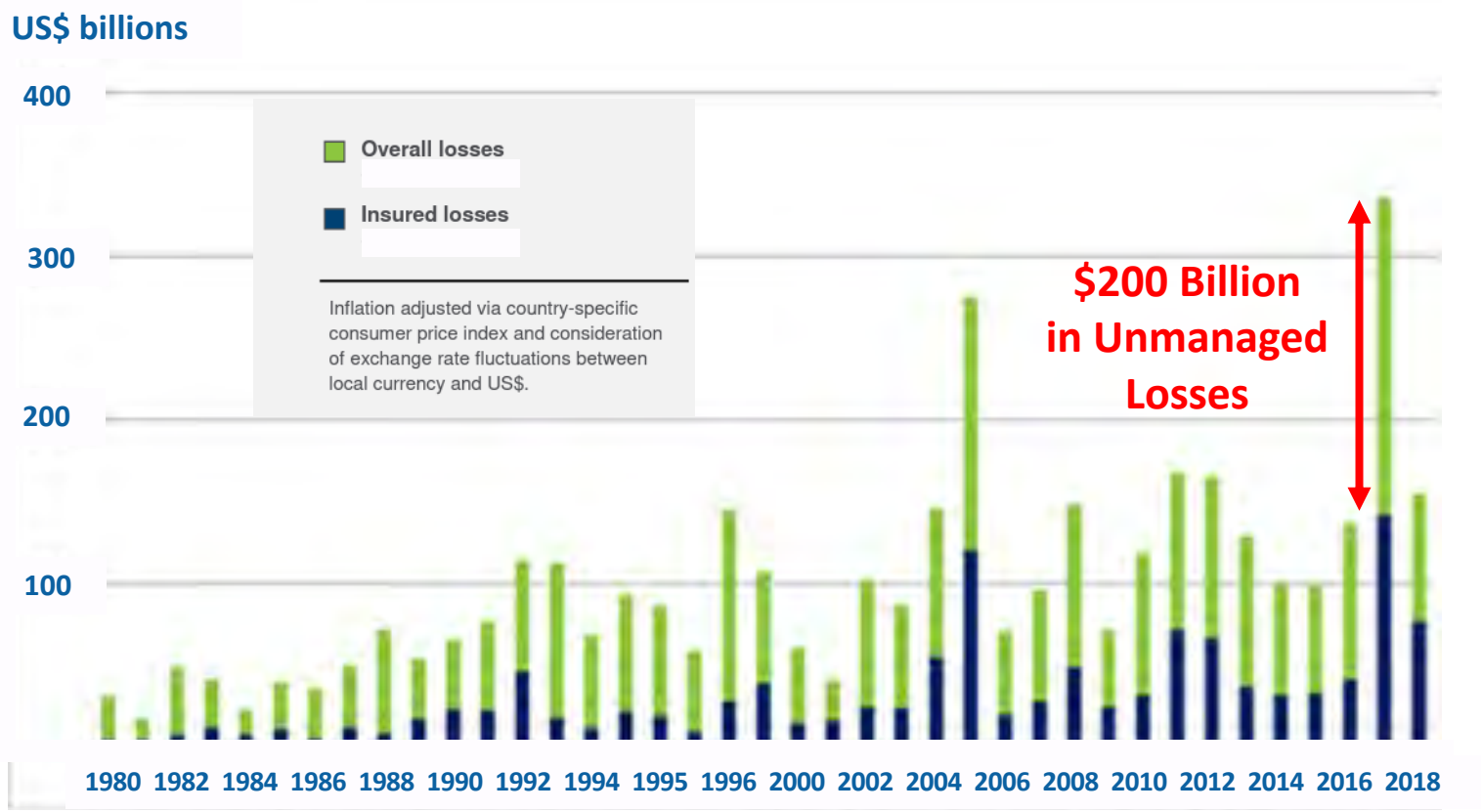
Environmental financial risks are growing



- Environmental events represent a risk to many sectors and activities
- Risks/Losses growing with increasing natural variability

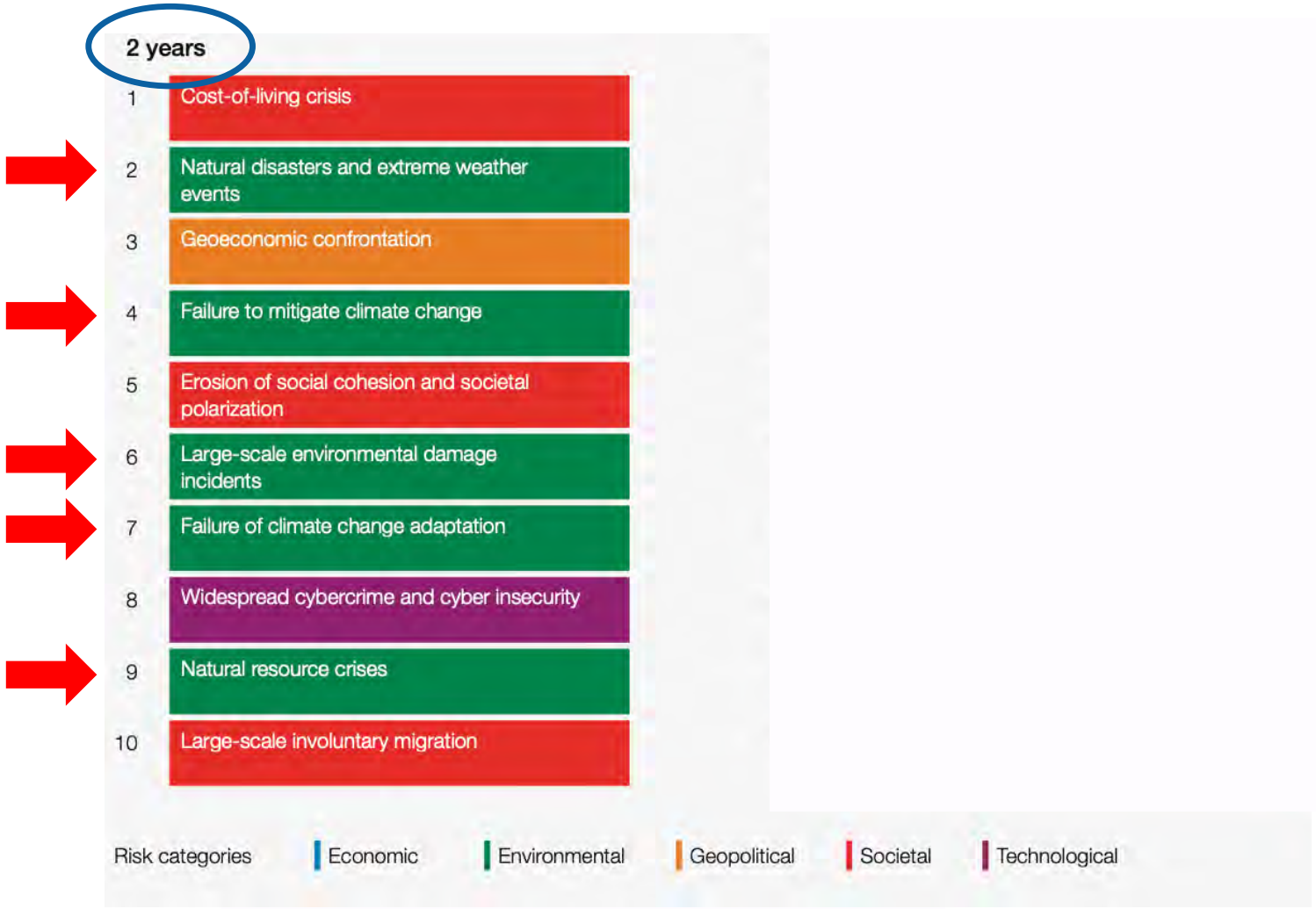
Unmanaged portion of risk is also growing



- Gap between insured and uninsured natural hazard losses is growing
- Suggests the need for improved strategies and tools for limiting losses

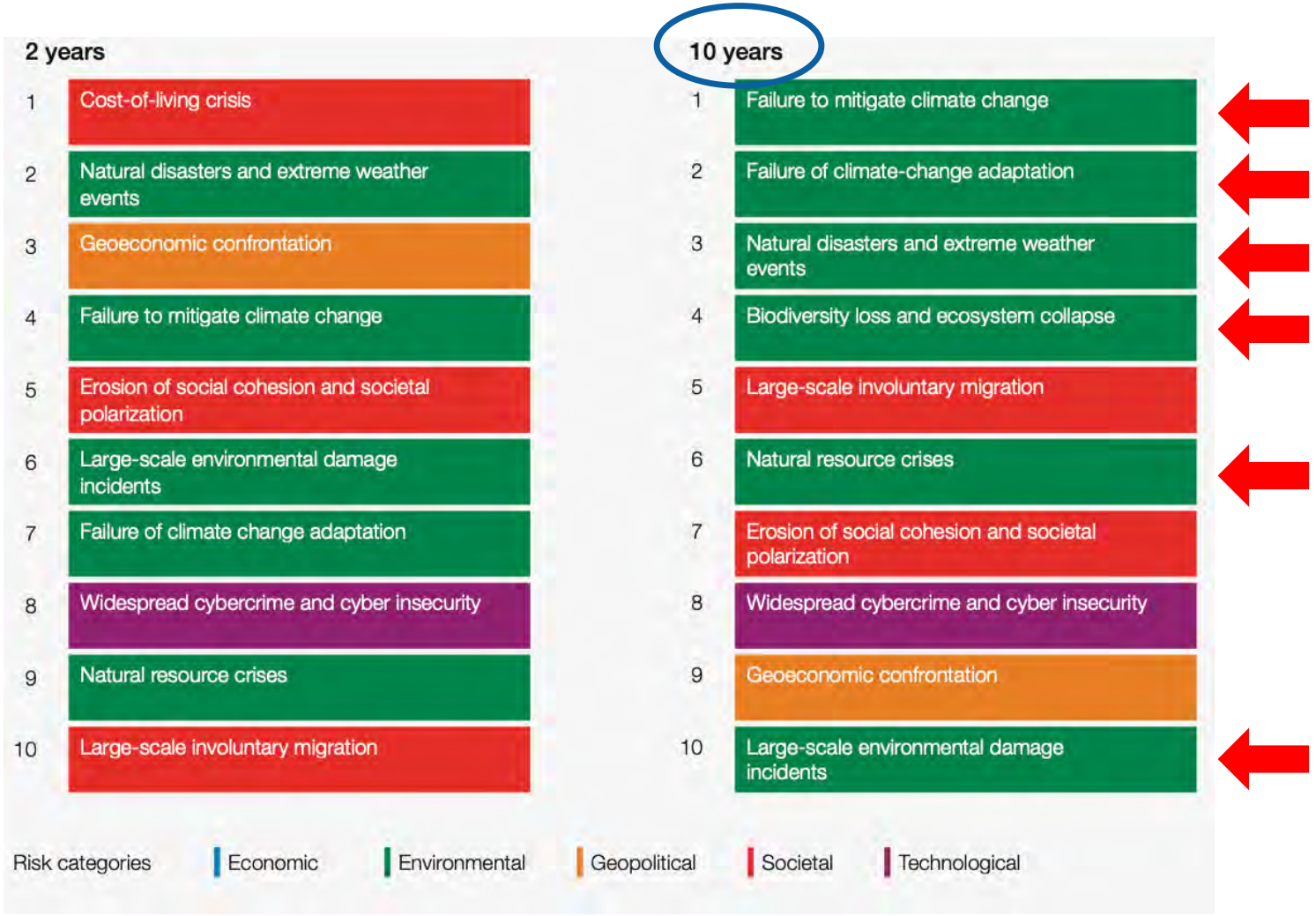
Source: 2018 Munich Re Geo Risks Research

2023 Ranking of Global Risks



Source: World Economic Forum, Global Risks 2023

2023 Ranking of Global Risks

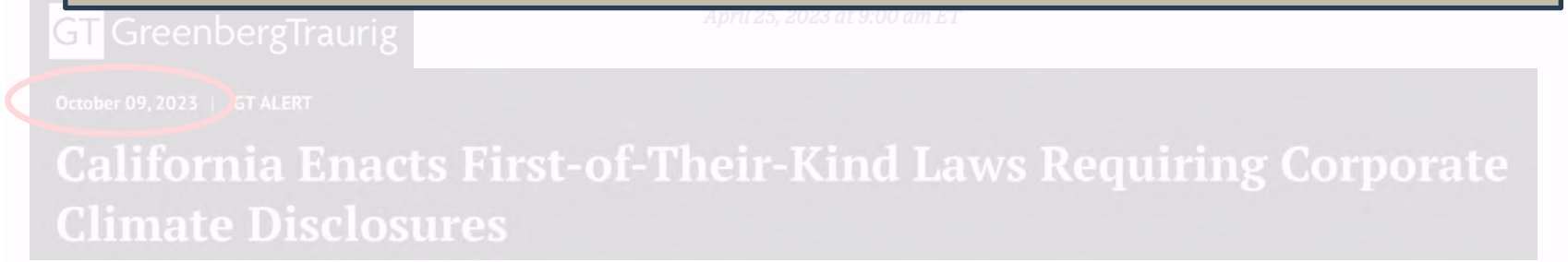


Source: World Economic Forum, Global Risks 2023

Attention to these risks has grown recently

However, the existing disclosure regime has not resulted in disclosures of a scope, breadth, and quality to be sufficiently useful to market participants and regulators

- MANAGING CLIMATE RISK IN THE U.S. FINANCIAL SYSTEM
Market Risk Advisory Committee
U.S. Commodity Futures Trading Commission



Opportunities for both quantifying and managing these risks

FT FINANCIAL TIMES

Boom times for modellers of climate change

Extreme weather events and mandatory disclosure rules for companies spur demand for risk assessments

John Dizard AUGUST 14 2021

Wildfire in Greece on August 9. A recent IPCC report warned that temperatures would continue to rise until at least 2050 and lead to further extreme weather events © AFP via Getty Images

- "Weather (financial) risks" => assumes stationary climate
- "Climate (financial) risks" => uncertainty about non-stationary weather risks
- "Environmental financial risks" => weather + climate + other (e.g., COVID)

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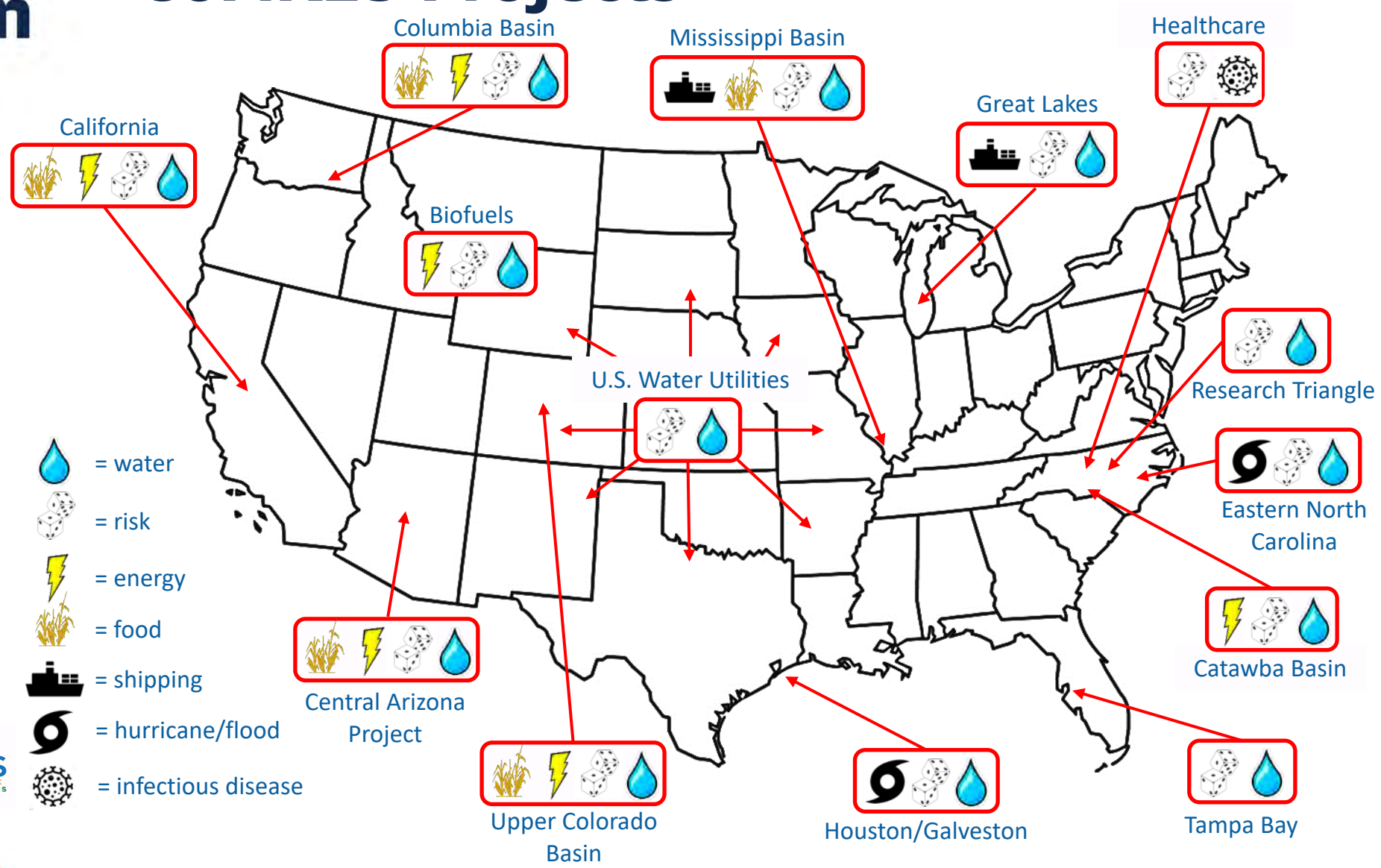
CoFiRES Projects



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Flooding and financial risk in the housing market

The New York Times

Climate Risk in the Housing Market Has Echoes of Subprime Crisis, Study Finds

WASHINGTON — Banks are shielding themselves from climate change at taxpayers' expense by shifting riskier mortgages — such as those in coastal areas — off their books and over to the federal government, new research suggests.

Bloomberg

When Climate Change Leads to Mortgage Defaults

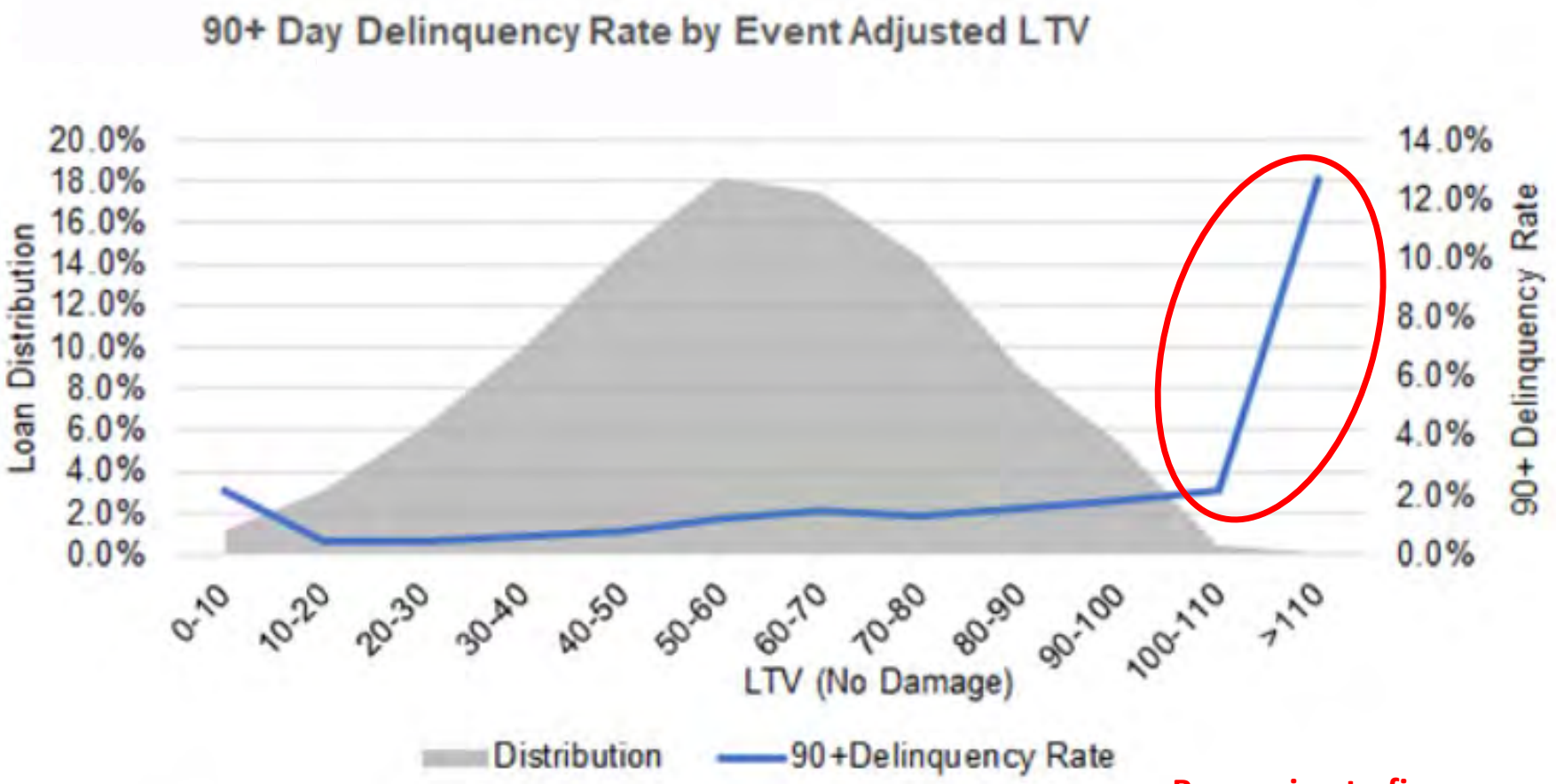
Milliman

Unpriced costs of flooding: An emerging risk for homeowners and lenders

By David D. Evans, Leighton A. Hunley, and Brandon Katz (KatRisk LLC)

28 January 2022

Probability of default can be impacted by flooding



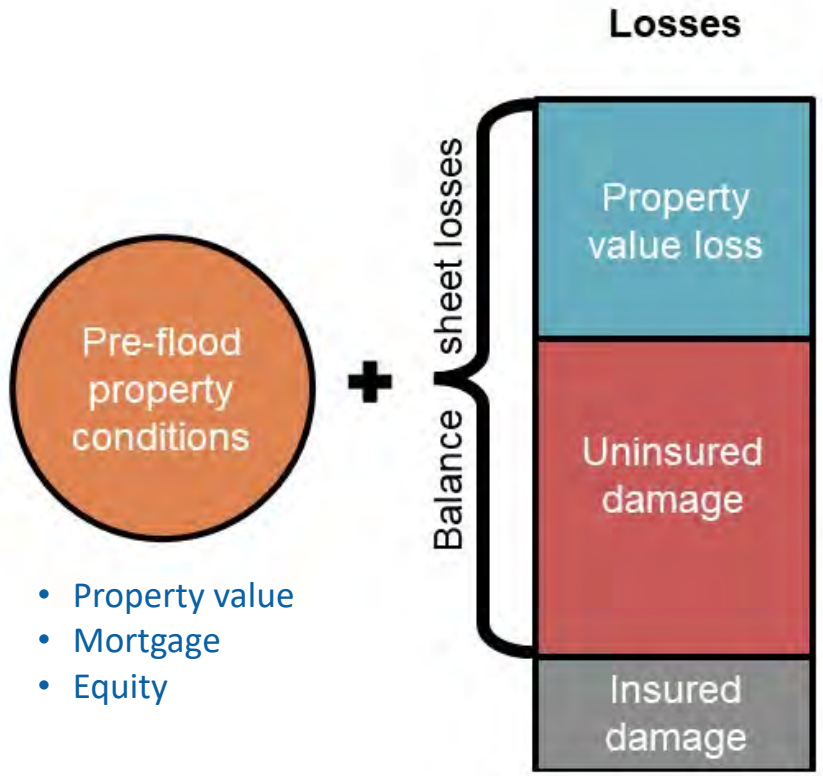
Loan-to-Value (LTV) Ratio = $\dfrac{\text{Loan/Mortgage Balance}}{\text{Property Value}}$ **x 100**

Borrowing to finance flood repairs raises debt

Flooding often depresses property value

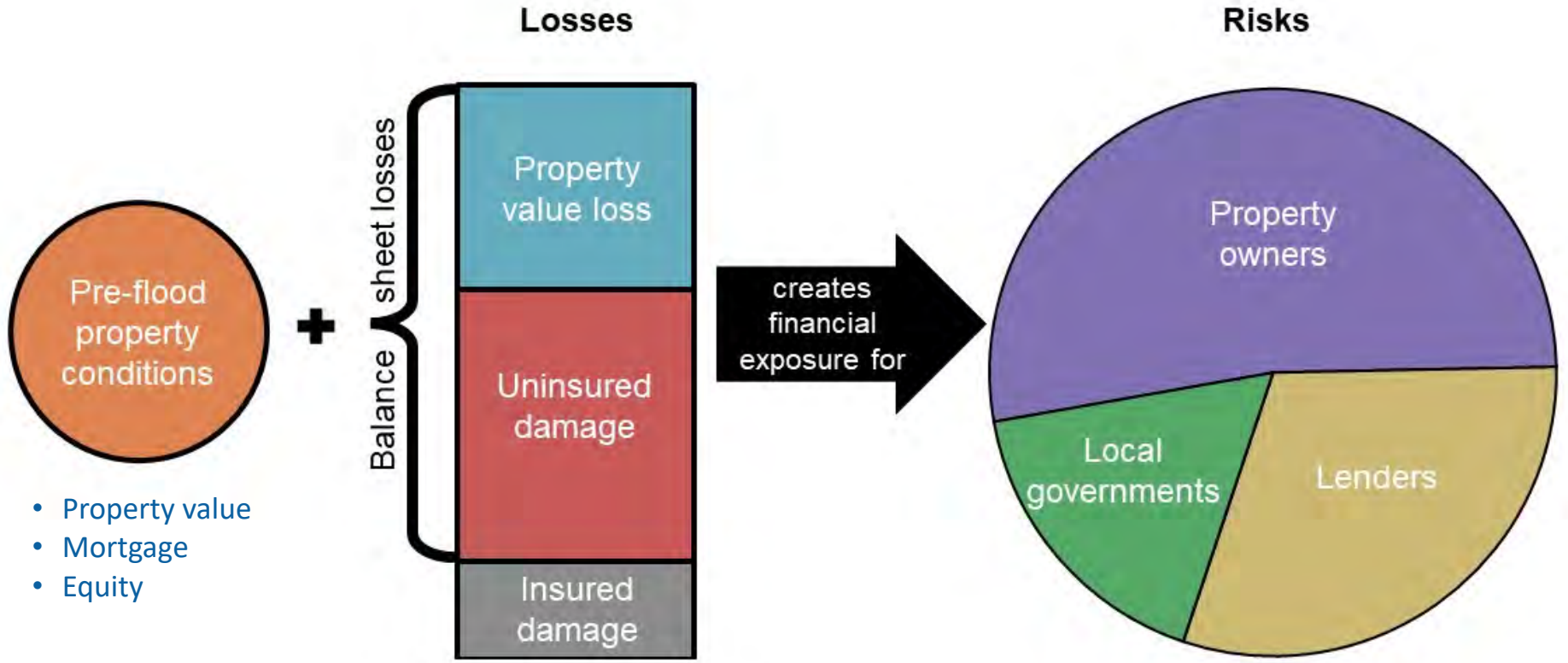
Source: CoreLogic: The Impact of Natural Disasters on Mortgage Delinquency. Amy Gromowski, https://www.corelogic.com/blog/2018/09/the-impact-of-natural-catastrophe-on-mortgage-delinquency.aspx

Pre-flood financial conditions and losses lead to risk



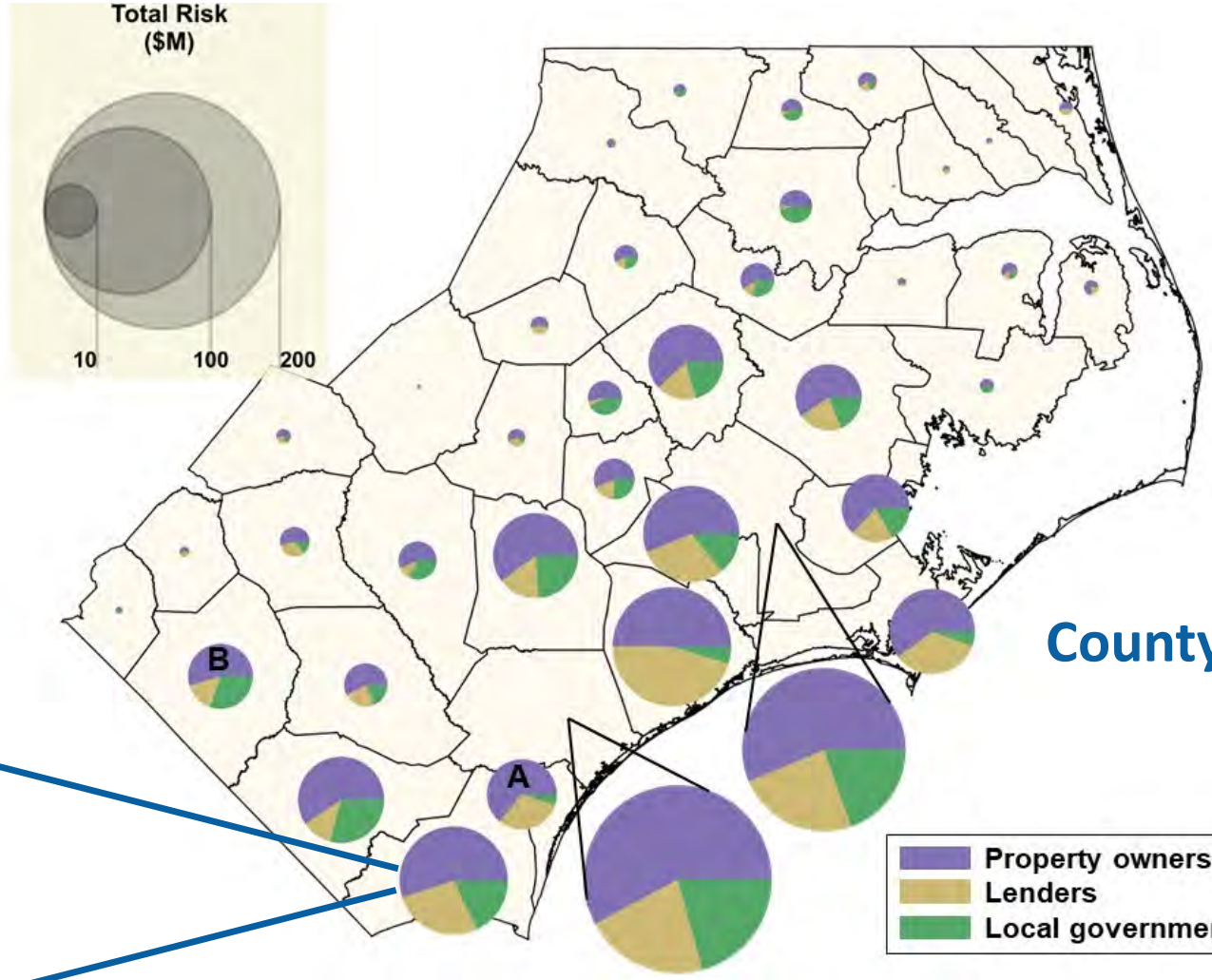
- Property value
- Mortgage
- Equity

Pre-flood financial conditions and losses lead to risk



- Property value
- Mortgage
- Equity

Distribution of risk evaluated at multiple scales

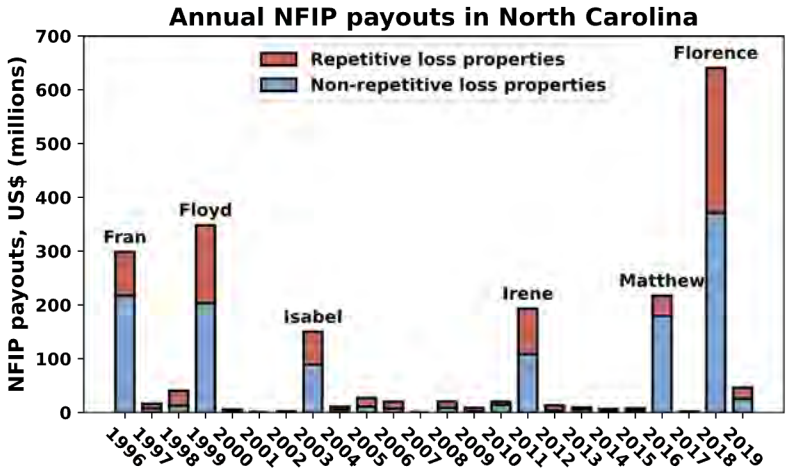


Parcel scale

County scale

Cumulative impacts of multiple storms

1. Identify major past flood events



Cumulative impacts of multiple storms

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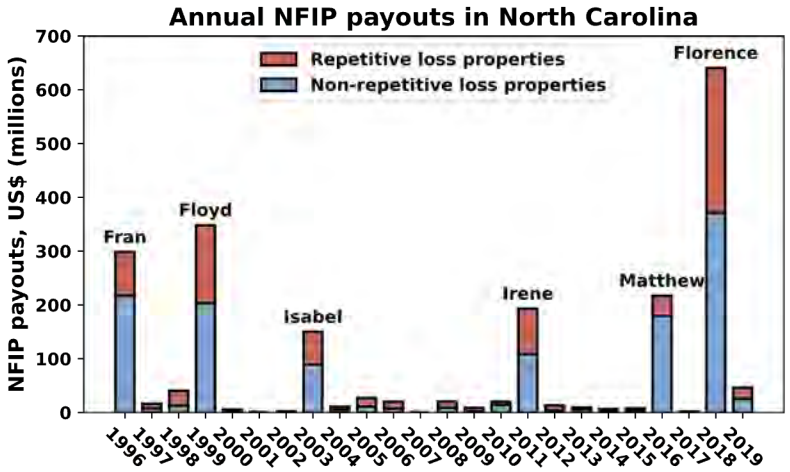
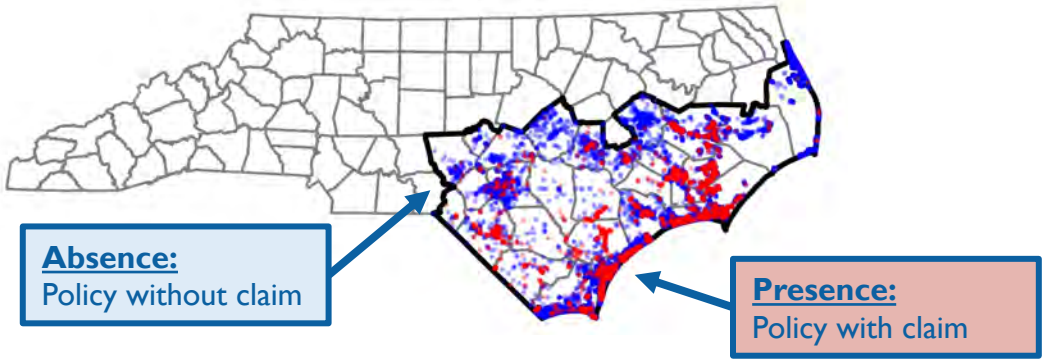


2. Extract flood damage locations from NFIP claim and policy data



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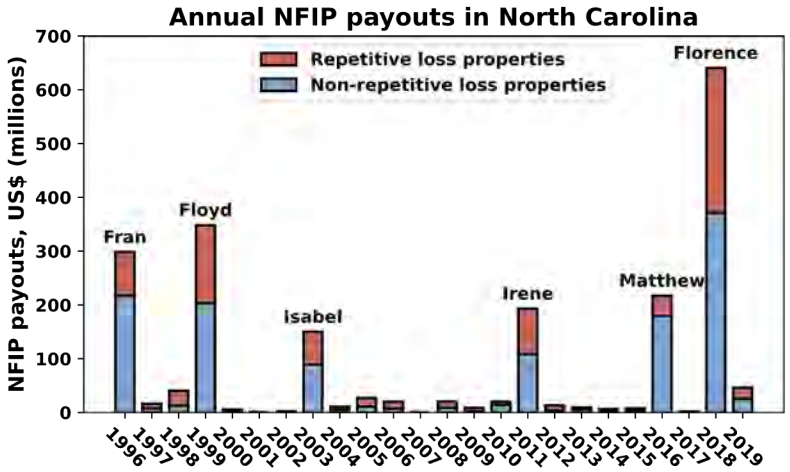

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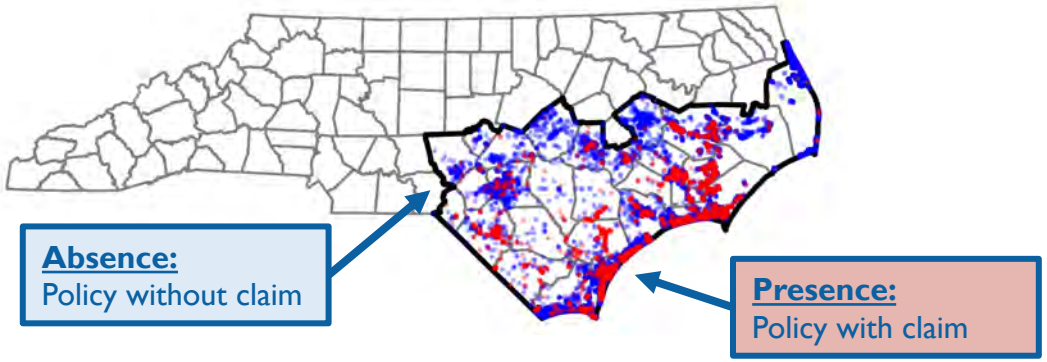
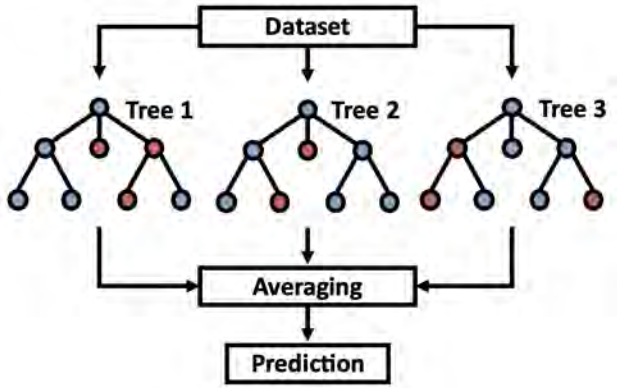


Absence:
Policy without claim

Presence:
Policy with claim

3. Train random forest model



Predictors:
HUC6
Elevation
HAND
Dist. to rivers
Dist. to coast
Imperviousness
SFHA

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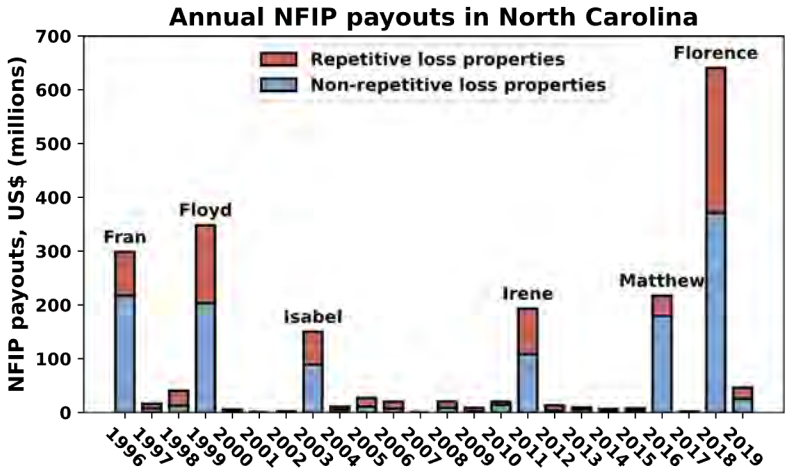
Cumulative impacts of multiple storms

1. Identify major past flood events



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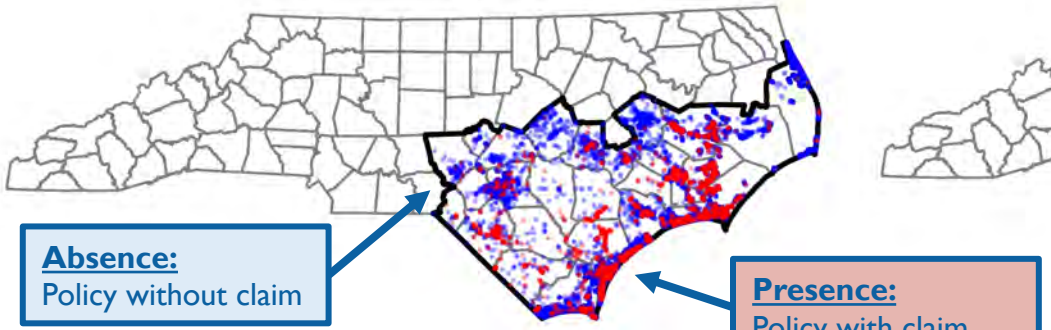

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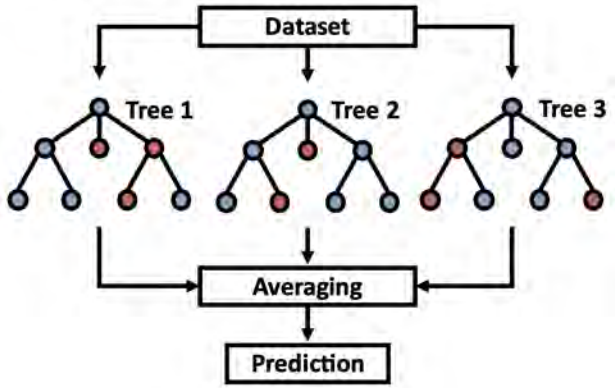
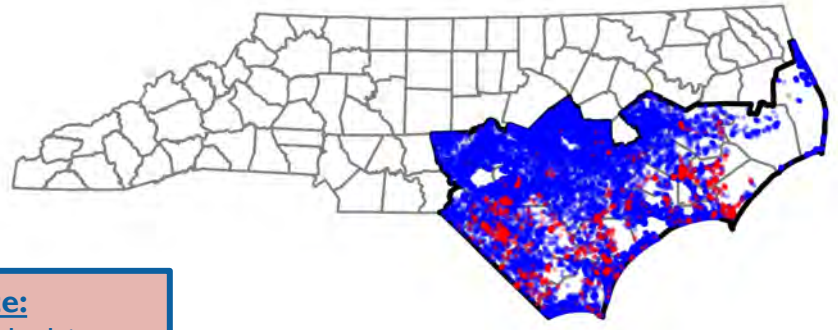


Predictors:
HUC6
Elevation
HAND
Dist. to rivers
Dist. to coast
Imperviousness
SFHA

4. Predict flood damage among uninsured households



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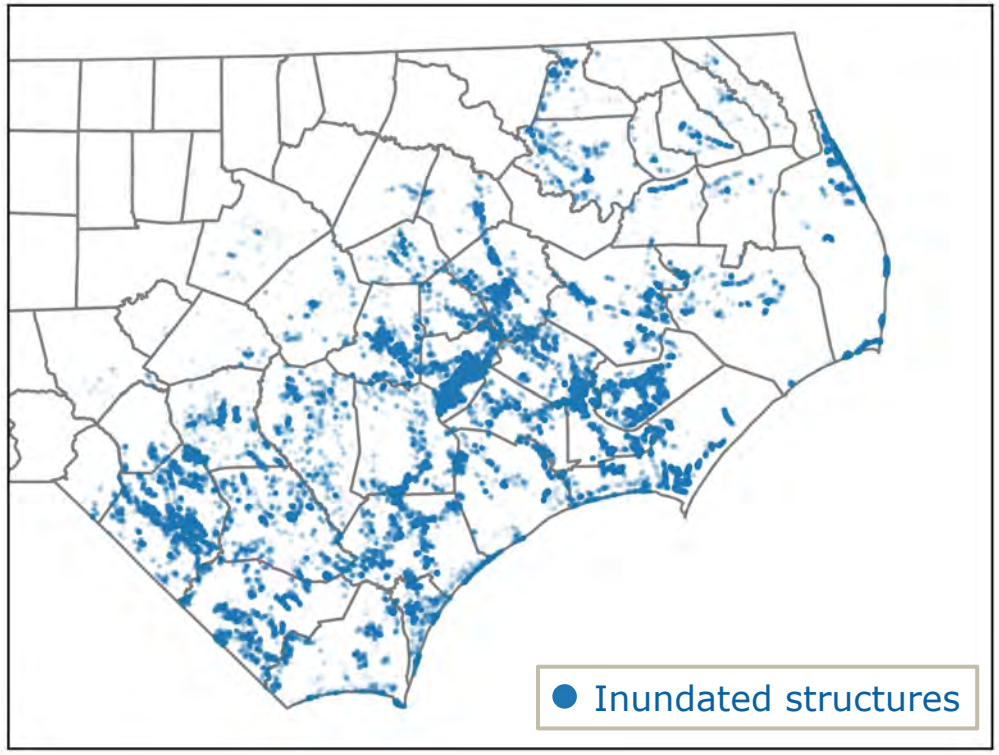
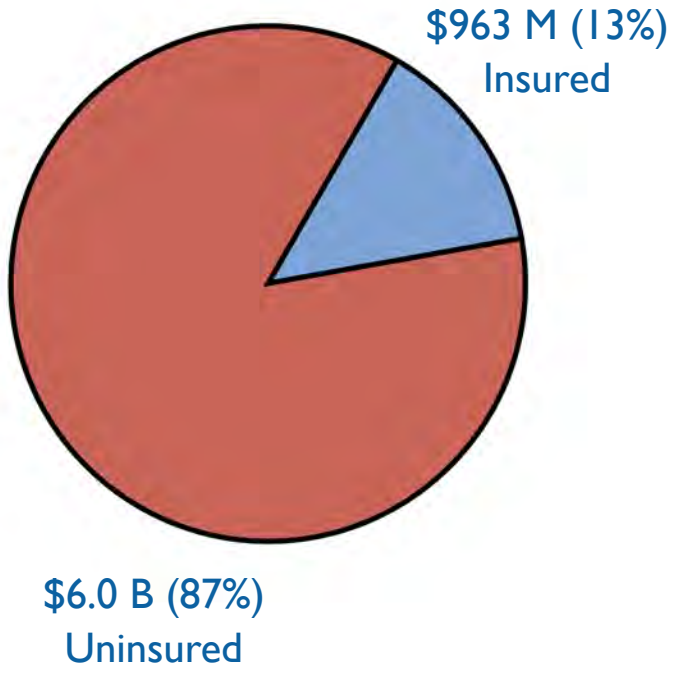
Cumulative impacts of multiple storms

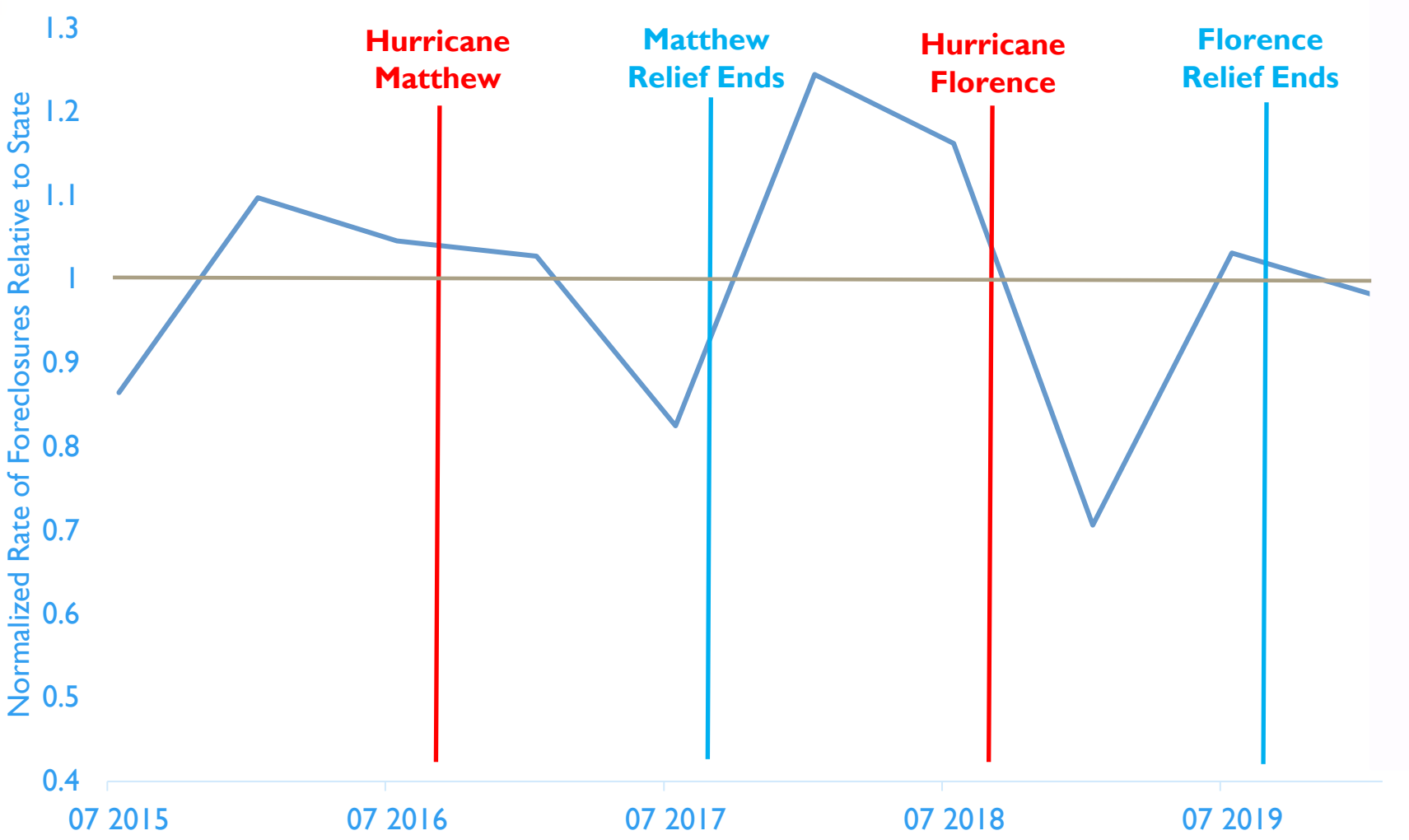
Structures flooded at least once



Total cost: $6.9 B



New direction: Impact of financial aid on foreclosures



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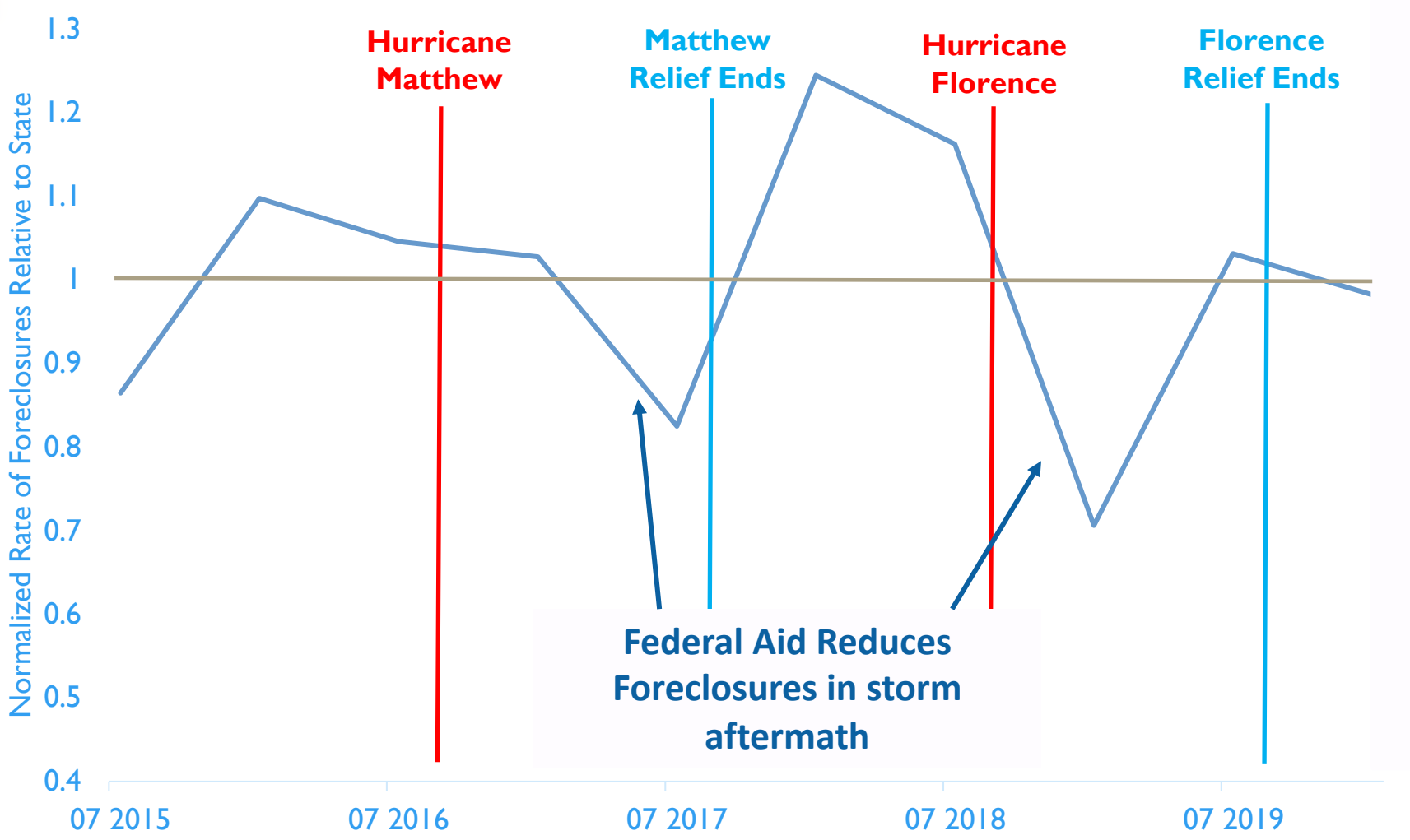

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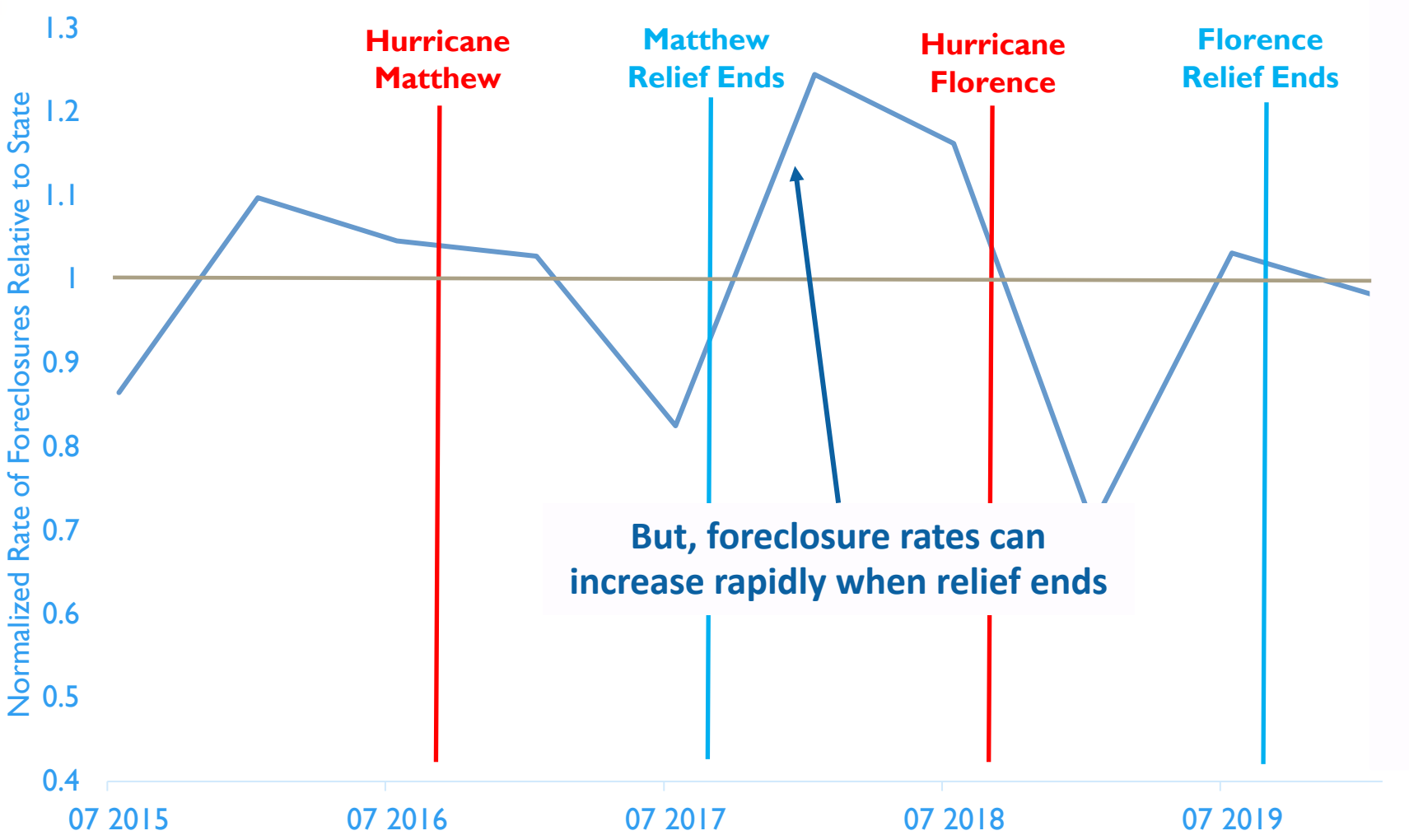

Risks in secondary markets: RMBS and CMBS

We believe there is the potential for unpriced or mispriced flood risk in both these markets

Residential MBS (RMBS)

- $7.7 trillion market
- Mostly issued by Fannie Mae, Freddie Mac, and Ginnie Mae (GSEs)
- Principal and interest guaranteed: GSEs bear the cost of defaults

Commercial MBS (CMBS)

- $1.5 trillion market
- Often issued by investment banks (e.g., Wells Fargo, Morgan Stanley)
- No guarantee: investors bear the cost of defaults

Fuster, Andreas, et al. Mortgage-Backed Securities. Federal Reserve Bank of New York (2022). https://www.newyorkfed.org/medialibrary/media/research/staff_reports/sr1001.pdf.

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Thanks from CoFiRES!

Flooding Research supported by:

collaboratory science. policy. solutions.

UNC INSTITUTE FOR THE ENVIRONMENT

TEXAS A&M UNIVERSITY Superfund Research Center

CoFiRES CENTER ON FINANCIAL RISK IN ENVIRONMENTAL SYSTEMS

UNIVERSITY Research WEEK

UNC RESEARCH

Lunch & Learn

Thank you!

Contact Greg Characklis at charack@email.unc.edu

Lunch & Learn

Mike Piehler

Professor and Director, UNC Institute for the Environment; Chief Sustainability Officer and Special Assistant to the the Chancellor, Sustainability

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Natural landscapes and flooding

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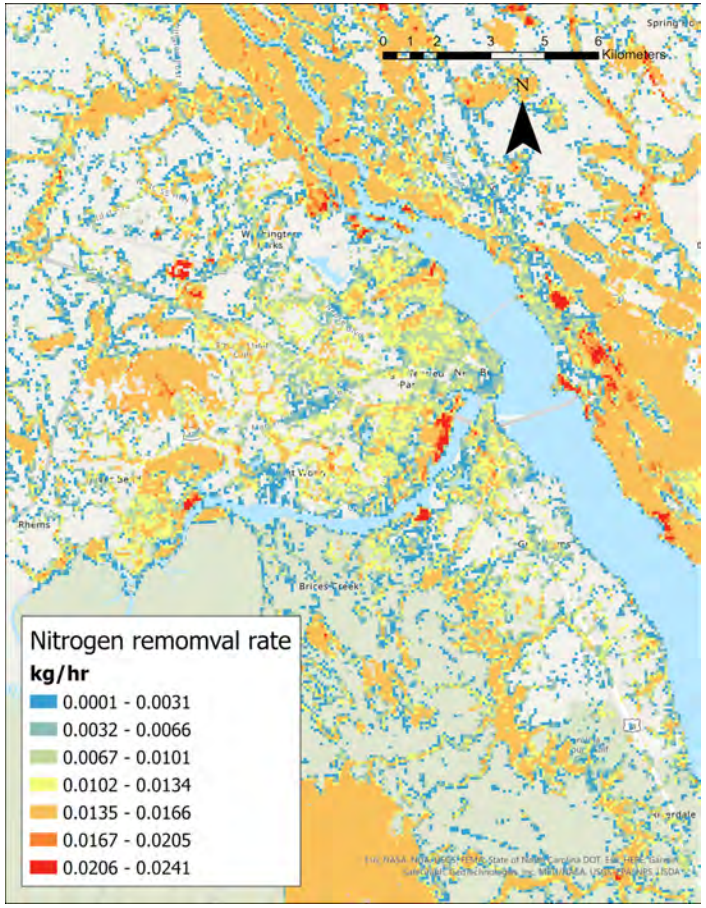
Measuring ecosystem services

N

Sediment core collection site

Water collection site

Esri, HERE, Garmin, SafeGraph, METI/NASA, USGS, EPA, NPS, USDA, Esri, NASA, NGA, USGS, Esri, HERE, Garmin, FAO, NOAA, USGS, EPA, Esri, USGS, NC CGIA, Earthstar



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Stormwater management

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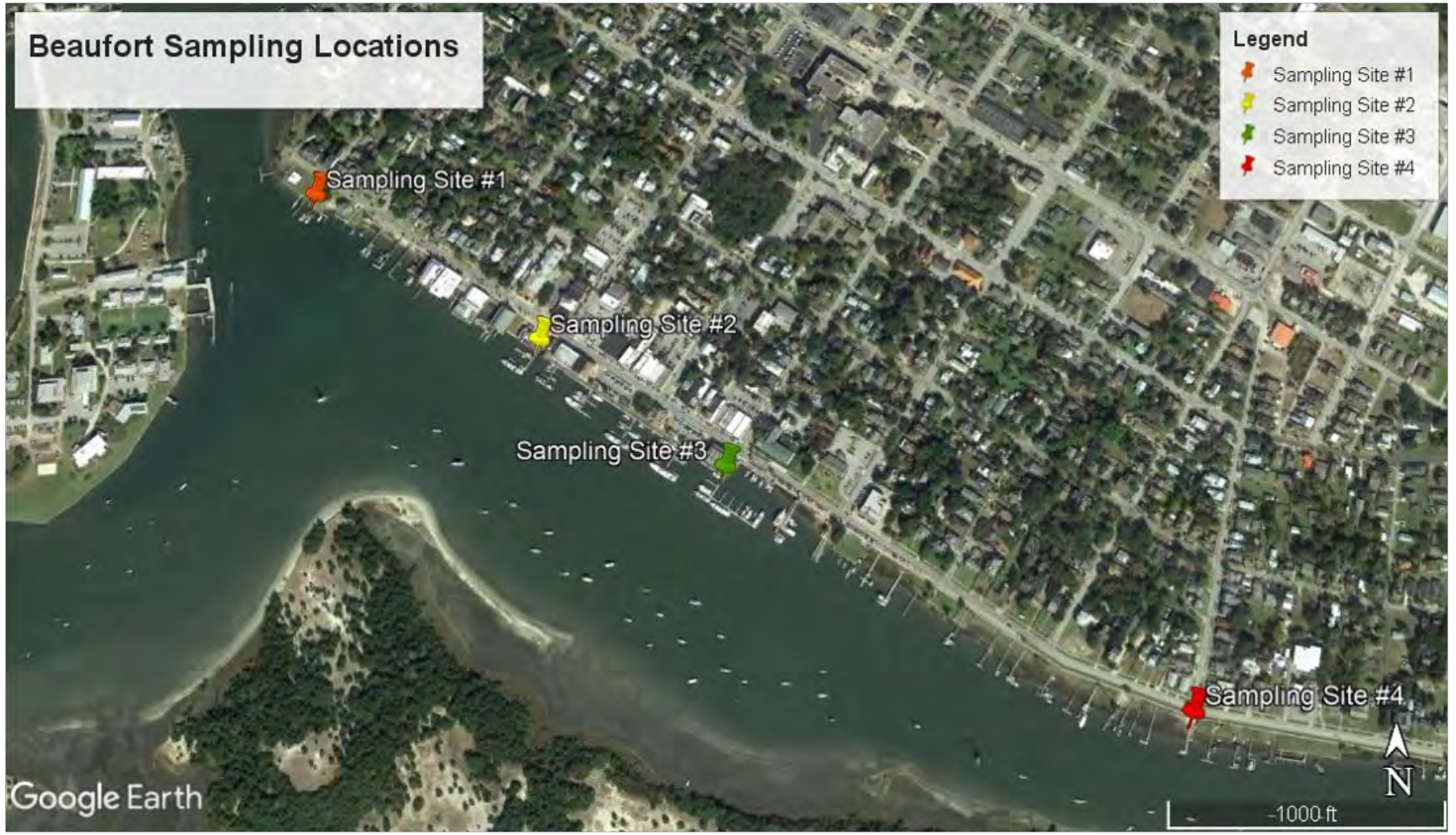
Stormwater control in the landscape

Storm drains and flooding



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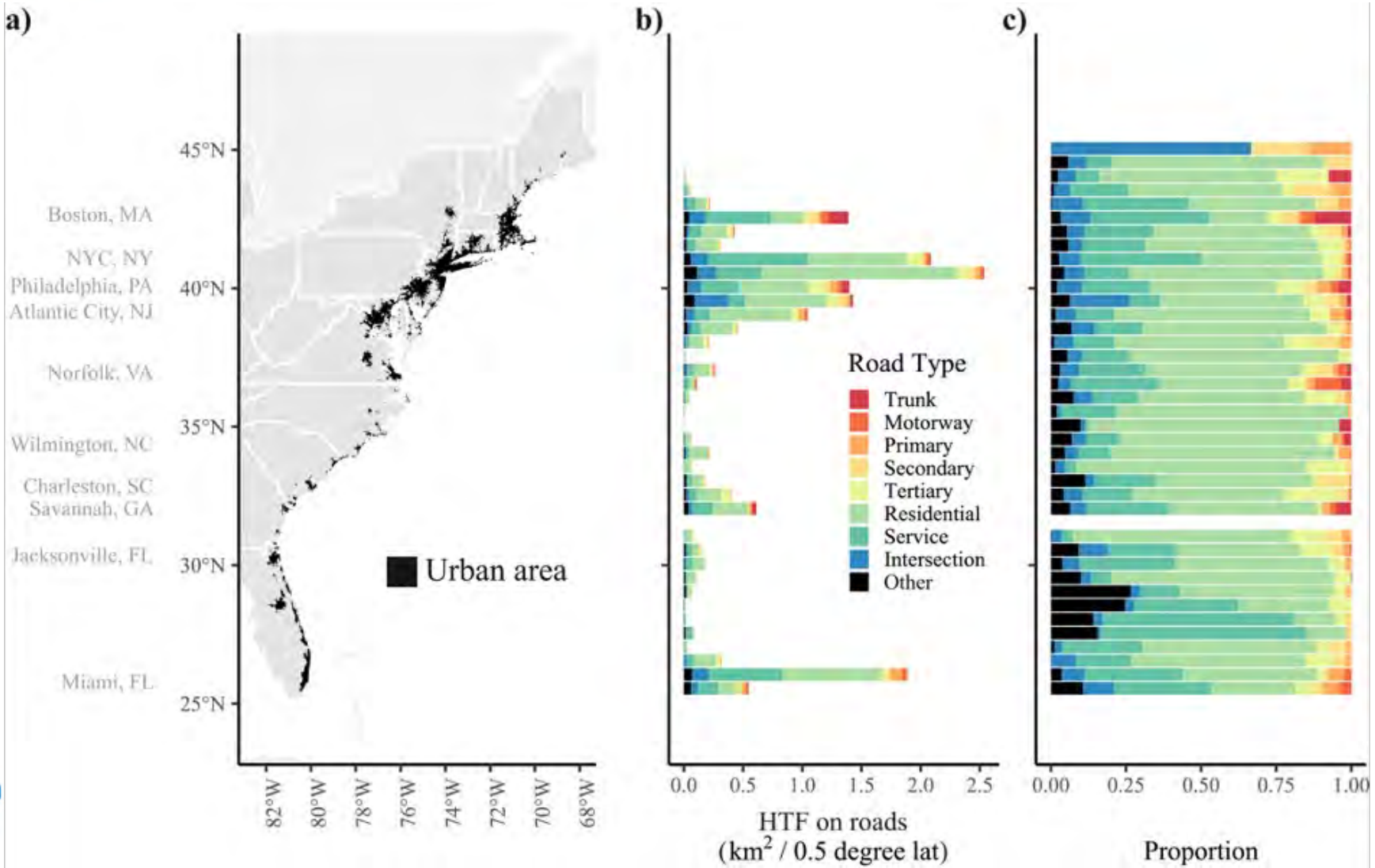

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Thank you!

Contact Mike Piehler at
mpiehler@email.unc.edu

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