



THE UNIVERSITY
of NORTH CAROLINA
at CHAPEL HILL

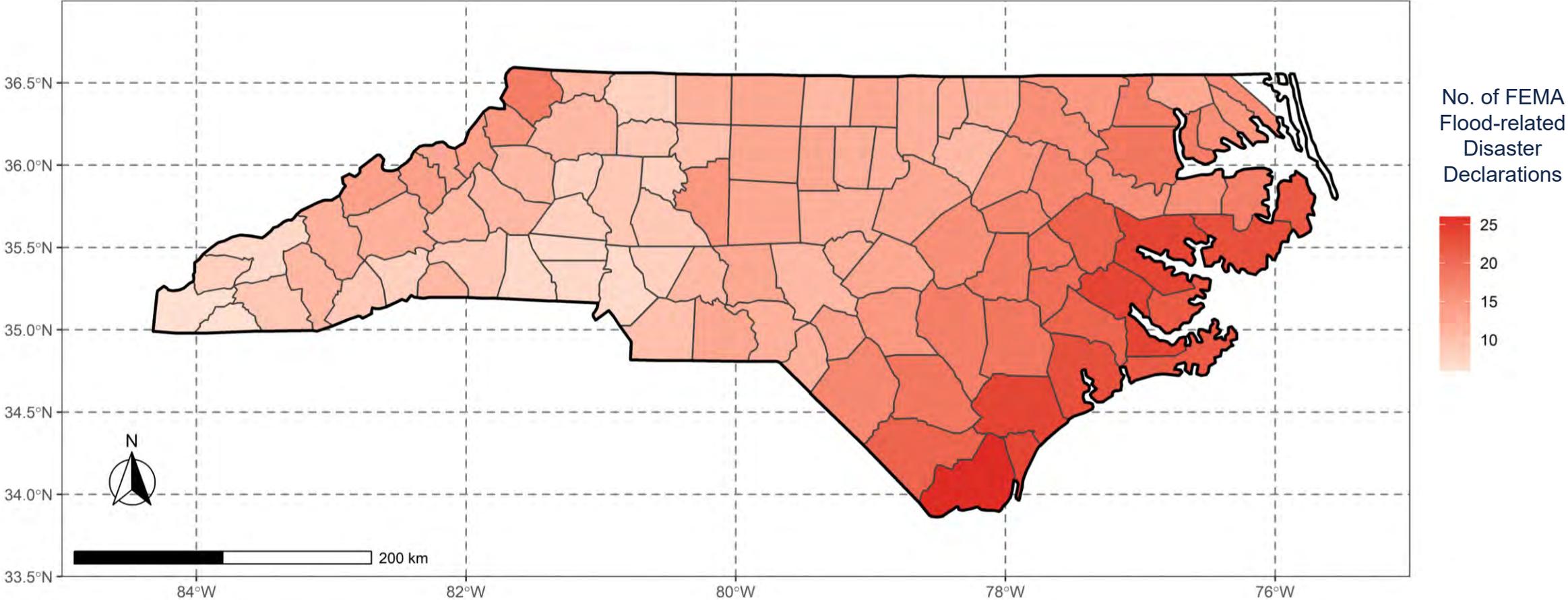
Recent Trends in Flood Hazards & Risk in North Carolina Watersheds

A Historical Perspective of the Drivers of Inland Flooding in North Carolina

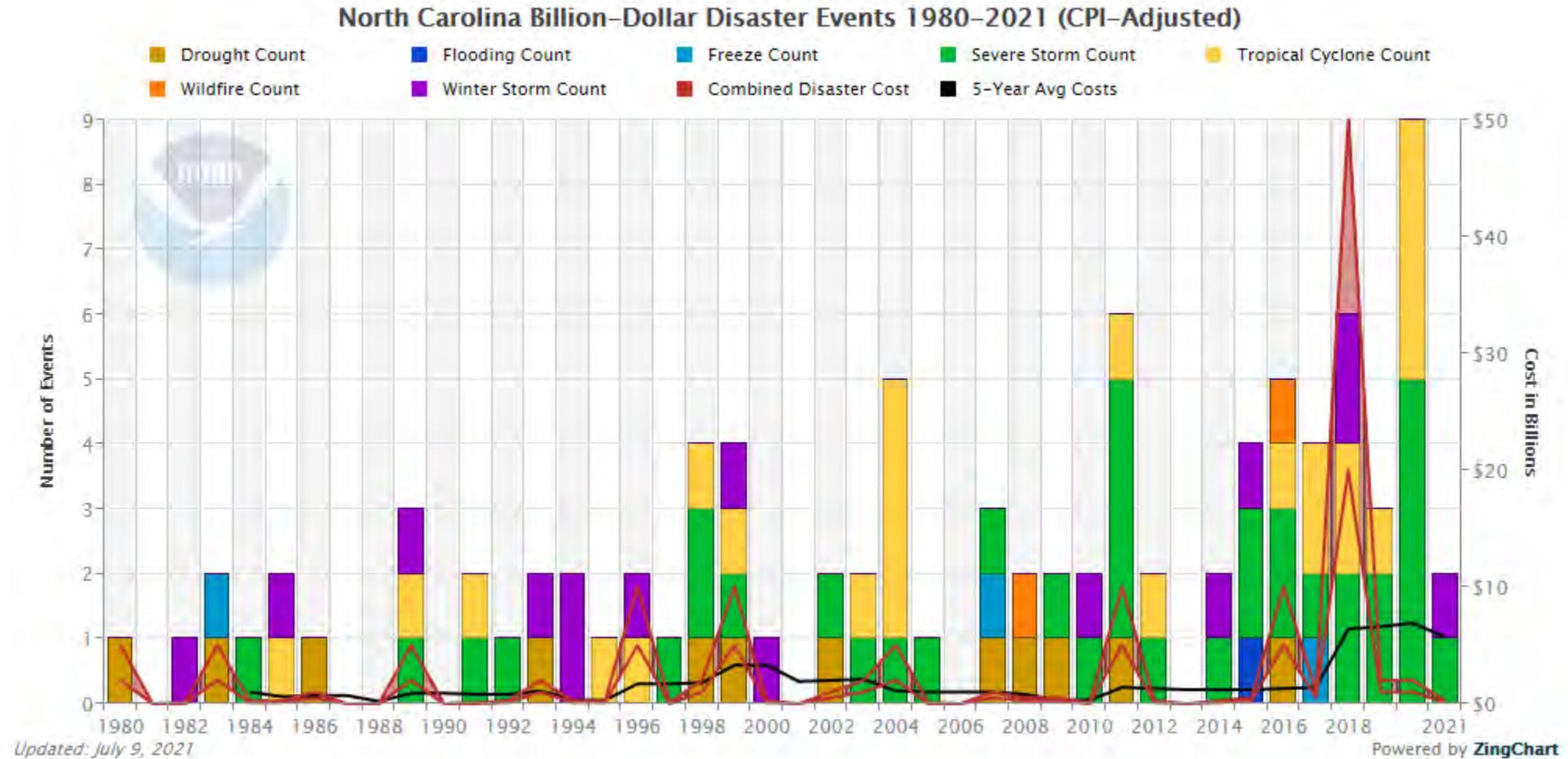
Dr. Antonia Sebastian, Assistant Professor

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

North Carolina is no stranger to devastating flood events

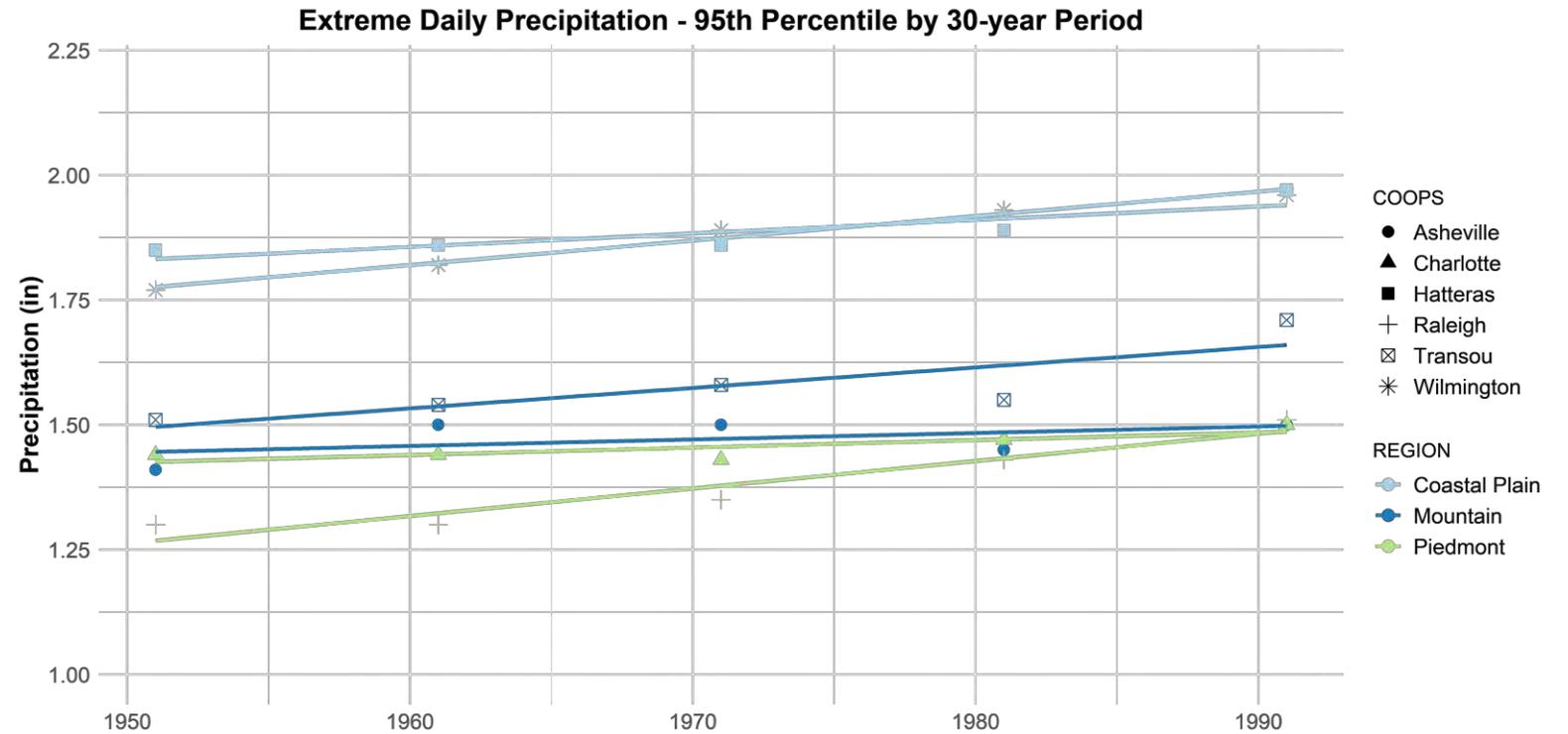


Damages from extreme events are increasing across NC, but why?

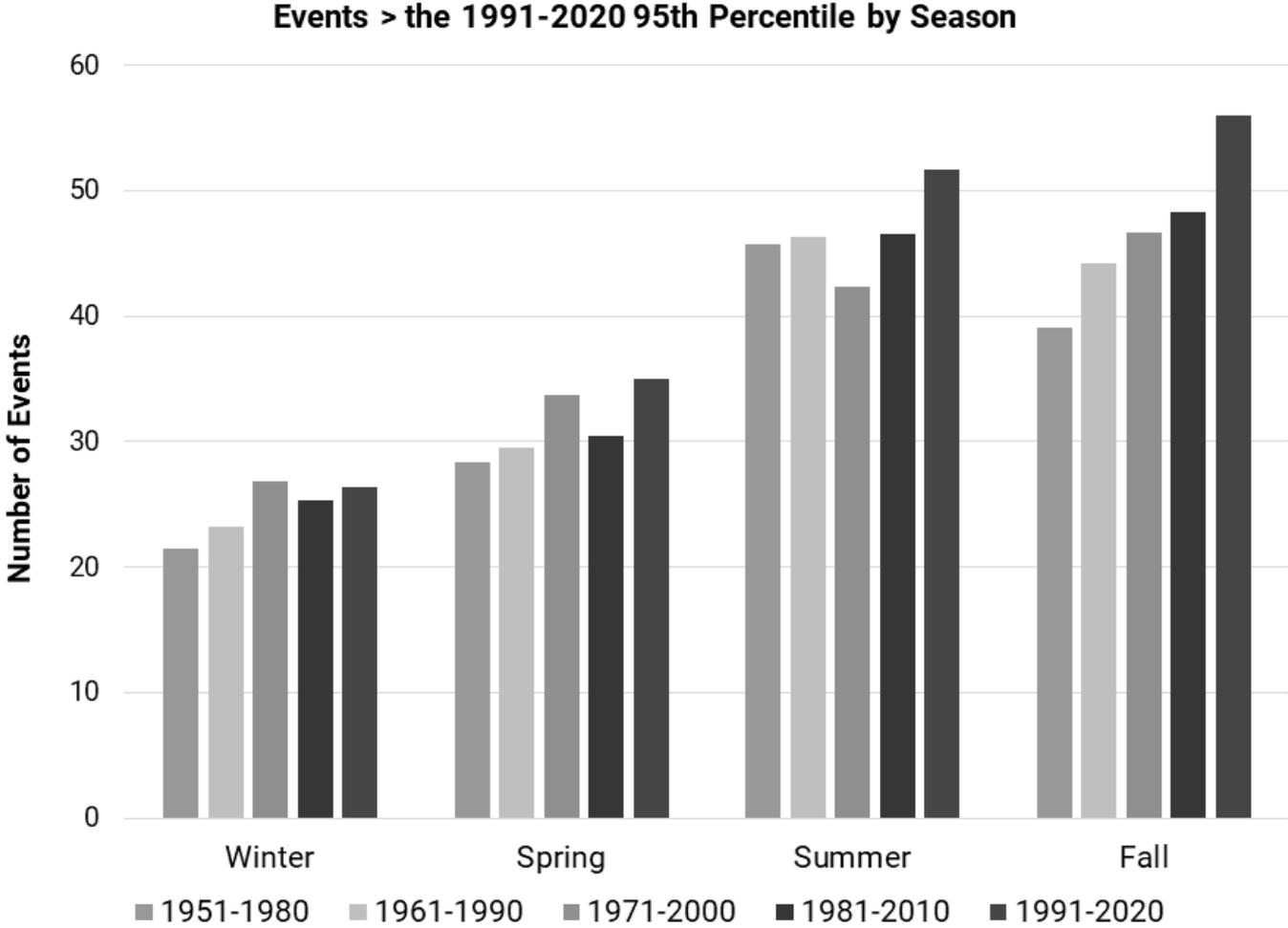


Extreme rainfall is increasing at many stations across North Carolina

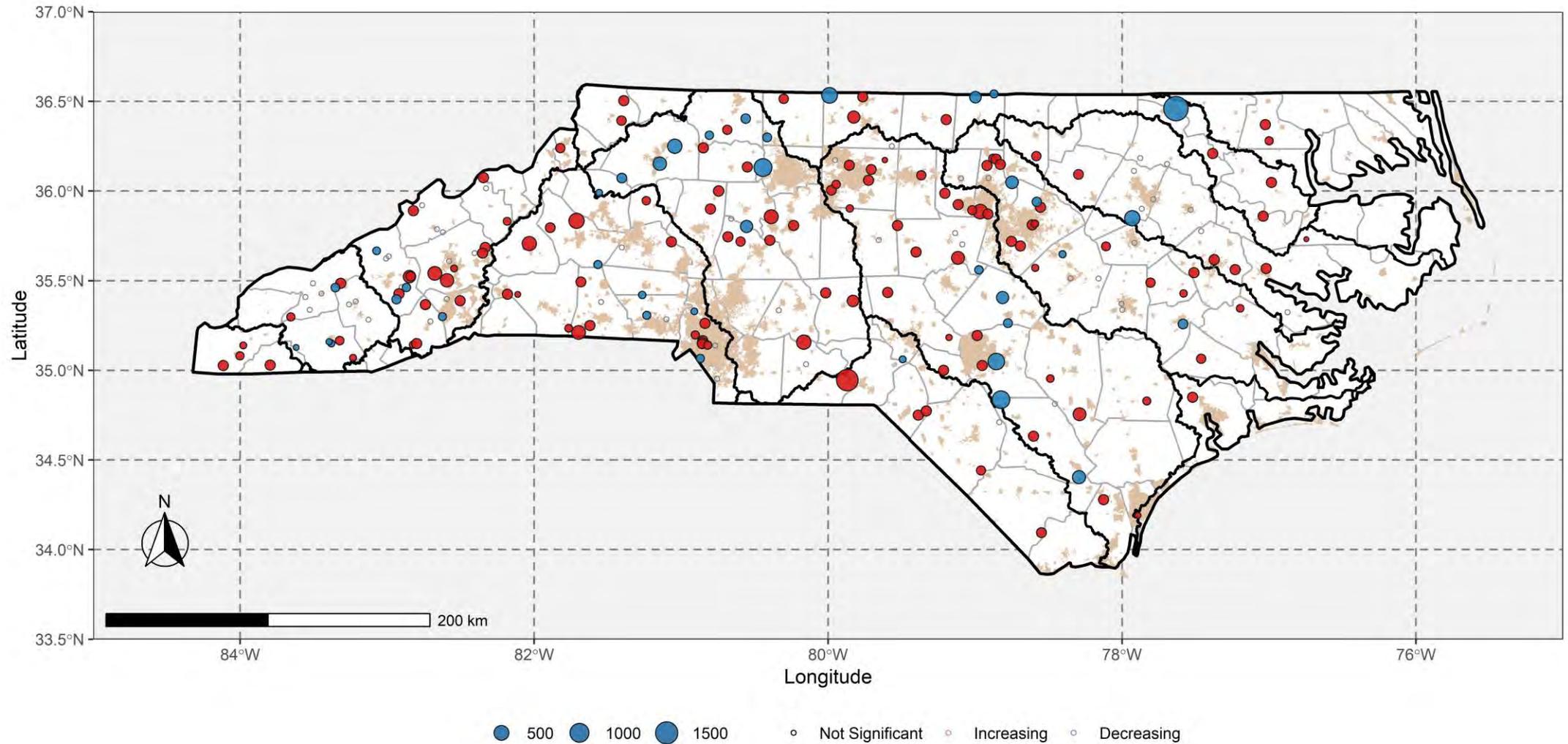
Station	Trend (inches per decade)
Asheville	0.01
Transou	0.04
Charlotte	0.02
Greensboro	0.02
Raleigh	0.06
Fayetteville	-0.01
Wilmington	0.05
Hatteras	0.03



The largest increases in extreme precipitation are observed in Fall



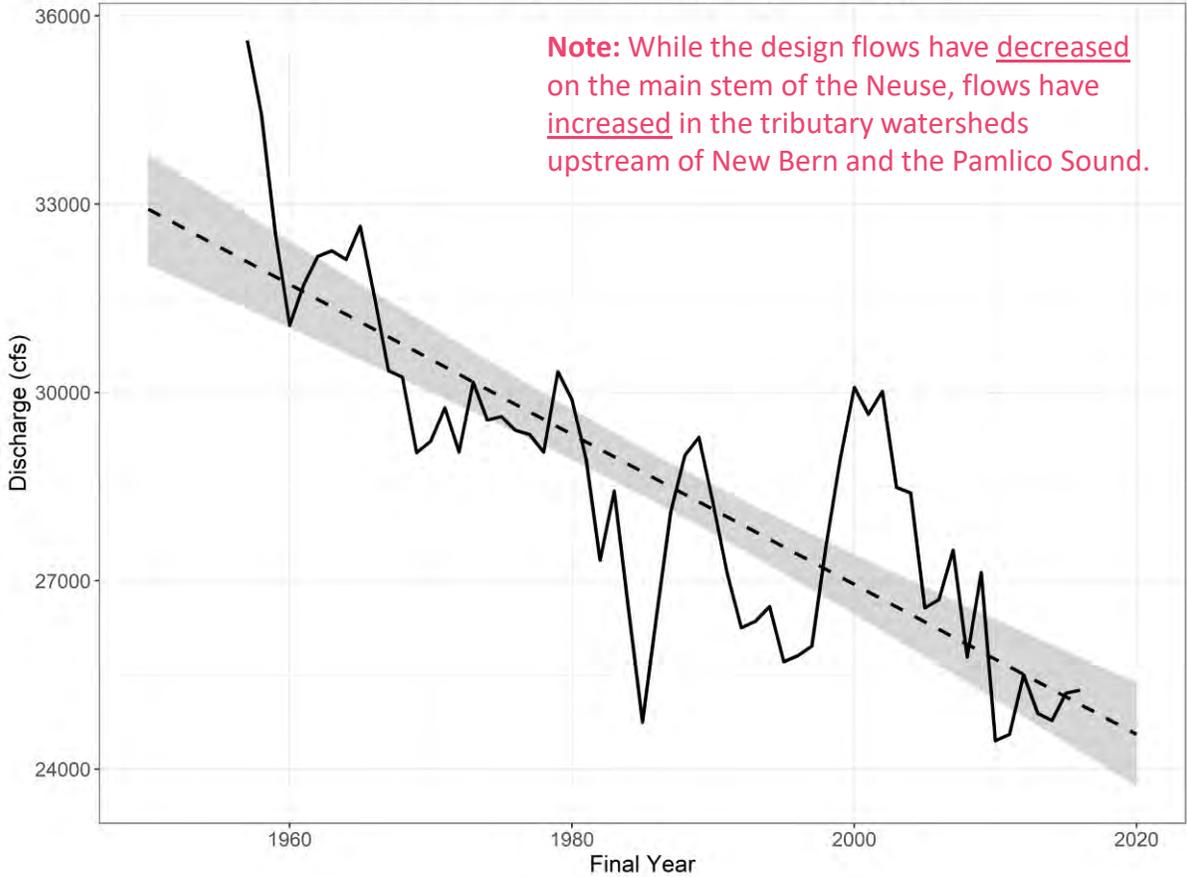
The magnitude of the 100-year flood is also increasing statewide



The 100-year flood is often assumed to be stationary, but the graphs show that it is highly variable.

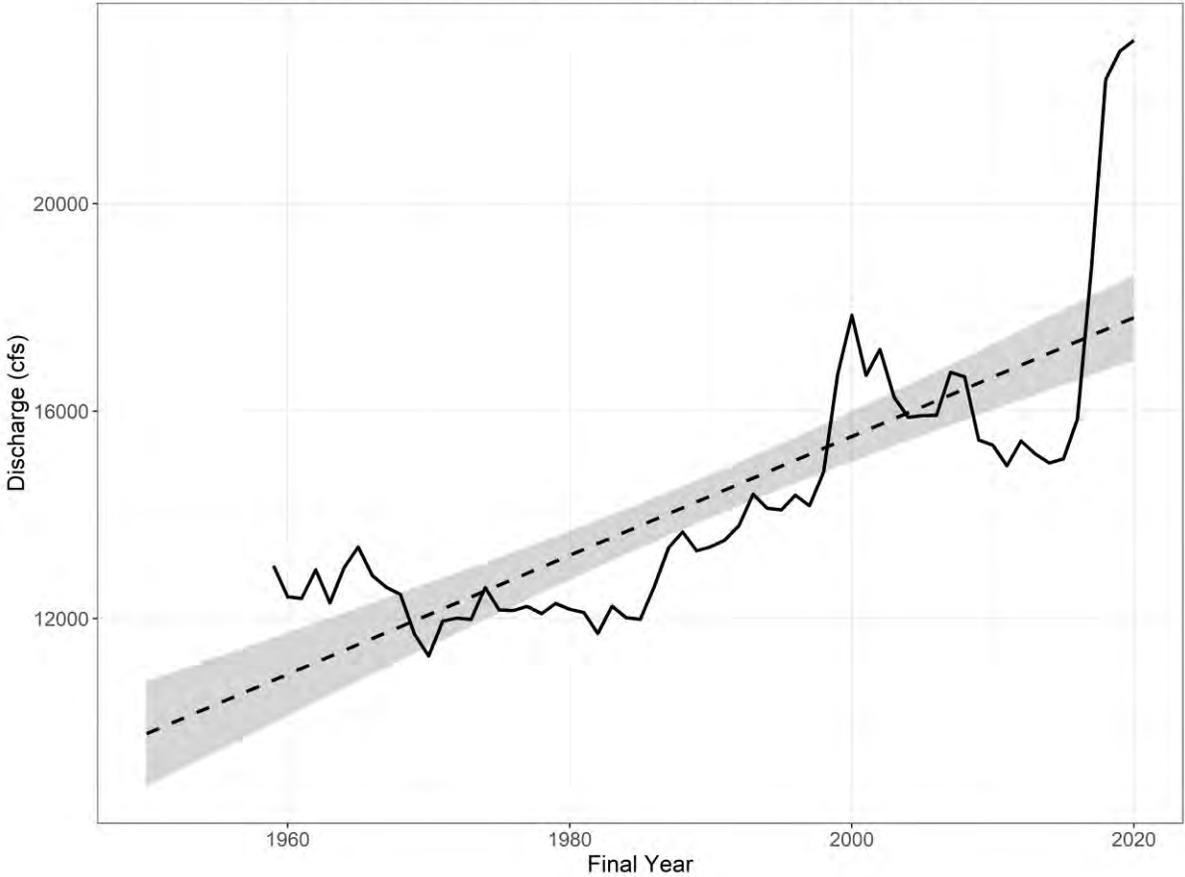
NEUSE RIVER AT KINSTON, NC

Annual Trends in 100-year Flows Using a 30-year Moving Window



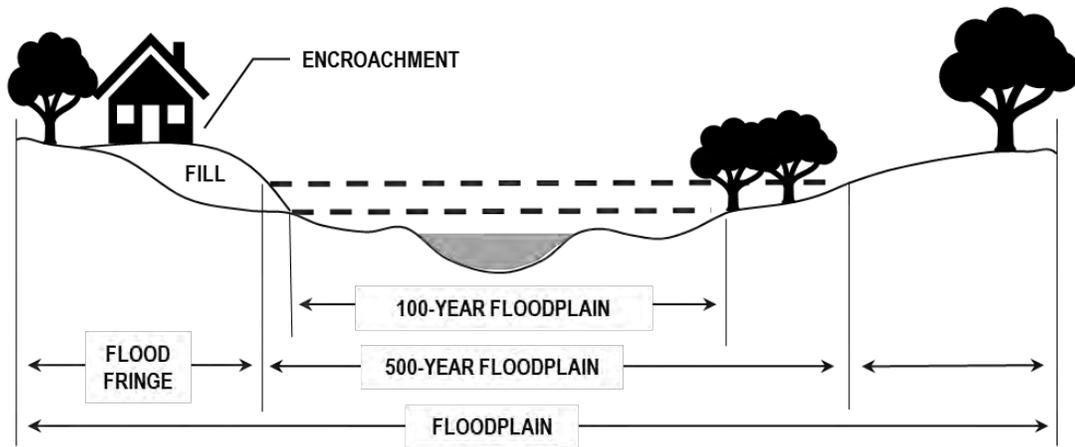
LUMBER RIVER AT BOARDMAN, NC

Annual Trends in 100-year Flows Using a 30-year Moving Window

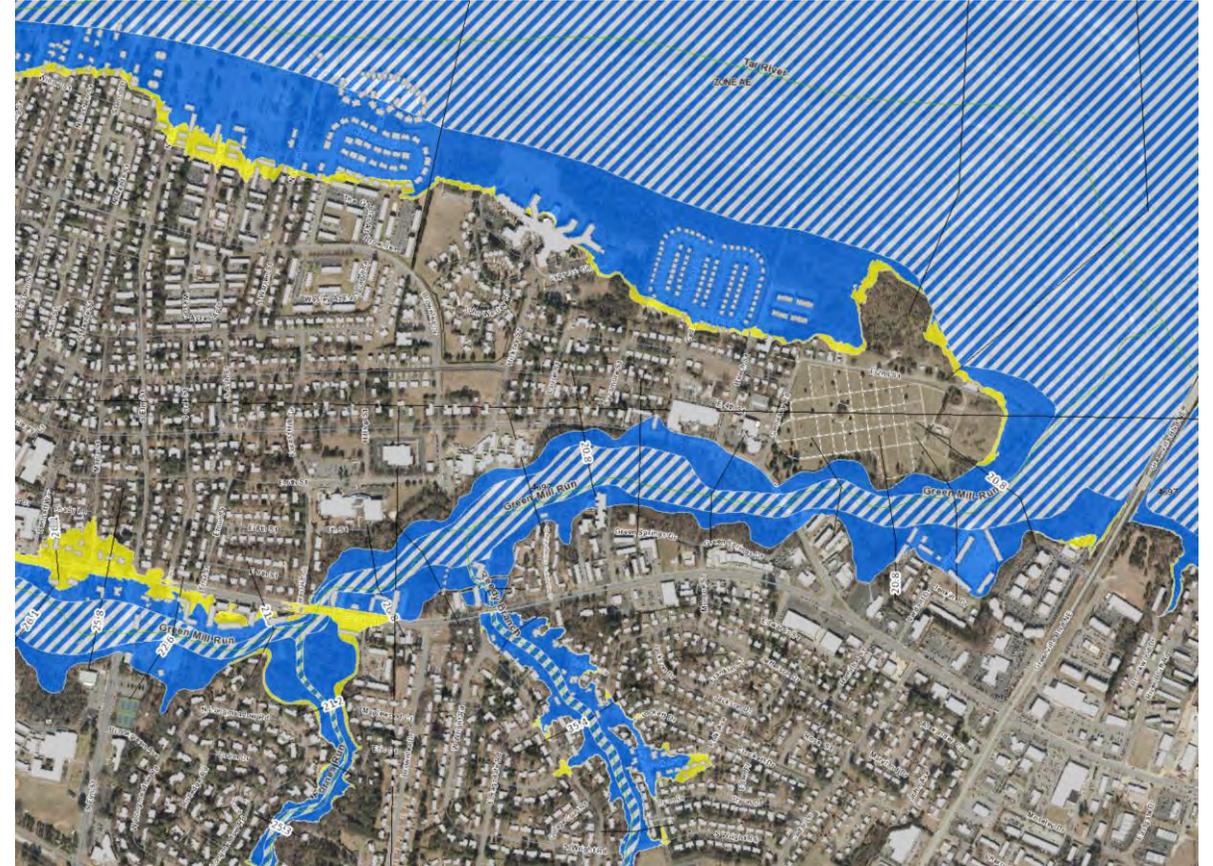


The 100-year floodplain is the primary marker of risk and an important planning tool, but it is poorly understood by the public.

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.



The regulatory maps also don't show flooding from other sources

Pluvial Flooding:



**Extreme
Precipitation**

**Storm Sewer or
Groundwater
Surcharge**

Photo: David Pfeiffer CC BY 2.0

Compound Flooding:



Storm Surge

**Extreme
Precipitation**

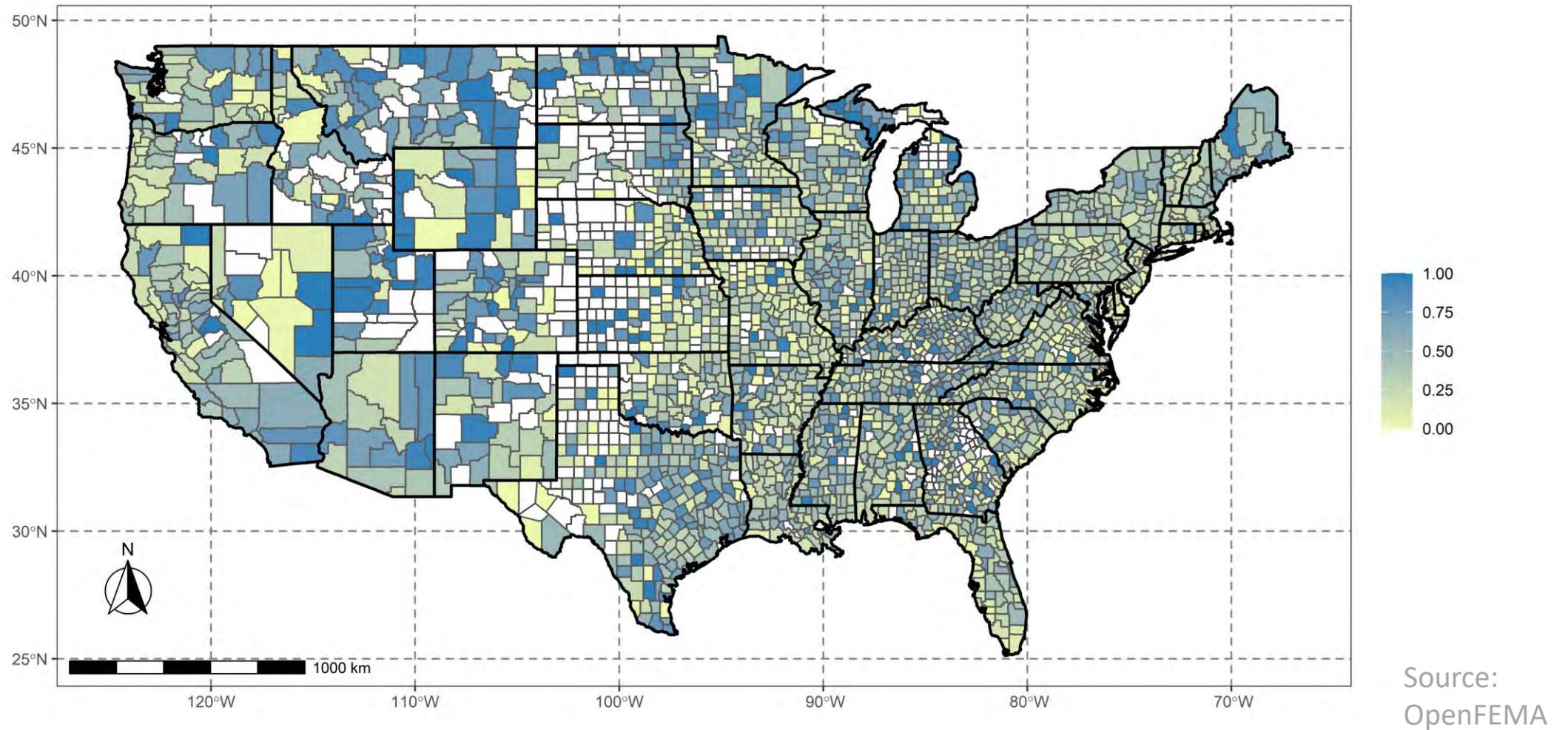
**Storm Sewer or
Groundwater
Surcharge**

Inland Flood Wave

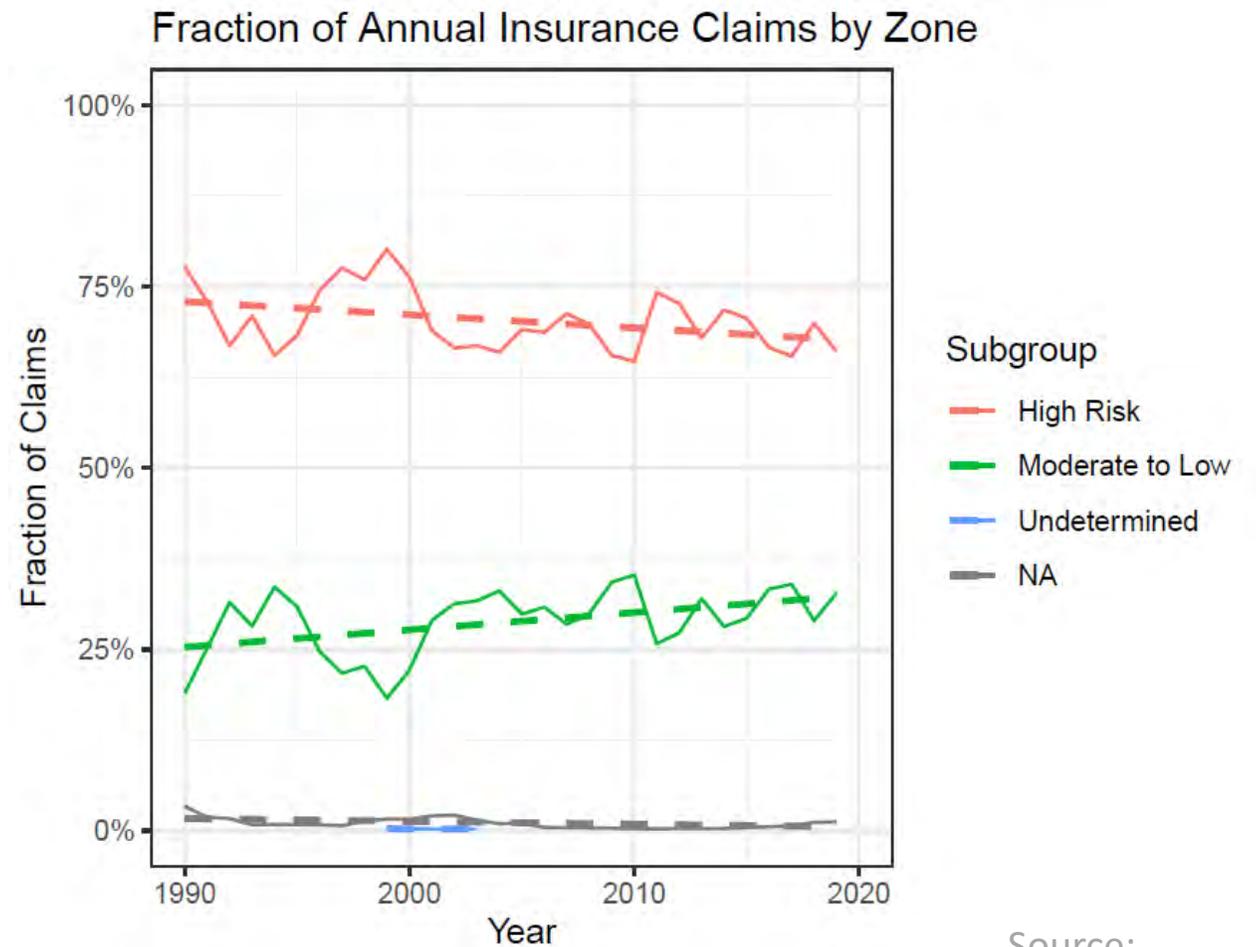
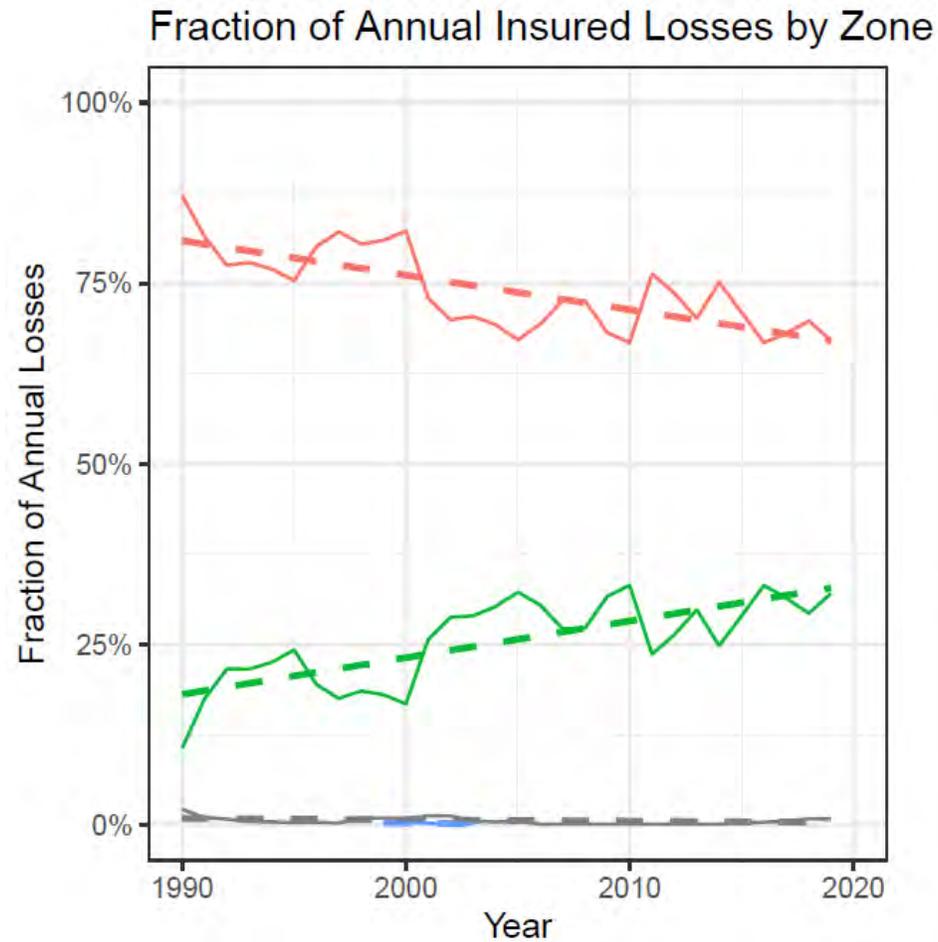
Photo: AP Photo/Steve Delaney

Flooding during Hurricane Florence in Englehard, NC looking towards Pamlico Sound

Nationwide, 28% of flood damage has occurred outside of floodplains

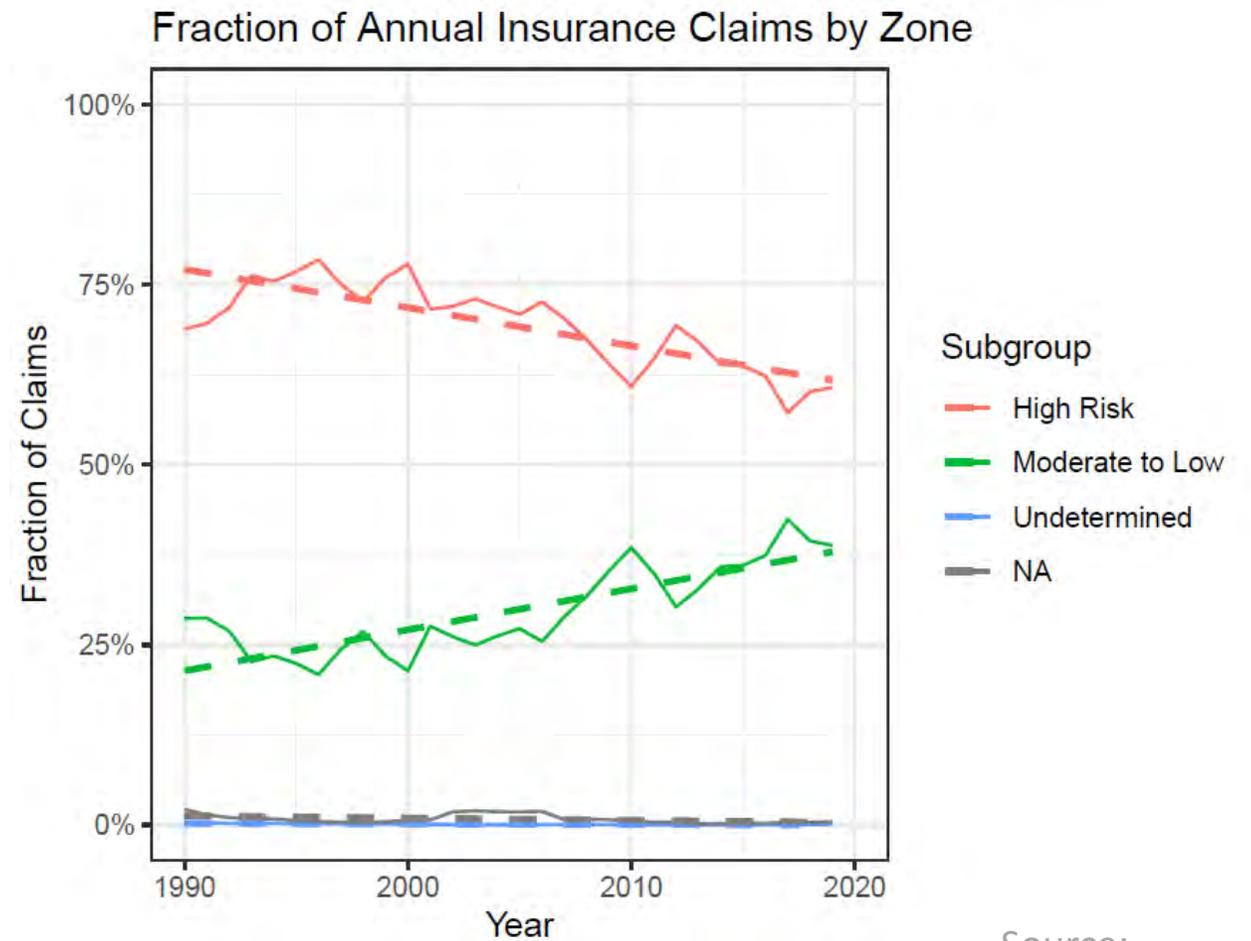
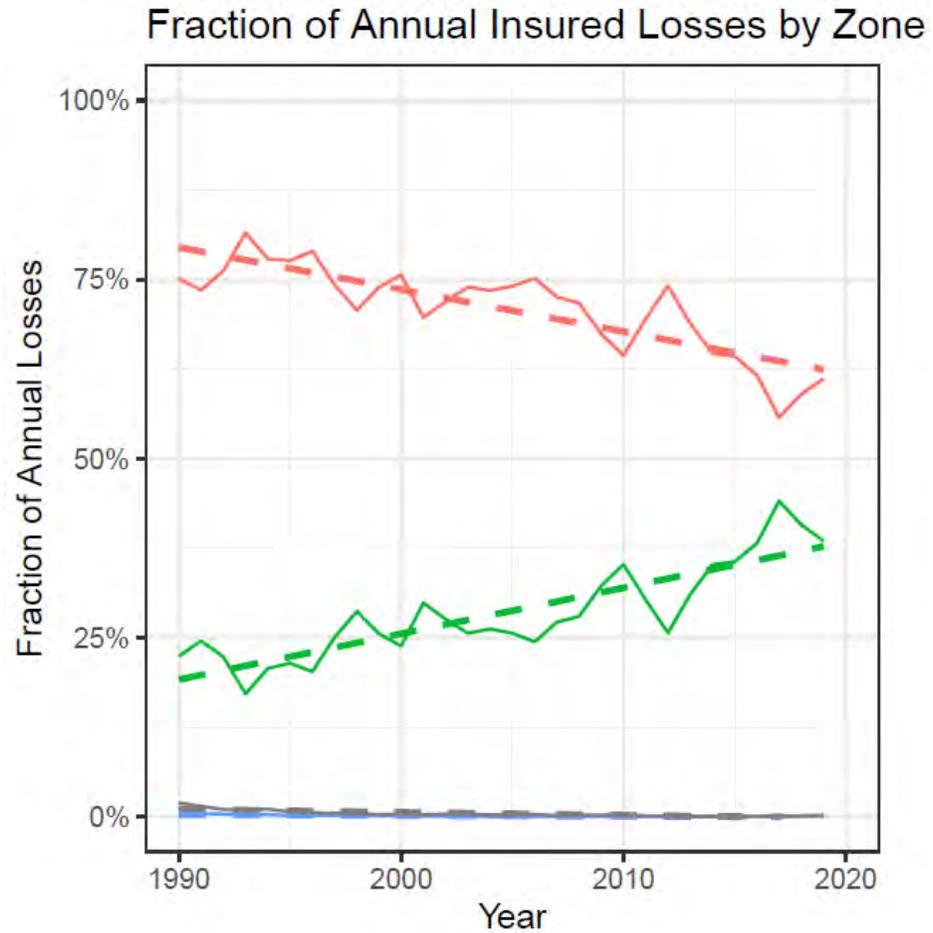


The rate of damage outside of mapped floodplain areas is growing...



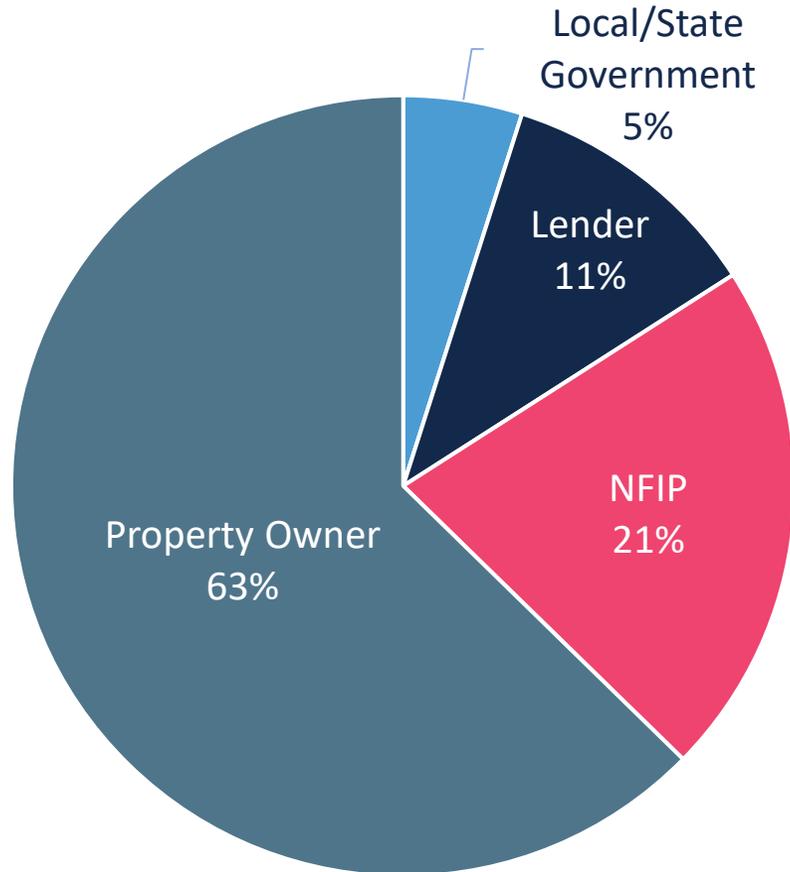
Source:
OpenFEMA

...and the trends are even starker in U.S. Gulf & Atlantic coastal areas



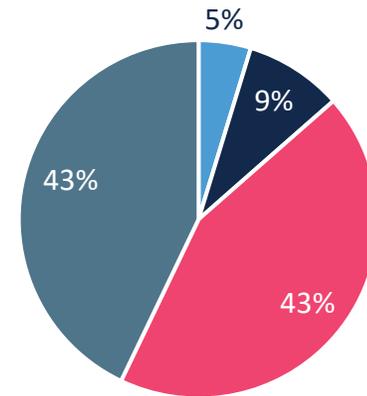
Source:
OpenFEMA

But insured flood damage is a small fraction of the total loss

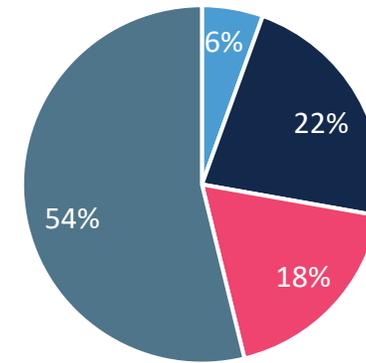


\$1.7B Residential Flood Loss after Hurricane Florence

- The NFIP provides a first line of defense for property owners, mortgage lenders and local government
- While property owners carry the brunt of the risk, uninsured losses (incl. property value losses) can **cascade** through the financial system
- The distribution of risk varies greatly by community:



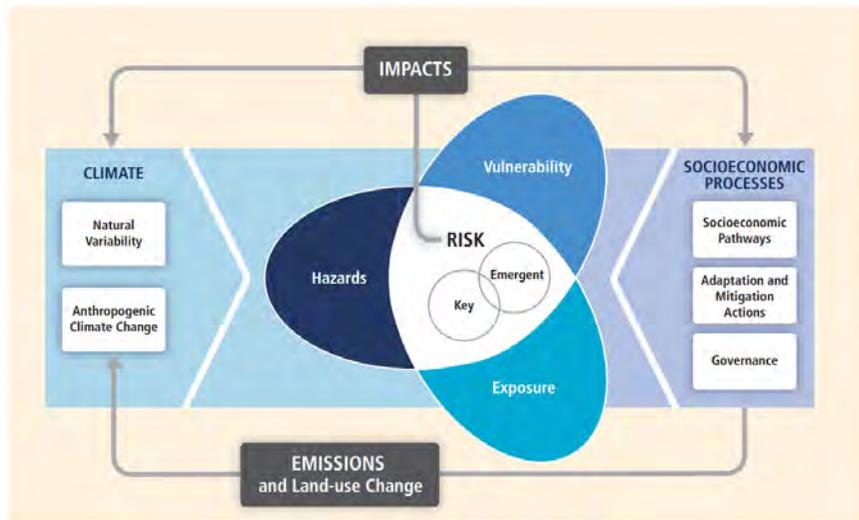
\$325M Craven County



\$38M Jones County

Flood risk is a function of hazard, exposure and vulnerability

- To mitigate and adapt to future floods, it is crucial to understand
 - where and how deep (or fast) it floods,
 - **who** and **what** is exposed, and
 - how vulnerable or susceptible they are to flood impacts now and *in the future*.



IPCC 2014

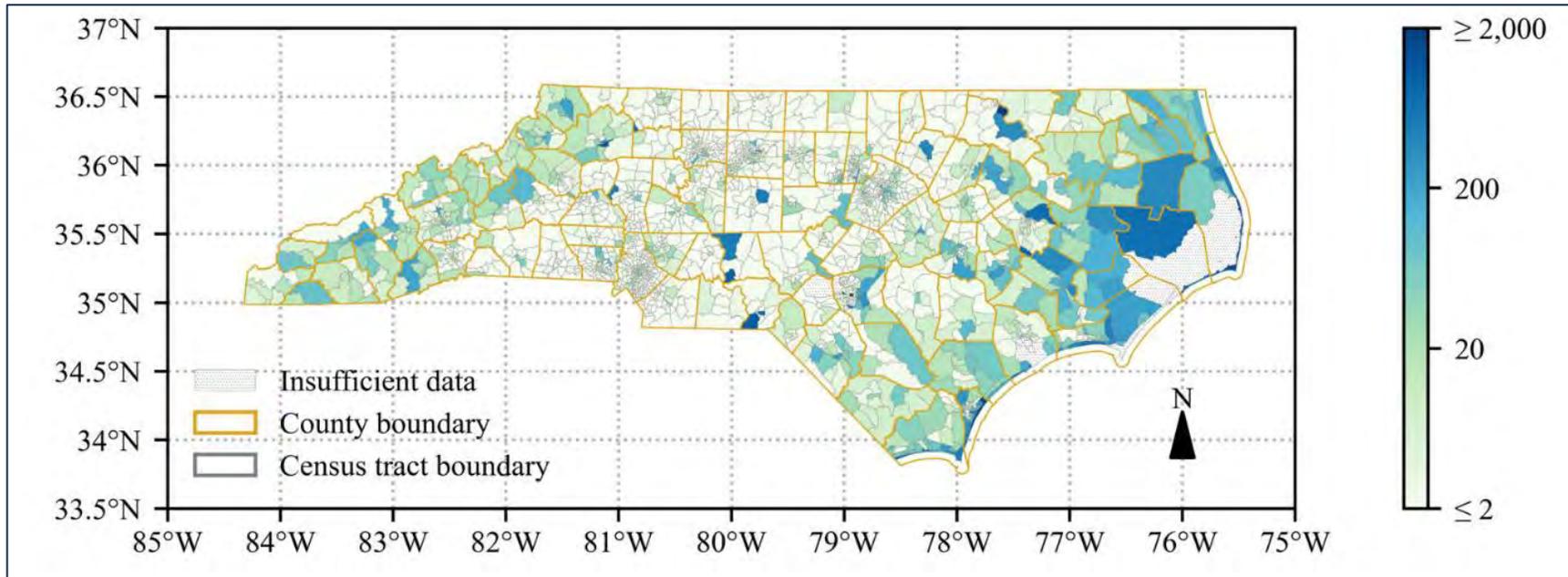


Photograph: Alex Wroblewski/Bloomberg via Getty Images



Photograph: Sean Rayford/Getty Images

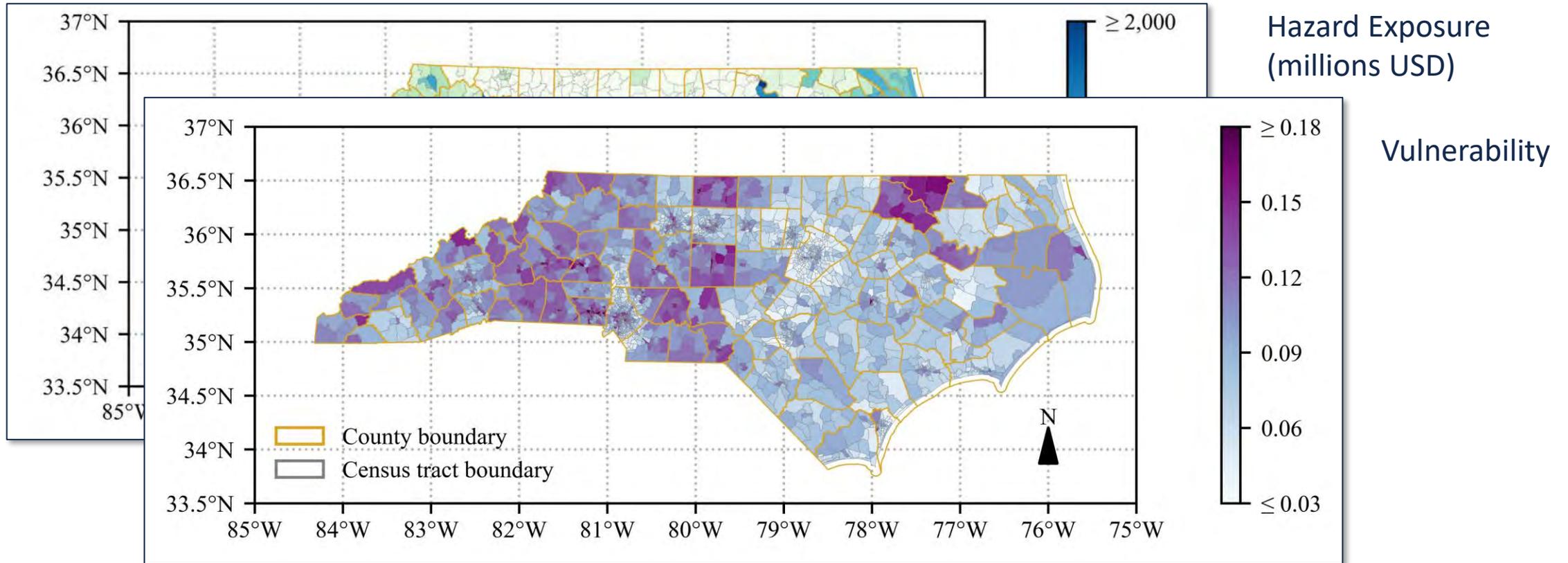
We aimed to map flood risk, starting with **hazard exposure**



Hazard Exposure
(millions USD)

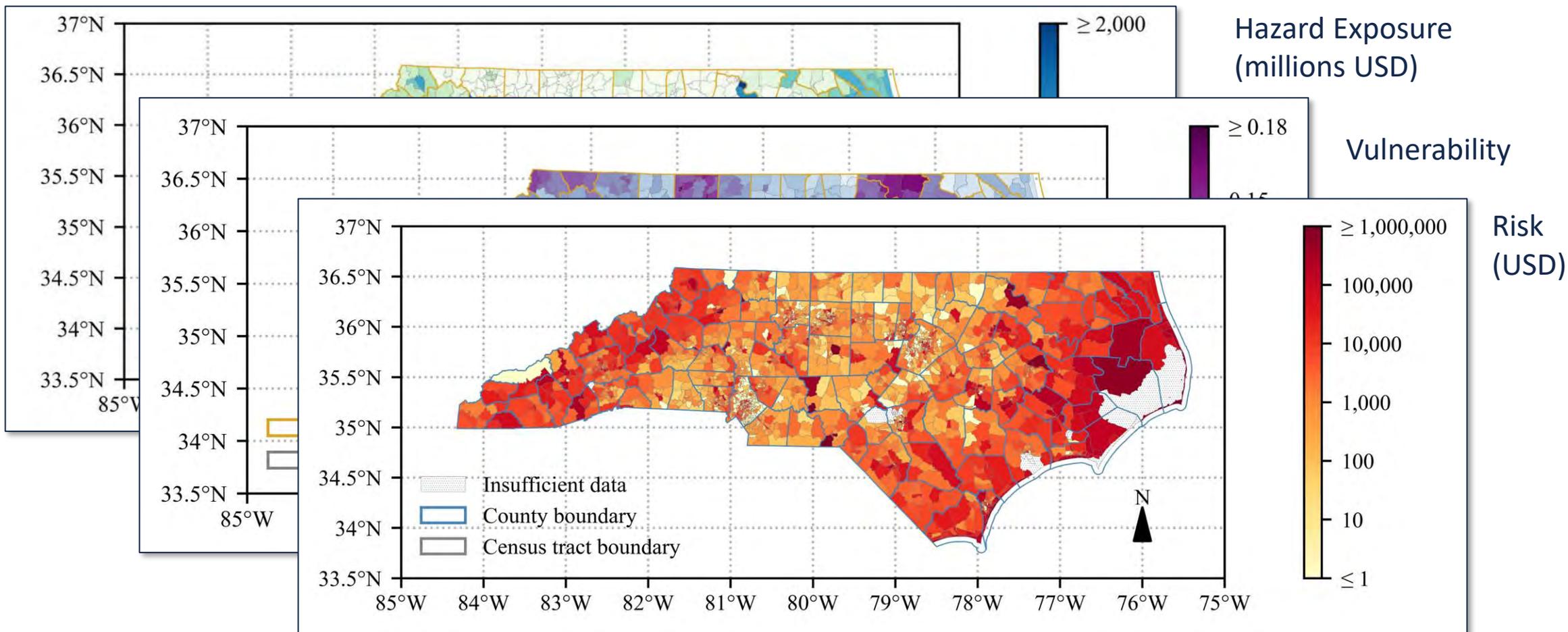
Wang & Sebastian, *JFRM* 2021

We then intersected hazard exposure with **vulnerability**...



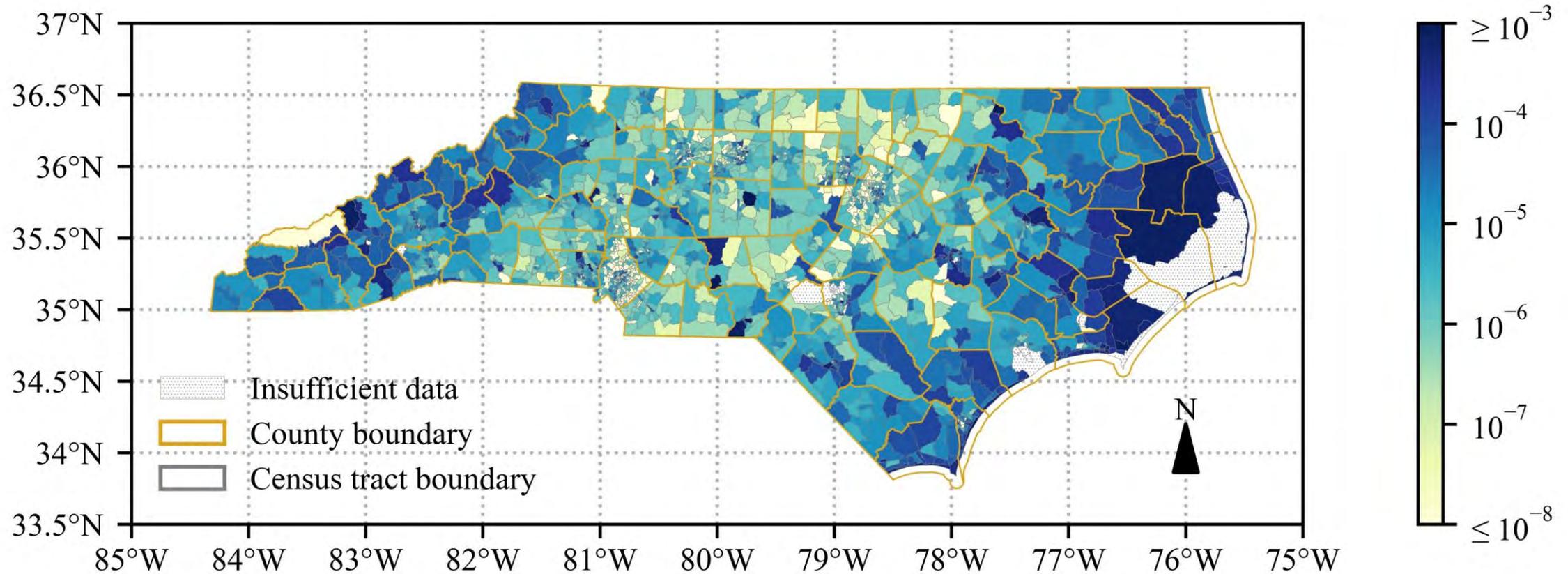
Wang & Sebastian, *JFRM* 2021

...to estimate annual expected uninsured damage



Wang & Sebastian, *JFRM* 2021

We also identified **hotspots** by normalizing the risk of uninsured damage by the total value of the property in each census tract



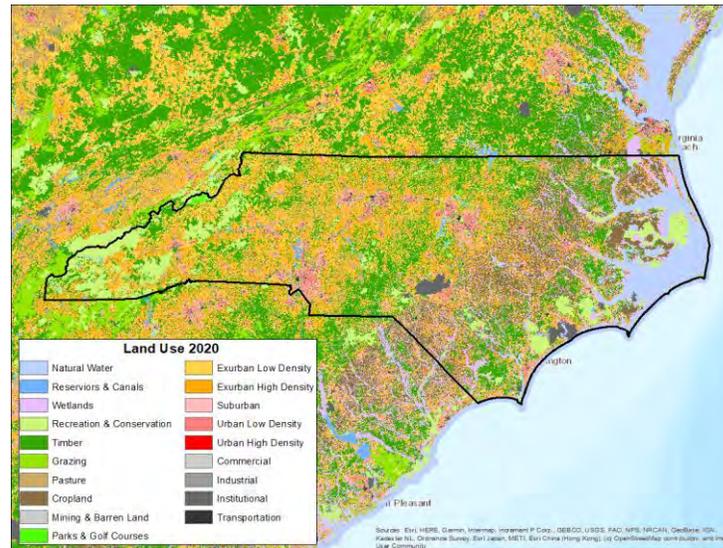
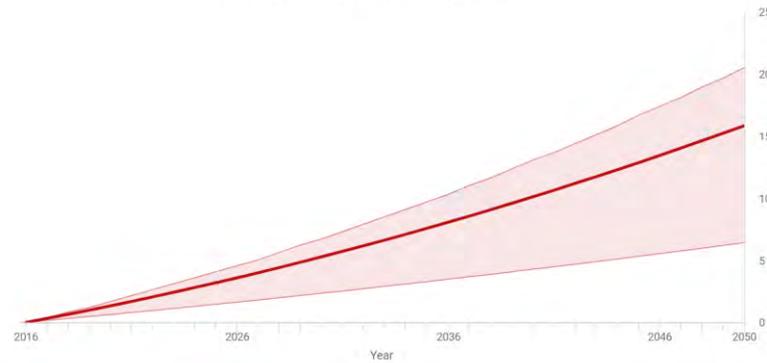
Wang & Sebastian, *JFRM* 2021

What does the future hold?

- Increases in **extreme precipitation** and **sea level rise**, coupled with **urban development** will increase the **hazard magnitude**

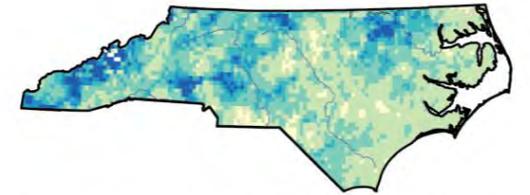
- The number of days with extreme precipitation (>3 in) could double in the Mountains by mid-century
- Sea level is expected to rise by 15 inches by mid-century (highly variable by location)
- NC Population will increase 1.3x by 2100

Beaufort Sea Level Rise Forecasts

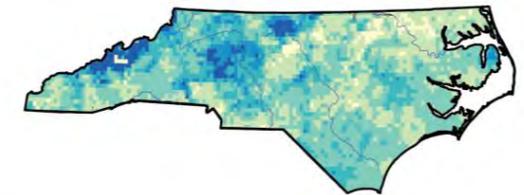


Projected Changes in Annual Number of Extreme Precipitation Events
Days with Precipitation ≥ 3 Inches

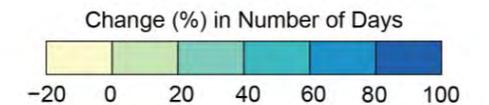
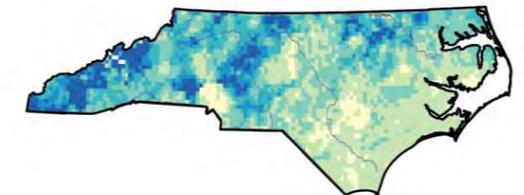
(a) Higher Scenario (RCP8.5), 2021–2040



(b) Lower Scenario (RCP4.5), 2041–2060



(c) Higher Scenario (RCP8.5), 2041–2060



What does the future hold?

- Increases in **extreme precipitation** and **sea level rise**, coupled with **urban development** will increase the **hazard magnitude**
- **Development decisions** and **aging infrastructure** will increase **exposure** and **vulnerability** leading to higher flood risk...

...where and how we build matters!

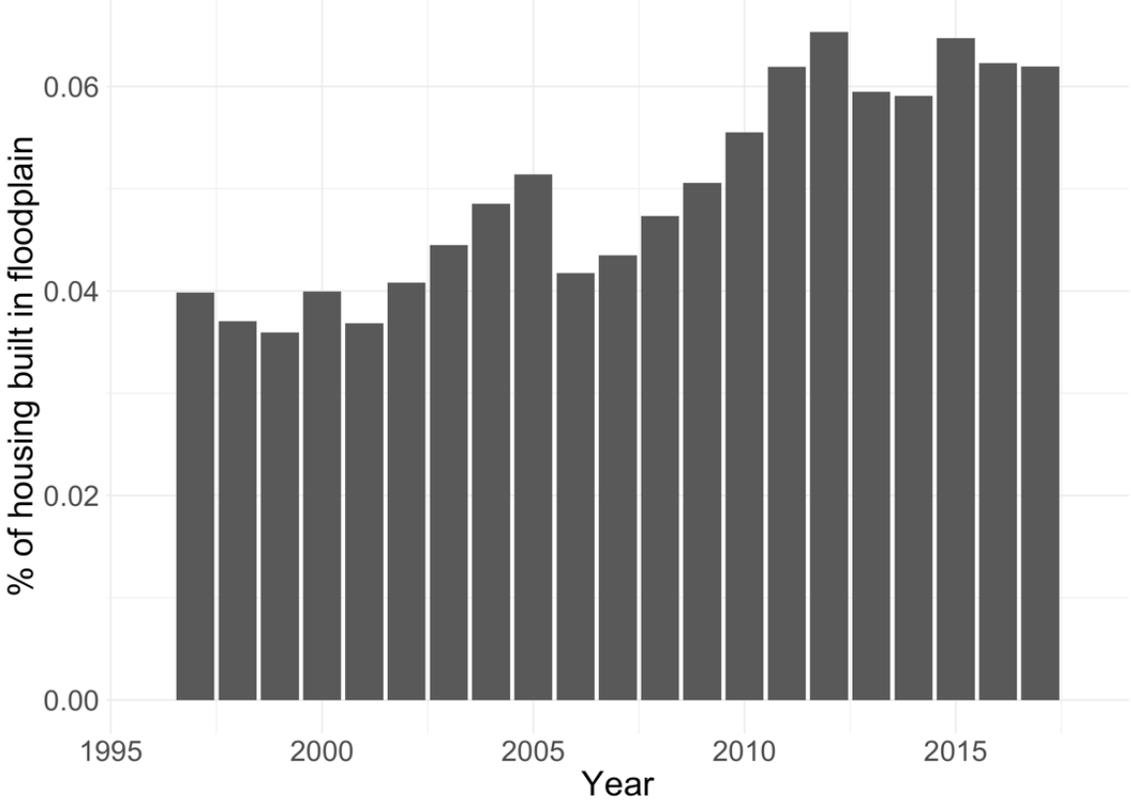
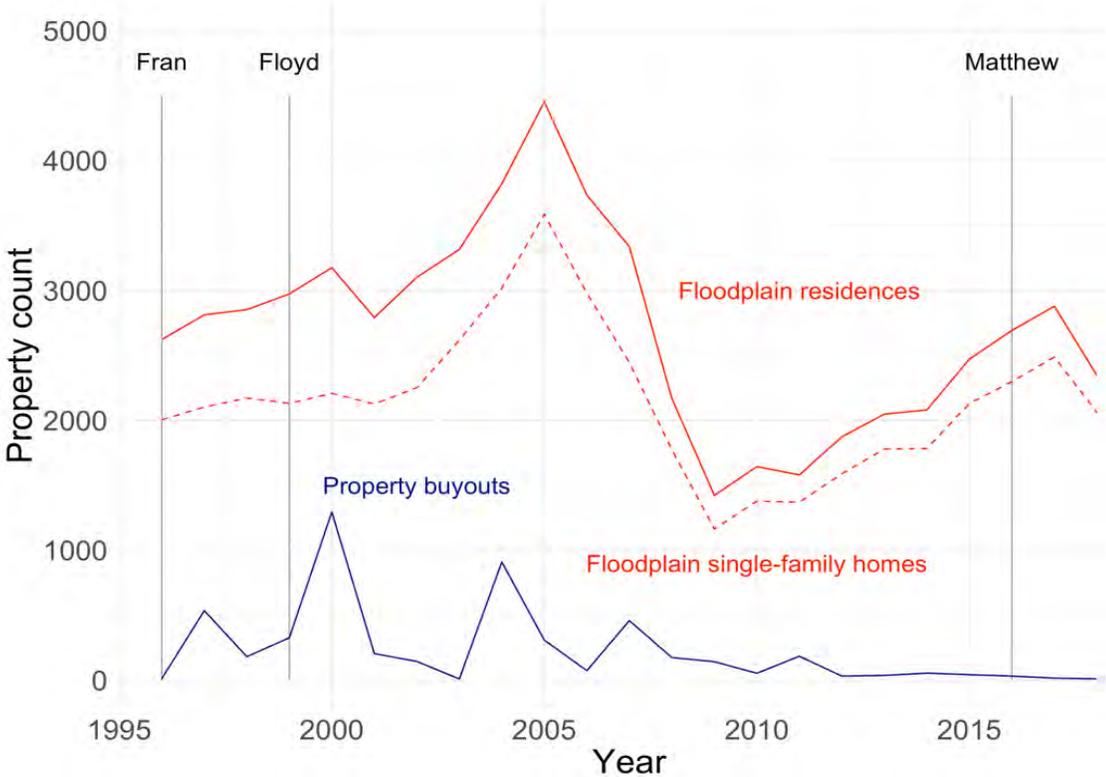


PHOTO: CHUCK BURTON AP



PHOTO: TRAVIS LONG/THE NEWS & OBSERVER/ASSOCIATED PRESS

Despite what we know, development inside of floodplain areas far exceeds the rate of mitigation across the State of North Carolina



There are 10 new structures built in the 100-year floodplain for every 1 structure bought out.

Hino et al. *in prep.*

Collaborations & Funding Acknowledgements



Dr. Kathie Dello
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Dr. HB Zeff



Dr. Miyuki Hino
Dr. Todd BenDor



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



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).



NSF 21-519 Growing Convergence Research (GCR). Dynamics of Extreme Events, People and Places (DEEPP) (2020-2025). Award No. 2021086.



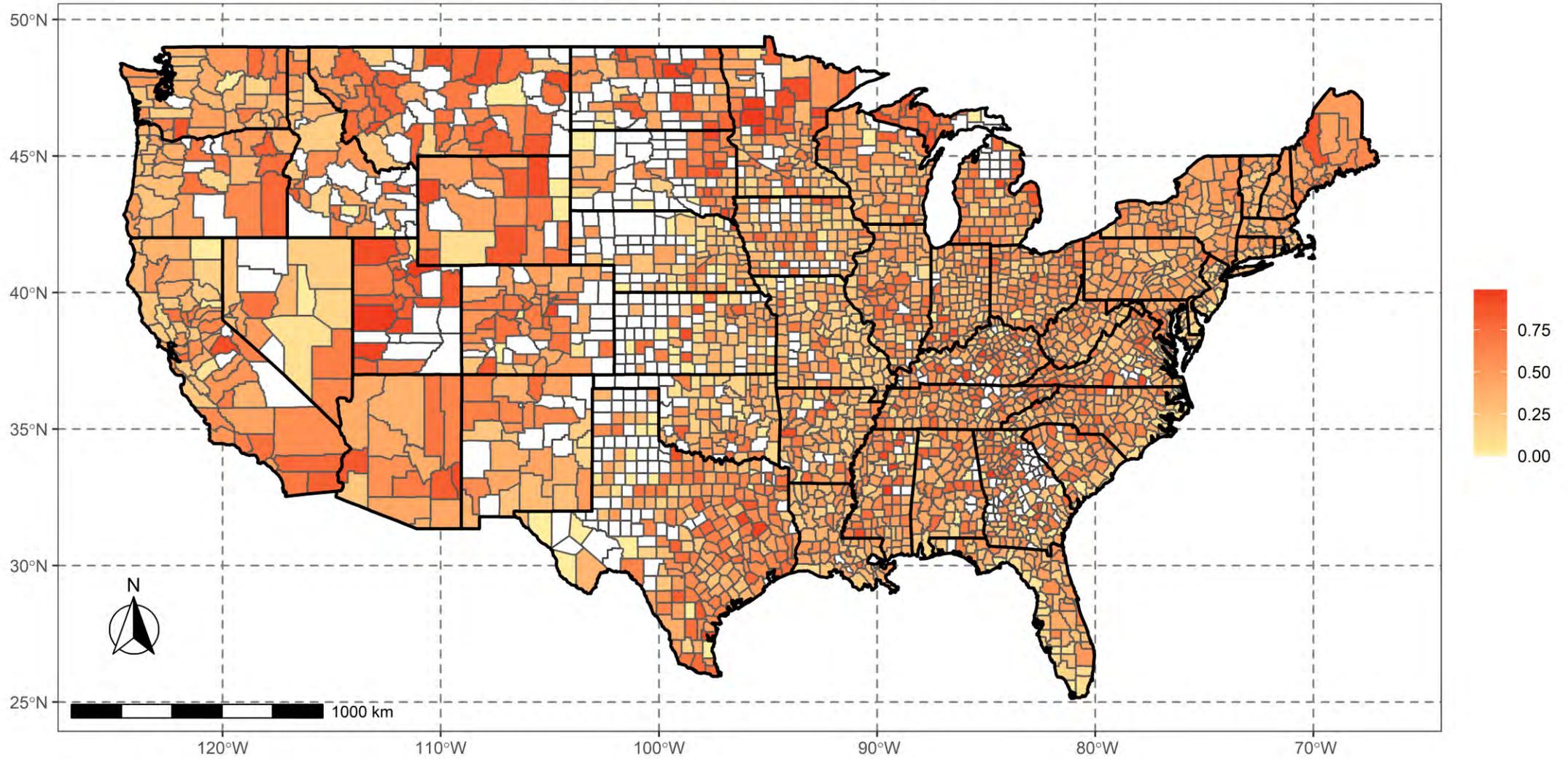
North Carolina WRI and USGS 104(b) Student Program. Understanding the Flood Mitigation Benefits of Buyouts: A Hydrologic Assessment of Property Acquisition in North Carolina Watersheds (2021-2022). Student Advisee: Hunter Quintal

... and many UNC students: Sarah Brannum, Lauren Grimley, Hunter Quintal, Hope Thomson, Rachel Kleiman

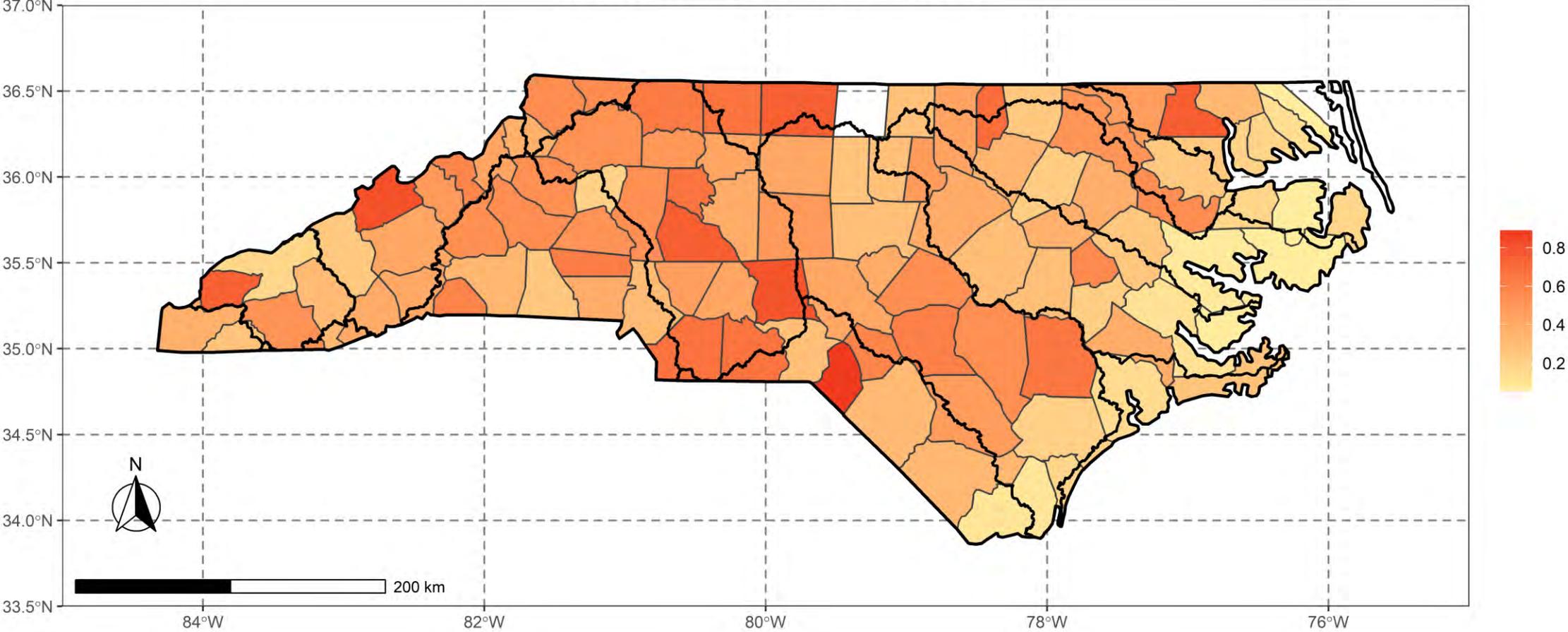


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Fraction of Claims Outside of FEMA SFHA



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Fix slide: damage
not claims!!

