Recent Trends in Flood Hazards & Risk in North Carolina Watersheds

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

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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

<table>
<thead>
<tr>
<th>Station</th>
<th>Trend (inches per decade)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asheville</td>
<td>0.01</td>
</tr>
<tr>
<td>Transou</td>
<td>0.04</td>
</tr>
<tr>
<td>Charlotte</td>
<td>0.02</td>
</tr>
<tr>
<td>Greensboro</td>
<td>0.02</td>
</tr>
<tr>
<td>Raleigh</td>
<td>0.06</td>
</tr>
<tr>
<td>Fayetteville</td>
<td>-0.01</td>
</tr>
<tr>
<td>Wilmington</td>
<td>0.05</td>
</tr>
<tr>
<td>Hatteras</td>
<td>0.03</td>
</tr>
</tbody>
</table>
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.

Note: While the design flows have decreased on the main stem of the Neuse, flows have increased in the tributary watersheds upstream of New Bern and the Pamlico Sound.
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

Compound Flooding:
- Storm Surge
- Extreme Precipitation
- Inland Flood Wave

Flooding during Hurricane Florence in Englehard, NC looking towards Pamlico Sound
Nationwide, 28% of flood damage has occurred outside of floodplains

Source: OpenFEMA
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

- 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:

  - $1.7B Residential Flood Loss after Hurricane Florence
  - $325M Craven County
  - $38M Jones County

Thomson et al. *in prep.*
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.

Photograph: Alex Wroblewski/Bloomberg via Getty Images
Photograph: Sean Rayford/Getty Images

IPCC 2014
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.
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
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!
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


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Fraction of Claims Outside of FEMA SFHA

Fix slide: damage not claims!!