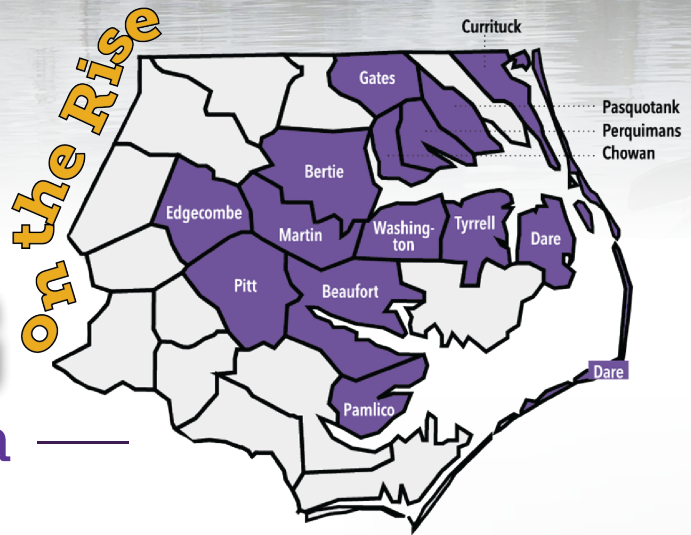




# COMPOUND FLOODING in Eastern North Carolina



## ■ Risk, Impacts, Challenges and Policy Directions

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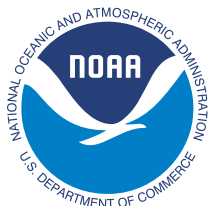
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JAMES B. NEAR CENTER FOR  
CLIMATE STUDIES

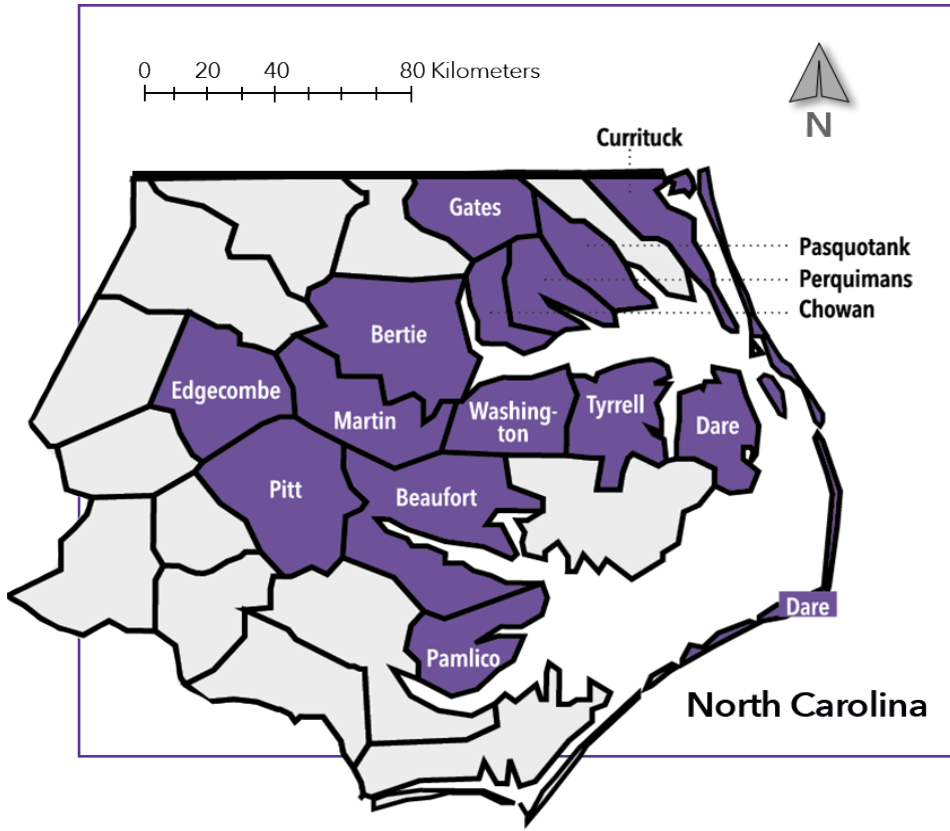


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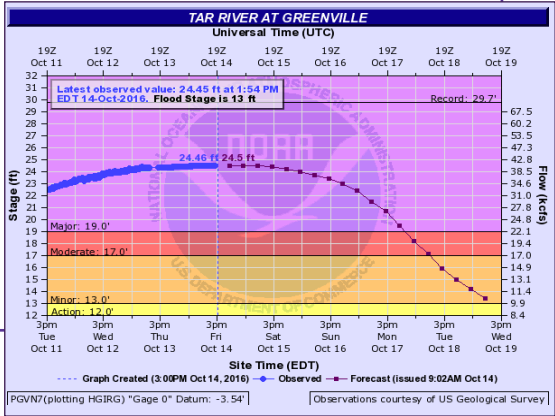
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The map highlights counties with representation at the 2020 and/or 2022 Compound Flood Workshops. North Carolina state officials and private corporations were also included in the discussions.

In the figure below, data from NOAA shows the Tar River at Greenville cresting during Hurricane Matthew.



### 2020 Workshop

	Planner	Emergency Management	Elected Official	Other Official	Private Entity
Female	6	2	4	4	0
Male	7	8	0	7	3
<b>Total</b>	<b>13</b>	<b>10</b>	<b>4</b>	<b>11</b>	<b>3</b>

### 2022 Workshop

	Planner	Emergency Management	Elected Official	Other Official	Private Entity
Female	3	1	3	2	0
Male	4	0	2	5	4
<b>Total</b>	<b>7</b>	<b>1</b>	<b>5</b>	<b>7</b>	<b>4</b>

The tables detail the numbers of hazard professionals attending the 2020 and 2022 Compound Flood Workshops. Note that the 2022 workshop, although in person, occurred when many COVID-19 restrictions were still in place.



# Introduction

- Floods are devastating to the economies and health of rural communities. In eastern North Carolina, flooding is complex, as hurricanes and nor'easters can bring a combination of extreme rain, storm surge and a rise in river levels.

We define a storm with pluvial, fluvial and tidal flooding characteristics as a compound coastal water event (CCWE). Hurricanes Matthew and Florence were recent examples of CCWEs. Unfortunately, studies project that CCWEs will be more commonplace in the future.

How prepared are rural communities to handle these flood events? What is needed to increase resilience to CCWEs?

In preparation for our study, we identified the following potential obstacles to resilience:

- CCWE management and planning requires unique expertise.
- There is often a divide between emergency managers and planners in the hazards cycle, which limits resilience systems thinking.
- Resources to prepare and respond are lacking in rural settings.
- Little is known about the joint economic and health impacts.
- Many online tools and resources focus on a single hazard, as opposed to complex events.

Our study “Preparing for, Responding to, and Mitigating Compound Coastal Water Hazards for Resilient Rural Communities” sought to help answer these questions. Funded by the National Oceanic and Atmospheric Administration (grant number NA19OAR4310312), the study identified risks, economic impacts, health impacts and mitigation strategies through investigating data and listening to the people whose job it is to keep people safe before, during and after a flood.

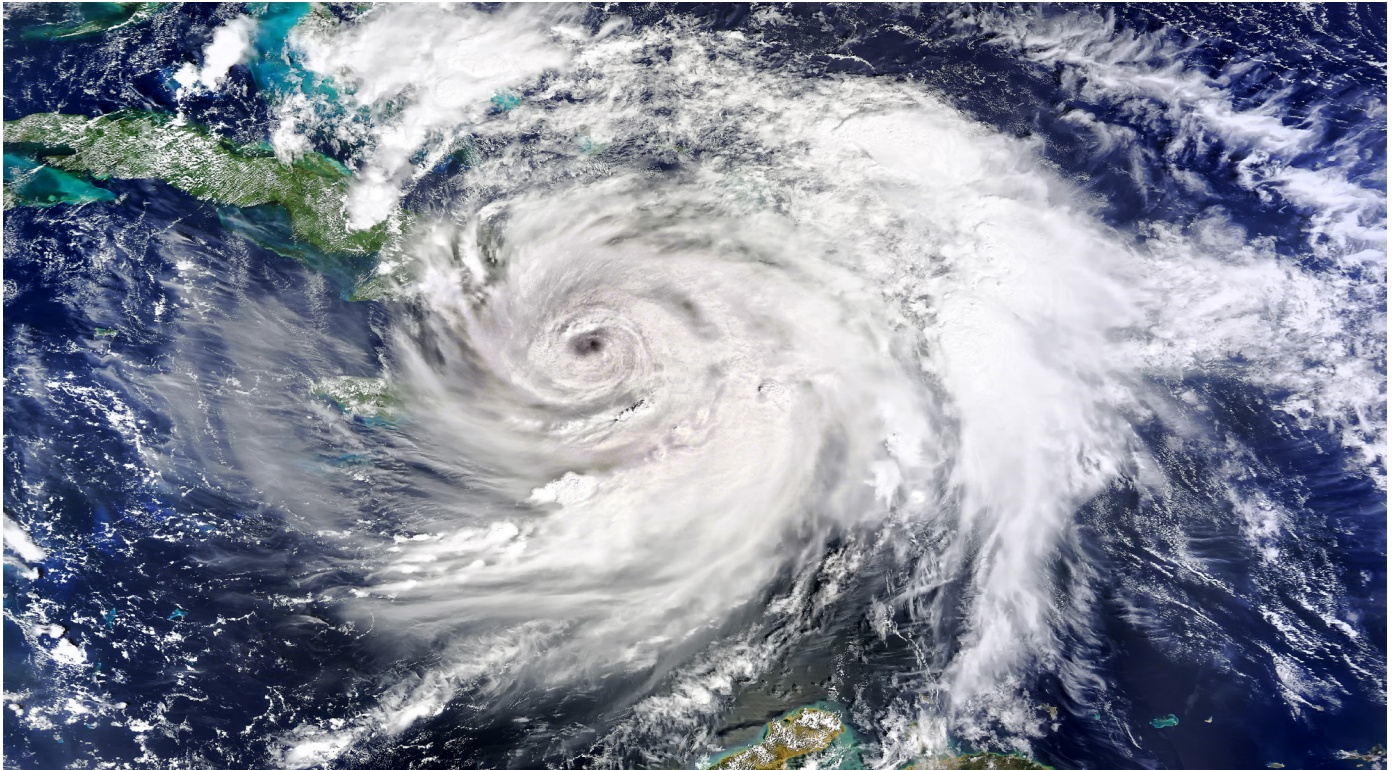
Two workshops were held on the campus of East Carolina University (February 2020 and February 2022). This report summarizes our findings.





# Risk

- In addition to the multihazard compounding of CCWEs, they can also be compounded in time and space.



During Hurricane Matthew, for example, coastal tide gauges across all of eastern North Carolina reached their maximum within about 24 hours after the hurricane's landfall, stressing emergency response effectiveness. Pluvial flooding is the "wild card," because it combines with fluvial and tidal flooding in unexpected ways. Thus, the sensitivity to CCWE arises from extreme rainfall.

## Challenges

The risk of pluvial, fluvial or tidal flooding (return interval or probability of occurrence) depends on location, which necessitates maps and other place-based tools. However, the risk of CCWE is fundamentally different and cannot be easily assessed. Normally, the risk of CCWE is greater than the sum of its parts. Likewise, one should use single-form flood risk maps with caution, as CCWE elevates those risks.

The concept of CCWE is recognized by hazard professionals. However, the lack of CCWE maps and tools

makes it difficult for them to not only respond to these events, but to communicate risk to their constituents. Most rely on past experiences as their primary source of information and are acutely aware of the different sources of flooding in their community.

The perception of a growing pluvial flooding – and thus CCWE – threat is thought to be a consequence of degraded stormwater infrastructure and poor land management.

## Policy Directions

The communication stream that needs the most attention is between governance levels, namely between local government and state and federal agencies. Hazard professionals blamed dysfunctional relationships and lack of trust on turnover and their exclusion from decision-making processes.

# Economic Impacts

■ The cumulative economic impacts of CCWEs fall under four areas:

- ✓ Physical infrastructure damage
- ✓ Property and business loss
- ✓ Damage to agriculture and fisheries
- ✓ Threat to community viability



Participants identified economic vulnerability metrics that they observe, such as access to help after an event, resources availability and access to education about CCWEs.

There are several community efforts undertaken by community members and leaders to reduce economic vulnerability, which include both physical adaptations (e.g., flood vents, dam restoration, drainage projects) and economic decisions to assess risk and land gifting to buyout participants.

## Challenges

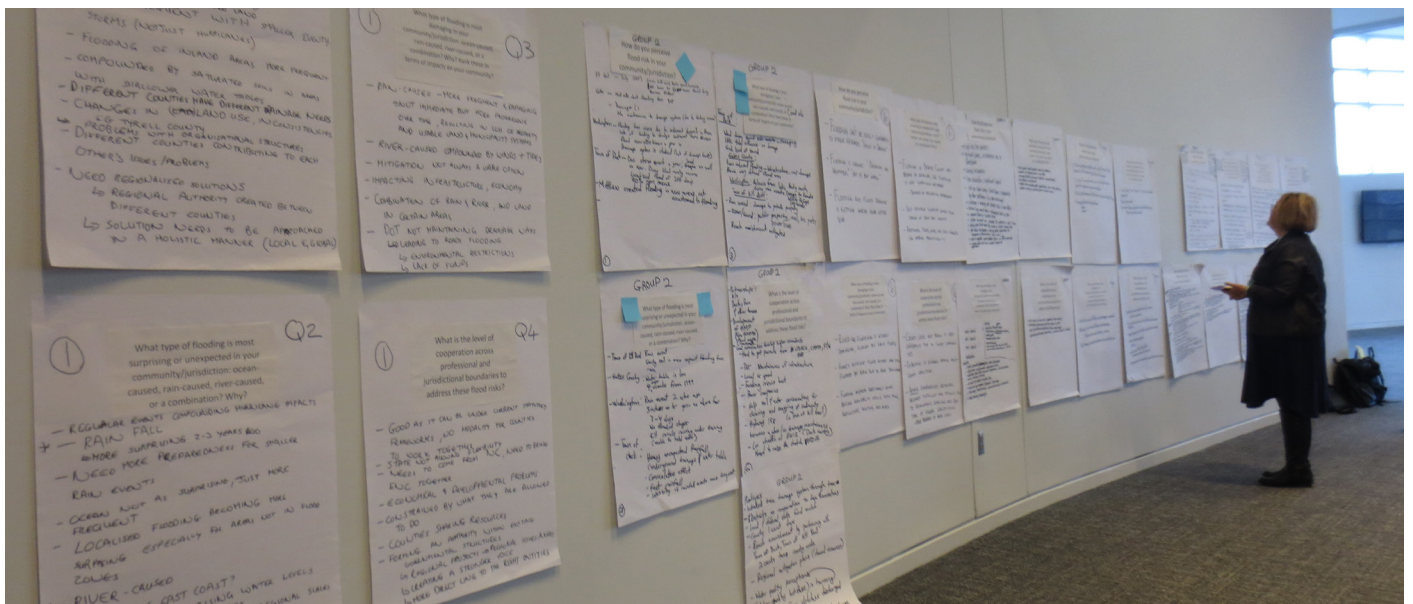
There is a lack of quantifiable data that could provide an accurate indicator of economic disruption. It is difficult to track economic impacts and challenging to know the “true impact” of CCWEs because the existing data is neither accurate nor complete.

## Policy Directions

Participants noted that resources (funding and education) need to be made available irrespective of the population threshold in a community.

There is concern about the mismatch in application for recovery funds and resilience planning ahead of future CCWEs. The best time to get community members to participate in block grant funding and FEMA efforts is immediately after CCWEs. These funds are needed to be delivered sooner than the typical 18-48 months post-event.

Community members and leaders spend a lot of time applying for various funding. Funding programs should consider working together to lessen the stress on community members and leaders through streamlined application processes and forms.





# Health Impacts

- Health impacts fall into three broad categories:

- ✓ Health care access for special-needs and aging populations
- ✓ Respiratory and waterborne diseases
- ✓ Stress and mental health

Mental health is recognized as an insidious long-term health consequence of CCWEs, which may not readily appear in hospital records.

There is some evidence from inpatient hospitalizations and emergency department admissions data of variation in the health impacts of disasters with respect to demographic and socioeconomic characteristics. In particular, communities with more disadvantaged populations have higher hospitalizations following disasters; however, these results are not statistically significant.

## Challenges

The presence of concentrated animal feeding operations in eastern North Carolina can increase exposure to microbial and chemical contaminants in water and the likelihood of gastrointestinal illness.

## Policy Directions

There is a need to relate long-term CCWE vulnerabilities (e.g., drinking water contamination) with existing rural health challenges such as cancer and neurodegenerative conditions.

Specific policy approaches to make rural communities more health-resilient include the following:

- Training for primary care physicians on the impacts of CCWE, like mold exposure
- An increase in mental health vulnerability assessments through the Hope4NC program
- Expanding the community care medicine program
- Evaluation of the collection of health data so that impacts of CCWE can be tracked over time



# Mitigation

- Mitigation activities fall into four broad areas:

- ✓ Infrastructure maintenance and repair
- ✓ Clearing streams and channels
- ✓ Seeking mitigation funds for buyouts and elevation projects
- ✓ Flood plain planning and management to minimize exposure to floods

## Challenges

The sluggish funding process due to procedural and other delays compound ongoing and future mitigation challenges.

Funding streams and processes currently in place are out of date and do not reflect the dynamic and changing nature of mitigation needs and related barriers in rural coastal regions.

## Policy Directions

The need exists for holistic mitigation approaches that are flexible, sensitive and responsive to the specific needs of rural coastal communities.

Specific policy approaches include the following:

- Creating a clean line of communication from the state to the local level through the presence of a designated unit at the state level as a single clearinghouse for various funding opportunities
- Dedicated staff at the state level to help communities through the process of applying for appropriate funding
- Funding streams that target locally driven pre-disaster mitigation projects such as living shorelines, infrastructure maintenance, repair and relocation, and affordable housing options for households moving out of the 100-year flood plain

# Buyouts

- The advantages of a buyout in a rural community are green space restoration, repetitive flood prevention and flexible alternative land use.

## Challenges

There are mixed reasons why people do not participate in buyout programs: attachment to property, title issues on the property, unsatisfactory appraisal value, strong social networks in the community and delays in the buyout process.

Several problems with buyouts were identified, including lack of trust in the government and a slow process. The long process of approval for a buyout and a lack of communication among the stakeholders contribute to delays in the buyout process. The slow process exacerbates health problems and financial strain.

Buyouts can work if there is accessible land outside of the flood plain for relocation. Counties do not want people to relocate outside of the county and thus lose the tax base.



# Other Coping Mechanisms



Outside of buyouts, there are community efforts to cope with recurrent CCWEs. These can be classified as environmental and structural adaptations.

For those close to the ocean or sound, environmental solutions include building of dunes and living shorelines, planting vegetation and beach renourishment. Nature-based solutions are favored over structural options, such as hardening the shoreline.

Homeowners also install flood vents, use sandbags, elevate their homes, waterproof their homes or rent storage units.

Businesses rely on flood insurance primarily, but they also waterproof their walls and doors.





## Further Reading

**Mukherji, A., Curtis, S., Helgeson, J., Kruse, J.K. and Ghosh, A.** (2023). Mitigating compound coastal water hazards in eastern North Carolina. *Journal of Environmental Planning and Management*. DOI: <https://doi.org/10.1080/09640568.2023.2183112>

**Curtis, S., Mukherji, A., Kruse, J.K., Helgeson, J. and Ghosh, A.** (2022). Perceptions of risk to compound coastal water events: A case study in eastern North Carolina, USA. *Progress in Disaster Science*, 16: 100266. DOI: <https://doi.org/10.1016/j.pdisas.2022.100266>

**Curtis, S., DePolt, K., Kruse, J.K., Mukherji, A., Helgeson, J., Ghosh, A. and Van Wagoner, P.** (2021). Spatially compounded surge events: An example from hurricanes Matthew and Florence. *Natural Hazards and Earth System Sciences*, 21: 1759-1767. DOI: <https://doi.org/10.5194/nhess-21-1759-2021>

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