

A detailed historical map of the Mississippi River basin, showing various geographical features, rivers, and place names. The map is overlaid with a dark grey horizontal band containing white text. The text includes the journal title, issue information, and a URL. The map itself shows the Mississippi River winding through the center, with numerous tributaries and lakes. Labels include 'CHIPEWAY COUNTRY', 'MISSISSIPPI RIVER', 'M'DEWAKANTON COUNTRY', and 'WARTPEKUTEY'. There are also many smaller place names and geographical features like 'Red Lake', 'Little Fork', and 'St. Croix River'.

ISSUE TWELVE : FALL 2018  
OPEN RIVERS :  
RETHINKING WATER, PLACE & COMMUNITY

WATERY PLACES & ARCHAEOLOGY

<http://openrivers.umn.edu>

An interdisciplinary online journal rethinking the Mississippi from multiple perspectives within and beyond the academy.

ISSN 2471-190X

The cover image is a detail from Hydrographical Basin of the Upper Mississippi River From Astronomical and Barometrical Observations Surveys and Information by Joseph Nicolas Nicollet, 1843.

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*Open Rivers: Rethinking Water, Place & Community* is produced by the [University of Minnesota Libraries Publishing](https://www.librariespublishing.org/) and the [University of Minnesota Institute for Advanced Study](https://www.umn.edu/advanced-study/).

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ISSN 2471-190X

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PERSPECTIVES

# RIVERS FLOOD REGULARLY DURING HURRICANES, BUT GET LESS ATTENTION THAN COASTLINES

By Craig Colten



*Flooding in Kinston, North Carolina during Tropical Storm Florence, September 14, 2018. NC National Guard (<https://flic.kr/p/2a1u8yj>), (CC BY).*

## Note from the Editor

*Hurricane Florence generated a great deal of discussion in the water world this fall, and certainly the questions about climate change, about environmental justice, and about the role of human decisions in “natural disasters” are far from over. The eminent geographer Craig Colten, in this piece originally published in The Conversation, reminds us that rivers are important actors in the watery tragedies that hurricanes bring.*

—Patrick Nunnally, Editor

**H**urricane Florence dropped record-setting rainfall on parts of North Carolina. Many river gauges rose above their respective flood stages. Flash and long-term flooding, as well as a risk of landslides, continued for days.

Since the 1950s, coastal communities have ordered evacuations to move people out of the paths of dangerous storms. Coastal residents also prepare by building homes elevated above anticipated high water levels, and building codes commonly call for reinforced construction to endure high wind speeds.

Today, however, risk from hurricanes is extending inland. Some of the worst damage from Eastern Seaboard hurricanes in the past several decades has come from inland flooding along rivers after storms move ashore. Hurricane

evacuations typically direct coastal residents to retreat inland, but river flooding can put them at risk if there are not enough shelters and accommodations in safe locations. And inland communities may not take adequate measures to ensure the safety of their residents.

Much of my research, including my book, *Southern Waters: The Limits to Abundance*, has focused on the complex historical geography of water in the American South. What I have seen is that inland river flooding linked to hurricanes and heavy storms is a huge risk in the Southeast, but receives far less attention in emergency plans than coastal areas.

*See drone footage of flooding in Baton Rouge, Louisiana, after heavy rains, Aug. 16, 2016.*

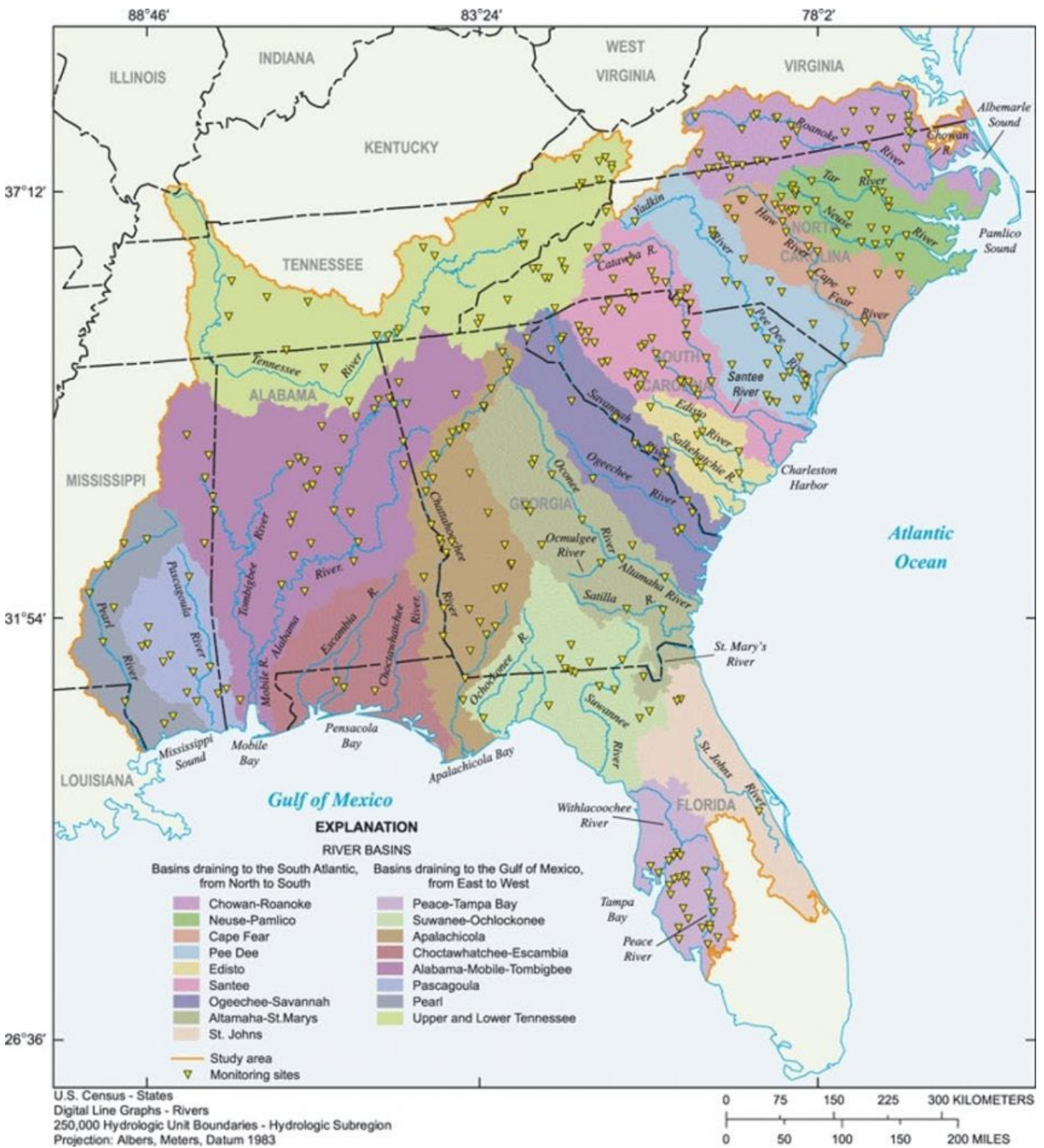
## Warm, rainy watersheds

The U.S. Eastern Seaboard is particularly susceptible to river flooding due to tropical weather that moves onshore. From New England to Georgia, a dense network of rivers flows down from the eastern Appalachians across the Piedmont – a broad, rolling plateau extending from the mountains to the coastal plain – and drains into the Atlantic Ocean. Steep gradients move water quickly down the mountain slopes.

On the Piedmont, many small streams merge and then become meandering rivers on the low-lying coastal plain. When tropical weather systems

lumber onshore and move inland, they rise up the steep face of the Blue Ridge Mountains. As the saturated air moves upward, it cools and releases huge quantities of rain – a process known as orographic precipitation.

This phenomenon, coupled with heavy rainfall dumped on lower elevations by these tropical systems, unleashes dramatic downpours that funnel into river networks and rush toward the sea, often spilling over the banks of overwhelmed channels.



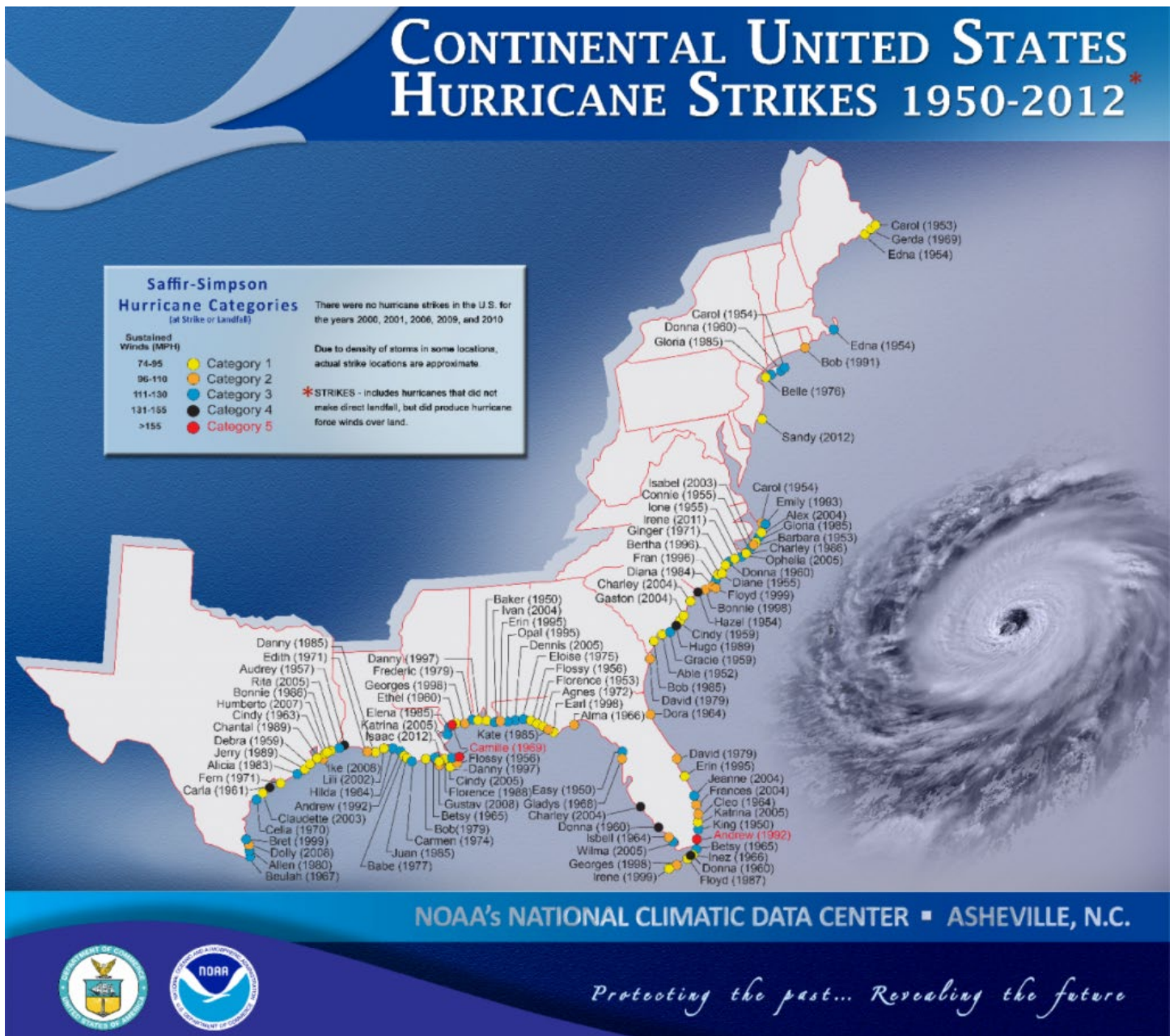
Rivers draining to the southeast U.S. Atlantic coast. Garcia et al, 2011., (CC BY).

# Planning centers on coastal communities

A series of storms in the 1950s prompted federal agencies to start planning for extreme tropical weather events. In August 1954, Hurricane Carol grazed the Outer Banks of North Carolina before battering Long Island and Rhode Island and causing extensive flood damage in New England. Hurricane Edna followed a similar path two weeks later, but remained offshore. And an

October storm dumped up to 10 inches of rain across the Appalachians as it moved inland, causing serious flooding, damage and fatalities in Maryland and Pennsylvania.

In 1955 Hurricane Connie unleashed huge amounts of rain over upstate New York. Days later, Hurricane Diane produced modest damage



*The southern United States is regularly affected by hurricanes.*

along the coast, but caused extensive river flooding as it continued across New England. Although both of these storms made landfall in North Carolina, their impacts in the more heavily populated northeast spurred federal action.

Following these tragic back-to-back seasons, the U.S. Army Corps of Engineers launched a series of hurricane risk assessments for communities along the Atlantic and Gulf coasts, and the Weather Bureau – the forerunner of the National Weather Service – commenced studying tropical weather systems. The Corps considered building structural protection for most cities, but found

## The growing inland threat

Hurricane Floyd in 1999 showed that tropical weather events could wreak havoc inland, mainly through river flooding. Floyd moved onshore near Cape Fear, North Carolina, in mid-September with wind speeds of about 105 miles per hour and traveled northward, dumping up to 20 inches of rain along a path stretching into New England and Canada.

Copious rainfall pushed inland ahead of the storm's eye overwhelmed most of the rivers in eastern North Carolina. Emergency responders conducted hundreds of inland freshwater rescues. Some river flood crests did not occur until over a week after the storm had passed. Millions of hogs, chickens and other farm animals drowned, and dozens of animal waste lagoons overflowed, contaminating water supplies.

## Prepare inland

As the record shows, places adjacent to the sea are not the only danger zones during hurricanes. Inland river flooding from hurricanes is a major risk, particularly in areas with dense populations. Urban expansion and suburban sprawl have placed more people in areas where no one lived

that flood walls were too expensive in most locations. Instead, it recommended evacuations, building codes and zoning to limit exposure in areas subject to storm surge – that is, in the immediate coastal zone.

The Weather Bureau issued a model for hurricane planning in 1959 that used a hypothetical community situated directly on the coast. It emphasized effective emergency communication, public education, preparation, and most importantly, evacuation. Neither agency paid any significant attention to inland flooding.

Floyd's impact was compounded by the fact that it followed Hurricane Dennis by about 10 days, so soils were already saturated. And rivers were still at higher-than-normal stages when Hurricane Irene arrived a month later. Total damage from Floyd alone was estimated at US\$6.5 billion, much of it from inland flooding. Now preliminary reports indicate that Florence is setting new North Carolina rainfall records.

Massive floods in Columbia, South Carolina, in 2015 and southeast Louisiana in 2016, caused by rare heavy rainfall events, soaked major urban areas and triggered evacuations – again, mainly through river flooding. And in 2017, Hurricane Harvey dropped at least 52 inches of rain on Houston in six days, an amount NASA described as “unfathomable.”

in 1955 and the coastal Carolina region has seen extensive development.

As warmer ocean temperatures contribute to heavier rainfalls and slower moving hurricanes, inland flooding is likely to increase. Until



hurricane planning fully incorporates this threat, coastal communities will risk evacuating people straight into harm's way and inland residents will share a false sense of security.

*This is an updated version of an article originally published on September 13, 2018.*

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## Recommended Citation

Colten, Craig. 2018. "Rivers Flood Regularly During Hurricanes, But Get Less Attention Than Coastlines." *Open Rivers: Rethinking Water, Place & Community*, no. 12. <http://editions.lib.umn.edu/openrivers/article/rivers-flood-regularly-during-hurricanes/>.

## About the Author

Craig Colten is the Carl O. Sauer Professor of Geography at Louisiana State University. He has been involved with studying the geography of hazards for over 30 years, and started his career looking at the pre-EPA era practices for managing hazardous wastes and where such activities took place. More recently, he has focused on a range of urban flood hazards and community resilience. With a group of colleagues and students, he has considered the specific practices used at the community and family level that enable people to rebound from devastating events like hurricane, giant oil spills, and river floods. His books include *An Unnatural Metropolis*, *Perilous Place and Powerful Storms*, and *Southern Waters*.