# A Mississippi river diversion helped build Louisiana wetlands, geologists find

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The extensive system of levees along the Mississippi River has done much to prevent devastating floods in riverside communities. But the levees have also contributed to the loss of Louisiana's wetlands. By holding in floodwaters, they prevent sediment from flowing into the watershed and rebuilding marshes, which are compacting under their own weight and losing ground to sea-level rise.

Reporting in *Nature Geoscience*, a team of University of Pennsylvania geologists and others used the Mississippi River flood of the spring of 2011 to observe how floodwaters deposited sediment in the Mississippi Delta. Their findings offer insight into how new diversions in the Mississippi River's levees may help restore Louisiana's wetlands.

While scientists and engineers have previously proposed ways of altering the levee system to restore some of the natural wetland-building ability of the Mississippi, this is among the only large-scale experiments to demonstrate how these modifications might function.

The study was headed by Douglas Jerolmack, an assistant professor in the Department of Earth and Environmental Science at Penn, and Federico Falcini, who at the time was a postdoctoral researcher in Jerolmack's lab and is now at the Consiglio Nazionale delle Ricerche in Rome. Benjamin Horton, an associate professor in the Earth and Environmental Science Department; Nicole Khan, a doctoral student in Horton's lab; and Alessandro Salusti, a visiting undergraduate researcher also contributed to the work. The Penn researchers worked with Rosalia

Santoleri, Simone Colella and Gianluca Volpe of the Consiglio Nazionale delle Ricerche; Leonardo Macelloni, Carol B. Lutken and Marco D'Emidio of the University of Mississippi; Karen L. McKee of the U.S. Geological Survey; and Chunyan Li of Louisiana State University.

The 2011 floods broke records across several states, damaged homes and crops and took several lives. The destruction was reduced, however, because the Army Corps of Engineers opened the Morganza Spillway, a river-control structure, for the first time since 1973 to divert water off of the Mississippi into the Atchafalaya River Basin. This action involved the deliberate flooding of more than 12,000 square kilometers and alleviated pressures on downstream levees and spared Baton Rouge and New Orleans from the worst of the flood.

For the Penn researchers, the opening of the Morganza Spillway provided a rare look into how floods along the Mississippi may have occurred before engineered structures were put in place to control the river's flow.

"While this was catastrophic to the people living in the Atchafalaya Basin, it was also simulating—accidentally—the sort of natural flood that used to happen all the time," Jerolmack said. "We were interested in how this sort of natural flooding scenario would differ from the controlled floods contained within levees that we normally see in the Delta."

To capitalize on this opportunity, the team began examining satellite images showing the plume of sediment-laden water emerging from the mouths of the Atchafalaya and Mississippi rivers. They calculated the amount of sediment in the plumes for the duration of the flood based on the ocean color in the satellite images and calibrated these data to field samples taken from a boat in the Gulf of Mexico. Their boat sampling also allowed them to gather data on the speed of the plume and the extent to which river water mixed with ocean water.

From the satellite images, researchers observed that the Mississippi River unleashed a jet of water into the ocean. In contrast, the waters diverted into the Atchafalaya Basin spread out over 100 kilometers of coastline, the sediment lingering in a wide swampy area.

"You have this intentionally flooded Atchafalaya Basin and when those flood waters hit the coast they were trapped there for a month, where tides and waves could bring them back on shore," Jerolmack said. "Whereas in the Mississippi channel, where all the waters were totally leveed, you could see from satellite images this sort of fire hose of water that pushed the sediment from the river far off shore."

The researchers used a helicopter to travel to 45 sites across the two basins, where they sampled sediment cores. They observed that sediment deposited to a greater extent in the Atchafalaya Basin than in any area of the Mississippi Basin wetlands, even though the Mississippi River plume contained more total sediment.

The recently deposited sediments lacked plant roots and were different in color and consistency from the older sediments. Laboratory analyses of diatoms, or photosynthetic algae, also revealed another signature of newly deposited sediments: They contained a higher proportion of round diatoms to rod-shaped diatoms than did deeper layers of sediment.

"This diatom ratio can now serve as an indicator for freshwater floods," Horton said. "With longer sediment cores and analyses of the diatoms, we may be able to work out how many floods have occurred, how much sediment they deposited and what their recurrence intervals were."

Taken together, the researchers' findings offer a large-scale demonstration of how flooding over the Atchafalaya's wide basin built up sediment in wetland areas, compared to the more-focused plume of water from the Mississippi River. Jerolmack says this "natural experiment" provides a convincing and reliable way of gathering data and information about how changes in the Mississippi's levees and control structures could help restore marsh in other areas of the Delta.

"One of the things that we found here is that the Atchafalaya, which is this wide, slow plume, actually produced a lot of sedimentation over a broad area," Jerolmack said. "We think that what the Atchafalaya is showing us on a field scale is that this is the sort of diversion that you would need in order to create effective sedimentation and marsh building."

Provided by University of Pennsylvania