# In the Hurricanes' Wake

*Georgia Tech experts respond to Katrina and Rita with research, training and service projects.*

By Jane M. Sanders

IMAGE COURTESY OF NOAA

***RIGHT:** Hurricane Katrina was a Category 4 storm when it hit the Gulf Coast on Aug. 29, 2005. At one point in the Gulf of Mexico, it was a Category 5 storm.*

***BELOW:** Hurricane Katrina inflicted massive damage to this bridge in the Biloxi, Miss., area. The storm lifted huge slabs of concrete out of their positions.*

PHOTO BY PAUL SCHLUMPER

The massive impact of Hurricane Katrina and her cousin Rita this past summer captured the nation's attention and compelled many to respond.

At the Georgia Institute of Technology, experts across campus responded with research, training and service projects. Among their goals are better infrastructure design, configuration of port operations to reduce down time, protection of cleanup and construction workers, and accessibility to services and housing for hurricane victims with disabilities.

"During the coming months and years, there will be many opportunities for the talents of our unique community to help our fellow citizens in the impacted areas recover from this stunning disaster," says Georgia Tech President Wayne Clough.

Following are some of the efforts already under way.

## Structural Damage and Port Recovery Assessments

With a grant from the National Science Foundation (NSF), Professor of Civil and Environmental Engineering David Frost organized three teams of researchers, including graduate students, to conduct week-long field studies. They assessed infrastructure damage in the Gulf Coast region early this fall.

Frost and his colleagues have conducted numerous post-disaster reconnaissance studies following major natural and human-induced events, including earthquakes in Asia and California, the Indian Ocean tsunami and the 9/11 terrorist attacks in New York City.

"These studies have yielded significant new insights into both the characteristics of the events as well as the performance of manmade infrastructure subjected to these catastrophic events," notes Frost, who is director of Georgia Tech's Savannah, Ga., campus.

One of the research teams — led by Professor of Civil and Environmental Engineering Glenn Rix — is determining the link between physical damage from Hurricane Katrina and the operational capacity and recovery of Gulf Coast ports, including the Port of New Orleans. Meanwhile, researchers led by Frost are analyzing wind and storm surge damage data they collected from across the Gulf Coast region.

The studies may help define a zone that is potentially subject to certain types of damage. Then engineers could design structures within a certain distance of the shore to a higher standard than those farther inland, Frost explains. For example, in Savannah, one set of building codes applies to structures on the east side of Interstate 95 and another set to buildings on the west side of the highway.

The researchers collected information along the Gulf Coast, as they have done at other disaster sites in recent years, using integrated digital data collection systems Frost and his colleagues have developed. Included among these are data collection systems — called P-Quake and P-Damage — that run on a personal digital assistant (PDA) and incorporate data from handheld GPS devices, digital cameras and digital voice recorders. The systems allow researchers to collect data in a timely way to ensure its quality in an environment where it could potentially perish as cleanup begins, Frost notes.

A second team, led by Assistant Professor of Civil and Environmental Engineering Hermann Fritz of

Georgia Tech Savannah, was the first Georgia Tech research group to conduct reconnaissance in the Gulf Coast area in late September and early October. (See photos at **www.gtsav.gatech.edu/cee/groups/katrina/index.html**). They started near Mobile, Ala., and proceeded west into Mississippi and Louisiana. They recorded storm surge watermarks ranging from 6 to 10 meters and assessed hurricane-damaged structures, focusing on the hardest hit Mississippi and Louisiana coasts.

"Most amazingly, hurricane-proof designed buildings did not suffer major wind damage, even in areas with peak hurricane winds," Fritz notes. "However, all buildings — even massive structures such as hotels and office buildings — were washed out at the height of the storm surge.

Another team, led by Frost, gathered data along the path of Katrina from the coast northward. "We wanted to assess the overall infrastructure damage," Frost says.

Frost's team also is making a detailed assessment of structural damage to high-rise buildings. They collected data and will analyze it face by face and floor by floor. "We are trying to determine, for example, why there might have been more damage at a lower level or why one hotel and not the one next to it was damaged," he explains.

The research team led by Rix is focusing on the Gulf Coast ports, including the Port of New Orleans. Collaborating with Rix are Associate Professor of Civil and Environmental Engineering Reggie DesRoches, Associate Professor of Public Policy Ann Bostrom and Assistant Professor of Industrial and Systems Engineering Alan Erera.

Rix and DesRoches made an initial visit to the Port of New Orleans in October, and the entire team plans to follow up with operations managers there several times next year to track the recovery process.

"We are looking at the Port of New Orleans and its response to this natural disaster from a systems-level perspective," Rix explains.

The team's efforts to understand the impact of Katrina and Rita on Gulf Coast ports is closely linked to a recently funded project on seismic risk mitigation at ports as part of the Network for Earthquake Engineering Simulation (NEES) program of the NSF. In that project, a large group that includes researchers from Georgia Tech, nine other universities and consultants, are studying methods to reduce the impact of earthquakes on ports. The five-year, $3.6 million project got under way this fall.

"Although the damage to Gulf Coast ports was caused by hurricanes rather than an earthquake, it still provides valuable information on the effects of natural hazards on port operations and will allow us to calibrate our models of how ports respond to significant disruptions," Rix notes.

In a related project done under the auspices of the American Society of Civil Engineers' (ASCE) Technical Committee on Lifelines and Earthquake Engineering, DesRoches and his collaborators spent several days gathering data on the damage that Hurricane Katrina inflicted on bridges and the transportation network in the Gulf Coast region.

The information they collect will be used in computer models for earthquake recovery prediction, DesRoches explains. In addition, the data may help improve infrastructure design and rehabilitation of existing infrastructure, he notes.

"We're trying to determine the impact of damage on the recovery process," DesRoches explains. "Our models will help us make projections about the impact of an earthquake — in particular in Charleston, S.C., should another major earthquake, like the one in 1886, occur again.

This project is funded by the Mid-America Earthquake Center and the American Society of Civil Engineers.

"This research is a rare learning event, an opportunity to see first hand the impact of such a natural disaster," DesRoches says. "We do a lot of simulation and experimental work in our lab. But you cannot learn this kind of information in a lab or simulation. You have to learn it in the field."

## Health and Safety Training and Information

To help train workers involved in cleanup and rebuilding in the Gulf Coast and south Florida areas damaged by hurricanes Katrina, Rita and Wilma, the U.S. Department of Labor's Occupational Safety and Health Administration (OSHA) awarded a one-year, $400,000 Susan Harwood Training Grant to the Georgia Tech Research Institute (GTRI) on Sept. 30.

GTRI researchers led by project director and senior research engineer Paul Schlumper developed and are providing training materials and conducting training sessions that address occupational and safety health hazards that may be encountered by disaster recovery workers, supervisors and employers.

"Work zone safety and fall protection for people who are working on roofs is OSHA's top priority for us," says Dan Ortiz, chief of the Occupational Safety and Health Division in GTRI's Health and Environmental Systems Laboratory. "…. Our concern is that in the zeal to remove debris and restore buildings, workers and employers will take shortcuts. We want to have resources out there to make sure workers have the proper protective equipment and knowledge of environmental hazards."

In a related GTRI effort, researchers are collaborating with colleagues at Louisiana State

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PHOTO BY CHRISTOPHER KYLE CRAIG

PHOTO BY PAUL SCHLUMPER

***ABOVE TOP:** Katrina ripped through the brick walls of First Baptist Church in Gulfport, Miss.*

***ABOVE:** Hurricane Katrina moved a casino barge, right, in Biloxi, Miss., across the street, and it landed on a hotel, left.*

# Brewing Storm

***Hurricanes have gotten stronger in the past 35 years.***

By David Terraso

The number of Category 4 and 5 hurricanes worldwide has nearly doubled over the past 35 years, even though the total number of hurricanes has dropped since the 1990s, new research shows.

The shift occurred as global sea-surface temperatures have increased over the same period. The research by the Georgia Institute of Technology and the National Center for Atmospheric Research (NCAR) appeared in the Sept. 16, 2005 issue of the journal *Science*.

Peter Webster, a professor at Georgia Tech's School of Earth and Atmospheric Sciences, along with NCAR's Greg Holland and Georgia Tech's Professor Judith Curry and senior research scientist Hai-Ru Chang, studied the number, duration and intensity of hurricanes (also known as typhoons or tropical cyclones) that occurred worldwide from 1970 to 2004. The National Science Foundation (NSF) sponsored the research.

*BELOW: This chart shows the increase in Category 4 and 5 hurricanes worldwide during the past 35 years.*

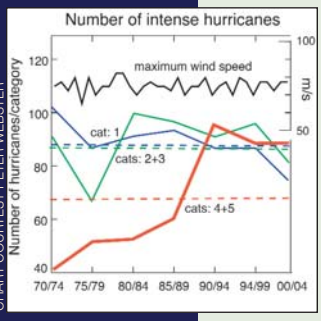


CHART COURTESY PETER WEBSTER

"What we found was rather astonishing," Webster says. "In the 1970s, there was an average of about 10 Category 4 and 5 hurricanes per year globally. Since 1990, the number of Category 4 and 5 hurricanes has almost doubled, averaging 18 per year globally."

Category 4 hurricanes have sustained winds from 131 to 155 mph; Category 5 systems, such as Hurricane Katrina at its peak over the Gulf of Mexico, feature winds of 156 mph or more.

"Category 4 and 5 storms are also making up a larger share of the total number of hurricanes," says Curry, chair of the Georgia Tech School of Earth and Atmospheric Sciences. "Category 4 and 5 hurricanes made up about 20 percent of all hurricanes in the 1970s, but over the last decade, they account for about 35 percent of these storms."

The largest increases in the number of intense hurricanes occurred in the North Pacific, Southwest Pacific, and the North and South Indian Oceans, with slightly smaller increases in the North Atlantic Ocean.

All this happened as sea-surface temperatures rose across the globe — ranging from one-half to one degree Fahrenheit, depending on the region — from 1970 to 2004.

"Our work is consistent with the concept that there is a relationship between increasing sea-surface temperature and hurricane intensity," Webster says. "However, it's not a simple relationship. In fact, it's difficult to explain why the total number of hurricanes and their longevity has decreased during the last decade when sea-surface temperatures have risen the most."

The only region that is experiencing more hurricanes overall is the North Atlantic, where the storms have become more numerous and longer-lasting, especially since 1995. The North Atlantic has averaged eight to nine hurricanes per year in the past decade, compared to the six to seven per year before the increase. Category 4 and 5 hurricanes in the North Atlantic have increased at an even faster clip — from 16 during the 1975 to 1989 timeframe to 25 from 1990 to 2004, a rise of 56 percent.

"This long period of sustained intensity change provides an excellent basis for further work to understand and predict the potential responses of tropical cyclones to changing environmental conditions," says NCAR's Holland.

A study published in July 2005 in the journal *Nature* yielded conclusions similar to the Georgia Tech and NCAR study. Focusing on North Atlantic and North Pacific hurricanes, Professor Kerry Emanuel of the Massachusetts Institute of Technology found an increase in their duration and power, although he used a different measurement to determine a storm's power.

But whether this trend stems from human-induced global warming is still uncertain, Webster says. "We need a longer data record of hurricane statistics, and we need to understand more about the role hurricanes play in regulating the heat balance and circulation in the atmosphere and oceans."

Jay Fein, director of NSF's climate and large-scale dynamics program, which funded the Georgia Tech and NCAR research, says: "Basic physical reasoning and climate model simulations and projections motivated this study. These results will stimulate further research into the complex natural and anthropogenic processes influencing these tropical cyclone trends and characteristics."

At NCAR, Holland and his colleagues are conducting a series of computer experiments capable of resolving thunderstorms and the details of tropical cyclones. "The results will help explain the observed intensity changes and extend them to realistic climate change scenarios," Holland explains.

In ongoing research at Georgia Tech, Webster is trying to determine the basic role of hurricanes in the climate of the planet. "The thing they do more than anything is cool the oceans by evaporating the water and then redistributing the oceans' tropical heat to higher latitudes," he says. "But we don't know a lot about how evaporation from the oceans' surface works when the winds get up to around 100 mph, as they do in hurricanes."

This physical understanding will be crucial to connecting trends in hurricane intensity to overall climate change, Webster explains.

"If we can understand why the world sees about 85 named storms a year and not, for example, 200 or 25, then we might be able to say that what we're seeing is consistent with what we'd expect in a global warming scenario," he says. "Without this understanding, a forecast of the number and intensity of tropical storms in a future, warmer world would be merely statistical extrapolation."

**@ Read more at:**
**www.gatech.edu/newsroom/release.php?id=654**

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IMAGE COURTESY HERMANN FRITZ

*ABOVE: In Dauphin Island, Ala., Assistant Professor Hermann Fritz surveys a transect across the over-washed island with a laser range finder. In the background is an off-shore oil platform that broke loose from its moorings and drifted 66 miles from Louisiana to Alabama.*

University (LSU) to provide information to residents and contractors in the region on the health and environmental hazards they may face as they clean up and renovate hurricane-damaged homes. Senior research scientist Bob Schmitter is leading the Georgia Tech portion of the project, which is funded by the U.S. Environmental Protection Agency through its regional Technical Outreach Services to Communities (TOSC) programs operated by Georgia Tech and LSU (Regions 4 and 6, respectively).

Among the hazards homeowners face are asbestos, lead-based paint, mold and various hazardous materials, Schmitter notes. TOSC experts compiled written information and distributed it to residents in shelters and home improvement stores.

## Waste Disposal and Recycling

In addition, at the request of the Federal Emergency Management Agency, GTRI researchers are evaluating the feasibility of using a GTRI-designed plasma furnace system to dispose of some of the tremendous volume of debris in the region.

"There's not enough landfill space available to handle this much waste, and open burning of it would pose such a huge environmental problem," says senior research scientist Ken Johnson.

GTRI's plasma pyrolysis gasification system uses plasma arc technology, which creates a form of "artificial lightning," using electricity to convert an ionized gas, such as air, into a plasma state. The extremely hot plasma temperature can gasify organic wastes into low-BTU fuel gases and melt inorganic wastes into an inert rock-like glassy residue.

To date, the furnace system has been used in the lab only. GTRI's lab model could be transported to the region and handle 12 tons of waste a day. But the need exists for a mobile system that could handle 1,000 tons a day. Johnson has discussed construction of such a system with a company that could build it quickly.

## Referrals for Hurricane Victims with Disabilities

In the aftermath of Hurricane Katrina, FEMA and the American Red Cross listed in its victim hotline database a Georgia Tech-based center that promotes voluntary compliance with the Americans with Disabilities Act (ADA). Hurricane victims with disabilities misunderstood the center's mission, though, and flooded it with calls about all kinds of relief and assistance.

The Southeast Disability and Business Technical Assistance Center (DBTAC) housed at the Center for Assistive Technology and Environmental Access in the Georgia Tech College of Architecture was inundated with over 2,200 calls in the month following Katrina over its toll free hotline (1-800-949-4232). So the Southeast DBTAC, funded by the National Institute on Disability and Rehabilitation Research, became a referral center, says assistant project director Pamela Williamson.

People sought housing assistance, general financial assistance, food, information on how to get prescriptions filled, replacement of various assistive devices and medical equipment that were lost or damaged in the storm, and answers to insurance questions. DBTAC staff even handled some calls from potentially suicidal hurricane victims.

Though DBTAC's grant does not cover these services, staff members compiled a resource list to refer callers to the correct organizations.

"We tried to be as customer-service oriented as possible," Williamson says. "We already had some of the referral agencies in our database, but we added many more to our list so we could help hurricane victims with disabilities."

In light of its response to Katrina, the Southeast DBTAC has revamped its work scope in Mississippi for the coming year to focus its efforts on providing ADA-related assistance to hurricane victims with disabilities, says director Shelley Kaplan. These efforts include ensuring that temporary housing is accessible, providing interpreters for people who are deaf so they can communicate with relief organizations and working with contractors to ensure that rebuilding is done in accordance with ADA Standards for Accessible Design.

@ Read more at:
**gtresearchnews.gatech.edu/reshor/rh-f05/katrina.html**

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*BELOW: A coastal Mississippi home was washed across the street by Hurricane Katrina. This location was about 1 mile from the beach.*

PHOTO BY PAUL SCHLUMPER

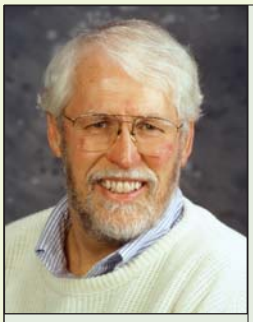

PHOTO BY STANLEY LEARY

*Robert Craig is a professor in the Georgia Tech College of Architecture.*

# Faculty Column

*Thoughts on the cultural impact of Katrina — people and things.*

BY ROBERT M. CRAIG
*Professor, College of Architecture*

In a classic scene in *The Grapes of Wrath*, author John Steinbeck describes the uprooting of lives and the heart-wrenching decisions of dust-bowl victims forced to abandon their homes and to leave behind the material souvenirs of their lives. Crowded into ragged vehicles that will transport them westward, desperately trying to decide what, among their belongings, they have room to carry with them, the men prepare a bonfire to burn the artifacts of their past lives, (perceived as personifications of past bitterness), while the women lament, "How can we live without our lives? How will we know it's us without our past?"

In tragic times of displacement, whether brought about by natural or man-made disaster, our values realign to move "from sense to soul" from "things" to family, from material possessions and accumulated belongings to what really counts in life.

With the loss of life and displacement of citizens from their homes brought about by hurricanes Katrina and Rita, one hesitates to talk about lost or damaged buildings or cultural artifacts resulting from a hurricane coming ashore. Nonetheless, at times such as these, as an architectural historian whose career has focused on the study of buildings, art, and the culture of the past, I find compelling Steinbeck's representation of Okies displaced from those "places," as well as "objects" of their lives, and I found myself searching for news regarding the survival of historic landmark architecture, of pottery workshops and art collections along the Gulf Coast, and of archival records of centuries of New Orleans history.

Man, for centuries, has recorded the present, with an eye that future generations will glean meaning from this documentation, artifacts of what for our children is past. In *St. Mark's Rest*, John Ruskin wrote, "Great nations write their autobiographies in three manuscripts — the book of their deeds, the book of their words, and the book of their art." As a researcher, I questioned whether, in the palimpsest of time, Katrina had erased much of the autobiography of the Gulf Coast region and lower Mississippi Valley. I sought to learn what buildings still stood, what archival records or art collections had not flooded, and what cultural aspects of these extraordinary places called New Orleans, coastal Mississippi, bayou country, and The South, remained intact, and what had been destroyed.

Civilization and culture mean different things to different people. Our experience or knowledge of New Orleans may encourage us to focus on food, music, architecture (high style and urbane, or vernacular), literature, and drama, and our interests range from Cajun culture, Voodoo, Mardi Gras, and Bourbon Street to Spanish moss, shotgun houses, and a sense of place that is New Orleans.

Take food, for example. We all have "tasted" New Orleans culture in the literal sense of enjoying its regional food. New Orleans means "beignets and crawfish bisque and jambalaya... grillades for breakfast, a po-boy with chow-chow at bedtime, and tubs of gumbo in between," writes Tom Robbins in *Jitterbug Perfume.* It means blackened redfish, boiled crawfish, oyster bars, and shrimp remoulade, but Katrina raised the question of the continuing supply of the very ingredients of such local cuisine. It is projected to take three years for the local shrimp and oyster industries to recover from the storm.

New Orleans means celebrity chefs Paul Prudhomme and Emeril Lagasse and famed restaurants that help shape the culture of this place, and the researcher is motivated by more than academic curiosity in asking how long before they may reopen. Displaced food industry workers number about 55,000. In New Orleans, almost 10 percent of the labor force worked in the city's estimated 3,400 restaurants. We are at once brought back to people.

Similarly, as one contemplates the impact of Katrina on the region's culture, some of us may well ask when jazz, born in New Orleans in the late 1800s, will return to the streets. The architectural embodiment of New Orleans jazz is the saxophone player in the open square, the brass band and funeral parade in the street, and most especially the legendary jazz institution Preservation Hall.

> "Given the disturbing news in the aftermath of Katrina and Rita, with its horrific images televised and printed, many of us may better understand, perhaps, New Orleans' association with that related musical idiom, the blues."

PHOTO BY CHRISTOPHER KYLE CRAIG

***ABOVE:** Hurricane Katrina gutted this house east of Gulfport and west of Biloxi, Miss. The second-floor structure is missing. Note the second-floor fireplace on the upper left wall.*

We await the return of the people's music to the streets and halls of New Orleans, the reopening of Preservation Hall. But the future is uncertain for much of what we may have taken for granted as always there in this city.

Given the disturbing news in the aftermath of Katrina and Rita, with its horrific images televised and printed, many of us may better understand, perhaps, New Orleans' association with that related musical idiom, the blues. The Associated Press reported on one noted blues player who became a victim of the hurricane. Clarence "Gatemouth" Brown, born in Vinton, Louisiana, was a resident of Slidell, a low-lying dormitory suburb of New Orleans. He evacuated his residence to the town in Texas where he had been raised, and on September 10th, at 81, Brown died. He was "completely devastated ... and heartbroken, both literally and figuratively," his booking agent said. We cannot help but return to people even as we think of cultural loss.

And yet, New Orleans is also "brick and mortar," and mostly wood frame. As we contemplate the *physical* city in our mind's eye, we may readily question whether that peculiar ambiance of New Orleans as a place, its streets and neighborhoods and the character of the ensemble, will be lost forever. The streets around Elysian Fields Avenue, for instance, were described by Tennessee Williams in "A Streetcar Named Desire" as "poor but, unlike corresponding sections of other American cities, it has a raffish charm." That character, somehow conveyed by the everyday whole more than by "high-style" parts, is often best known to us in literature and drama, in vernacular architecture and popular culture, and in poetry and song.

Recognizing the raffish charm of New Orleans, a September 1 *New York Times* article observed that Katrina ushered in "A Sad Day, Too, for Architecture." The city "faces the loss of some of America's most notable historic architecture ... in neighborhoods like Treméé and Mid-City, which extend along Bayou Road toward Lake Pontchartrain and are rich in 18th- and 19th-century homes, shops, churches and social halls." The survival of more elevated sections of New Orleans conveys a lesson about the wisdom of selecting building sites on higher ground, an issue which informed French colonial and 19th-century builders' decisions, but which has not always motivated 20th-century developers. All this is to say nothing about broken levees and the "bowl effect," Gulf Coast beachfront condos, historic districts on the beach, or even ordinary towns along the Gulf. Architectural research must make renewed inquiries into issues of design and regional aesthetics, structure and construction materials, and behavioral psychology and sociology in order to define a new future for the Ninth Ward neighborhood, the beach house, and development in the wetlands.

As the winds died down, the initial focus for me was to obtain a status report on people and things. Therefore, "research at Georgia Tech," for this researcher, involved activities different from those more typically reported in the pages of this magazine. As an historian focused on architecture considered as an embodiment and expression of culture, and as a researcher vitally interested in the survival of documentary records of the past, I was immediately interested in the cultural impact of Katrina. I investigated the status of art collections, archives, museums, historical records, forts, lighthouses, plantation "out buildings" (including preserved slave cabins), 300-year-old oak-lined allées, an aquarium, a zoo, and even noteworthy modern buildings. I learned of the survival of 19th-century plantation houses, and the complete destruction of others.

Three years ago, I visited two houses in Ocean Springs, Mississippi, designed in 1890 by Frank Lloyd Wright for famed Chicago-architect Louis Sullivan and for his friend James Charnley as vacation homes. The owner of the Sullivan House reported that this early work by America's best-known architect, had "vaporized" when Katrina made landfall, and the Charnley House next door was blown off its foundation with major destruction to the wood-frame structure.

How did other architectural landmarks of Louisiana and the Gulf Coast fare? Beyond observing obvious flood damage to low-lying neighborhoods, one may readily note that it will be a long time before one knows the full extent of water damage to cemeteries, to the city's infrastructure, and to the presumed more substantial structures of even relatively recent date.

My "research report" on the cultural impact of Katrina on Louisiana and Mississippi is posted on the *Research Horizons* web site at **gtresearchnews.gatech.edu/reshor/rh-f05/craig-report.html.** The report gathers together some known information as of late September, concerning the impact of Katrina on regional landmarks of 19th-century culture, on historic architecture, and on museums and repositories of 19th-century artifacts and art. I report some good news, and, unfortunately, some very bad news.

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PHOTO BY ROBERT CRAIG

PHOTO COURTESY OF DAVID PREZIOSI, MISSISSIPPI HERITAGE TRUST

***ABOVE: This cottage (top photo) in Ocean Springs, Miss., was designed in 1890 by Frank Lloyd Wright as a vacation home for famed Chicago architect Louis Sullivan. Its owner reported that this home designed by America's best-known architect had "vaporized" when Hurricane Katrina made landfall (photo below).***