# Restoring and Protecting Coastal Louisiana

**The challenges facing the Gulf Coast reflect a national inability to come to grips with the need to deal with neglected infrastructure, both natural and built.**

Robert R. Twilley
Professor, Department of Oceanography and Coastal Sciences
Associate Vice Chancellor, Research and Economic Development
Louisiana State University

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Water is probably one of the most important resources that will define the economic, public health and environmental issues in the next century, certainly by 2050. Today, water resource quantity and quality across well-defined regional river basins represent highly engineered landscapes to support critical economic infrastructure that is being subjected to a changing global climate that will challenge our national priorities. Thus water resource planning through the development of public policy is arguably one of the most important features of our national security, our ability to sustain natural resources, provide for public health, and promote economic development. The following two sections are from previously published manuscripts that define some of the urgent challenges to establish national priorities in restoring and protecting the Gulf Coast region.

**Infrastructure needs of Coastal Protection and Restoration:**

The sustainability of coastal Louisiana is critical to the nation. It is the location of a large part of the nation's oil and gas industry and its largest port complex. It provides vital habitat for economically important fisheries and threatened and endangered species. Yet this region is under siege. The catastrophic effects of Hurricane Katrina in 2005 and recent storms in 2008 brought to the nation's attention the fragility of the region's hurricane defenses and the continuing loss of wetlands and ecosystems; a loss that has continued for more than a century with little or no abatement. Slowly, the flood protection system in New Orleans is being restored; even more slowly, attention is shifting to restoring the coastal deltaic system. But there is a lack of strong support for these two linked efforts, protection and restoration. There is a lack of funding but also the lack of a prioritization system at the federal level for allocating funds for critical water resources infrastructure. The challenges facing the Gulf Coast reflect a national inability to come to grips with the need to deal with neglected infrastructure, both natural and built, and the realization that both provide security to coastal communities. It will not be possible to protect and restore coastal Louisiana without significant changes in the way federal and state governments deal with these issues.

According to the American Society of Civil Engineers (ASCE), in its frequent report cards on the status of the nation's infrastructure, the United States is not maintaining and upgrading its infrastructure and is especially neglecting its natural and built water resources infrastructure. The ASCE indicates that the cost of all needed infrastructure work in the United States exceeds $1.5 trillion. Funding for water and wastewater treatment facilities is falling behind at a rate of more than $20 billion each year. Funding for flood-risk management, navigation, hydropower, and ecosystem restoration (wetland and aquatic), not including the short-term levee repair efforts in

New Orleans, also continues to decline. With so many clear and pressing needs, it is vital that the United States devise more rational approaches to the funding and prioritization of infrastructure projects, including critical water resource projects such as those in coastal Louisiana.

The 2005 disaster in New Orleans awakened the nation to the serious vulnerabilities in flood protection that exist across the country and to the fact that the nation lacks a realistic assessment of the infrastructure, both built and natural, it takes to reduce these vulnerabilities. The failures of levees and other infrastructure that have occurred since Katrina, including those that occurred during the Midwest floods of 2008, have more clearly defined this issue as national in scope. At the same time, the need for national priorities in ecosystem restoration has lacked attention. The loss of coastal wetlands along the Gulf had been well known for decades, and environmental groups had been campaigning for action to restore this deltaic coast. Resources were going to projects in other parts of the country such as the $7.8 billion federal initiative to restore the Florida Ever-glades and the joint federal/state efforts to reduce pollution in the Chesapeake Bay. Other regions also deserve attention. The need for ecosystem restoration has been recognized in the Missouri River, the upper Mississippi River, the California Bay Delta, the Great Lakes, and numerous smaller areas across the country. There is an urgent need to assess investments in natural and built environments to reduce vulnerabilities to increased flooding risks.

Coastal Louisiana sits at the end of a natural funnel that drains 41% of the coterminous United States and parts of two provinces of Canada. This watershed, the Mississippi River basin, delivers water to the Gulf of Mexico through the mouths of the Mississippi and Atchafalaya Rivers. Extending more than 11,400 square miles, this coastal area was formed during the past 6,000 years by a variety of deltaic lobes formed by the Mississippi River switching east and west from Lafayette to Slidell, creating an extensive system of distributaries and diverse wetland landscapes as freshwater and silt mixed with coastal processes of the Gulf of Mexico. Periodic river flooding by breaches in natural levee ridges (crevasses) along the numerous distributaries across the deltaic landscape out to the barrier islands limited salt water intrusion and added sediments to coastal basins. These river and coastal processes built and sustained an extensive wetland ecosystem, the eighth largest delta in the world. In addition to providing nurseries for fish and other marine life and habitat for one of the largest bird migration routes in North America, these wetlands serve as green infrastructure, providing natural buffers that reduce flood risks to the vast energy production and port facilities of the Gulf area as well as human settlements inland from the coast. Early settlers in New Orleans were more concerned by flooding from the Mississippi than by the threat of Gulf storms, which would be buffered by extensive coastal forests that stood between the city and the Gulf of Mexico.

Long before Katrina, coastal wetlands were disappearing because of considerable human influence and disruption in the natural processes of a deltaic coast. Levees were built along the banks of the Mississippi to keep the river from overflowing into floodplains and coastal environments to protect lands that had been converted to agriculture, industry, and human settlement. The sediment that once breached natural levees and nourished the wetlands was instead channeled out into the Gulf of Mexico, in essence starving the delta and causing it to recede rather than grow. The effect of levees was exacerbated by the construction of channels and pipeline corridors that crisscrossed the wetland landscape to provide access for extracting much needed domestic oil and gas resources by providing reliable navigation channels that could be connected to Mississippi River commerce. During the 1960s and 1970s, coastal land, mostly wetlands, disappeared at the rate of 39 square miles per year.

The potential conflict of human activities and processes necessary for a sustainable deltaic coast were identified after the 1927 flood. But pressure for protection and economic development ignored the call for more prudent management of river resources to integrate both protection and restoration policies. By the mid-1980s, coastal scientists had brought the public's attention to the loss of wetlands and the degradation of the Mississippi River delta. Very little was done to address the enormous problem because the environmental consequences were not deemed sufficient to justify the expense of restoration and mitigation. In 1992, the Mississippi River Commission, recognizing the problem of increased salinity that threatened deltaic habitats along the coast, opened a diversion structure through a Mississippi River levee at Caernarvon, south of New Orleans. This diversion structure simulates a levee breach by allowing Mississippi River water to flow by gravity (flood gates are opened during elevated river levels) into the wetlands behind the levees during certain periods of the year. This became the first significant step in what may become a series of such structures to the south of New Orleans.

New Orleans and the surrounding region have been protected in various ways from potential Mississippi River

floods since the city was settled in 1717. After the disastrous 1927 flood, the Army Corps of Engineers instituted a massive river levee-rebuilding program that was accompanied by floodways and channel modification. This river-protection system has performed as expected since that time.

Coastal protection became the additional authority of the Corps in 1965, when Hurricane Betsy flooded parts of New Orleans. Until the arrival of Katrina, federal and local efforts had focused on providing protection against a storm defined by the National Oceanic and Atmospheric Administration (NOAA) as the standard project hurricane. Shortly after construction began in earnest, NOAA increased the estimated size of the standard project hurricane. In contrast to the river-protection system, funding for the coastal-protection system was through individual projects that came in dribs and drabs, thus limiting the ability of the Corps to change its design to accommodate the new, larger target hurricane. Instead, the Corps decided to move ahead to first complete all the work at the original level of protection. But as individual construction projects took place, ever-present subsidence was diminishing the level of protection provided by the newly constructed levees. When Katrina hit, the degree of completion of the major components of the protection system varied from 65 to 98% of the original design standards, not taking into account datum errors, subsidence, and sea level rise that had taken place since the original design. The failure during Katrina of several components of the protection system, together with the massive size of the hurricane itself and the loss of coastal habitat, resulted in a loss of more than 1,400 lives, the devastation of major housing districts within the city, and other damage throughout the region.

**Finding solutions**

Postmortems on the impact of the hurricane flooding recognized the longstanding relationship between extensive coastal wetlands and community protection, resulting in a great deal of debate about whom or what was to blame for failing to implement integrated protection and restoration. Now, however, it is more important that we devote our attention to finding solutions that will leave this important region with reduced risks from hurricanes, a navigation system that will support the substantial foreign trade through the Port of New Orleans, support for the area as a viable energy producer for the nation, and a rich and vibrant coastal wetland ecosystem.

Although there are now cooperative efforts to deal with the problems of coastal Louisiana, the picture is far from rosy. Two parallel efforts, one led by the state of Louisiana and the other by the Corps, have been under way since Katrina to determine the appropriate combination of structural activity (levees, flood walls, gates, and so forth), non-structural features (for example, building codes and evacuation planning), and wetland restoration needed to protect urban areas and distributed assets across the coastal landscape. The state plan has been approved by the Louisiana legislature, but the Corps plan has yet to be completed and submitted to Congress. Both plans call for restoration of the wetlands through diversions of the Mississippi River, and both would rely on adaptive management of the process to address the substantial design uncertainties in such a large dynamic deltaic system. A coastal ecosystem restoration program, much like that for the Everglades, was authorized by Congress in the Water Resources Development Act of 2007. Only a few preliminary projects were authorized, however, and funding has not yet been provided. This authorization establishes a structure to oversee this work but does not identify methods to be used to determine priorities among the various components of the overall program, nor does it provide an effective means for competent project authorization and funding. The state has recently announced plans to spend nearly $1.2 billion over the next three years on protection and restoration projects that are consistent with the state master plan. Although this is an impressive investment, it is an order of magnitude less than even some of the conservative estimates of system-level project costs for both coastal ecosystem restoration and storm risk reduction.

The specter of climate change is adding to the water and coastal management challenges. Climate change will bring about changes in weather patterns and the potential for increased flooding, drought, and sea-level rise. Existing projects will have to be modified to accomplish the purposes for which they were originally designed, and additional attention will be required to deal with the already significant strain on recovering ecosystems. The vulnerabilities of coastal landscapes to projected environmental changes are relative to the capacity of ecosystems to adapt. The present rate of wetland loss in this region suggests that these adaptive mechanisms are insufficient to deal with present rates of sea-level rise and subsidence.

Those working on coastal Louisiana restoration and protection have attempted to deal with the program on a comprehensive (watershed) basis, recognizing that the problems of southern Louisiana are not solely those of that state. The sediment required to replenish the wetlands will come from lands scattered throughout the basin and will

be affected by the activities in the basin states. Much of the original sediment load of the Mississippi is trapped behind major dams on the Missouri River system. A major dead zone (an area where marine life is stressed because of lack of oxygen) now exists in the Gulf of Mexico along Louisiana and parts of Texas as a result of excessive nutrients traveling down the Mississippi from the farmland of the Midwest. The flux of nitrate has increased threefold since the 1960s. Although sediments are critical to rebuilding the wetlands of the Mississippi River Delta, additional nutrients flowing through river diversion structures could potentially impair inland waters of the state. Two strategies have been suggested to limit the potential water quality issues along coastal Louisiana. An upstream strategy is a significant reduction in the application of chemicals to the farmland of the Midwest, along with restoring wetland buffer strips on the edge of fields that can reduce nutrient loading in river waters. Downstream in the coastal delta, wetland restoration is considered another mechanism of nutrient reduction to coastal waters. Both strategies have uncertainties in system capacity of nutrient reduction and political will in implementation. So a potential conflict in diverting river sediment for wetland restoration may be limited by coincident nutrient enhancement of hypoxia.

**Funding limitations**

Even though the nation's largest port and energy complex, a metropolitan area of nearly a million residents, and coastal wetlands of immense value are at risk, funds to support the restoration and protection of coastal Louisiana have been slow in coming. The Corps has been provided with about $8 billion to restore the levee system around New Orleans to the level of a 100-year flood. This level of protection is below that of a 400-year storm such as Katrina, but it will relieve New Orleans residents of the requirement to buy flood insurance against a potential hurricane. Congress has directed the Corps to study and report on the costs of providing New Orleans with protection against a category 5 hurricane. Early estimates indicate that the costs of such a project would exceed $10 billion. The cost of coastal restoration has been estimated at as much as $20 billion. Even in these days of mega-bailouts, those are big numbers.

The ability to move ahead with the protection and restoration of coastal Louisiana will require substantial funding. The Bush administration's budgets have kept funding for the water sector flat except for periods when disasters required immediate attention. In constant-dollar terms, the funds available for these projects are going down each year. In the tight funding environment of recent years, budget decisions have been driven largely by the historical record of funding, not an evaluation of the nation's risks and needs. The current fiscal crisis will only increase the pressure on the limited dollars that are available.

The largest source of funds for dealing with major water projects is found in the budget of the Corps. But the restoration and protection of coastal Louisiana is but one of many flood and hurricane protection, navigation, ecosystem restoration, and other projects that demand Corps and related federal water dollars. Major flood problems in the central valley of California, the reconstruction of levees in the Midwest, and the repair and upgrade of other structures identified in recent levee system inspections provide competition for New Orleans and coastal Louisiana. The aggregate projected costs of restoration projects in the Everglades (now $10.9 billion), upper Mississippi, Chesapeake Bay, Great Lakes, and California Bay Delta exceed $50 billion. Costs for other programs, such as the Missouri River basin, remain to be calculated.

Unfortunately, priority setting is tied to a rudderless system for allocating federal funds and assessing national needs. It is difficult to justify a national priority when objectives at the national level are not clear. Developing a needs assessment is dependent on having national policies that appropriately define national goals for water use. Whom do we protect from flooding? What infrastructure is at risk? What losses and risks will have national consequences? What ecosystems need to be restored or are the most valuable to the economic, ecological, and social well-being of the nation? How important are ports to the economy of the country? Recent National Research Council studies of the Corps' planning processes and projects have indicated that the Corps is faced with conflicting laws and regulations that make prioritization and description of needs difficult to achieve.

Within the federal government, requests for funds are initiated by the departments and are based on guidance from the Office of Management and Budget, which establishes prioritization criteria for items to be included in the president's budget. But these priorities are only tangentially related to actual needs and are driven by economic cost/benefit criteria, not national needs. In making decisions on the budget, Congress, as was noted at a recent hearing on watershed planning, tends to deal with the authorizations and appropriations for specific projects with

little consideration of the relationship of the projects to the greater needs of the nation or even the watershed in which the projects are to be built. With some exceptions, Congress supports projects on the basis of the political weight they carry.

Prioritizing funding on a watershed basis would not be new to the United States. In 1927, Congress directed the Corps to conduct studies of all U.S. river basins in order to plan for integrated development of the water resources of these basins. These "308 reports" (named for the section of the law that authorized the studies) became the basis for the development of the Tennessee Valley and Columbia River basins, among many others. In cases in which such basin/watershed planning has taken place in a collaborative manner, the results have been outstanding. The Delaware River Basin Commission brings together the states of New York, Pennsylvania, and New Jersey for cooperative management of that important river basin.

In recent years, members of the House and Senate have tried to establish a needs-based approach for allocating funds, but the efforts failed because too few members were interested in giving up the benefits of selecting projects on their political merit. During a 2007 debate on an amendment to a bill to create a bipartisan water resources commission to establish priorities for water project funding, Sen. John McCain (R-AZ) noted that, "We can best ensure safety of our nation's water resources system by establishing a process that helps us to dedicate funding to the most critical projects. The current system allows more of the same, where members demand projects that are in the members' interests, but not always in the public's." The amendment went nowhere.

**Looking for other approaches**

Is there a substitute for federal money to support water resource projects? Because of the massive costs of major restoration efforts, doing without Congress doesn't seem to be a reasonable approach. States are already participating in the funding of major projects. Louisiana has announced its intention to allocate substantial funding to coastal restoration and protection activities (more than $1 billion in the next three years). California recently passed a $5 billion bond issue to repair levees. With federal appropriations slow in coming, Florida has contributed more funding for restoring the Everglades and acquiring critical lands. But states are also in a funding squeeze and cannot provide all that is needed to support projects that are in the national interest.

Several alternative ways of financing infrastructure projects have been proposed and should be seriously considered. Former senator Warren Rudman and New York investment banker Felix Rohatyn have proposed the establishment of a National Investment Corporation (NIC) with the authority to issue bonds with maturities of up to 50 years to finance infrastructure projects. The bonds would be guaranteed by the federal government and, as long-lived instruments, would align the financing of infrastructure investments with the benefits they create. Bond repayment would allow the NIC to be self-financing. In a similar approach begun after Katrina, a working group commissioned by the Corps proposed the creation of a congressionally chartered coastal investment corporation to support needed development projects. In 2007, Louisiana established the Coastal Protection and Restoration Financing Corporation that "will be responsible for selling bonds based on the expected revenue from future oil and gas royalty payments" and that will allow funding of projects over the next 10 years "instead of having to wait until a steady revenue stream arrives from the federal government in 2017." In the face of the current fiscal crisis and the need to develop a long-term approach, the development of the NIC offers the most realistic method of dealing with the need for the development of a sustainable funding stream.

Another challenge is coordinating federal funding and establishing regional priorities. In the past, the United States successfully established processes to deal with the challenge of developing priorities and funding to deal with water issues of national significance. In 1879, Congress established the Mississippi River Commission with the mission of providing a navigable Mississippi and reducing the ravages of frequent floods. After the 1927 flood, Congress passed the Flood Control Act of 1928, which created a comprehensive a Mississippi River and Tributaries (MR&T) project. This permitted the commission to deal with the lower valley as a whole: one mission, one entity, working cooperatively with all interested parties to integrate the resources needed to meet the challenge. Although the operations and size of government have changed since 1879 and 1928, the need to deal with work in the lower Mississippi Valley in a comprehensive manner remains. The continuous funding of work on the lower Mississippi River for nearly 80 years and the comprehensiveness of the effort show the utility of developing a separate federal project, similar to the MR&T, for restoring and protecting coastal Louisiana.

Protection and restoration of coastal Louisiana should be a major priority for the United States. The nation cannot

live without its water resources and deltaic coast. It cannot continue to watch coastal Louisiana disappear. Sooner or later, it will have to address the problem. The longer we wait, the more difficult the problem will become, and the more money the eventual solution will cost.

**Restoration vs Eutrophication**

Delta restoration – system design toward a resilient, self-sustaining delta – is a generic environmental problem worldwide in which human and natural dynamics are strongly and inherently coupled. The urgent need for wetland restoration and rehabilitation at large spatial scales have been addressed through the diversion of riverine water from the Mississippi River. This management strategy aims to deliver sediment-laden water to declining wetlands areas and promote wetland productivity using human water control structures in major basin areas undergoing wetland loss (e.g., Barataria Bay, Breton Sound) (Day et al. 2005). The conflict to resolve ecosystem needs of river and coastal processes to sustain the delta with demand for structural features from levees and floodgates to protect people and infrastructure has always historically favored investments in resiliency of the social system at the expense of the natural system. However, reductions in sediment loading to the deltaic region and restricted distribution of river flow across wetland landscapes combine to constrain the resources needed in large scale diversion projects that are needed to have any chance of stabilizing some wetland footprint in this area.

The challenge to develop bold new ideas of river management to reintroduce sediment to the coast are further complicated by how the chemistry of the river has changed over the last four decades. The Louisiana coastal region is at the receiving end of a large input of nitrate from upstream agricultural activities. Because of large nitrogen loading through the Mississippi River basin, there is increasing coastal eutrophication and the development of a large hypoxia zone (up to 21,000 $km^2$). As nitrogen is delivered to coastal waters, there is a risk of exacerbating eutrophic conditions through seasonal algae blooms (e.g., toxic), excess organic matter production, low oxygen concentrations in water and sediments, and long term nitrogen and phosphorous accumulation (Brown et al. 2006). As more freshwater diversion projects are planned along major waterways throughout the state of Louisiana, there is concern that this new constituent of nitrate will contribute to reduced water quality conditions of shallow bays and estuaries of the delta. Concerns about creating large human health risks as result of toxic algal blooms induced by increasing nitrogen inputs, underscore the difficulty of implementing large-scale restoration plans in coastal region.

Denitrification is the conversion of nitrate to nitrogen gas and is currently considered a critical ecological function for the removal of highly enriched N from anthropogenic sources. Since nitrate is generally the dominant form of excessive nitrogen entering coastal regions, it is potentially viable to ameliorate water quality problems through the reduction of nitrate via direct denitrification (Mitsch et al. 2001). As nitrate-enriched water masses flow through the landscape, the presence of riparian, headwater streams, and coastal wetlands can efficiently remove reactive nitrogen. Comparative studies of wetland and riparian ecosystems along the Mississippi River basin suggest that those habitats can retain up to 70% of nitrate inflow (Mitsch et al., 2005). However, large-scale managed input of nutrient-enriched Mississippi waters into wetlands and open waters has been controversial since its implementation in coastal Louisiana ( Day et al. 2007). Presently there is no clear consensus on whether restoring wetlands with sediment from the river will also enhance the capacity of nitrate removal, thus reducing risks to eutrophication.

Delta restoration involves one or more carefully sited, partial river diversions (controlled avulsions, in a sense) that set in motion the natural processes that created the delta, but in a controlled manner that either builds new land area or nourishes existing wetlands preventing them from drowning. With increased nitrate concentrations over the last four decades, the reintroduction of river water into coastal areas may potentially contribute to harmful algal blooms and increased incidence of hypoxia. Social benefits will depend on how these increments of river input will alter existing physical, biological, and chemical characteristics to degrees of river flow. These natural science processes are coupled to human dynamics through tradeoffs such as displacing marine fisheries with freshwater species, or hard versus soft forms of coastal protection, or threats of hypoxia versus new wetland formation. In the end, these tradeoffs will determine the level of delta restoration (magnitude of river input) will take place under various incremental scenarios of river management.

In summary, the Mississippi River delta faces another round of human control through expanded public work projects following the catastrophic realities of hurricanes in 2005 and 2008. The challenge is even greater with complex interactions of land-use change throughout the catchment to the coast that must be resolved to

accommodate bold new river management plans in concert with structural protection. First, expansion of engineered landscapes to reduce risks to hurricane flooding may further reduce the opportunities in systems-level approaches to river management using diversion structures to replenish sediment to the deltaic plain. Second, agricultural practices of land use and fertilization in the Mississippi River further complicate the opportunities to changing river management, since nitrogen enrichment contributes to expanding eutrophication problems of the region. Thus, urgent solutions to post-Katrina issues in the Mississippi River involve providing increased protection to communities while expanding river processes to restore wetland landscapes, which will also require changing approaches to agriculture land-use to reduce nitrogen load and risks of eutrophication. This juxtaposition of protection, wetland restoration, and eutrophication, all linked to bold new approaches to river basin management, has all been highlighted by the post-Katrina challenges for a sustainable coast. Managing all these competing tradeoffs to sustain the economic and natural resources of this region are representative of how we must consider new approaches to watershed – coastal catchments throughout the world. Water resource quantity and quality are largely determined by highly engineered landscapes of public work projects and agricultural land use interacting with a changing global hydrologic cycle. Thus water resource planning is arguably one of the most important features of national security, public health, economic development, and natural resource management in the next century. Ecosystem services derived from healthy natural resources will support our national wealth depending on how well we manage the finite water resources to satisfy our social needs.

(This last section is from : Twilley, R. R. and V. H. Rivera-Monroy. **2009**. Sediment and nutrient tradeoffs in restoring Mississippi River Delta: Restoration vs Eutrophication. Journal of Contemporary Water Research & Education 141:1-6. )

***Recommended reading***


J.W. Day Jr., D.F. Boesch, E.J. Clairain, G.P. Kemp, S.B. Laska, W.J. Mitsch, K. Orth, H. Mashriqui, D.R. Reed, L. Shabman, C.A. Simenstad, B.J. Streever, R.R. Twilley, C.C. Watson, J.T. Wells, and D.F. Whigham, "Restoration of the Mississippi Delta: Lessons from Hurricanes Katrina and Rita," *Science* 315 (2007): 1679–1684.

Everett Ehrlich, *Public Works, Public Wealth: New Directions for America's Infrastructure* (Washington, DC: Center for Strategic and International Studies, 2005).

Committee on Environment and Natural Resources, *Integrated Assessment of Hypoxia in the Northern Gulf of Mexico* (Washington, DC: National Science and Technology Council, 2000), (available at http://oceanservice.noaa.gov/products/pubs_hypox.html#Intro).

National Research Council, *U.S. Army Corps of Engineers Water Resources Planning: A New Opportunity for Service* (Washington. DC: National Academies Press, 2004).

National Research Council, *Drawing Louisiana's New Map: Addressing Land Loss in Coastal Louisiana* (Washington, DC: National Academies Press, 2005).

National Research Council, *Regional Cooperation for Water Quality Improvement in Southwestern Pennsylvania* (Washington, DC: National Academy Press, 2005).

Felix G. Rohatyn and Warren Rudman, "It's Time to Rebuild America. A Plan for Spending More—and Wisely—on Our Decaying Infrastructure," *Washington Post*, December 13, 2005, p. A27.

Mitsch WJ, Day JW, Gilliam JW, Groffman PM, Hey DL, Randall GW, Wang N 2001. Reducing Nitrogen Loading to the Gulf Mexico from the Mississippi River Basin: Strategies to Counter a Persistent Ecological Problem. *Bioscience* 51:373-388

Mitsch WJ, Day JW, Zhang L, Lane RR 2005. Nitrate-nitrogen retention in wetlands in the Mississippi river basin. *Ecological Engineering* 24:267-278

Working Group for Post-Hurricane Planning for the Louisiana Coast 2006, *A New Framework for Planning the Future of Coastal Louisiana after the Hurricanes of 2005* (Cambridge, MD: University of Maryland Center for Environmental Science, 2006) (available at http://www.umces.edu/la-restore/).

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*Gerald E. Galloway (gegallo@umd.edu) is the Glenn L. Martin Professor of Engineering at the University of Maryland, a former chief of the U.S. Army Corps of Engineers, and a former member of the Mississippi River Commission. He was recently appointed to the Louisiana Governor's Advisory Commission on Coastal Protection, Restoration and Conservation. Donald F. Boesch is professor of marine science and president of the University of Maryland Center for Environmental Science. He serves as chair of the Science Board for the Louisiana Coastal Area Ecosystem Restoration Program. Robert R. Twilley is professor of oceanography and coastal sciences, and associate vice chancellor of the Coastal Sustainability Agenda at Louisiana State University, Baton Rouge*

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