Mapping for Sustainable Resilience in the Gulf Coast of the United States

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"One of the penalties of an ecological education is that one lives alone in a world of wounds." Aldo Leopold (1993)

The Gulf Coast of the United States has been battered by major hurricanes in recent years and the results have been devastating. On August 29, 2005, Hurricane Katrina slammed into the Gulf of Mexico. At landfall, it had winds of 140 miles per hour, a storm surge of more than 30 feet and impacted a 108,000 square-mile area (figure 1). It left 527,000 people homeless, resulted in 1,299 casualties and caused well over $250 billion in property damage. A few weeks later, hurricanes Rita and Wilma also ripped through the area. By late December, FEMA had taken 2,530,657 registrations from the hurricane victims. Figure 2 provides a typical example of the hurricane destruction in Holly Beach, Louisiana where more than 500 structures were leveled by Hurricane Rita's tidal surge and winds.

The hurricanes wrecked havoc on the region's natural resources, sweeping away more than thirty square miles of Louisiana wetlands and 25% of Mississippi marshes. These losses contributed to a longstanding environmental problem. Since the 1930s the Louisiana coast has lost about 1,900 square miles of marsh and swamp making it increasingly vulnerable to hurricane and storm surges. Furthermore, as is well-known, New Orleans reaped the results of this ecological damage when its levees and floodwalls failed; inundating the city with water as deep as 20 feet in many places (figure 3).

Hurricane Katrina caused such costly damage because several million people currently live in coastal communities along the Gulf of Mexico, a 350% increase since the 1950s (figure 4). The combination of the waterfront amenity and a lull in severe storms along the Gulf Coast over the last decades, has lent a sense of false security to government officials, the development community and buyers who are driving this growth. This folly is apparent in figure 5, an illustration of the paths of all severe storms hitting the Gulf Coast from 1851 to 2000. These historical data underscore the danger of current settlement patterns. Past trends of natural disasters are expected to continue in the future. A major hurricane has hit the Gulf Coast every year since 1994, and, in 2005, the area experienced 26 named storms and 14 hurricanes, 7 of them major.

Being able to determine which areas are most likely to be impacted by hurricanes, storm surges, flooding, and other natural disasters would assist decision-makers in

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preparing for and minimizing their impacts. This paper presents the beta version of a developmental sustainability analysis tool, a set of nested maps, for such purposes. The tool provides guidance for today's rebuilding and tomorrow's land development. It aims to help enhance the region's resilience–a word rooted in the Latin verb *resilire*, resilience meaning to spring back or rebound–and its sustainability.

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Towards a Resilient and Sustainable Region: Disaster or Not

In the post-9/11 world we tend to associate resilience with disasters. Recently, Lawrence Vale and Thomas Campanella, editors of *The Resilient City: How Modern Cities Recover from Disaster* (2005a), examined how societies have recovered after natural and human-made disasters, concluding, "Many disasters may follow a predictable pattern of rescue, restoration, rebuilding, and remembrance, yet we can only truly evaluate a recovery based on special circumstances" (2005a, B6). Lawrence Vale applied this observation to New Orleans for this book (see Vale 2006).

While Vale and Campanella link urban resilience to the specific qualities of the place where it occurs, they also present twelve axioms that generally characterize resilience after disaster. Four seem especially important for the Gulf Coast region: 1) disasters reveal the resilience of governments; 2) local resilience is linked to national renewal; 3) resilience, like disaster, is site-specific; and 4) resilience entails more than rebuilding. In a recent speech, former New Orleans Mayor Marc Morial expanded the latter notion, noting that today's challenge "is not only about rebuilding New Orleans and the Gulf Coast, it is about rebuilding a culture, a human system" (Morial 2006).The mapping tool, explained later in this chapter, provides spatial criteria to address the four axioms, especially the third, listed above.

Recently, understanding the ecological resilience of urban places has advanced through the work of the National-Science-Foundation-funded long-term ecological research (LTER) projects in Phoenix and Baltimore (http://www.caplter.asu.edu and http://www.beslter.org). The National Science Foundation supports 24 LTERs. Most are far removed from large cities, but the Phoenix and Baltimore LTERs focus on studying the ecology of urban systems (Grimm and Redman 2004; Pickett et al. 2005).

Finally, knowledge of history supplements recent urban resilience literature. When the French sited New Orleans in the early eighteenth century, they respected the Mississippi Delta's ecological constraints as they settled on the highest ground behind the area's natural levees (Lewis 2003; Barry 1997). New Orleans thrived as a result of that wisdom. Later, outside forces, often at odds with natural systems, altered the developmental patterns of the region and the city (Lewis 2003). Taken together, contemporary and historical teachings could begin to light the path towards the creation of truly resilient and sustainable cities and regions.

Mapping Environmentally Sensitive Areas: A Beginning

Today's challenge is to apply this and other knowledge to rebuild the Gulf Coast region. An important first step is gaining a better and more systematic understanding of the area's natural constraints. After Hurricane Katrina people and groups, locally and globally, offered help based on their particular expertise. New York City had experienced a similar outpouring of interest after the 9/11 attacks, and in Fall 2001, the Regional Plan Association (RPA) organized the Civic Alliance, a consortium of more than eighty-five civic, business, environmental and community associations. Its collective work in participatory decision-making, highlighted by the successful “Listening to the City” meetings capturing widespread citizen input, shaped the World Trade Center rebuilding efforts.

In 2005, midst myriad public and private post-Katrina recovery efforts, RPA identified another need, a vacuum related to understanding large-scale environmental issues in the extended Gulf Coast region. It convened representatives from several national design and planning organizations, universities and corporations to address this concern. They formed the National Consortium to Map Gulf Coast Ecological Constraints. The authors of this essay are founding members of the Consortium. The narrative below outlines the Consortium’s work.

Mapping Environmentally Sensitive Areas: The Approach

We chose to give attention to an *extended* Gulf Coast region, running from the coast of Texas to the edge of the Florida panhandle, an area united by its environmental cohesion and economic importance (Lang and Zandi 2006). One of ten to twelve very large, rapidly growing “megapolitan areas,” in the United States, the Gulf Coast megapolitan area has more than ten million residents, including more than 5 million in the region’s most important city, Houston (University of Pennsylvania School of Design 2004; Lang and Dhavale 2005). Due to its geography, the entire area is susceptible to hurricanes and flooding.

The Gulf Coast megalopolis plays an important role in the national economy especially in the energy and trade sectors. For example, the Port of South Louisiana is the largest (in tonnage) US port and fifth in the world. It has annual exports of fifty-two million tons (corn, soybeans and wheat) and annual imports of fifty-seven million tons (crude oil, chemicals, fertilizers, coal and concrete). Geopolitical analyst George Friedman offers a succinct summary: “a simple way to think about the New Orleans port complex is that it is where the bulk commodities of agriculture go out to the world and the bulk commodities of industrialism come in" (Friedman 2005).

We did not attempt to produce a Gulf Coast or New Orleans plan or even specific designs, many others are engaged in those efforts.[2] Instead, we aimed at organizing public and proprietary information for service in rebuilding with sustainable resilience. We had observed that while a profuse amount of data was available for the Gulf Coast, it lacked coordinated organization and maintenance. Additionally, due to its rapid Internet dissemination, it had little or no explanatory metadata with regard to its generation and use. These data, encompassing hurricanes, high winds, storm surges, flooding, land loss, development patterns and the impacts of hurricanes Katrina, Rita, and Wilma, are overwhelming even for the skilled analyst much less the ordinary decision-maker.

Flowing from public and private entities, the data are at once confusing and remarkable for their breadth and depth. Several groups supply a wide array of

[2] Our group gathered at the ASLA headquarters in Washington, D.C., for our kick-off meeting on December 19, 2005. Senior representatives from EDAW and the U.S. Geological Survey explained the wide-range of data available for New Orleans and the Gulf Coast region. We quickly concluded that we were not facing a data shortage challenge. Rather, the challenge was to assess that data and, then, clearly communicate it to decision-makers, professionals involved in the recovery and restoration efforts, and citizens both locally and nationally.

information in many formats–GIS, remote sensing, aerial imagery, and others. Some data are freely available, other are open to selected users. Five cabinet-level departments and several independent federal agencies provide information. A least four private groups actively disseminate data. Additionally, several collaborative data systems related to Katrina exist. In the past two years, we have also seen an incredible increase in the number of web-based map servers that provide imagery for such significant events as hurricanes or other natural disasters. For example, Google Earth and NASA WorldWind have downloadable data. Imagery from NOAA and DigitalGlobe was available on Google Earth a day or so after Hurricane Katrina hit. Google Earth has an option to log into a server that directly accesses data about specific hurricanes.

We are using these resources to design and implement a mapping tool for rebuilding with sustainable resilience. We did not to create science, but to employ data-driven environmental analysis to minimize future loss of life and property and protect public health, safety, and welfare. Our goal was to create a GIS-based "development suitability analysis" tool that takes into account natural, social, and economic factors to prioritize developable land and places. EDAW and ESRI lead the endeavor, supported by a voluntary national advisory committee of geologists, landscape ecologists, transportation planners, urban designers, architects, landscape architects, water resource specialists, demographers, and regional planners.[3] We completed the initial mapping in March 2006 and have been disseminating the results ever since.

Mapping Environmentally Sensitive Areas

The "developmental suitability analysis" tool consists of a set of environmental assessment maps for the Gulf Coast Region from Pensacola, Florida, to Houston, Texas. Figure 7 illustrates the key map, an overview of a part of the Texas coast. The map summarizes the composite potential risk for the area based upon data from the Coastal Risk Atlas. This map ranks development suitability according to five risk levels, ranging from "no build" to "build" indicated in shades of red with the darkest representing the highest risk. The first zone, "Highest Risk," indicates places not to build under almost any circumstance. The second zone, "High Risk," and the third zone, "Medium Risk," outline places that should be built only at the risk of the property owner with no public subsidy, insurance guarantee, or emergency relief. The fourth zone, "Low Risk," displays places where building can occur under special state and/or local regulatory disaster control measures. The fifth zone, "Minimal Risk," encompasses places that can be developed according to local norms and regulations.

We can replicate figure 6 for other localities along the coast. Additionally we can adapt specific information to show a single environmental factor. Figure 7, for example, illustrates the potential storm surge areas near Houston.

Geospatial data and prediction models drawn from the 18 sources listed in Table 1 provide the base information for these maps. These data types were combined to create a composite map that indicates the areas of greatest concern. Future research is needed to determine how these factors should be weighted. For this effort, all factors were weighted

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[3] See, for example, the work of WRT and the Urban Land Institute in New Orleans (Barnett 2006; Taylor 2006), Fregonese Calthorpe for Louisiana, and Andres Duany and the Congress for the New Urbanism in Mississippi (www.mississippirenewal.com).

the same. These maps are intended to compliment ongoing mapping efforts and to expand upon this existing work by adding sensitivity and vulnerability information.

Table 1. Modeling Processes Combined to Determine Vulnerability

- Societal Risk (*Coastal Risk Atlas*)
- Flood Risks (*FEMA*)
- High Wind Risk Areas (*MEOW*)
- Storm Surge (*Coastal Risk Atlas*)
- Population Density (*US Census Bureau*)
- Population Growth Projections (*Local county governments*)
- Economic Impacts (*HAZUS*)
- Impact on Natural Resources (*HAZUS*)
- Displaced Households
- Sea Rise Vulnerability (*CVI*)
- Historic Hurricane Patterns—Allen, Andrew, Aubrey, Betsy, Camille, Opal, unnamed 1915, unnamed 1928, unnamed 1935) (*National Hurricane Center*)
- HAZUS-MH—FEMA Software Program for Estimating Potential Losses from Disasters
- Coastal Risk Atlas (CRA)—developed by NOAA, NCDDC and CSC.
- The Inland Wind Model and the Maximum Envelope of Winds (MEOW)—developed by NHC.
- SLOSH (Sea, Lake and Overland Surges from Hurricanes)—model run by the NHC to estimate storm surge heights and winds.

This developmental suitability analysis tool has additional application for planning and implementing sustainable resilience. For example, we can represent environmental assumptions about the future spatially. We undertook such an exercise with sea rise predictions to see how they would affect the flood plain calculations in Lacombe, Louisiana. First, we mapped Lacombe’s existing flood plain levels (figure 8). Next, we applied the scientists’ anticipated 21” to 44” rise in sea elevation over the next 50 to 100 years, using the median number, 35”, to determine the new high tide mark (figure 9) Finally, we calculated the new flood plain after a 35” rise in sea elevation (figure 10). This quick study indicates that even if there are no hurricanes or severe storms along the Gulf Coast, many areas are still in danger because of sea rise. In Lacombe, much of the existing town will be in the new floodplain that will result from a rise in sea elevation.

We can also show the relationships between natural systems and demographic factors. Figure 11, for example, shows that that the elderly poor, those with no automobile, and those living in public housing, rental housing or in older structures built before 1970 were more vulnerable to Katrina than others. This type of map emphasizes the importance of including social and economic factors in planning for sustainable resilience.

Additional diagnostic maps for the Gulf megapolitan region can be relatively easily produced using the same process.. Included are ones that go back in time, show current conditions, and develop environmental scenarios for the future, 2030 or 2050. They will incorporate hurricane patterns, climate change, flooding, land subsidence, land use and associated social and economic costs.

Conclusion

Katrina flooded the media, breaking through the levees of our inattention. Environmental neglect collided with social inequity on the evening news before the local shooting of the day. Images from the streets of New Orleans, along the coasts of Mississippi, and across the interstate highways of the Gulf region challenged how we think about our nation, and our leaders.

Interest, like oil supplies, peaks. Interest, like the tides, subsides. We move on. Natural disasters come and go: From Hurricane Andrew in 1992, through the Mississippi Floods of 1993, on to the Indian Ocean tsunami of December 2004.

Might Katrina be different? Might it present an opportunity for learning? For rethinking urbanism and regionalism? For rethinking humanity in this first urban century? As the media flood recedes, might Katrina challenge us for a bit longer?

Katrina left many wounds in its wake and revealed many more that had festered before the storm. These wounds are clear to even those without an ecological education. The residents of the Gulf Coast region need not live alone with those wounds. Ecological understanding can be advanced through mapping exercises, but such mapping should be viewed as part of a larger network of thinking about how people interrelate with land and water.

Advanced ecological planning theory asserts that the "insight relevant to linking ecology with planning and design is that *human perception, learning, and resultant actions are a part of the human ecosystem*" (Pickett 2004, 378). Mapping environmentally sensitive areas thus becomes a vital part of the "learning loop" initiated by Katrina. Universities, private firms, and non-profit organizations can contribute to this learning loop, as illustrated by the National Consortium to Map Gulf Coast Constraints. If we can learn from disasters such as Katrina, the promise is we can reduce the loss of life and of property and can minimize the disruptions to lives. Floods will continue to inundate the lands along the Mississippi River. Hurricanes will continue to create surges along the Gulf Coasts. We can map the lands prone to flooding and storm surges with relative accuracy. Let us learn from those maps and plan our future settlements with that knowledge.

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