UNISDR
The United Nations Office for Disaster Risk Reduction

GAR
Global Assessment Report on Disaster Risk Reduction

2013

Background Paper prepared for the Global Assessment Report on Disaster Risk Reduction 2013

Resilience in the Social and Physical Realms: Lessons from the Gulf Coast

Ann Carpenter, Phd

Senior Research Associate, Georgia Institute of Technology,
Georgia Tech Research Institute
Visiting Researcher, Federal Reserve Bank of Atlanta,
Community and Economic Development Department, Research Division
acarpenter@gatech.edu

Geneva, Switzerland, 2013

Resilience in the Social and Physical Realms: Lessons from the Gulf Coast

2013 Global Assessment Report on Disaster Risk Reduction

Ann Carpenter, PhD
Senior Research Associate, Georgia Institute of Technology,
Georgia Tech Research Institute
Visiting Researcher, Federal Reserve Bank of Atlanta,
Community and Economic Development Department, Research Division
acarpenter@gatech.edu

Abstract

The mounting frequency and scale of natural disasters, increasing urbanization, a growing reliance on interdependent technologies and infrastructure, inflated expectations of emergency response interventions, and the transition to a just-in-time economy are responsible for greater disaster vulnerability and demonstrate the need to establish more resilient communities ahead of a disaster. The decisions of the private sector are among the reasons for increased vulnerability, for example through unsustainable or unsound real estate development.

One factor that is known to impact resilience is social capital, particularly as manifested in strong social networks. The built environment has been shown to influence social networks in multiple ways. Building on the work of Jane Jacobs, research has shown that walkable, mixed-use neighborhoods with a higher concentration of social gathering places and public space encourage the development of social capital and place attachment through an increase in social interaction. The built environment is a physical, social, and symbolic anchor to everyday habits and a familiar framework of orientation. Most importantly for resilience, it is a support system for social networks. In short, the built environment connects residents to a place and can serve as a benchmark for recovery. The private sector influences this relationship through the decisions made with respect to real estate development.

This paper examines how social networks and the built environment reinforce one another to create greater resilience to disasters using the communities of the Mississippi Gulf Coast before and after Katrina as a case study. Given that 1) social networks increase community resilience to all types of disasters, 2) social networks are shown to be influenced by certain types of space, and 3) the built environment is a common intervention for planners, this paper explores the potential for creating cities that are more resilient by encouraging private development that fosters social networks.

Introduction

It has been eight years since Hurricane Katrina struck the U.S. Gulf Coast, including Louisiana, Mississippi, and Alabama. In that time, tremendous progress has been made toward recovery given the enormous devastation. However, these gains have been uneven, illuminating disparities in resilience, or a community's ability to rebound to a healthy state following a major disruption such as a disaster. One factor shown to influence community resilience is social capital, in particular the existence of strong social networks that can be engaged in the survival and recovery phases of a disaster.

At the community level, certain characteristics of the built environment influence and support social capital that in turn reduces disaster vulnerability and facilitates recovery. Social networks are the foundation of social capital and those networks with the greatest impact on resiliency are rooted in the built environment. The nature, strength, and quantity of these social ties are influenced by development patterns. Accordingly, planning and policy interventions that guide private real estate development can impact disaster resilience. In order to test this proposition, communities along the Gulf of Mexico Coast (Gulf Coast) of Mississippi have been analyzed to determine the impact of the built environment on relative levels of resilience after Hurricane Katrina.

There is significant evidence that formal and informal interpersonal ties within one's own neighborhood are invaluable for a positive quality of life. Within the literature from various disciplines, these social networks have been shown to positively impact health and well-being (Berkman, Glass, Brissette, & Seeman, 2000), access to employment opportunities (Granovetter, 1973) and financial resources (Ben-Porath, 1980). Scholars have repeatedly shown that even in the most distressed conditions, social connections allow individuals and families to overcome their economic conditions, however grim (Gans, 1962; Stack, 1979; W. F. Whyte, 1943).

Given these benefits for individuals and households, the benefits of social networks for disaster resilience are not surprising. Social networks reduce disaster vulnerability factors that are also contingent on socioeconomic status (Cutter, Boruff, & Shirley, 2003), assist in disaster mitigation and response activities (Aguirre, 2006), and increase knowledge of resources that facilitate preparedness (Paton, 2003). In terms of membership in formal associations, research has demonstrated the positive impacts of community groups in disaster recovery efforts (Patterson, Weil, & Patel, 2010). Essentially, disaster management activities at all phases of preparedness and recovery are supported by community leaders and social networks (Magsino, 2009). These benefits are well known enough that they have been institutionalized in emergency planning efforts, for example as a stated goal of the Resilient Washington State Initiative.

Face-to-face social interactions and community social connections by necessity occur in space. The built environment impacts the quality and quantity of social interaction one is likely to have. Therefore, the influence of the built environment on social networks has also been visited by many scholars. William Hollingsworth Whyte and Jane Jacobs were early proponents of design that mixes social groups and promotes an active urban culture, including varied and functional streetscapes (Jacobs, 1961; W. H. Whyte, 1980). Both eschewed designs meant to exclude or inhibit activities. Fundamentally, the built environment and its deliberately structured spaces reflects and influences our social connections and communications (Rapoport, 1994). Proponents of New Urbanism have examined the link between density, diversity, and design and sense of community, including social interconnectedness (Talen, 2002). Place attachment, another link between physical and social realms, is based on our past interactions and the potential for future interactions between ourselves and our physical surroundings (Milligan, 1998). Disasters often disrupt the built environment and social networks alike. However, even when faced with a community in physical ruin, social ties generally are reinforced, with increased feelings of intimacy and solidarity (Erikson, 1976).

In the U.S., development patterns have undergone several transformations since the inception of city planning as a profession. The earliest forms of city beautification and zoning were meant to promote community health. After World War II, planning tended to favor unrestricted motion in private automobiles, with less emphasis on public space and public life (Sennett, 1977). Indeed, this kind of automobile-dependent development has been empirically shown to be associated with reduced social ties within neighborhoods (Freeman, 2001). More recent trends in neo-traditional development return to a focus on human and environmental health and social capital, a movement that may have additional benefits in promoting disaster resilience and facilitating a more effective recovery.

In order to examine the relationship between elements of the built environment that foster social networks, and therefore in turn foster resilience, communities in coastal Mississippi that were in the direct path of Hurricane Katrina in 2005 have been analyzed. New Orleans, Louisiana was not included as the damage incurred was much different in nature, stemming primarily from failure of the levee system rather than direct storm damage.

Analysis of Post-Katrina Resilience in Coastal Mississippi

Touted as a family-friendly affordable getaway, the Mississippi Gulf Coast is associated with casinos and beaches for many nonresidents. However, the area possesses a rich history and unique cultural and environmental resources. From humble beginnings, steady economic and population growth over more than three centuries has been disrupted by war and disaster (particularly hurricanes), imbuing residents with a resilient spirit.

The first European settlers of the Mississippi Gulf Coast arrived in 1699, although Paleo-Indian settlements in the area date back several millennia. The settlers attempted to secure the Mississippi River Delta by fortifying Biloxi, which became a strategic position contested for over a century by French, Spanish, English, and U.S. forces. About one hundred years later, during the antebellum period, cities along the Mississippi Gulf Coast grew and prospered as resort spas and getaways for the urban south. At the onset of the U.S. Civil war in 1861, the Mississippi Gulf Coast boasted 12,000 year-round inhabitants, with populations doubling or tripling in the summer.

By the war's end in 1865, much of the coast's building stock was damaged or destroyed and the population waned. However, owing to post-war reconstruction the first rail line was built, which brought employment, industrialization, and renewed tourism to the region. Growth continued through the turn of the century; starting in World War I, the region leveraged industrial and transportation advantages to contribute to the military-industrial complex. By World War II, the coast's suitability for supporting the war effort brought several new military installations. Despite major hurricanes (including a monster storm in 1969, Hurricane Camille), the area continued to grow in population and expand its economy in tourism and gambling, heavy industry, and military production. In 2004, just before Hurricane Katrina struck, approximately $1 billion in development projects were underway, including expansions of the convention center and airport, and several new hotels and casinos. The pre-Katrina, 2004 population of the three Mississippi counties along the coast was approximately 374,000, according to U.S. Census estimates.

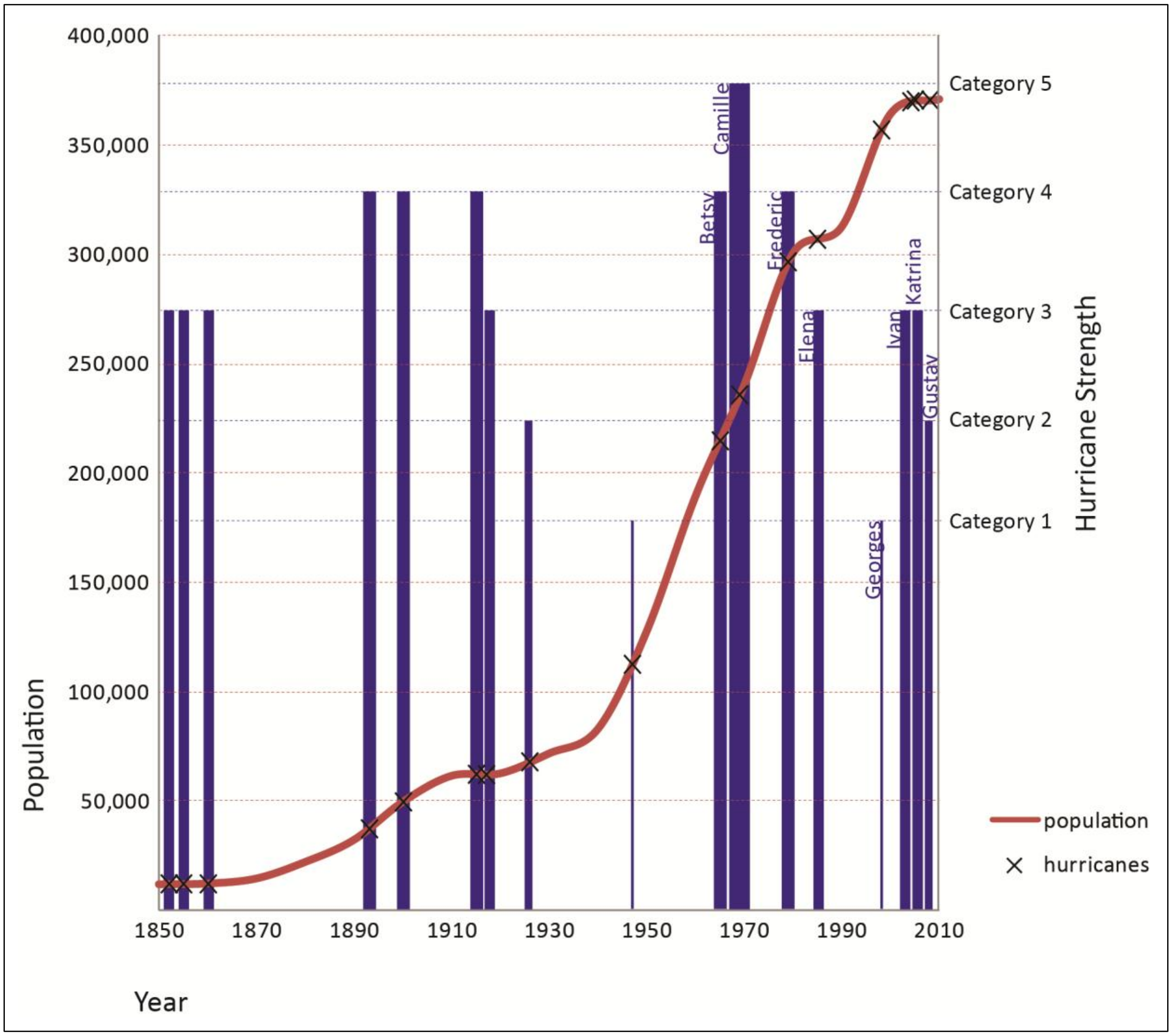
On the morning of August 29 2005, Hurricane Katrina descended on the Louisiana-Mississippi border of the U.S. Gulf Coast. For almost two hours, the wind and surging ocean bombarded the region with 125 mile per hour winds and up to 30 foot storm surges, affecting an area with a radius of 140 miles. The landfall location and strength of the storm made it among the deadliest and the most costly hurricanes in U.S. history, with more than 1,800 dead, one million people displaced, $80 billion in property damage, and 90,000 square miles of land impacted (Cutter et al., 2006). In Mississippi alone, there were 230 deaths, more than 100,000 left homeless, and more than 200,000 homes received some damage (Governor's Report on Recovery, 2010).

Along the 80 linear miles of Mississippi coast that were affected, the landscape looked as if a bomb had been dropped, “houses reduced to debris, a rubble-land, buildings razed as if by one of the companies that do that for a living” (Barthelme, 2005). Trees were stripped of leaves, native fauna retreated or perished, and abandoned pets roamed the streets. Important economic drivers in Mississippi, such as tourism (particularly off-shore casino gambling) and the seafood industry, were devastated by the storm. The under-construction, Frank Gehry-designed Ohr-O’Keefe art museum was damaged when an unmoored casino barge slammed into the structure. Storm surge and winds scattered deadly debris, notably shipping containers and tons of lumber from the Port of Gulfport.

As shown in Figure 1, the coast has witnessed many significant hurricanes that made landfall in the area in the past 160 years. On average, the region has experienced a storm of at least Category 1 hurricane strength every 9.4 years since 1850. The most intense of these was Hurricane Camille, the second-strongest hurricane in recorded U.S. history. Camille’s winds topped 230 miles per hour and storm surges rose to 25 feet in some areas, resulting in 144 deaths and about $1.4 billion in property damage. Almost no structure was spared, and many historic buildings, including the iconic Biloxi lighthouse built in the 1870’s, were destroyed. Camille was the bellwether for all subsequent storms until Katrina.

Hurricanes have had seemingly little effect on population growth (for example, the strong hurricanes hitting during a population surge from 1940 to 1980), or have even preceded spurts in growth (including several hurricanes before the same population surge). However, the impact of four major hurricanes in ten years from 1998 to 2008 has been at least partly responsible for a flattening of population growth during those years. Given 30 year forecasts for more frequent and intense hurricanes (Webster, Holland, Curry, & Chang, 2005), the population and economy of the coast may face enormous challenges in the future without strategic planning for greater disaster resilience.

Figure 1: Population and incidences of hurricanes, 1850-2010

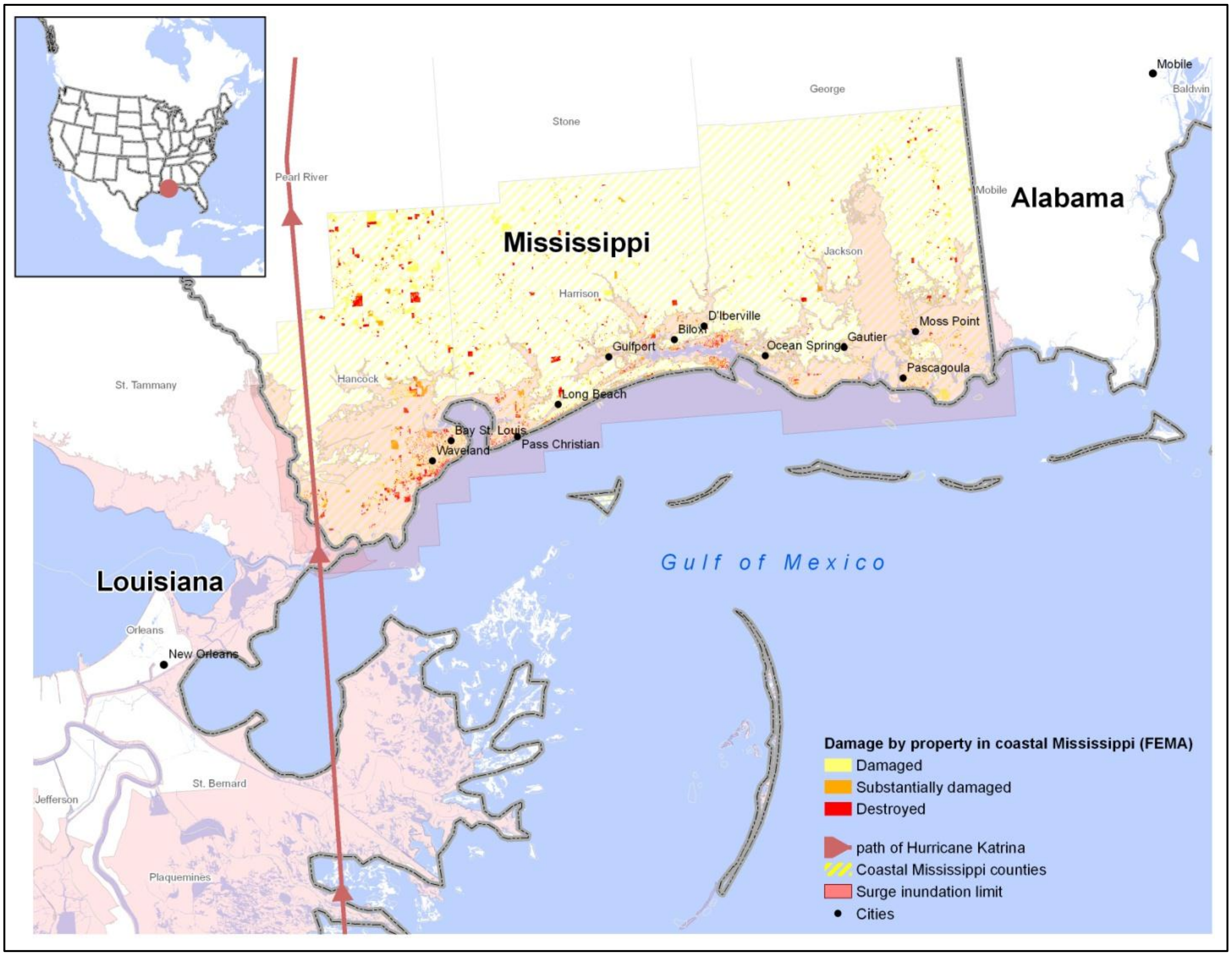


In recent interviews with survivors of Hurricane Katrina in Bay St Louis, Mississippi, formal and informal social ties emerged as critical resources for surviving and recovering from the disaster (Carpenter & Montoya, 2011). Ties between residents and their physical environment were also revealed to be critical for recovery, in that residents were less likely to move away permanently and were fiercely protective of the pre-Katrina landscape during rebuilding. This supports the findings of previous studies. As stated previously, social networks have been repeatedly shown to promote community resilience to disasters while the built environment supports these attachments. Given the established relationships between the phenomena, what are the exact impacts of development patterns on disaster resilience?

An ordinary least squares (OLS) multivariate regression model was developed to test the hypothesis that a built environment with features that support social networks creates a more resilient community. A study area was chosen consisting of the three counties in Mississippi that were directly exposed to storm surge and wind damage from Hurricane Katrina in August 2005: Hancock, Harrison, and Jackson

County (Figure 2). These counties include the metropolitan area of Gulfport-Biloxi as well as small beach communities such as Bay St Louis and Pass Christian and the more industrialized city of Pascagoula.

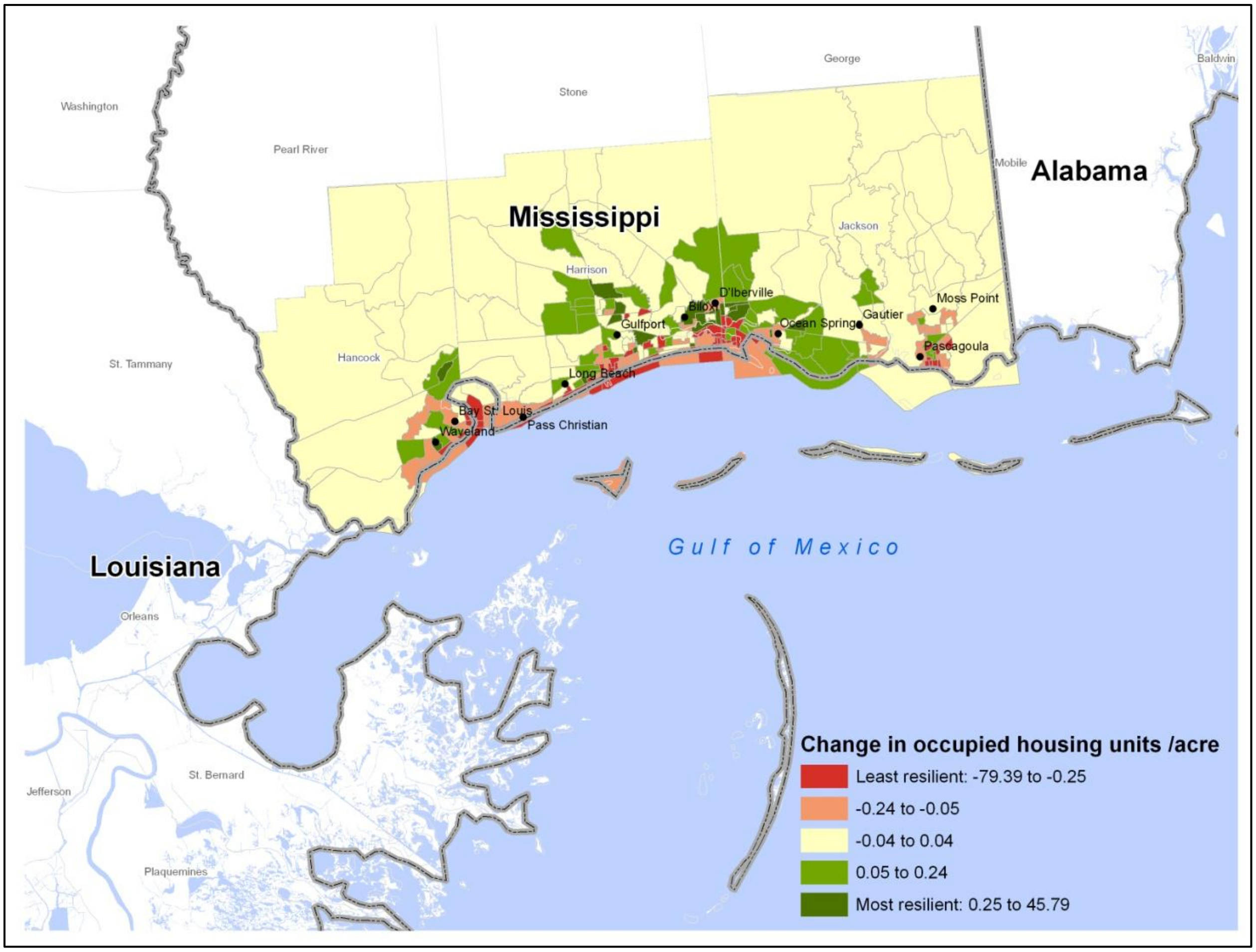
Figure 2: Study area, Mississippi Gulf Coast



The units of analysis chosen for the model were Census blocks, which correspond to city blocks, bounded by city streets, railroads, or bodies of water. Census blocks are the smallest units available and are more suitable than larger geometries, which tend to be larger than neighborhoods and are particularly large in sparsely populated areas. In order to capture the community or neighborhood scale, a larger buffer around each block was created. There are approximately 14,000 blocks in the 3-county study area. However, blocks that did not fall in the storm inundation limit, were less than a half-acre, or had fewer than 5 occupied housing units were excluded, reducing the sample size to 3,222 blocks. Blocks outside the storm inundation limit were excluded to control for amount of damage (percent damage was also included as an independent variable). Very small or nearly unpopulated blocks were excluded to ensure reliability, as population counts are less accurate at such small increments.

In order to test the theory that the built environment and private development can predict resilience, resilience was first quantified. Resilience is the ability of a system to rebound following a disturbance. While many measures can and have been advanced, in terms of disaster recovery, this is most accurately captured in a return to original conditions. For a community, it is possible to study residential population, businesses, employment, or various combinations of these variables. For this study, the return of occupied housing units was chosen, as the theories and mechanisms of social networks referenced above are shown to promote household resilience, rather than the resilience of businesses (although there are certainly parallels between the two). Resilience was therefore measured by the change in occupied housing units from 2000 to 2010, normalized by area in order to account for the wide range of block sizes. Occupied housing units, rather than population or total housing units, were chosen in order to capture the relative vibrancy of a neighborhood. For example, if a block with ten single-family homes in 2000 was severely damaged but all ten units were still standing vacant in 2010, this particular block would seem to be stable using the metric of total (including vacant) housing units. If one home out of the ten was inhabited in 2010, but all ten families were sharing the residence, the block would seem to be stable using the metric of population. Given the interest in recovery of viable residential communities, change in occupied housing units was the ideal measure. The results of this measure, aggregated from Census blocks to larger Census block group units (a cluster of several similar Census blocks) for map legibility, is shown in Figure 3.

Figure 3: Resilience, or the change in occupied housing units, 2000-2010, normalized by area



The independent variables were chosen to measure the suitability of the built environment for supporting social networks and therefore resilience. Metrics of the built environment included a set of variables and indices of the relative social vibrancy or isolation a community. Many specific, measurable properties of the built environment have been shown to contribute to greater social capital in a community. Included are an entropy measure of land use mix, residential density, and intersection density. These metrics are positively associated with pedestrian activity (Frank, Bradley, Kavage, Chapman, & Lawton, 2008) and social interaction (Lund, 2002). Other variables include park and open space availability and social networking organizations and places density. These measures capture access to spaces in which people are likely to gather. Neighborhood parks, for instance, stitch together diverse functions and populations (Jacobs, 1961). Social networking organizations, or the types of establishments that facilitate social networks, are partly derived from an "associational activity" measurement of social capital (Isserman, Feser, & Warren, 2007) in addition to social gathering places known to facilitate richer social networks (Rupasingha, Goetz, & Freshwater, 2000). The lists include bowling centers, public golf courses, membership sports and recreation clubs, civic and social associations, religious organizations, labor organizations, business associations, professional organizations, political organizations, and eating and drinking establishments. These data were extracted from a pre-Katrina, 2004 business directory purchased from a commercial service. Historical site density, based on lists of state and national historic sites listed prior to Katrina, was used as a proxy for place attachment, as monuments and heritage sites promote a sense of place. Single family homes were removed from the historic sites database, leaving 111 commercial and institutional structures and sites built between 1850 and 1975.

Several intervening variables were introduced in the model as well. These include socioeconomic factors that have been shown to be significant for vulnerability and resilience, including race, income, tenure and housing type, home sales price, age of housing in the area, percent of population living in poverty, and percent of the population that lived in the area for five or more years (a measure of population stability). Other factors included percent damage to the block and amount of aid received in order to control for the feasibility to rebuild. Growth from the previous Census period of 1990-2000, normalized by area as in the dependent variable, was included to control for endogenous growth or contraction in the population. The number of occupied housing units in 2000, normalized by area, was also included as an intervening variable to control for the large variance in block populations, as population density can vary greatly throughout the region.

Finally, local fixed effects were incorporated by creating a dummy variable for the local government area each block was located in, which included 27 municipal and unincorporated county areas. Therefore, 26 dummy variables were included in the model, with one of the 27 areas excluded. This was meant to capture the effects of local government efficacy and the political will of local leadership. Levels of infrastructure restoration and other public built environment improvements funded by local governments varied across localities. Furthermore, some leaders were more aggressive about locating funding and ensuring residents' needs were met after Katrina.

The built environment variables and intervening variables were collected for a one kilometer buffer around the Census block unit of analysis, as the block in which a household lives is influenced by a wider swath of the built environment rather than merely the block in isolation. A distance of one kilometer is often cited as a distance easily walkable in 10 minutes (Frank et al., 2008). Furthermore, walkability is associated with greater social capital, social encounters, and knowledge of one's neighbors (Leyden, 2003).

Most built environment data were obtained at the parcel level, the smallest level of analysis possible, and aggregated to the block or block buffer. Demographic data were collected at the Census block or block group level. All built environment and demographic data were pre-Katrina data. Data sources included the U.S. Decennial Census, the U.S. Federal Emergency Management Agency (FEMA), the open source mapping project OpenStreetMap.org, the Mississippi Department of Archives and History, and the business directory ReferenceUSA.

The OLS regression model is as follows, with results shown in Table 1 :

Resilience = Built environment factors + intervening factors

$$D_{resilience} = \beta + \beta_{LUMix} + \beta_{NRD} + \beta_{SocOrgs} + \beta_{Parks} + \beta_{HistSiteDens} + \beta_{IntDens} + \beta_{IntDens} + \beta_{\%AfAmer} + \beta_{MedInc} + \beta_{\%RentOccMF} + \beta_{MedSale} + \beta_{MedAge} + \beta_{\%Pov} + \beta_{\%Stable} + \beta_{\%Damage} + \beta_{AidAmount} + \beta_{D90\text{-}00} + \beta_{Occ00} + \text{local fixed effects} + \varepsilon$$

Table 1: Results of model

Variable	β	Std.Error	t	Sig.
Constant		0.420	-6.325	0.000***
Independent variables (variable name code in parentheses):				
Land use mix (LUMix)	0.015	0.254	0.868	0.386
Net residential density (NRD)	0.052	0.030	1.860	0.063*
Log social networking organization density (SocOrgs)	0.029	0.016	2.012	0.044**
Dummy indicating the presence of a park in buffer (Parks)	-0.035	0.076	-2.032	0.042**
Log density of historic sites (HistSiteDens)	0.030	0.013	1.799	0.072*
Intersection density (IntDens)	0.082	0.632	3.107	0.002***
Intervening variables (variable name code in parentheses):				
% African American (%AfAmer)	0.027	0.282	1.016	0.310
Median income, in U.S. dollars (MedInc)	0.124	6.30E-06	4.269	0.000***
% Renter-occupied, multifamily housing (%RentOccMF)	0.080	0.469	3.880	0.000***
Median home sales price, in U.S. dollars (MedSale)	0.036	2.50E-06	1.488	0.137
Median age of housing, in years (MedAge)	3.01E-04	.005	0.009	0.993
% Population living in poverty (%Pov)	0.001	0.792	0.038	0.969
% Population living in region for 5 or more years (%Stable)	0.154	0.259	7.444	0.000***
% Damage (%Damage)	-0.045	0.136	-2.791	0.005***
Amount of aid distributed, in U.S. dollars (AidAmount)	-0.040	3.22E-08	-2.761	0.006***
Control variables (variable name code in parentheses):				
Change in occupied housing units, 1990 to 2000 (D90-00)	-0.194	0.002	0.018	0.000***
Occupied housing units in 2000 (Occ00)	-0.575	0.001	0.018	0.000***
Spatial local fixed effect coefficients for 26 local dummies not shown here ***** significant at 1%, ** significant at 5%, * significant at 10% confidence interval*				
R^2 = 0.489				
N = 3,222				
The dependent variable is the change in occupied housing units, 2000 to 2010, normalized by area (resilience)				

Discussion of Results

The model displayed good explanatory power (R-squared of 0.489). Of the built environment variables, intersection density had the most influential (and a positive) effect on resilience, as measured by standardized coefficients. Of the built environment variables, intersection density had the most influential (and a positive) effect on resilience, as measured by standardized coefficients. A one standard deviation increase in intersection density (0.08 intersections per square kilometer) is associated with 8.2 percent of a standard deviation increase in resilience. This, in turn, is equivalent to an increase of 0.16 occupied housing units per acre from 2000 to 2010. Given the mean resilience of -0.47 units per acre, this is a consequential effect. In reverse order of magnitude, net residential density, historic site density, the density of social networking organizations, and land use mix all had a positive effect (the effect of land use mix was not significant, however). For net residential density, a one standard deviation increase in units per residential acre (1.89 units per acre) is associated with a 5.2 percent of a standard deviation increase in resilience, or 0.10 occupied housing units per acre. For historic site density, a one standard deviation increase in the natural log of sites per acre (1.03 sites per acre) is associated with 3.0 percent of a standard deviation increase in resilience, or 0.06 occupied housing units per acre. For the density of social networking organizations, a one standard deviation increase in the natural log of sites per acre (1.47 sites per acre) is associated with 2.9 percent of a standard deviation increase in resilience, 0.06 occupied housing units per acre. For land use mix, a one standard deviation increase in the land use mix index (a change of 0.14 on a scale of 0 to 1) results in 1.5 percent of a standard deviation in resilience, or 0.03 occupied housing units per acre. The presence of parks actually had a negative impact on resilience, in which a one standard deviation increase in parks by buffer (0.45 parks) is associated with a 3.5 percent of a standard deviation decrease in resilience, or a decrease of 0.07 occupied housing units per acre from 2000 to 2010.

Of the intervening variables, percent of the population living in the area in 1995 and median income had the most influential positive effects on resilience, which were greater than the effects of the built environment variables as measured by the standardized coefficients. Percent multifamily rental housing had a significant positive impact similar to the magnitude of intersection density. Percent damage and amount of aid each had a relatively strong negative impact on resilience. The other intervening variables (percent African American, median housing value, housing age, and percent of population living in poverty) had a weaker positive influence than all built environment variables except land use mix.

Control values of change in occupied housing units from 1990 to 2000 normalized by area and occupied housing units normalized by area each had a significant, relatively large negative impact on resilience.

The built environment effects demonstrated the influence on resilience of many built environment features that are associated with greater social interaction and social networking activity. Intersection density, which is associated with connectedness, accessibility, and walkability was the most significant example of these effects. Although the bivariate correlation between intersection density and resilience was negative, when controlling for demographics, damage, and other significant variables, intersection density actually influenced the return of households. Better connected areas are likely to be more visible and centrally located due to street patterns in the area, where higher intersection density tends to occur near the well-traveled waterfront and central business districts. Therefore, residents are more likely to have chance social encounters and richer social networks, based on theories from the literature. This could have also had a psychological effect on residents and former residents, as returning to a remote area where few homes had been rebuilt would seem to be undesirable. Similarly, net residential density, which also had a positive effect on resilience, increases the probability of social encounters and local social networks through increasing the number of network connectors within the neighborhood. In essence, intersection density and net residential density measured social integration in the area and positively influenced resilience.

The density of historic sites, based on state and national historic designations, was used as a proxy for the age of the neighborhood and also to attempt to quantify place attachment through significant monuments and cultural icons in the area. The natural log of historic site density produced a somewhat weak positive effect on resilience in the model. This variable was the third-most influential built environment variable with a positive impact on resilience, demonstrating historic features have some importance for resilience. This is particularly noteworthy in that historic sites in Mississippi tended to be located in more vulnerable and damage-prone areas near the coast due to historic patterns of development near the shore and other waterways. It is a testament to the draw of areas with greater historic character that these areas have seen a greater return in population.

The density of social networking organizations and land use mix also had a relatively weak positive effect on resilience. Social networking organizations included places of worship, schools, restaurants, and types of recreational facilities, among others. These have been shown to improve social networks and, not surprisingly, also had a positive impact on resilience in the model. Based on the literature suggesting that social networks are most effective in recovery when they have a physical address from which to operate (Sherraden & Fox, 1997), the impact of the density of social networking organizations is noteworthy. Though not always considered in city planning research, community centers, be they commercial endeavors, nonprofits, or publicly funded institutions, are clearly important for recovery and should be embraced and nurtured by communities.

Land use mix, which also had a weak positive, but statistically insignificant, effect on resilience, measures the evenness of three land uses – residential, commercial, and other. Land use mix increases opportunities for commercial activity and employment in a neighborhood, reduces possible trip distances, increases how easily one can navigate between places, and promotes nonmotorized traffic such as biking and walking. The measure was meant to capture whether blocks were located in a diverse and vibrant neighborhood. An increase in walkability due to greater land use mix also increases encounters with other pedestrians and therefore social networking opportunities. This measure was not significant in the model. Although the expectation was that land use mix would have a positive influence on resilience, density and the presence of certain types of enterprises that promote social networking activity were more important. High-intensity commercial areas in low-density, disconnected development patterns are common in the region. Therefore, the type of commercial development may be more important than the mix of land uses in predicting resilience, at least in the Mississippi coast region.

The presence of parks actually had a negative impact on resilience, despite the fact that parks are also shown to increase chance encounters and provide a gathering point for neighbors. All area parks were included in calculating the dummy variable, which included 42 total parks that were within the one kilometer buffer of the 3,222 study area blocks. Almost all parks were located in Harrison and Jackson Counties, with only three parks found in Hancock County. The uneven spatial distribution of parks and the higher incidence of parks in undevelopable coastal areas that sustained great storm damage may have skewed the model; however, based on the evidence in Mississippi, parks had no influence on resilience.

Certain intervening variables behaved as expected, such as the percent of the population living in the area in 1995 and median income, which had the greatest positive effects on resilience, greater than the effects of the built environment variables. Percent of the population living in the area in 1995 captured the stability of the population prior to Katrina, but also the potential for richer social networks, developed through residents living in the area for at least a five-year period of time. Because the resilience indicator was not able to pick up actual movement of households, only net change in occupied housing, this measure was included to take into account how established the base population was prior to Katrina. It is not surprising that the indicator had a significant impact on resilience. Higher median income also positively influenced resilience, which was expected as greater income provides households the means to rebuild and is associated with reduced social vulnerability to disaster.

Percent multifamily rental housing had a surprising positive impact on resilience. This variable was created, as mentioned above, to include the effects of both tenure and higher-density housing. Owner-occupied housing as a standalone measure was associated with greater resilience but was highly correlated with percent multifamily housing. Interestingly, combining the inverse statistic, percent renter-occupied housing, with percent multifamily housing did not have a cumulative negative effect. Because this measure, like the other independent variables, was calculated for one kilometer buffers around the block, it may be that residential density was associated with the same areas that also had greater social networking organization density and net residential density. These neighborhood characteristics had a positive influence on resilience in the model and are associated with social capital creation by planning scholars and theorists.

The sign of the percent African American coefficient was, perhaps surprisingly, positive, although it was statistically insignificant. Ethnic and racial minority populations have been shown to exhibit greater social vulnerability to disasters. However, the weak and statistically insignificant positive effect may be a product of the demographics and spatial distribution of ethnic and racial groups in the area. African American (and relatively poor) neighborhoods tended to be located further inland in coastal Mississippi where real estate was less expensive and therefore were likely to experience lower levels of damage from Katrina.

Median housing value also had a positive influence on resilience, weaker than only the built environment variables of intersection and net residential density. Similar to income, housing value is correlated with household resources and captures an economic incentive to rebuild. Larger housing values may also be correlated with levels of insurance on a home, as owners may be more likely to protect a larger investment and have the means to do so. Housing age had essentially no impact on resilience. This may have been related to tension between historic or older neighborhoods that exhibited greater resilience, based on the above factors, and the period of growth that occurred between 1990 and 2000 (discussed below). Further, storms such as Hurricane Camille in 1969 and Hurricane Georges in 1989 have destroyed many older properties, with uneven spatial effects, and therefore significantly older properties are not present in enough numbers to make a difference in the model.

Percent of population living in poverty had a very weak and almost negligible positive influence on resilience. This influence was weaker than most other variables, including all built environment variables. Although this influence was not statistically significant, as with percent African American, this variable was expected to have a negative influence on the dependent variable of resilience based on previous studies linking poverty and social vulnerability to disasters. This measure was correlated with median income, median housing value, and percent African American, weakening the effects of poverty on the dependent variable. As noted previously, vulnerable populations based on race and income actually tended to be protected from Katrina due to spatial demographic patterns in coastal Mississippi, with relatively poor neighborhoods located further inland. Because of this, the effects of socio-demographic variables did not always behave as expected.

Percent damage and amount of aid each had a relatively strong negative impact on resilience. Clearly, damage was a factor in households returning. Aside from the difficulty and cost in repairing damaged housing units, homes with greater than 50 percent structure damage were subject to new building codes after Katrina. In many cases, this required elevating the home, which was cost prohibitive or logistically impossible for those with reduced mobility, such as elderly residents. Badly damaged areas may have also been more likely to receive aid based on need. It has been shown that local governments often find it difficult to make use of disaster aid resources due to a lack of organizational capacity (Berke, 1993), which may also contribute to the failure to convert aid resources to housing recovery.

The negative effects of the control variables of change in occupied housing units from 1990 to 2000 normalized by area and occupied housing units normalized by area can be explained by the high rate of growth in the time period of 1990 to 2000, when casinos were legalized and the local population was rapidly growing. During this time, many blocks reached carrying capacity for housing units and therefore could only lose and not gain housing units from 2000 to 2010. Several high growth blocks between 1990 and 2000 were multifamily structures near the waterfront. One waterfront high-rise in Biloxi was added in the time period of 1990 to 2000 and was converted to a hotel post-Katrina. A second high-rise was a senior housing tower built after Camille in 1969. The complex experienced growth in the 1990 to 2000 time period and survived Katrina. The senior units were replaced further inland and there have been stated plans to refurbish the currently vacant 13-story tower. One inland example of high growth 1990 to 2000 was a section of land near the former Bayou Auguste homes in East Biloxi, which was converted to single family homes during that decade. In short, previously built-out areas that could only lose housing units, as well as a few low-density areas that have been converted to condominium or higher-density housing, were responsible for the unexpected control variable effects.

Local fixed effects on resilience were mixed as expected. Only six localities exerted a statistically significant effect on resilience, and all of these six had a positive effect, demonstrating that these areas were more resilient, controlling for other variables, than the omitted place category of unincorporated Jackson County. The high-resilience areas with the largest unstandardized coefficients included Ocean Springs, which had the greatest positive impact on resilience, Gulf Park Estates, St Martin, Diamondhead, D'Iberville, and unincorporated Hancock County.

The results of this analysis support various theories of social networks, the built environment, and resilient development. In particular, these results show that intersection density, residential density, historic sites, and physical infrastructure that promotes organizational activity – including cafés, meeting halls, and recreational facilities – contribute to greater capacity for disaster recovery and positively impact resilience. These findings actually validate the strategies that have been employed in rebuilding the Gulf Coast, such as the incorporation of walkability and other New Urbanism principles in building codes and master plans (McKee, 2005). Creation of additional parks and public community centers and neighborhood commercial districts is outlined in post-Katrina plans, such as the master plans for Biloxi and Gulfport. In addition, after the Biloxi Bay Bridge was destroyed, leaders in the community fought to include a well-traveled pedestrian and bicycle lane. These types of planning efforts are likely to improve overall resilience to future disasters.

Implications for Resilient Development

This analysis demonstrated the importance of design and development that facilitates social interaction, emphasizing the presence of connections and gathering points. From the information gathered from the model, physical attributes of communities explained some of the difference in ability to recover among communities on the Mississippi Coast. The results provided generalizable recommendations for planning interventions in the physical domains that would improve disaster resilience.

There were several notable factors that have influenced recovery that are not included in the model. On the Gulf Coast, hurricanes have driven the repeated overhaul of building codes and insurance standards. Hurricanes Audrey (1957) and Betsy (1965) led to modifications in coastal planning, including preservation of an open beachfront with a seawall and artificial sand beach for the public. At this time, the Southern Standard Building Code and Federal Housing Authority (FHA) standards were in use and the informal building elevation standard was 10 feet above sea level (Hearn, 2004). Hurricane-specific standards had not been formalized prior to Camille in 1969, and the massive property loss prompted codification. After Camille, a 13.2 foot building elevation standard was adopted. Despite these efforts, standards meant to protect residents were later ignored, including the risky development of casinos and recreational land uses on once-protected beachfront. Reports made after Camille called for future planning to limit exposure and take into account vulnerability of the community, particularly by adopting county- or region-wide hazard mitigation plans (Hearn, 2004).

For those building or rebuilding after 2005, Hurricane Katrina moved the bar significantly. Building elevations were revised, raising 3 to 8 feet above the levels recommended in pre-Katrina Flood Insurance Rate Maps (FIRMs) in some locations. Local governments adopted the International Building Code for wind and flood requirements and many employed municipal Smart Code ordinances, based on urban design rather than traditional land-use-based zoning. While these standards were enacted to protect residents, they have made rebuilding cost-prohibitive, particularly for those properties that front the Gulf, which suffered the most damage and face the greatest restrictions. However, seeking economic development, local governments may succumb to pressure from private developers and relax building standards or enforcement in the future. Unfortunately, this hubris seen after previous hurricanes is a common pitfall in long-term resilience.

Insurance has also stymied reconstruction. Many residents did not have coverage for flood damage, given that these properties were beyond the pre-Katrina 100-year floodplain. Furthermore, many homes had not been flooded in Hurricane Camille, and residents were confident that Camille's high-water mark would not be breached in their lifetime. Therefore, many affected households were not insured against the significant flood damage that occurred. Aid was distributed to these properties, including funds from the state development authority. However, since flood maps were redrawn by FEMA post-Katrina, these same properties have seen dramatic increases in insurance premiums and in some cases have been refused insurance. Some residents reported paying four or eight times the pre-Katrina rates in recent interviews. Wind insurance, obtained through the state, is an additional cost. The public sector can reduce the burden on residents and businesses by employing a strategy like that of Waveland, Mississippi. Under the FEMA Community Rating System (CRS), Waveland has been classified a Class 5 community, which allows a 25 percent discount on flood insurance for properties. Through the program, communities can earn credits through flood mapping, regulations, preparedness, damage reduction, and public information campaigns in order to receive up to a 45 percent discount on residents' premiums in the highest-risk flood zones.

A balanced economy is another important aspect of resilience, and reliance on tourism dollars is an issue for the Gulf Coast. The tax revenue supplied by casino gambling has provided capital for economic development, including schools and historic preservation. The casinos and resorts lining the shores of the Gulf Coast were among the first structures rebuilt. While casino revenues fell by 28 percent immediately after the storm, casinos turned record profits within two years (Rivlin, 2007). Unfortunately, this boom and bust cycle is likely to repeat itself with every future crisis (as demonstrated after the 2010 BP oil spill), limiting the ability to effectively recover from a disaster. Casinos and other major employers may be persuaded to engage in corporate social responsibility efforts such as providing community centers and temporary housing after a disaster. These practices may protect their labor resources while encouraging greater community resilience through their own employee-based social networks. In addition to the casinos in Hancock and Harrison Counties, shipyards and a fuel refinery are major employers in Jackson County. While the response of many employers was outstanding, large employers have a unique ability to engage in public-private partnerships that promote community resilience, not only in sponsoring preparedness programs but also in providing resources for even the smallest community-based organizations that promote social networks and resilience and in supporting resilient urban planning strategies.

The strength of the nongovernmental organizations was another major factor in recovery. Based on recent interviews with residents, immediate clearing as well as later rebuilding efforts were often undertaken by nonprofits and other volunteer organizations. Federal and state government was subject its own, often bureaucratic, protocols, making it difficult to mobilize public sector resources. To fill this gap, organizations from around and from outside the area, particularly faith-based organizations, were helpful in supplying skilled labor and equipment. While these efforts were often ad hoc, such organizations were able to effectively organize to meet residents' needs. Partnerships between the public, private, and nonprofit sectors in pre-disaster planning efforts would only expand the influence and increase the available resources for rebuilding. Some examples exist, and philanthropy and volunteerism on the Gulf Coast are notably strong; however, institutionalizing such partnerships, particularly with the private sector, is necessary to ensure that partnerships and networks are able to effectively mobilize in a disaster situation.

Eight years after Hurricane Katrina, the recovery is still in progress. There are many considerations that impact private development: physical restrictions, such as zoning, environmental impacts, and building codes; cost restrictions such as financing and insurance standards; and the economy and market demand. Rebuilding after a hurricane produces an influx of public and private money and other resources that can stimulate the local economy and spur spontaneous decision making by public and private entities. Yet, hurricanes are only one stimulus that has altered the Gulf Coast over time. For example, in the last century, dredging and development eroded barrier islands and coastal marshes, and, like many other small and mid-sized cities in the U.S., historic business districts were systematically abandoned for suburban strip- and shopping- malls. These activities have largely made the population more vulnerable; however, post-Katrina recovery appears to be reversing this trend with its focus on creating civic centers and locally appropriate design. While the factors influencing resilience and recovery are complex and wide-ranging, planning and policy interventions that influence private real estate development, as well as direct public and private interventions in the built environment, have the potential to make an enormous impact on a community's ability to withstand and recover from a disaster.

Works Cited

Aguirre, B.E. (2006). On the Concept of Resilience (Vol. Preliminary Paper #356): University of Delaware Disaster Research Center.

Barthelme, Frederick. (2005, September 2). Mississippi's Morning After, *The New York Times*.

Ben-Porath, Yoram. (1980). The F-Connection: Families, Friends, and Firms and the Organization of Exchange. *Population and Development Review, 6*(1), 1-30.

Berke, Philip R. (1993). Recovery After Disaster: Achieving Sustainable Development, Mitigation, and Equity. *Disasters, 17*(2), 93-109.

Berkman, Lisa F., Glass, Thomas, Brissette, Ian, & Seeman, Teresa E. (2000). From social integration to health: Durkheim in the new millennium. *Social Science & Medicine, 51*, 843-857.

Carpenter, Ann, & Montoya, Nancy. (2011). Plugging into the Power of Community: How Social Networks Energize Recovery. In R. V. Anglin, A. Liu, R. M. M. Jr. & A. Plyer (Eds.), *Resilience and Opportunity: Lessons from the U.S. Gulf Coast after Katrina and Rita Development* (pp. 220-234). Washington: Brookings Institution Press.

Cutter, Susan L., Boruff, Bryan J., & Shirley, W. Lynn. (2003). Social Vulnerability to Environmental Hazards. *Social Science Quarterly, 84*(2), 242-261.

Cutter, Susan L., Emrich, Christopher T., Mitchell, Jerry T., Boruff, Bryan J., Gall, Melanie, Schmidtlein, Mathew C., . . . Melton, Ginni. (2006). The Long Road Home: Race, Class, and Recovery from Hurricane Katrina. *Environment, 48*(2), 8-20.

Erikson, Kai. (1976). *Everything in Its Path: Destruction of Community in the Buffalo Creek Flood*. New York: Simon and Schuster.

Frank, Lawrence, Bradley, Mark, Kavage, Sarah, Chapman, James, & Lawton, T. Keith. (2008). Urban form, travel time, and cost relationships with tour complexity and mode choice. *Transportation, 35*(1), 37-54.

Freeman, Lance. (2001). The Effects of Sprawl on Neighborhood Social Ties: An Explanatory Analysis. *Journal of the American Planning Association, 67*(1), 69-77.

Gans, Herbert J. (1962). *The Urban Villagers*. New York: The Free Press of Glencoe.

Governor's Report on Recovery, Rebuilding and Renewal. (2010). Five Years After Katrina: Progress Report on Recovery, Rebuilding and Renewal. Jackson: Office of Recovery and Renewal, State of Mississippi.

Granovetter, Mark S. (1973). The Strength of Weak Ties. *The American Journal of Sociology, 78*(6), 1360-1380.

Hearn, Philip D. (2004). *Hurricane Camille: Monster Storm of the Gulf Coast*. Jackson: University of Mississippi Press.

Isserman, Andrew M., Feser, Edward, & Warren, Drake. (2007). Why Some Rural Communities Prosper While Others Do Not: U.S. Department of Agriculture Office of the Under Secretary for Rural Development.

Jacobs, Jane. (1961). *The Death and Life of Great American Cities*. New York: Random House.

Leyden, Kevin M. (2003). Social Capital and the Built Environment: The Importance of Walkable Neighborhoods. *American Journal of Public Health, 93*(9), 1546-1551.

Lund, Hollie. (2002). Pedestrian Environments and Sense of Community. *Journal of Planning Education and Research, 21*, 301-312.

Magsino, S.L., rapporteur (2009). Applications of Social Network Analysis for Building Community Disaster Resilience: Workshop Summary *National Academies Press*. Washington: National Research Council of the National Academies.

McKee, Bradford. (2005, December 4). Out of the Muddy Rubble, a Vision for Gulf Coast Towns, *The New York Times*.

Milligan, Melinda J. (1998). Interactional Past and Potential: The Social Construction of Place Attachment. *Symbolic Interaction, 21*(1), 1-33.
Paton, Douglas. (2003). Disaster preparedness: a social-cognitive perspective. *Disaster Prevention and Management, 12*(3), 210-216.
Patterson, Olivia, Weil, Frederick, & Patel, Kavita. (2010). The Role of Community in Disaster Response: Conceptual Models. *Population Research and Policy Review, 29*(127–141).
Rapoport, Amos. (1994). Spatial Organization and the Built Environment. In T. Ingold (Ed.), *Companion Encyclopedia of Anthropology*. London: Routledge.
Rivlin, Gary. (2007, July 16). Casinos Booming In Katrina's Wake As Cash Pours In, *The New York Times*.
Rupasingha, Anil, Goetz, Stephan J., & Freshwater, David. (2000). Social Capital and Economic Growth: A County-Level Analysis. *Journal of Agricultural and Applied Economics, 32*(3), 565-572.
Sennett, Richard. (1977). *The Fall of Public Man*. New York: Alfred A. Knopf.
Sherraden, Margaret Sherrard, & Fox, Ellen. (1997). The great flood of 1993: Response and recovery in five communities. *Journal of Community Practice, 4*(3), 23-45.
Stack, Carol B. (1979). *All Our Kin*. New York: Harper & Row.
Talen, Emily. (2002). The social goals of new urbanism. *Housing Policy Debate, 13*(1), 165-188.
Webster, P. J., Holland, G. J., Curry, J. A., & Chang, H.-R. (2005). Changes in Tropical Cyclone Number, Duration, and Intensity in a Warming Environment. *Science, 309*, 1844-1846.
Whyte, William Foote. (1943). *Street Corner Society: The Social Structure of an Italian Slum*. Chicago: The University of Chicago Press.
Whyte, William H. (1980). *The Social Life of Small Urban Spaces*. Washington: The Conservation Foundation.