THROUGH THE LENS OF KATRINA: A HISTORICAL GEOGRAPHY OF THE SOCIAL PATTERNS OF FLOOD EXPOSURE IN NEW ORLEANS, 1970-2005

THESIS

Presented to the Graduate Council of
Texas State University-San Marcos
in Partial Fulfillment
of the Requirements

for the Degree

Master of SCIENCE

by

A. Case Watkins, B.G.S.

San Marcos, Texas
August 2008

THROUGH THE LENS OF KATRINA: A HISTORICAL GEOGRAPHY

OF THE SOCIAL PATTERNS OF FLOOD EXPOSURE

IN NEW ORLEANS, 1970-2005

Committee Members Approved:

Ronald R. Hagelman, III, Chair

Frederick A. Day

Craig E. Colten

Approved:

J. Michael Willoughby
Dean of the Graduate College

COPYRIGHT

by

A. Case Watkins

2008

To New Orleans and its people

ACKNOWLEDGEMENTS

My committee worked diligently in support of this document, and for these efforts, I am extremely grateful. Dr. Hagelman, Louisiana lost a valuable asset when Katrina facilitated your return home, but I am sure Texas is proud to have reclaimed you. Without your insight into environmental geography, hazards, and research techniques, this project is inconceivable. Your guidance and support during my Masters studies are greatly appreciated. Dr. Day, your expertise in the distributions of peoples was an invaluable resource in the development of this document and in my academic career. I was fortunate to have access to the both of you while at Texas State. Dr. Colten, I am truly thankful for your willingness to serve on my committee across state lines. Your lifetime of research and contemplation on New Orleans and Louisiana proved extremely informative to this venture.

I am exceptionally grateful to my mother and father who have provided me with unflinching support and encouragement through the years. Thanks, y'all!

Kristin, in you I have found a partner, a companion, a colleague, and a limitless source of inspiration and enlightenment. Thank you for being you. Vamos ao Brasil, meu amor!

This manuscript was submitted on 25 April 2008.

TABLE OF CONTENTS

Page

ACKNOWLEDGEMENTS v

LIST OF TABLES viii

LIST OF FIGURES ix

ABSTRACT xi

CHAPTER

I. INTRODUCTION 1

II. RESEARCH QUESTIONS 6

III. SITE, SITUATION, AND FLOOD HAZARD 8

Site and Situation 8
Human Ecology and Flood Hazard in New Orleans 18

IV. LITERATURE REVIEW 28

Understanding “Landscape” and its Conflations 28
Historical and Urban Geographies of New Orleans 31
Defining the Contemporary Era 45
Vulnerability and the Contextualized
Study of Hazards 56
The “Naturalness” of Disaster 62
The “Science” of Katrina 65
Social Geography, Quantitative Methods, and GIS 68

V. DATA 72

Inundation Data 72
Census Data 73

VI. METHODOLOGY 82

GIS Data Preparation 82
Data Analysis 87

VII. RESULTS 97

Initial Analysis of 2005 New Orleans 97
Temporal Analysis, 1970-2000 99

VIII. DISCUSSION 103

REFERENCES 115

LIST OF TABLES

Table **Page**

1. Race and Ethnicity within the Study Area 90

2. Results of the Initial Analysis for the Year 2005 98

3. Racial Proportions among Whites and African-Americans only within the Study Area 100

4. Temporal Logit Analysis 101

LIST OF FIGURES

Figure **Page**

1. Contemporary New Orleans and its Surrounding Area................................. 9

2. The Mississippi River, its Hydrologic Network, and Drainage Basin........... 10

3. The Original Site of New Orleans 12

4. A Google Earth Image (Digital Globe and Terra Metrics 2008) Depicting Natural Water Courses and Human-built Canals, St. Mary and Terrebonne Parishes, Louisiana 16

5. Generalized Patterns of Inundation Produced by Hurricanes Betsy and Katrina in Urban Areas.. 23

6. Lake Pontchartrain and Vicinity Project Map (U.S. Army Corps of Engineers 1965).. 24

7. Elevation Data Depicting the Topography of New Orleans and its Environs 27

8. A Parish-level Representation of White Flight in the New Orleans Region from 1970-2000 (data source: Geolytics, Inc. and the Urban Institute 2003).. 34

9. Change in the Total Number of Households in New Orleans and Surrounding Areas by Census Tract, 1970-2000 (Geolytics, Inc and The Urban Institute 2003) 35

10. Levee Improvements Authorized by Lake Pontchartrain and Vicinity, Louisiana, Hurricane Protection Project (United States Army Corps of Engineers 1965).. 47

11. A Graphic Representation of White Flight by Census Tract within the Urbanized Area surrounding New Orleans, 1970-2000......................... 52

12. Katrina-induced Flood Depths and Extent for 2 September 2005 73

13. Census Block Groups nested within Census Tracts in New Orleans.......... 75

14. Several Census Tracts fit inside the Conventional Neighborhoods of New Orleans 77

15. Census Block Groups along the Southern Shore of Lake Pontchartrain 84

16. Census Block Groups within the Contiguous Urbanized Area surrounding New Orleans 85

17. Census Tracts within the Contiguous Urbanized Area Surrounding New Orleans 88

18. Conceptual Model of the Methodology 89

19. Frequency Distributions for the Independent Variables used in the Initial Analysis 91

20. Racial Plurality by Block Group 92

21. Initial Analysis 98

22. Trends in the Odds Ratios produced by the Temporal Analysis............... 102

23. Proportion of African-American Residents with a Generalized Zone of Katrina-induced Inundation and Parish Boundaries 105

24. Median Household Income with a Generalized Zone of Katrina-induced Inundation and Parish Boundaries 107

25. Sprawl-driven White Flight and the Observations of Gilbert White et al. (1958) on Urban Floodplain Occupance 114

ABSTRACT

THROUGH THE LENS OF KATRINA: A HISTORICAL GEOGRAPHY

OF THE SOCIAL PATTERNS OF FLOOD EXPOSURE

IN NEW ORLEANS, 1970-2005

by

A. Case Watkins, B.G.S.

Texas State University-San Marcos

May 2008

SUPERVISING PROFESSOR: RONALD R. HAGELMAN, III

Two and a half years after Hurricane Katrina, its reverberations remain evident in New Orleans and throughout the academic literature. Although scholars have written extensively on apparent social inequities present in the city before, during, and after the storm, an empirical consensus on the racial and socioeconomic distributions of the population relative to Katrina-induced flooding remains elusive. In response to this lacuna, I employ the U.S. Census, digital inundation data, and a GIS to analyze New Orleans' racial and socioeconomic geographies as they related to patterns of flood inundation in the city during the storm. Katrina's inundation, however, represents only a brief episode within the greater history of New Orleans. While a temporally isolated analysis of a distinctive hazard event such as Katrina can be informative in and of itself, it does little to illuminate the evolution of the social landscape before or after the

storm. Therefore, after conducting the initial analysis, I then replicate the methodology across the three decennial census periods prior to 2000 (1970, 1980, and 1990). While the initial assessment discerns the statistical relationship among race, socioeconomics, and Katrina's inundation, the subsequent temporal analysis illuminates the historical patterns of social change that led to the landscape of exposure wrought by the storm in 2005. In essence, this research asks, "If Hurricane Katrina struck in 1970, 1980, or 1990, how, if at all, would the socioeconomic or racial geographies of flood exposure evident during each period differ from the patterns evident during the actual event in 2005?" I use Katrina's inundation, then, as a lens through which we can view 35 years of urban social changes in New Orleans. I contend that it is not enough to understand merely whom the storm affected. Rather, scholars, managers, and policymakers at every level benefit by recognizing the evolution (or devolution) of social landscapes into those ripe for human disaster.

CHAPTER I

INTRODUCTION

On August 29, 2005, Hurricane Katrina made its third and final landfall in coastal Louisiana as a strong Category 3 storm. The National Atmospheric and Oceanic Administration (NOAA) measured hurricane force winds in four states, but the storm affected Louisiana—and particularly the city of New Orleans—most severely (Knabb, Rhome, and Brown 2005). The hurricane breached and overtopped levees and canal walls in and around New Orleans, inundating 80 percent of the city in depths that exceeded fifteen feet in some areas. The U.S. Army Corps of Engineers (USACE) (2006) spent 53 days draining 250 billion gallons of water from the city—enough to cover Washington, D.C. in 17 feet of inundation. The effects of the hurricane were extraordinary when compared to previous storms. Authorities ordered over 1.2 million people along the U.S. Gulf Coast to evacuate in anticipation of the storm (Knabb, Rhome, and Brown 2005). Researchers with the Congressional Research Service (CRS), estimated that as many as 5.8 million people experienced hurricane force winds, and 700,000 people may have been "acutely impacted" by flooding or significant structural damage (Gabe et al. 2005, 2). The scale of human displacement associated with Katrina was unprecedented. Though disaggregated figures are unavailable, the Federal Emergency Management Agency (FEMA) estimated that Hurricanes

Katrina and Rita displaced a combined two million Americans. In all, 44 states and the District of Columbia received Presidential declarations of emergency in support of local influxes of survivors, designating Katrina the single biggest disaster in U.S. history (Federal Emergency Management Agency 2006a). Katrina's official death toll stands at 1,833, with 1,464 of the deaths affecting Louisiana residents and 135 persons still officially listed as missing (Louisiana Department of Health and Hospitals 2006). Although it is uncertain where Katrina ranks nationally in terms of hurricane-induced fatalities, most observers place the storm third behind the Galveston, Texas, hurricane of 1900 and the 1928 hurricane over Lake Okeechobee, Florida (Knabb, Rhome, and Brown 2005). With an initial price tag of over $81 billion in damage, Katrina easily ranks as the costliest natural disaster in U.S. history (U.S. Department of Commerce 2006).

Popular coverage of the hurricane and its aftermath came as a barrage of reports from broadcast, print, internet, and other media. Many journalists speculated on the roles that race and socioeconomic status may have played in numerous aspects of the storm and in the government's response to it (Broder, Wilgoren, and Alford 2005; Bumiller 2005; Duke and Wiltz 2005; Fletcher 2005; Fletcher and Morin 2005; Johnson 2005; Milloy 2005; No Author 2005a, 2005b; Page and Puente 2005; Weisman 2005; Wickham 2005; Young 2006). Following the storm, the U.S. was embroiled in a heated discussion of race, poverty, and disaster (Dyson 2006). Much of the public debate surrounding Katrina, race, and socioeconomics gave particular attention to the issue of evacuation. Because a majority of New Orleanians who were unable or unwilling to evacuate were African-American, and media coverage of Katrina's aftermath portrayed this racial component, many of the popular and academic discussions spawned by Katrina focused on those residents who were unable to evacuate or otherwise chose to stay (Sharkey 2007). While this dialogue provided a compelling avenue for the discussion of racial relations and poverty in the U.S., it failed to address the relationship between Katrina's floodwaters and the *a priori* social geography of New Orleans at the time of the storm. Given the public debate surrounding Katrina's social implications and the high level of general public interest in the event, it is counter-intuitive that an empirical consensus on the racial and socioeconomic distributions of the population relative to Katrina-induced flooding remains elusive. While journalists and scholars alike have offered much speculation, commentary, and scientific inquiry on the topic, we still do not fully understand the patterns of flood exposure as they relate to the racial and socioeconomic distributions of New Orleans' population.

Because assessments of Katrina's inundation patterns and their relationship with New Orleans' social geography have been broadly defined, and previous findings have been contested and debated, a comprehensive empirical study can clarify the issue. In response to this lacuna, this research begins with a quantitative analysis of the relationship among socioeconomics, race, and flood exposure in New Orleans. Doing so illuminates the spatial distribution of New Orleans' social geography and its relationship to the inundation patterns produced by Hurricane Katrina, and clarifies the links amongst race, class, and inundation. While a temporally constant analysis such as that described above represents a worthwhile primary analysis, to take merely a snapshot of New Orleans' social geography immediately prior to the hurricane would yield an unrealistically static representation of the city, effectively isolating its perspective from the historical forces that produced the social realities apparent as Katrina pushed ashore.

As Lewis (2003), Colten (2005), and Campanella (2006) have noted, social phenomena such as white flight and wetland-drainage-suburbanization have drastically altered the social landscape of New Orleans during the modern era. While these authors have documented the existence of white flight and other agents of social restructuring in New Orleans, the explicit relationship between such evolutions in the social landscape and Katrina-induced flooding has yet to be explicated. Therefore, as the second major analytical component of this study, I traced the historical shifts in New Orleans' social geography during the contemporary period (1970-2000) to illuminate the patterns of social change that led to the social landscape evident as Hurricane Katrina inundated the city in 2005. Essentially, this research uses Katrina's patterns of inundation as a lens to view shifts in New Orleans' social geography.

This research intends not only to clarify our understanding of the socio-spatial patterns of flood exposure in 2005, but also to demonstrate how the social landscape evolved to produce the patterns revealed by Katrina's inundation. The results produced via this research are valuable to scholars, policymakers, managers, and planners at all levels of government. In general, if a study such as this finds that certain social groups were disproportionately exposed to Katrina's inundation, local policymakers and federal engineers could use the results to increase the protection of such communities in future development plans. Researchers or government officials at other levels or in other regions could use the methodology offered here to delineate and analyze social landscapes elsewhere in the nation and the world, using various phenomena as a "lens" through which social landscape change can be viewed. By contextualizing an event or phenomenon (in this case Katrina), this socio-historical approach recognizes major shifts in the social landscape, yielding clues as to how a given pattern of urban development creates distinct socio-spatial distributions.

By tracking the changes in the city's social geography over the three decades prior to Katrina, this study demonstrates to scholars and officials how the social distributions of New Orleans' population have changed since 1970, and how these changes relate to the city's most recent and most devastating hazard event. Furthermore, an understanding of the changing social landscape in New Orleans provides a benchmark for further studies investigating the trends of re-population as the city attempts to rebuild in the wake of the storm. In sum, the analysis described here illuminates the historical progression of the underlying social factors associated with the tragic events of Hurricane Katrina, offering both theoretical and practical insights.

CHAPTER II

RESEARCH QUESTIONS

This research explores the following broad questions: What is the relationship among race, socioeconomic status, and Hurricane Katrina-induced patterns of inundation in New Orleans? Did the African-American community experience disproportionate exposure to the flood when compared to the white community? Did poorer residents experience disproportionate exposure to the flood when compared to wealthier residents? How, if at all, has this relationship changed during the contemporary period? Specifically, this research operationalizes the following research questions: Based on residential settlement patterns in New Orleans in 2000, is race or socioeconomic status the more salient variable in understanding exposure to Katrina-induced inundation? Once the composition of this relationship is established, I conducted a comparative temporal analysis. The temporal analysis asked: Relative to the relationship among race, socioeconomic status, and Hurricane Katrina-induced patterns of inundation evident in 2005, how would the composition of this relationship change based on the social landscapes apparent in 1970, 1980, or 1990? In other words, how has the social landscape changed since 1970, and what can this tell us about exposure to Katrina's flooding and the future of vulnerability to flooding in New Orleans?

What was the trajectory of the social landscape such that various social groups found themselves disproportionately affected by the storm?

In this research, I essentially evaluate the role of race and socioeconomic status in understanding exposure to Hurricane Katrina-induced inundation, assess how these roles have changed during the contemporary period, and discuss what these changes mean for New Orleans as well as for other cities.

Certainly, there are countless options for viewing and analyzing social landscape change and hazard vulnerability in New Orleans or in any other city. In this study, I use the patterns of inundation wrought by Hurricane Katrina as a lens with which to view changes in New Orleans' social geography during the contemporary era. Therefore, this study provides an empirical evaluation of the socio-spatial distribution of New Orleans' population relative to Katrina's patterns of inundation, traces the changes in the contemporary social landscape that led to the setting apparent as Katrina struck the city, and relates the evolution of the social landscape to the patterns of inundation evident as Katrina struck New Orleans.

CHAPTER III

SITE, SITUATION, AND FLOOD HAZARD

Site and Situation

Commenting on its site and situation, geographer Pierce Lewis (2003, 19) proclaimed New Orleans, "the impossible but inevitable city." New Orleans' site (see Figure 3), or in Lewis' (2003, 19) words, "the actual real estate which the city occupies," is, and always has been, extremely unwelcoming to urban development. However, the city's situation, that is, its natural surroundings at the intersection of the Mississippi River and the Gulf of Mexico, provide its settlers (both historical and current) with extraordinary economic and expeditionary advantages. The opportunities for trade and exploration throughout the river and its vast network of tributaries combined with access to the open ocean at the Gulf of Mexico supplied adequate situational incentives for colonial settlers to confront the geographic challenges of the city's site (Kelman 2003; Lewis 2003; Colten 2005). Therefore, Lewis' famous declaration implies that, while geographic difficulties render New Orleans' site "impossible," the city's existence, due to the strategic importance of its situation, was, and remains, "inevitable."

As Europeans began exploring the North American continent, they immediately realized the immense importance of the Mississippi River as a commercial and exploratory thoroughfare (Martin 1976; Colten 2000; Kelman 2003; Lewis 2003). The mouth of the Mississippi River is the largest and most important outfall in North America. Encompassing an area of approximately 1.2

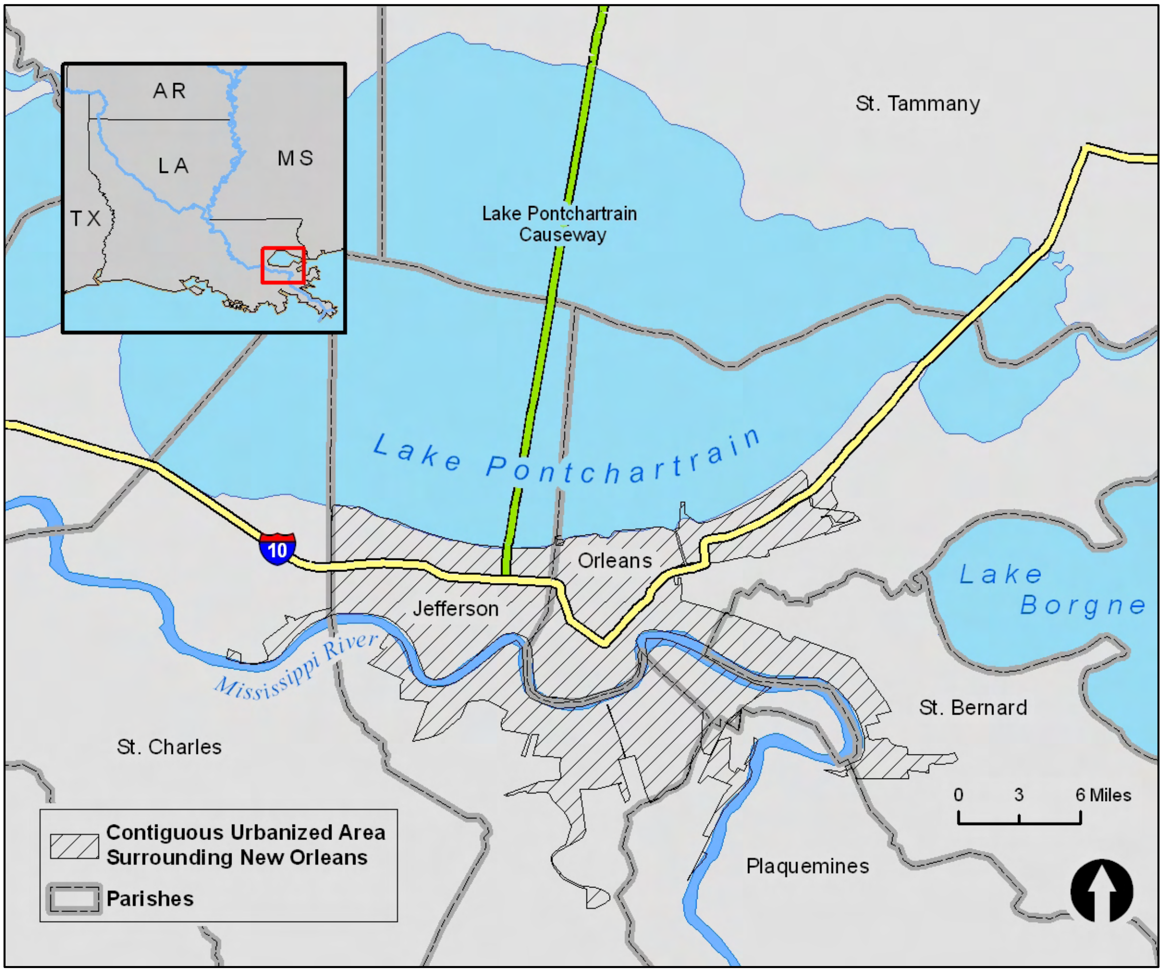

Figure 1: Contemporary New Orleans and its Surrounding Area.

million square miles, the drainage basin of the Mississippi River ranks as the world's third largest. The river and its sprawling hydrologic network drain in excess of 40 percent of the conterminous United States, including portions of 32 states and two Canadian provinces (Kelman 2003) (See Figure 2). Therefore, those who control the river's mouth effectively control access to a major portion of the interior contiguous United States (Kelman 2003). Since the colonial era, this strategic advantage has enticed numerous entities to seek possession of the present-day city and its situation, and the relatively vast array of sovereign groups and nation-states that have made claim to New Orleans provides evidence of its significance to the continent on which it lies. The site of present-day New Orleans has, at one point or another, been administered by the

Figure 2: The Mississippi River, its Hydrologic Network, and Drainage Basin.

Indigenous Americans, France, Spain, the United States, and the Confederacy (Martin 1976).

In the early eighteenth century, Bourbon France, realizing the strategic importance of the Mississippi River to North America, sought to establish a settlement at its mouth in order to control access to the river and the giant swath of the continent accessible via its hydrologic network. When Bienville founded

New Orleans in 1718, he chose a location along a sharp bend in the Mississippi's natural levee approximately 120 miles upstream of the river's mouth. The exact location was advantageous to the French for three vital reasons. The original site rested on the relatively high and stable natural levee, was sufficiently upstream from the river’s mouth to avoid the sandbars and shallow meandering delta that began in earnest just downriver, and, most importantly, was only a short portage from the Bayou St. John (Lewis 2003) (see Figure 3). This bayou, shown to Bienville by local Choctaw Indians, provided the settlers with access to Lake Pontchartrain, and thus to the Gulf of Mexico (see Figure 3) (Colten 2000; Lewis 2003). Because of the mere two-mile portage separating the Mississippi River from entrée to the Gulf of Mexico at the Bayou St. John, the new city's location provided maritime access to both the river and the open ocean. Thus, the city's situation represented a strategically important transportation hub to its founders (Colten 2000), helping to explain Lewis’ assertion, “New Orleans did not grow to become a city; it was decreed a city from the moment of its founding” (Lewis 2003, 39).

Although the city’s situation presented its early settlers with vast opportunities, the city's site presented them with a unique set of environmental challenges. The original site of New Orleans was located on a portion of the Southern Holocene Meander Belt (natural levee) that draped the Mississippi River (Lewis 2003; Campanella 2006; Daigle et al. 2006). However, the contemporary city is spread across a much larger area, and encompasses a variety of eco-regions (Daigle et al. 2006). The problems plaguing New Orleans' site, as Lewis (2003) pointed out, read like a laundry list. The current site of New Orleans is: mostly at or below sea level, continually subsiding, surrounded by

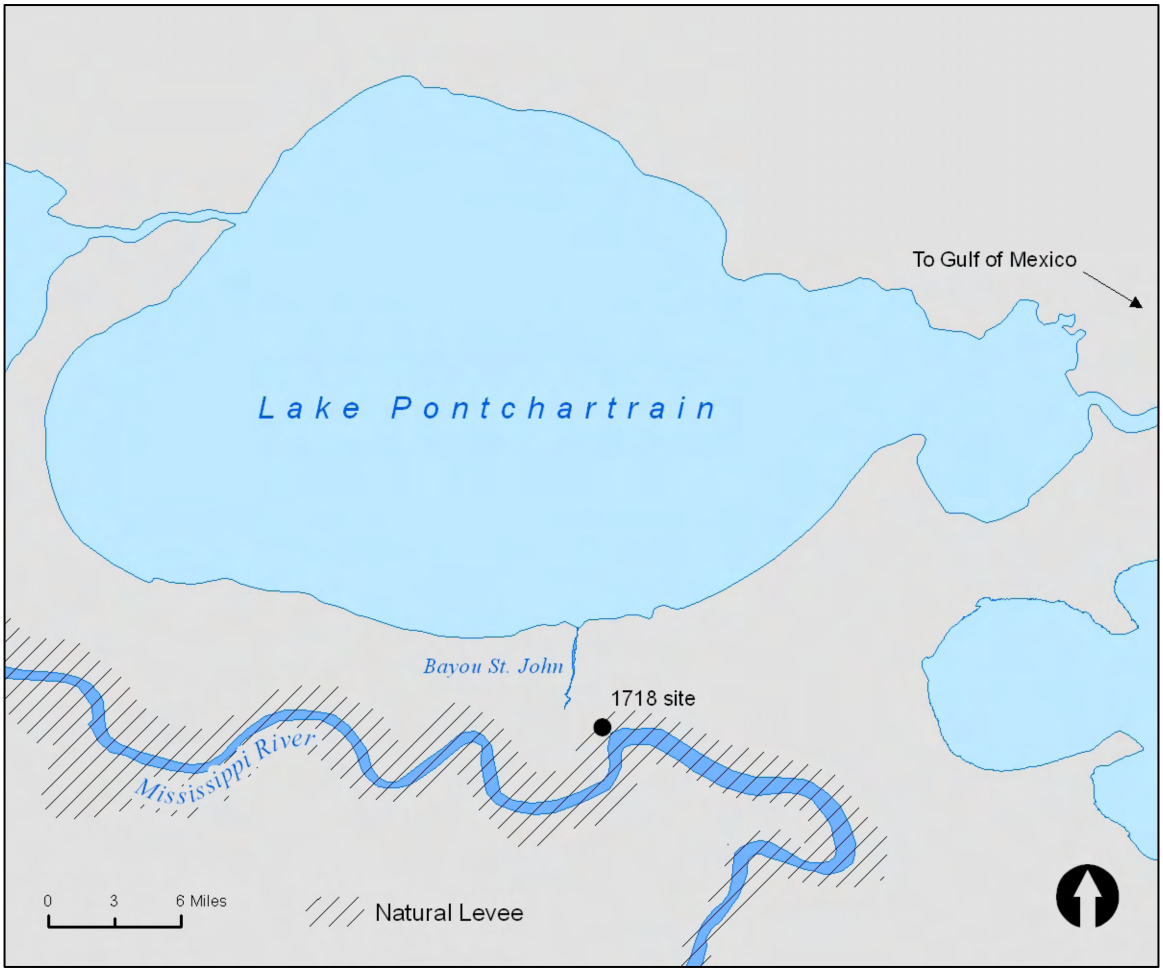

Figure 3: The Original site of New Orleans. Note Bayou St. John and the natural levees.

swamps and marshes, under seasonal threat of tropical storms and hurricanes, lacking in solid ground suitable for structural foundations, and with low relief and the water table just beneath the surface, most of the area drains very poorly, if at all. The city of New Orleans, then, as Colten (2005) has argued, can perhaps be best understood via its strategies of environmental management, most notably, flood avoidance. As New Orleans has sustained an epic struggle against the threat of inundation throughout its history, the city's environmental management strategies continue to shape its physical and social geographies (Colten 2005; Campanella 2006).

For all the undesirable aspects of New Orleans' site, its situation has provided the impetus for the city's economic and cultural development since its inception. When one views New Orleans through the perspective of human ecology (Barrows 1923), one can better understand the complex relationships between its people and the natural environs surrounding the city. Just as there are extreme risks associated with New Orleans' site, there are vast and compelling opportunities afforded by the city's situation. As Burton, Kates, and White (1993) explain, humans' relationship with nature is a balancing act. If humans are to wrest economic rewards from nature, they must simultaneously mitigate the negative repercussions of their activities. In other words, anyone who would gain from nature must also be prepared to compensate reciprocally for this gain by means of environmental management. Geographers view the positive outcomes of this process as *resources* and the negative outcomes as *hazards* (Burton, Kates, and White 1993). New Orleans portrays the extremes of both the positive and negative repercussions of human-environmental interaction, and via its physical geography, its relationship with industry, and its environmental management strategies, the city represents a convincing case-in-point for understanding the human ecology paradigm.

Though New Orleans' site exposes the city to great peril, its situation grants it access to an array of local, regional, national, and international economies. At the crest of these markets is the global economy of scale administered by the vastly important import/export shipping industry. Certainly, maritime transportation represents the original rationalization for New Orleans' founding, and it remains atop the list of justifications for the city's continued existence (Lewis 2003). Yet the importance of the shipping industry goes far beyond the confines of New Orleans, as it is a vital cog in the national and international economies. As "America's gateway to the global market," the Port of New Orleans boasts the world's busiest import/export complex at the mouth of the Mississippi, the world's busiest river. More than half of the nation's grain exports travel down the river and out the Port of New Orleans, and the port leads the U.S. in the importation of steel, natural rubber, plywood, and coffee (Board of Commissioners of the Port of New Orleans 2008). As New Orleans' *raison d'être*, the importance of the port to its city remains paramount, and its current facilities represent the contemporary manifestation of the original rationale for the city's colonial founding (Lewis 2003).

Second only to the port in terms of economic importance in New Orleans is the energy industry. Like the shipping industry, the energy industry is a critical facet of both the national and global markets (Lewis 2003). Those who seek to emphasize this point need only to cite the spike in petroleum prices immediately following Hurricane Katrina (Colten 2006b; Killian 2006). New Orleans is an important hub for petroleum and natural gas extraction and refinement on and off the coast of Louisiana. Among all U.S. states, Louisiana ranks first in crude oil production (26.4 percent of the U.S. total) and second in natural gas production

(18.3 percent of the U.S. total) when wells offshore of Louisiana's coast are included in the tabulation (Scott 2007). Certainly, the nation relies heavily on Louisiana's energy production, and New Orleans, with its port and petroleum refineries, is an integral component of the state's energy industry as it is currently configured (Lewis 2003).

New Orleans' benefits from the energy industry do not come without cost, however. In yet another example of the balancing act between resources and hazards, damaging environmental impacts have accompanied the economic boon provided by the energy industry in New Orleans. Since the early 1930s, petroleum companies have carved more than 10,000 miles of navigational canals in Louisiana's coastal wetlands (see Figure 4) (Tidwell 2003; Austin et al. 2004). These canals are an important agent of relatively rapid land loss on the Louisiana coasts (Day et al. 2000), and this land loss has been linked to an increased physical vulnerability to hurricanes among coastal communities along the U.S. Gulf Coast, including New Orleans (Day et al. 2007). Therefore, while the national and international markets reap the benefits of New Orleans' association with the energy industry, coastal Louisiana alone endures most of the energy industry's negative effects (Barry 2007). These differential impacts are at the forefront of recent arguments for increased federal funding by lobbyists and policymakers on behalf of New Orleans and the State of Louisiana (Barry 2007).

Like its economic footholds in the shipping and energy industries, New Orleans' tourism industry is a product of its geography. New Orleans' colonial and cosmopolitan roots as a port city created an important and unique cultural legacy for the city. As Campanella (2006, 86) notes, by virtue of the people and products it has sent to and through the city over the years, the Mississippi River has served New Orleans as a “cultural conduit.” Remarkable manifestations of the city’s culture include unique forms of architecture, music, food, and a

Figure 4: A Google Earth Image (Digital Globe and TerraMetrics 2008) Depicting Natural Water Courses and Human-built Canals, St. Mary and Terrebonne Parishes, Louisiana.

distinctive New Orleanian *joie de vivre* that has become legendary throughout the world (Lewis 2003). New Orleans’ cultural legacy has become an essential economic asset, as it has bolstered a thriving tourism economy in the city. The importance of tourism to the economic vitality of contemporary New Orleans is difficult to overstate. However, much like the city's natural environment, New Orleans' relationship with tourism provides both positive and negative repercussions. Though tourism has grown to become the most lucrative industry to the city itself, it has also caused much social strife due to the primarily low-paying, unreliable, and dead-end jobs associated with the industry (Lewis 2003). Furthermore, many have argued that, by catering to throngs of tourists, the tourism industry in New Orleans has altered the city's landscape—particularly in the French Quarter—via "Disneyfication," or the commodification of a controlled, contrived experience (Zukin 2003; Souther 2007). Lewis (2003) points to concerns over the conversion of former residential buildings in the French Quarter to 24-hour bars, restaurants, and t-shirt shops. Nevertheless, tourism remains an indispensable facet of New Orleans' local economy.

While tourism sustains the city's coffers, the shipping and energy industries play fundamental roles in national and international economies of scale. New Orleans' role in the international economy helps to justify the relatively large federal subsidies necessary to insulate the city from its watery environs, and without this federal support, New Orleans cannot continue as an urban settlement. The rest of the U.S. has essentially agreed to compensate the city for its dreadful site in return for the economic advantages derived from the city's lucrative geography. In other words, the economic rewards reaped by the shipping and energy industries temper the concerns of taxpayers and legislators regarding the extreme physical risk inherent to New Orleans' location, and provide the rationalization for the continued flow of federal subsidies to the city.

Perhaps no other city boasts such a desirable situation on such a "wretched" site (Lewis 2003, 19). Due to this unique association between site and situation, New Orleans' geographic setting represents at once both the city's greatest risk (site) and its greatest reward (situation). Certainly, even today, a spectrum of Americans from laypersons to scholars to members of Congress debate the site's suitability for urban settlement (Associated Press 2005; Coy 2005; Davis 2005; Glaeser 2005; Jacob 2005; Shafer 2005; Kates et al. 2006). However, those who argue in favor of the city's continued existence cite evidence that New Orleans' economic and cultural resources exceedingly justify its geographic risk (Davis 2005; Friedman 2005; Gingrich and Barry 2005; Piazza 2005; Romero 2005; Barry 2007).

Human Ecology and Flood Hazard in New Orleans

The history of New Orleans is fraught with instances of flooding (Martin 1976; Kelman 2003; Lewis 2003; Colten 2005; Campanella 2006). Although New Orleans has been threatened by an array of other environmental hazards throughout its history—most notably fire and yellow fever—inundation continues to pose the greatest threat to the survival of New Orleans as an urban settlement (Colten 2005). There are two distinct forms and causes of flooding that have threatened New Orleans at one time or another—riverine flooding and storm-induced flooding (Lewis 2003).

Before European settlement, springtime flooding by the Mississippi River was a seasonally chronic event in the areas surrounding present-day New Orleans (Colten 2005). Shortly after their arrival, the French responded to the threat of seasonal floods by erecting a sporadic system of levees to protect their settlements (Colten 2005). This “levees only” policy continued for roughly 200 years, and by the 1920s, New Orleans’ levee system was generally sufficient to protect the city from the most daunting river floods (Colten 2005). Though it did not directly inundate New Orleans, the devastating Mississippi River flood of 1927 inspired Congress to pass the Flood Control Act of 1928, effectively ending the levees only policy. The act mandated the USACE to design, construct, and maintain a comprehensive and interconnected regime of river management mechanisms including levees, control structures, and spillways (Cowdrey 1977). The holistic, systemic approach currently in place has successfully protected New Orleans from riverine flooding since its implementation (Lewis 2003; Campanella 2006), and conventional wisdom dictates that the existing system all but guarantees the city’s protection from such flooding (Lewis 2003). Though many observers credit the Flood Control Act of 1928 with protecting the city from riverine flooding, the structural manifestations of the act have failed to protect New Orleans from storm-induced flooding. In 2008, U.S. District Judge Stanwood Duval cited the act as grounds for dismissing a class action lawsuit related to Hurricane Katrina filed on behalf of New Orleans’ private and commercial interests (Finch 2008). Therefore, even as the act has protected New Orleans from one type of inundation threat, it has failed to protect the city from flooding in general, and it shields the federal government from fiduciary responsibility related to the malfunction of its flood control infrastructure.

In New Orleans, storm-induced flooding is an all-together different phenomenon than riverine flooding. Storms can cause flooding via two interrelated processes. The first, and most common, is heavy precipitation. Extreme precipitation is relatively common in New Orleans. According to the NOAA-operated National Climatic Data Center (2006), from 1971-2000, total rainfall in New Orleans averaged 64.16 inches per year, almost double the national average of 34.68 inches for 250 cities within the contiguous U.S. Yet, over the past 58 years, the mean number of days with at least 0.01 inches of rain in the city is 107, scarcely more than the average of 102 days for 250 other cities in the contiguous U.S. (National Climatic Data Center 2006). These numbers suggests that when it rains in New Orleans, it tends to rain in high volume relative to other cities in the U.S.

Poor drainage inherent to the city's site forces New Orleans to combat rainwater inundation via outfall drainage canals fitted with massive Wood screw pumps, now placed in 22 strategic areas around the city (Sewerage and Water Board of New Orleans 2004). The pumps move accumulated water from low-lying areas and into adjacent canals for drainage into Lake Pontchartrain.

Previous studies suggest that the frequency and magnitude of heavy precipitation in New Orleans has increased in recent years. Keim (1990) notes that five of the city's ten greatest rainfall accumulation events on record have occurred since 1978. Keim and Muller (1992) studied precipitation events in New Orleans from 1871-1991. Their results suggest that precipitation events from 1978-1991 exhibited increased magnitude when compared to a normalized record of historical precipitation events since 1871. If precipitation events in New Orleans continue to increase in magnitude, the Sewerage and Water Board must take steps to amplify its pumping power to accommodate the increase in accumulation probabilities (Keim and Muller 1992).

The second and generally more devastating form of storm-induced flooding is hurricane storm surge (Lewis 2003). Storm surge has inundated New Orleans by overtopping or breaching the levees that surround the city (Colten 2005). Because storm surge is generally caused by particularly powerful tropical storms or hurricanes, rainwater inundation usually compounds the effects of the surge. While the rural areas around New Orleans are unprotected by levees and are therefore perpetually susceptible to storm surge, the urbanized area (generally defined as the territory inside the levees) is vulnerable to storm surge only if the surge manages to breach or overtop the levees or canal floodwalls that flank the city. During Hurricane Katrina, at least seven major instances of breaching or overtopping of levees and canal floodwalls led to flooding in approximately 80 percent of New Orleans (Knabb, Rhome, and Brown 2005; Campanella 2006). Storm-surge inundation that remained in the city following Katrina was compounded by the accumulation of heavy precipitation caused by the subsequent Hurricane Rita—a powerful storm that made landfall along Louisiana’s border with Texas less than a month after Katrina (Knabb, Rhome, and Brown 2005).

Hurricanes have been a seasonal threat to New Orleans since its establishment (Lewis 2003; Colten 2005; Campanella 2006). In fact, in

September of 1722, only four years after Bienville founded New Orleans, a hurricane destroyed much of the nascent city, and inspired the construction of the city's first significant artificial levees later in the same year (Campanella 2006). A hurricane in 1915 toppled church steeples and caused widespread damage, effectively reminding New Orleans' populace of the seasonal threat of hurricanes following a propitious stretch of several years without a devastating storm (Campanella 2006). During the 1920s, improvements in lakefront levees encouraged development along the southern shores of Lake Pontchartrain (Colten 2005). These new developments stood unchallenged until 1947, when a powerful hurricane struck the New Orleans region (Colten 2005). The 1947 hurricane revealed the vulnerability of such lakeside development by inundating a combined 39 square miles of residential area primarily along the lake in Jefferson and Orleans Parishes. Even after lakeshore levee improvements inspired by the 1947 flood, subsequent hurricanes have produced similar results along the lakeshore. In 1956, Hurricane Flossy overtopped the levees along the lakeshore and inundated a large segment of the Gentilly neighborhood, and 1964's Hurricane Hilda again overtopped the lakeshore levees, but caused only minimal damage to industries along the Inner Harbor Navigational Canal (IHNC) (Colten 2005). In 1965, Hurricane Betsy breached the levees along the IHNC inundating seven thousand homes and three thousand businesses in a maximum of eight feet of water (Colten 2005) (see Figure 5). Four years later, Hurricane Camille narrowly avoided New Orleans, but pummeled the historic Mississippi Gulf Coast (Colten 2005). Though New Orleans' hurricane protection system largely shielded the city from Camille, a small area along the IHNC was again flooded (Colten 2005). Betsy and Camille engendered the perception of security (albeit false) toward the lakeshore hurricane protection levees and revealed the weakness of the floodwalls along the IHNC. The continued breaching of the levees along the IHNC was due to storm surge and its wave-powered scouring (Colten 2005).

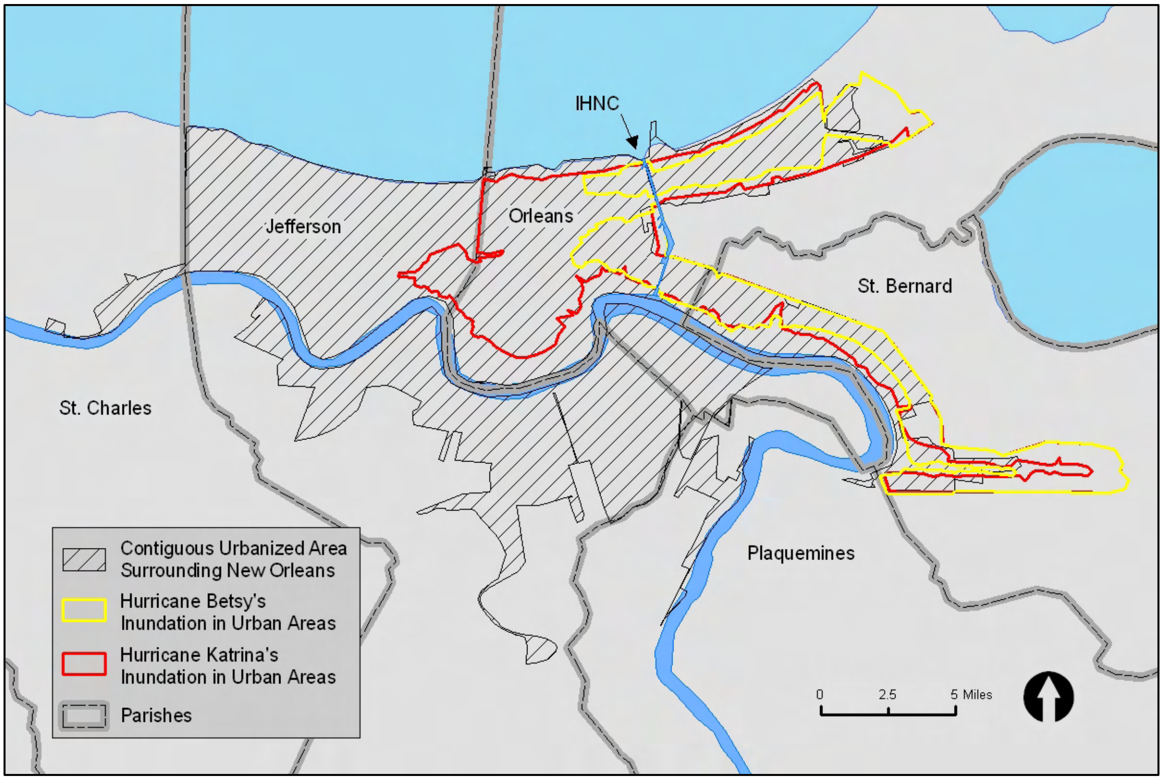

Figure 5: Generalized Patterns of Inundation Produced by Hurricanes Betsy and Katrina in Urban Areas. Note the IHNC. Floodwall failures along this canal accounted for much of the flooding during both storms.

Following Betsy, and in response to the repeated breaching of the IHNC levees, the federal government authorized the Lake Pontchartrain and Vicinity Hurricane Protection Project under the Flood Control Act of 1965 (see Figure 6) (Brouwer 2003). As part of the project, federal engineers constructed a system of hurricane protection levees around the peripheral wetlands that flanked the eastern edge of Orleans and St. Bernard Parishes (Colten 2005). This final implementation, though not fully completed at the time of this writing, marks the realization of the modern hurricane protection system, as it existed in 2005

Figure 6: Lake Pontchartrain and Vicinity Project Map (U.S. Army Corps of Engineers 1965).

before Katrina struck. Though the hurricane protection system has yet to be fully completed, federal engineers received congressional authorization and began designing and implementing the system's general footprint following 1965's Betsy. Ironically, the USACE intended their hurricane protection project, or "barrier plan" to "prevent storm surges from entering Lake Pontchartrain and overflowing the levees along the lakefront," the very scenario that caused much of the inundation in New Orleans during Katrina (United States Congress, House of Representatives 2005, 4).

Scholars who view the landscape through the perspective of human ecology recognize the reciprocal nature of human-environmental interactions. With this in mind, it is of no surprise that the anthropogenic modifications of New Orleans' environs designed to protect the city from riverine and hurricane-induced flooding would cause unanticipated detrimental effects. The city's system of levees provides a particularly compelling example of the balancing act between human-built and natural regimes in New Orleans. Approximately half of contemporary New Orleans lies below sea level. This topographic disadvantage was not the case during the colonial period, however (Campanella 2006). For millennia, the Mississippi River would overflow its banks and inundate the areas surrounding present-day New Orleans in water and sediment. This fluvial sediment formed the natural levees that drape the river, and has built up much of the natural land from just south of present-day Baton Rouge, Louisiana, to the Gulf of Mexico (Colten 2005), an area the French first deemed the *Isle of Orleans* (Lewis 2003). While the human-built levees that encircle New Orleans help protect the city from hurricane storm surge and spring river floods, they also isolate the city from the river's sediment and its land-building processes (Colten 2005). This deprivation of fluvial sediment has and continues to cause widespread land subsidence in New Orleans, and drainage of the peripheral wetlands has accelerated the process (Colten 2005). Subsidence caused a topographic "bowl" to form in the center of the city's urbanized area. Even with contemporary pumping power, in times of extreme precipitation or levee/floodwall breaches, the bowl can accumulate water faster than it can be pumped out (Colten 2005). A Digital Elevation Model (DEM) (United States Geological Survey 2007) of New Orleans clearly portrays the perilous association between levee construction and land subsidence (see Figure 7). In a vicious irony, the very levees designed to protect New Orleans from its watery environs have increased the city's vulnerability to flooding (Lewis 2003; Colten 2005).

Due to its physical geography, New Orleans is vulnerable to widespread and chronic flooding (Lewis 2003; Colten 2005). Throughout the city's history, humans have modified its landscapes with the intent of reducing the city's vulnerability to inundation (Colten 2005). These modifications have had mixed results, and while some credit for protection falls on human-built flood control infrastructure, such structures have engendered unanticipated detrimental consequences.

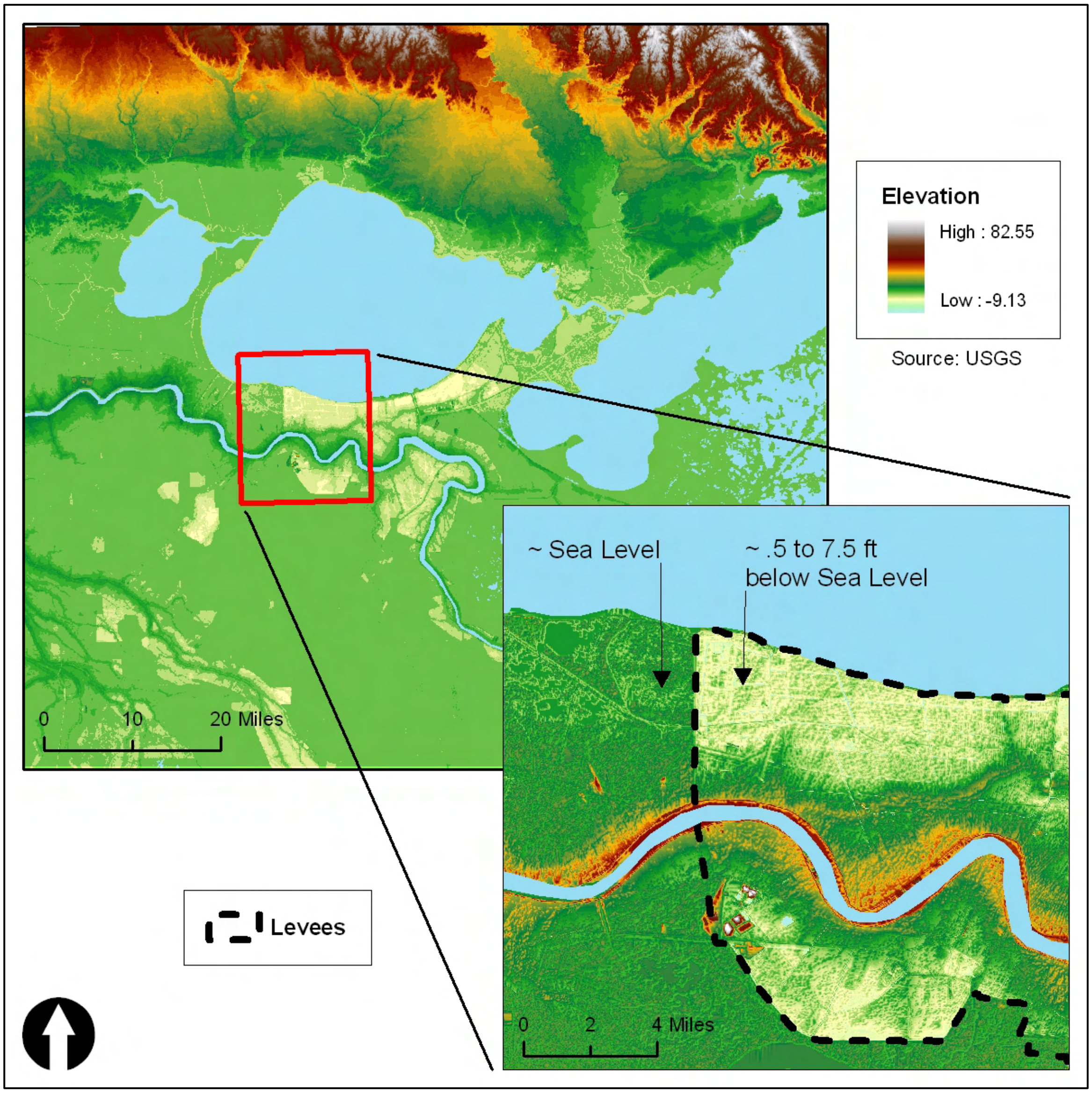

Figure 7: Elevation Data Depicting the Topography of New Orleans and its Environs. The lowest areas represent those inside the human-built levees. Note also the significantly higher Pleistocene shelf just north of the city.

CHAPTER IV

LITERATURE REVIEW

This study explores the social dimensions of exposure to an environmental hazard, specifically flooding in New Orleans, and charts the changes in these dimensions over time. The research questions described here weave through several aspects of the social sciences and humanities in both their established disciplinary niches and in the broader intellectual curiosities that they arouse. In my judgment, five bodies of academic literature relate to this research, and therefore deserve review by this study. These areas are:
1) The concept of “landscape” in geography and its applications to the distributions of social groups, 2) Historical and urban geographies of New Orleans, 3) Social science research pertaining to hazards, 4) Hazards geography, in particular its illuminations of human-environmental relations and its planning outcomes, and 5) The role of GIS and quantitative analysis in the study of social and historical geography.

Understanding “Landscape” and its Conflations

The term “landscape” takes on special meaning within the discipline of geography. Carl O. Sauer, an influential early American geographer, focused on the term “cultural landscape” in both his scholarly orientation and his research methodology (Sauer 1963; Mathewson and Kenzer 2003). To Sauer, cultural landscapes represent the spatial outcome of human influence on the natural world, as well as a physical setting (Sauer 1963). In his landmark volume, *The Morphology of Landscape* (Sauer1963), he studied and discussed the form and structure (morphology) of cultural landscapes in efforts to chart the historical progression of the human (or cultural) impacts and alterations of the natural world (or landscape). Due primarily to Sauer's work, the term "landscape" became synonymous with cultural geography, and, posthumously, Sauer remains the seminal figure within the subdiscipline (Price and Lewis 1993).

Others would debate the importance of "landscape" both as a scientific concept and as a research methodology, and, in reference to Sauer, Hartshorne (1939) sternly criticized geographers' use of the term. Instead, he offered his own ideas for organizing the discipline around regions and the idea of space.

Olwig (1996, 653) remarks that, in recent decades, the term "landscape" lost its "substantive" meaning in favor of a more aesthetic view of "nature as scenery." I argue that this non-substantive view of "landscape" is in line with popular connotations of the term, and, for the most part, not its disciplinary understanding within geography. Sluyter (2001, 410) offers a succinct summation of the use of landscape by geographers with his assertion, "Landscape, after all, is a key unit of geographic analysis and its transformation through social/biophysical processes a primary phenomenon of geographic inquiry."

The academic use of the term landscape has evolved over time to include a multitude of meanings. Meinig's (1979; 1992) work perhaps best represents the maturity of the term in contemporary geographic thought. Meinig (1979) views the landscape both as a source of data and as a symbol of human culture, and he and his contemporaries would "read" the landscape as a "text" in and of itself. Meinig has

> "…paid particular attention to symbolic landscapes as representations of American values and generally tried to use the landscape as a kind of archive full of clues about cultural character and historical change that one can learn to read with ever greater understanding." (Meinig 1992)

Meinig (1992) credits J.B. Jackson and Pierce Lewis as the academic mentors who cultivated his view of the "cultural landscape." Meinig's view of landscape then can be understood as a contemporary, humanistic refinement of the landscape perspective that Sauer initiated in the early parts of the twentieth century.

In this research, my use of the term landscape draws concurrently from traditional and more contemporary understandings of the term. By focusing on landscape change, I, much like Sauer and Meinig, am interested in anthropogenic changes in the natural environment, and my inquiry into such changes is congruent with Sluyter's (2001) general assessment of the term. However, my use of the term is most similar to Godfrey's (1995, 447) "social landscape." In this research, I analyze the social (i.e. demographic, racial, and socioeconomic) aspects of the population as they are distributed across geographic space. A basic characterization of the "social landscape" as I employ it here involves georeferenced census data. Specifically, the term "social landscape," as I understand and approach it here, represents census attribute data spatially distributed on a two–dimensional plane (in most cases, a map or an electronic GIS) that refer to actual locations on Earth. Therefore, in the research presented here, the social landscape represents a method of understanding groups of people as they are spatially distributed across a surface, in this case, a portion of the Earth known as New Orleans.

Even as this research traverses disciplinary boundaries into the interests of historians, sociologists, political scientists, engineers, emergency managers, and urban planners, this study's focus on landscape and the change inherent to it deems it an intrinsically geographic endeavor. As Meinig (1978, 1205) has proclaimed, "If we are primarily interested in areas and the kinds of changes they undergo…we might best turn to the geographer."

Historical and Urban Geographies of New Orleans

Pierce Lewis (2003) wrote that, despite a voluminous canon of written work on New Orleans, "solid reliable material that described how the city had evolved" was "seriously lacking" (xvi). Fortunately since then, new volumes by Campanella (2006, Lewis acknowledges Campanella and Campanella 2002), Kelman (2003), and Colten (2005) have contributed greatly to our understanding of the city's social and physical evolution. These works view New Orleans' past through various perspectives, each doing so with an aperture wide enough to address the city's history in its totality. That is, each author focuses broadly over the entire history of New Orleans to illuminate his perception of the city's development.

Since the publication of its first edition in 1976, many geographers have considered Pierce Lewis' *New Orleans: the Making of an Urban Landscape* a seminal work of historical geography on New Orleans (Meinig 1989, 81; Hagelman 2003). Now in its second edition, the text provides a reference for the geographical and social evolution of the city from its inception to the early twenty-first century. The author uses a narrative approach to survey the vast array of environmental challenges faced by New Orleanians, and to discuss the evolution of the city's social landscape since its colonial founding in 1718. Lewis divides his work into two "books." Book one, the original, first edition, traces changes in the city's physical and social geography as they relate to historical turning points of the city from its beginnings to the mid-1970s, when it was first published. Published in 2003, the second edition introduces Book Two. The second offering mimics the style and methodology of the first edition and effectively updates the volume to late 2002.

Though most disciplinary observers generally consider Lewis' *New Orleans* a work in *historical geography*, by necessity, it could also be considered a landmark work in *urban geography*. The author comments on much of the racial and social change in the city's history, and his attention to phenomena such as "white flight" is of particular interest to this research. He explains how *Brown versus Board of Education*, the landmark educational integration ruling of 1954, helped to initiate white flight in New Orleans. Improvements in the hurricane protection infrastructure (see Figure 6) and suburban style residential construction in the areas surrounding New Orleans coincided with the court's ruling, and these developments helped to expedite a significant out-migration of white New Orleanians to suburbs in Metairie, Kenner, and elsewhere in the

Greater New Orleans area and beyond. Improvements in transportation infrastructure, most notably construction of Interstate Highway 10 and the Lake Pontchartrain Causeway, led to an increased out-migration of primarily white residents to St. Tammany Parish. Interstate Highway 10 connects New Orleans with the relatively higher ground of the Pleistocene shelf at Slidell, Louisiana. The causeway is a toll bridge that bisects Lake Pontchartrain, thus linking New Orleans to Mandeville and Covington on the lake's northern shore (see Figures 1 and 8). Once these roadways were completed, motorists could easily commute to their jobs in New Orleans and return to their suburban homes in St. Tammany Parish after work. By 1970, a net out-migration from New Orleans caused a decline in the city’s population that continues unabated (see Figure 9). While desegregation provided much of the motivation for white flight, wetland-drainage-suburbanization provided the physical means for the expansion of the urbanized area (Lewis 2003). Although the timing of suburbanization was decades later than the post-war trends evident in typical urban areas in the U.S., the general process of spatial diffusion was the same. Because of the wetlands that surrounded the city, New Orleans’ process of suburbanization and expansion was dependent on the removal of spatial impediments rarely found in more typical U.S. cities.

Pulido (2000, 16) recognizes white flight and its connections to suburbanization as forms of “white privilege” which can act as spatial agents of environmental racism. While Pulido acknowledges the popular argument that malicious or racist intent is rarely the overt motivation for suburbanization, she maintains that intent is of little consequence if racial subordination is the result. She explains how this concept of white privilege benefits white communities at

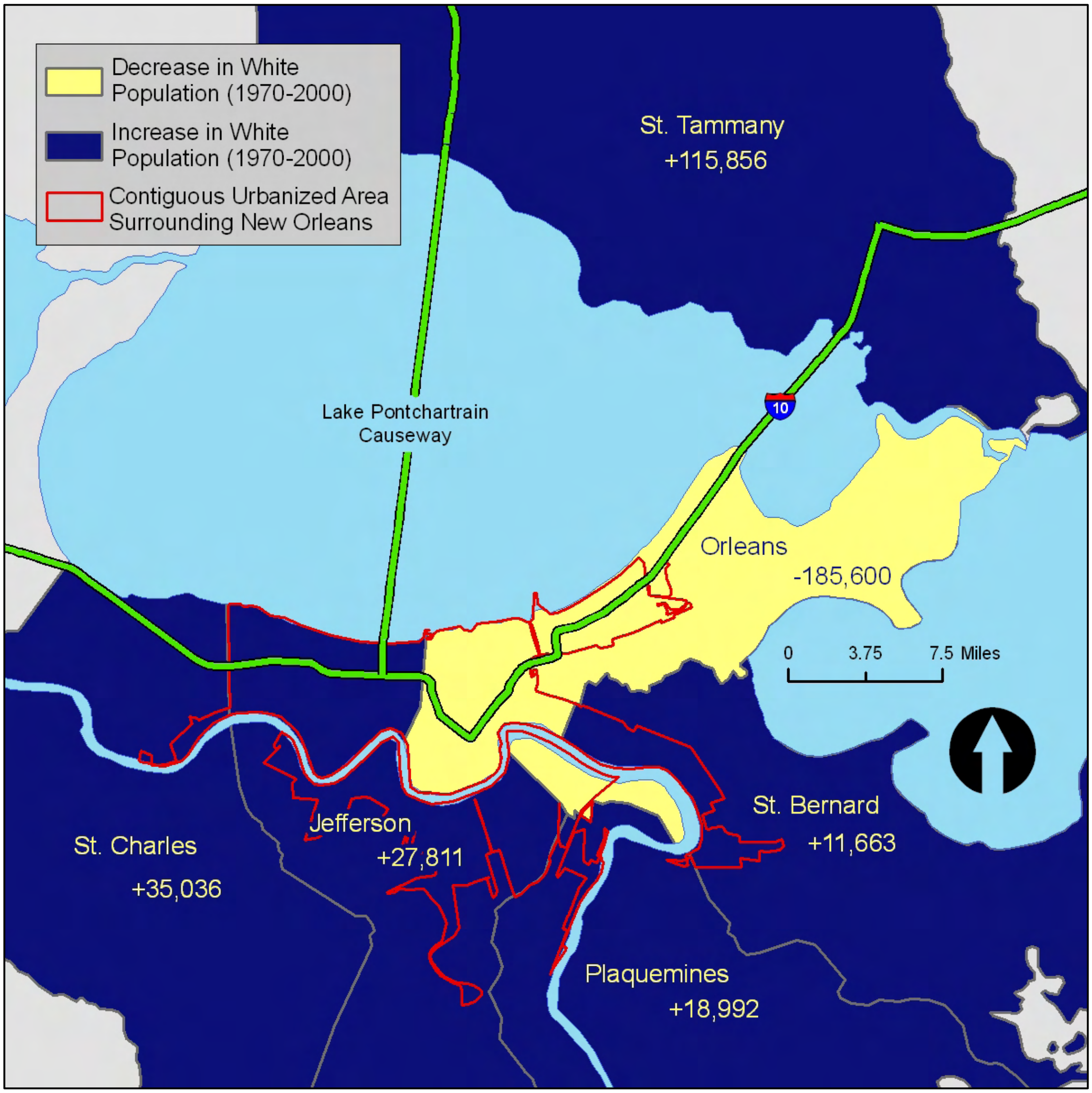

Figure 8: A Parish-level Representation of White Flight in the New Orleans Region from 1970-2000 (data source: Geolytics, Inc. and The Urban Institute 2003).

the expense of non-white communities. She claims that suburbanization and decentralization have—as agents of white privilege—contributed substantially to forms of environmental racism evident within the social landscape of urbanized areas. Because white flight and the social change that it helped to engender are central themes of this research, Pulido's (2000) work illuminates the human/institutional forces that have shaped the racial geography of New Orleans, particularly in their relationships to flood exposure.

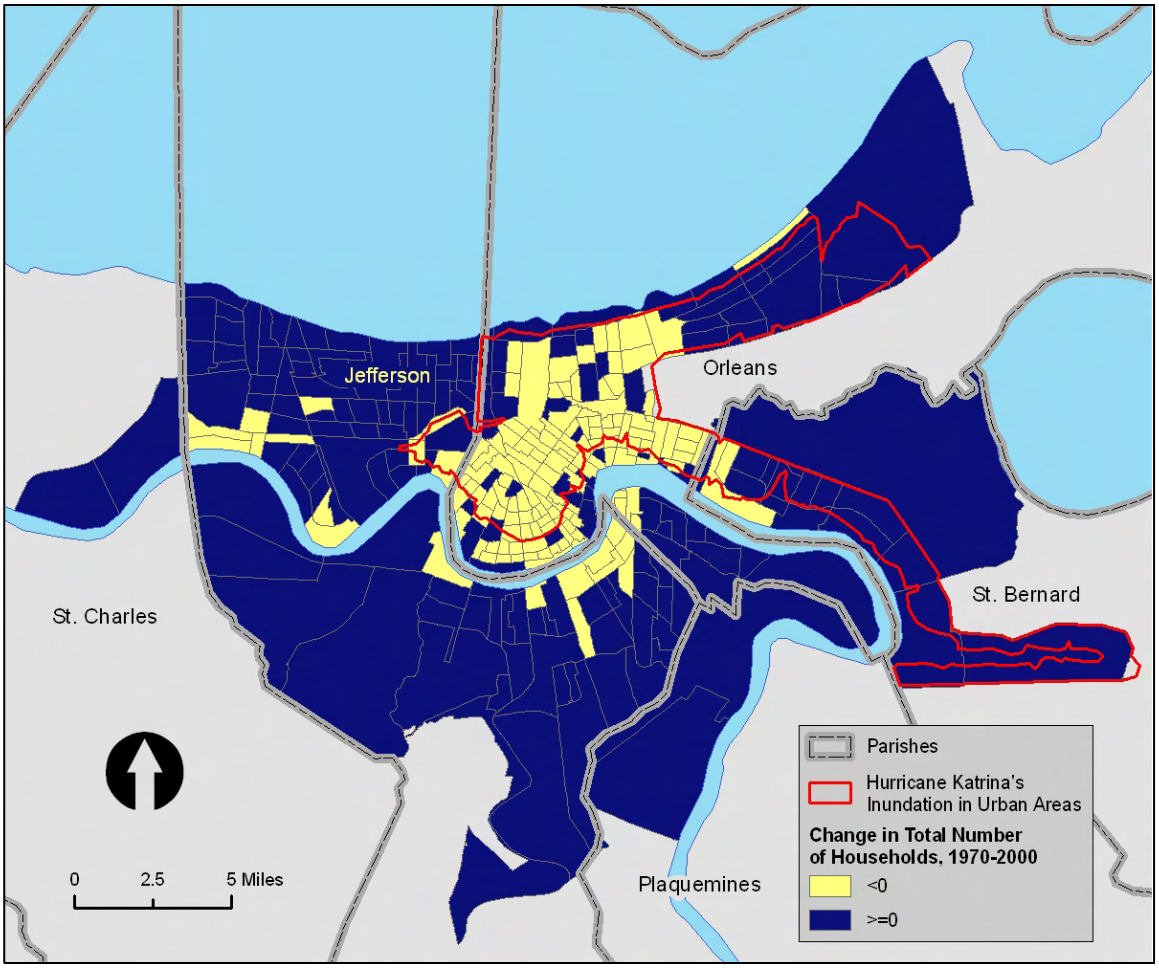

Figure 9: Change in the Total Number of Households in New Orleans and Surrounding Areas by Census Tract, 1970-2000 (Geolytics, Inc and The Urban Institute 2003).

Because white flight is a process that engenders racial segregation by homogenizing concentrations of racial groups within the landscape (Pulido 2000), it becomes necessary for this research to investigate the forms of segregation that have traditionally existed in New Orleans. Lewis (2003, 51) sees two forms of segregation apparent in New Orleans' landscape, one more "malevolent" than the other. He explains the first, and least malicious of the two forms, as the "superblock" form of segregation (2003, 50-51). Because members of different racial groups lived relatively close to members of other groups, and neighborhoods remained relatively stable, the kinds of geographic tension found elsewhere in the country was much less pronounced in New Orleans. New Orleans' second, more malicious form of segregation found the poorest African-Americans living in the "battures" and the "backswamps" of the city. Shelter in the battures consisted of temporary, makeshift housing that attracted squatters with few other options. The battures are the areas between the artificial levees and the river; these areas were vulnerable to periodic river flooding, and shared the loathsome aesthetics of the adjacent docks (2003, 51). Because of the importance of these areas to commercial shipping interests, squabbling over land rights was a protracted ordeal that continued into the modern era (Kelman 2003; Lewis 2003).

In the years directly following the civil war, many emancipated slaves migrated to New Orleans, and most of them, due to a lack of alternatives, settled on the fringes of the city in the so-called "backswamps" (Campanella 2006). The backswamps represented the worst conditions the site of New Orleans had to offer. Poor drainage, endemic mosquitoes, and soil unfit for structural foundations headlined the list of undesirable attributes associated with the area. While antebellum segregation in New Orleans seemed relatively innocuous when compared to other American cities, the African-American ghettos in the backswamps of the city resembled most closely the iniquitous “superghettos” common elsewhere in the United States during the same period (Lewis 2003, 51), and many historical settlement patterns in New Orleans such as those established by emancipated slaves in the rear of the city have remained relatively stable through the contemporary period (Campanella 2006). Jim Crow politics did, however, play a role in shaping the city’s patterns of suburbanization, and the areas along Lake Pontchartrain’s Southern Shore provide a clear example of this process. When suburban areas were developed there in the early twentieth century, they were done so as strictly segregated areas—Lakeview for whites, and Pontchartrain Park for African-Americans. These socio-spatial patterns have also, for the most part, held to the present day.

The concept of segregation serves as a powerful metaphor for understanding New Orleans as it compares to other American cities. While the forms and spatial patterns of segregation in New Orleans have been historically less egregious than the manifestations inherent to other American cities--particularly through the nineteenth century--these forms and patterns still existed (and continue to exist), and therefore the myth of New Orleans as a “unique” city is exposed in this perspective of segregation. As Lewis (2003, 11) quotes Liebling, “…New Orleans may be exotic in some respects but…in others it [is] exactly like everyplace else.” New Orleanians take pride in the “peculiar identity” of their city as a “unique” and “aberrant” urban entity tucked away in the American landscape, and rightfully so, but, if one is honest, New Orleans *is* after all a city in the American South, and therefore shares many commonalities, such as segregation and suburbanization, with other urban entities in the United States and elsewhere (Lewis 2003, 11).

Campanella has produced three important texts on the historical and urban geographies of New Orleans (Campanella and Campanella 1999; Campanella 2002; Campanella 2006). The first of his major texts, *New Orleans: Then and Now*, is co-authored with his wife, and amounts to a visual historical geography of the city (Campanella and Campanella 1999). The authors use an array of imagery ranging from conventional photos, aerial photos, maps, and satellite imagery to portray changes in New Orleans' landscape over time, circa 1847 to 1998. Essentially, the authors relate a historical geography of the city via time-sequence images arranged geographically (as opposed to chronologically) throughout the text. Using repeat photography as their research methodology, the authors assembled a collection of historical images and photos (many published for the first time), "rephotographed" each of the sites, and included both images side by side in the text for evaluation by the reader. The authors accompany each set of images with written descriptions of its site as well as the changes, or lack thereof, made apparent by the images. The result is a sound but approachable historical geography that speaks loudest via its visual, rather than verbal, contributions.

Campanella's (2002) second major text, *Time and Place in New Orleans*, is a classic historical geography. He uses three broad themes, "Situation," "Topography," and "Culture," to explicate the "history behind the geography and the geography behind the history" of New Orleans (2002, 11). Campanella charts the chronological expansion of neighborhood development in the city and points to long-term shifts in socio-spatial population patterns.

Campanella's third volume, *Geographies of New Orleans: Urban Fabrics before the Storm* (2006) is the most exhaustive text on the historical geography of New Orleans by any author, to date. While Lewis's text provides a broad overview of the historical morphology of the city's physical and social landscapes, Campanella's work contributes a finer level of detail to our understanding of the city's historical geographies.

Campanella's (2006, 193-380) section on "ethnic geographies" is of particular importance to this study. The author uses several primary and secondary data sources to describe and illustrate the spatial distribution of at least nine distinct ethnic groups within New Orleans. His section on the geography of the African-American subpopulation describes its historical distributions and illuminates the reciprocal relationship among the community and the social, physical, and economic forces that surrounded it. Although Lewis touches on New Orleans' most notable ethnic groups and their spatial distributions in his work, Campanella provides a level of detail previously unmatched. For instance, while Lewis touches broadly on the phenomenon of white flight, Campanella explains the trend in depth. For example, Campanella (2006, 22) writes that, by 1969, white student enrollment in New Orleans public schools began to decline for the first time in the city's history, while African-American enrollment had doubled over a short period.

Campanella (2002, 298) surveys the three traditional "castes" within the African-American community including "free people of color" (or the "creoles"), "freed slaves," and slaves. Campanella portrays a landscape of segregation for each of these groups in Antebellum New Orleans and discusses how relics of this segregated distribution are still evident today. He uses three broad periods to portray the evolution of the African-American landscape: Antebellum, Postbellum, and Post World War II. The author explains how the social landscape evolved during each era, and how the castes and periods in question shaped the spatial patterns of the social landscape apparent before Katrina.

The section on Katrina provides a perspective on the geographic agency of the storm. Campanella explains the radical geographic transformations caused by the storm, and touches on the ethnic geography of the flood. He uses a percentage based cross-tabulation methodology, similar to Logan's (2006), to argue that African-Americans were disproportionately exposed to the flood. Although he mentions the connections of the "poor" to the African-American community, he fails to the disaggregate socioeconomics from race in his analysis. In the research presented here, I employ a more robust quantitative methodology to illuminate definitively the connections between socioeconomics, race, and flood inundation.

Colten's *An Unnatural Metropolis* (2005) is a comprehensive review of environmental management in New Orleans. Colten argues that, perhaps more than any other city, New Orleans owes its continued existence to human alterations of its natural surroundings. His New Orleans is a city that perpetually battles to keep itself dry by “separating the human-made environment from its natural endowment” (2005, 2). Colten explains meticulously the strategies that the city has implemented to deal with the constant threat of hydrologic hazards. In the third chapter, "Inequity and the Environment," Colten argues that Progressive Era public works combined with Jim Crow political frameworks to construct racial inequities throughout the city's landscape. Colten points out that both the environment that surrounds the city and the municipal strategies for "harnessing" that environment have shaped the city's evolving social landscape. As various governmental entities implemented infrastructure and services designed to insulate and protect the citizenry from environmental hazards, the consequences of these implementations, both anticipated and unforeseen, have had differential impacts on different areas of the city, many times with adverse effects on minority groups. Therefore, just as the physical extent and character of the city is dependent on its environs, so, too are its social and racial geographies (Colten 2005).

As Gilbert White et al. (1958) first observed, the implementation of flood control infrastructure encourages urban settlement in flood plains. Colten (2005) points out that, in New Orleans, settlement in the floodplain is unavoidable. Even so, flood control infrastructure has greatly influenced the urban expansion of the city. In the early twentieth century, an important engineering development would drastically change both New Orleans’ flood control strategies and its patterns of development (Colten 2005). Giant flood-control pumps, first conceived by A. Baldwin Wood in 1913, provided the pumping power necessary to both drain the backswamps for urban development and lift water from low-lying areas throughout the city in times of flooding (Kelman 2007). The effect of the pumps was immediate and transformative, causing great excitement among the administrative and development communities in New Orleans. As former Mayor Martin Behrman famously exclaimed in a 1914 speech, “land before worthless, became at once available for agricultural or city development; mosquitoes were precipitously on the decrease; gutters were no longer stagnant, and the death rate dropped as if by magic” (Behrman 1914 in Landphair 1999, 39). By the 1920s, the pumps, combined with newly constructed levees and drainage canals, provided a flood control infrastructure sufficient to encourage the development of two new suburban-style, middle class neighborhoods, one for whites and one for African-Americans, along the southern shore of Lake Pontchartrain (Colten 2005). During this period, divisive Jim Crow politics forged segregated racial geographies in many cities throughout the U.S.; New Orleans was no exception, and these racial geographies, in large part, persist today (Colten 2005).

Kelman’s *A River and its City: the Nature of Landscape in New Orleans* (2003), provides a thorough environmental history of the relationship shared by the Mississippi River and the city of New Orleans. Like Colten (2005) and Campanella (2006), Kelman (2003, 8) finds “reciprocity” amid the city and its geography. Kelman focuses on the spatial union of river and city, i.e. the riverfront. He surveys the legal, social, and cultural significance of the river as it has combined with the population to produce a variety of landscapes throughout the history of New Orleans.

The unifying theme among the works reviewed here by Lewis, Campanella, Colten, and Kelman is historical inclusiveness. That is, each of these authors succeed in taking a certain scholarly perspective of New Orleans and using that perspective to propel the reader through the *entire* history of the city. Although none of the writers listed above would claim to have approached comprehensiveness or historical totality with their volume(s), each writer begins with the very beginnings of urbanization in New Orleans and continues through the present day. This methodology is certainly sound in its ability to cast a particular band of light on the city and view its history through it; in fact, most historical geographies do so. Lewis uses the classic Sauerian method of the historical narrative to chart the historical geography of the city. Campanella offers a spatial approach to geographic analysis, and, in his latest text (2006), he offers original contributions with the unprecedented minutia of his work. Further, Campanella relies heavily on his skills in cartography and remote sensing to invite the reader to his perspective. Colten uses New Orleans' epic struggle with its environs to explain its history, in particular with a sharp focus on flood protection and water resource development. Kelman's perspective is the spatial union of river and city, the riverfront. He focuses on land use issues there to chart a history of reciprocity between the river and New Orleans' citizenry. Each of these authors has succeeded in employing his unique perspective to portray various aspects of the historical geography of New Orleans. However, the vast amount of time between the city's founding and the current era forces the authors to focus broadly over the defining moments in the city's history, and to explain the often reciprocal relationship between the city's geography and these historical turning points.

This research offers a more modest but detailed approach via a much smaller temporal scale. I use the perspective of Hurricane Katrina to focus only on the contemporary period of 1970-2005. While the authors reviewed above have contributed broadly to our comprehensive understanding of New Orleans, its history, and its geography, the study described here contributes by adding detail to our understanding of New Orleans with a focus on the “contemporary” era. The scholars reviewed here have focused on New Orleans' entire history. While this is certainly valuable, their holistic use of temporal scale forces them to provide broad overviews, and thus contribute limited detail to our understanding of social change in the *contemporary* New Orleans. More specifically, this study seeks to chart social change in the contemporary era through the perspective of Hurricane Katrina, and by focusing on this relatively brief amount of time, provides a fine level of detail relative to the publications discussed above.

Somewhat like their historical perspectives, the *geographical* aspects of the analyses provided by Lewis, Campanella, Colten, and Kelman also operate at a rather broad scale when compared to the research presented here. While the previously cited researchers consider neighborhoods as the smallest units of analysis in their work, this research is the first to offer a multi-decadal analysis of social change in New Orleans at the census tract resolution. Areas considered neighborhoods in New Orleans often contain two or more census tracts (see Figure 14) (Greater New Orleans Data Center 2007); therefore, the research presented here employs a unit of analysis higher in spatial resolution than previous studies. Doing so advances an investigation of social landscape change at the smallest unit of analysis possible given the nature of the trans-decadal census datasets currently available (Tatian 2003).

The research described here adds to our understanding of the morphology of the city's social geography by charting quantitatively the urban change referenced by Lewis (2003), and to draw subsequent linkages from this change to the patterns of Katrina-induced flood exposure. Lewis (2003) has referenced white flight in the city of New Orleans as it relates to its metropolitan surroundings, and Campanella (2006) has analyzed the social distributions of Katrina-induced flood inundation. However, a robust quantitative analysis of social landscape change as it relates to actual inundation patterns for the entire urban area of Greater New Orleans at the Census Tract resolution has yet to be attempted. Therefore, this research contributes to the social science literature by analyzing multi-decadal social landscape change at the tract level for the contiguous urbanized area surrounding New Orleans and discussing the association of these changes to the patterns of inundation manifested by Katrina-induced flooding.

Defining the Contemporary Era

I consider the era from the mid-1960s to the present day "contemporary" for several reasons. In 1965, following Hurricane Betsy, the federal government began implementing the contemporary hurricane protection system as we know it today (Colten 2005). In the early 1960s, the federal judicial system forced the

Orleans Parish School System to integrate its schools, a phenomenon Lewis (2003) notes as replete with geographic consequences. By the 1970s, the powerful processes of desegregation and suburbanization had matured as agents of social landscape morphology (Lewis 2003), and since then, the city's population has experienced decline (Colten 2005). In 1964 and 1965 President Lyndon B. Johnson signed into law the Civil Rights Act and the Voting Rights Act, thus "modernizing" race relations in the United States (while this assertion is debatable, these acts certainly stands as the most important impetus for racial reconciliation in U.S. history) (Halpern 1995; Loevy 1997). And, finally, in the late 1960s and 1970s, the U.S. Congress enacted several landmark environmental laws, therefore modernizing environmental regulation in the United States (Merchant 2002).

As previously noted here, the U.S. Congress, in response to Hurricane Betsy, passed the Flood Control Act of 1965. Within the act, Congress authorized the USACE to begin work on the so-called Lake Pontchartrain and Vicinity, Louisiana, Hurricane Protection Project (Cowdrey 1977; Brouwer 2003). Although only a portion of the system was complete by 1970, and federal engineers consider the system incomplete as of this writing, the legislation passed in 1965 laid the general framework of the contemporary hurricane protection system (see Figure 10). Further, the Flood Control Act of 1965 remains the standard to which federal engineers adhere for the purposes of hurricane protection infrastructure design and construction. With but a few exceptions, the system, even in its varying stages of completion, prevented extreme flooding in New Orleans during the 40 years between Betsy in 1965 and Katrina in 2005. The Flood Control Act of 1965 also had a considerable effect on the perception of risk in New Orleans. White et al. (1958) first documented the

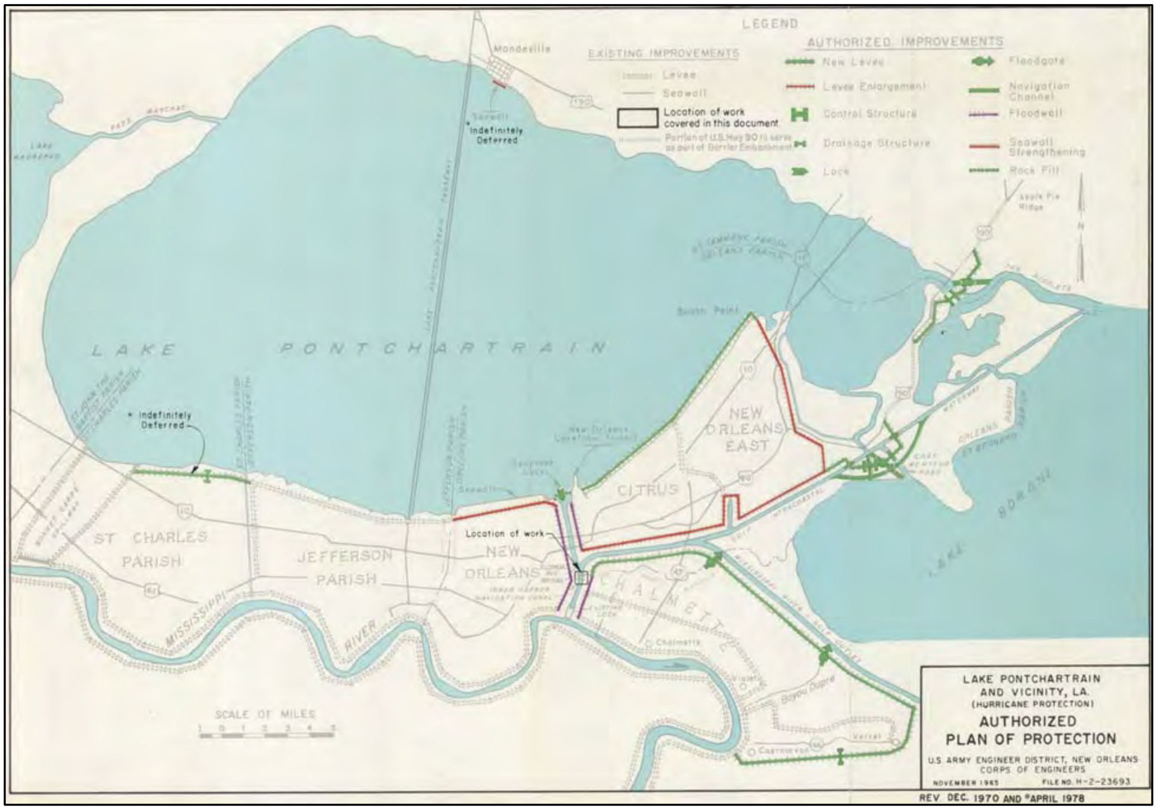

Figure 10: Levee Improvements Authorized by Lake Pontchartrain and Vicinity, Louisiana, Hurricane Protection Project (United States Army Corps of Engineers 1965). These improvements, though not yet fully implemented as of this writing, structurally and symbolically represent the contemporary hurricane protection system.

tendency of structural flood controls to promote a false since of security in those whose lives and homes are allegedly “protected” by such infrastructure. Colten (2006a, 8) notes that the hurricane protection levees in New Orleans proffered this “false sense of security” in the residents of New Orleans, thereby encouraging development and migration into low-lying, flood-prone former wetlands throughout the city. Therefore, while the incomplete and sporadic status of the hurricane protection system during the period of 1970-2005 is acknowledged, this research presupposes that the landscape of New Orleans, and the perception of the risk inherent to it, remained sufficiently similar during this period to assume the existence of the modern hurricane protection system, albeit symbolically if not structurally.

Pre-Jim Crow New Orleans was a place where racism assumed forms somewhat less egregious than the manifestations more typical of American urban environments during this time (Lewis 2003). However, Fairclough (2004) remarks that the forms of white supremacy openly practiced in 1940s New Orleans were as apparent as those of the more famously racist cities in Alabama and Georgia. He points to the institutional forces that subjugated African-Americans during this period. These forms of institutional racism included political invisibility via the exclusion of minorities from the democratic process, the biases of a white-administered criminal justice system, and the unjust economic oppression of white employers and captains of industry on minority workers (Fairclough 2004). During the decade of the 1940s, the political supremacy of whites in New Orleans and greater Louisiana began to decline for the first time due in large part to an unlikely coalition of the National Association for the Advancement of Colored People (NAACP), its Legal Defense Fund, and the Louisiana Education Association (LEA). The LEA agreed to fund the cases brought by the NAACP in Louisiana, and the LEA, in turn, gained credibility and increased registration from its association with powerful NAACP insiders such as Thurgood Marshall and A. P. Tureaud (Fairclough 2004). During an eleven-year period, the registration of black voters in Louisiana increased from 1,029 in 1944, to 161,000 in 1956, indicating the precipitous rise of black political power during the 1940s and 1950s. Also during this period, the political power of New Orleans' black community finally became evident on the city's landscape. In the 1940s, this rise in power coincided with a housing shortage and population pressure exacerbated by the anticipated return of American soldiers from World War II finally forced the city to extend basic sewerage, drainage, and water services to the Ninth Ward (Landphair 1999).

New Orleans and, in particular, its Lower Ninth Ward played an important if often overlooked role in national school desegregation. Landphair (2007, 840) points out that New Orleans' Ninth Ward provided both the "impetus" and the "setting" for public school desegregation in the U.S. She notes that the first, primarily symbolic acts of desegregation (i.e. African-American students entering a formerly all-white public school) in the Deep South occurred in two elementary schools in the Ninth Ward. On November 14, 1960, federal marshals escorted four African-American female students to two all-white schools, McDonogh 19 in the Lower Ninth Ward, and Frantz Elementary in the upper. The ward's white constituency bitterly opposed these acts of desegregation, however. As word of the action spread throughout the city, crowds of angry whites, mostly women, removed their children from the desegregated schools and demanded that the process be reversed (Landphair 1999).

Notwithstanding the resentment of its opponents, desegregation eventually became the norm in New Orleans as elsewhere in the U.S. However, this process was not without enduring geographic consequences. As Lewis (2003) notes, the process of desegregation had dramatic effects on both the racial geography and patterns of urban development in New Orleans. The development of suburban neighborhoods in Jefferson and St. Bernard Parishes coincided with the period of desegregation (Landphair 1999), and fears of racial mixing encouraged many white New Orleanians to join the national trend of suburbanization by moving their families from Orleans Parish to the newly developed, often exclusively white suburbs at the margins of the original city (Lewis 2003). Landphair (2007) adds that this process of white flight was particularly manifest in the Lower Ninth Ward, as thousands left for the newly constructed white enclaves in St. Bernard Parish (see Figures 8 and 11). If New Orleans had previously exhibited a relative diversity in its racial residential patterns, by the 1960s this trend was reversing if not annulled. An analysis of racial settlement patterns surrounding the two desegregated schools in the Ninth Ward during the period immediately following desegregation shows that white flight had begun to realign New Orleans' racial geography. In 1960, the area surrounding Frantz Elementary housed 2,110 whites, but by 1970, that number dwindled to only 536, a 74 percent loss. In the area surrounding McDonogh 19, the white population numbered 4,858 in 1960, but by 1970 had dropped to 1,098, a loss of 77 percent (Landphair 1999). Many of the migrating whites moved to newly developed suburban tracts in St. Bernard Parish, thereby contributing to the national trend of white out-migration to the suburban fringe (Landphair 2007) (see Figures 8 and 11).

As the reciprocal to white out-migration, the Ninth Ward experienced an in migration of African-Americans during the same period. The trend of “urban renewal” construction projects served as both push and pull factors for African-American migrants to the Ninth Ward (Spain 1979, 91). While the construction of the city’s largest African-American housing project served as a pull factor, construction projects elsewhere in the city during the 1960s (e.g., the Louisiana Superdome and the Interstate Highways) displaced many African-Americans (Spain 1979; Baumbach and Borah 1981). Because the Ninth Ward was one of the few remaining areas with relatively inexpensive rent and out-migration due to white flight was providing available housing stock, African-Americans began moving in at a quickened pace, and by the 1970s, the population of the Ninth Ward was 90 percent African-American (Spain 1979).

With the “suburban exodus” (Campanella 2007, 370) in full swing, Landphair (1994) notes that Hurricane Betsy’s arrival in 1965 further exacerbated the flow of whites to suburbia, particularly from the Ninth Ward. Because Betsy’s inundation was primarily focused on New Orleans’ eastern area (see Figure 5), the Ninth Ward received the brunt of the storm’s flooding in Orleans Parish. With many residents in need of new housing following Betsy, many whites took the opportunity to relocate to newly developed, racially homogenous suburban areas such as those in St. Bernard Parish. The shifts in racial geography that occurred in the Ninth Ward and St. Bernard Parish as a result of these pressures persist today.

An unwitting conspiracy of public school desegregation, a newly developed suburban fringe, infrastructure implementation, and Hurricane Betsy forged an urban realignment in 1960s New Orleans. Therefore, the temporal

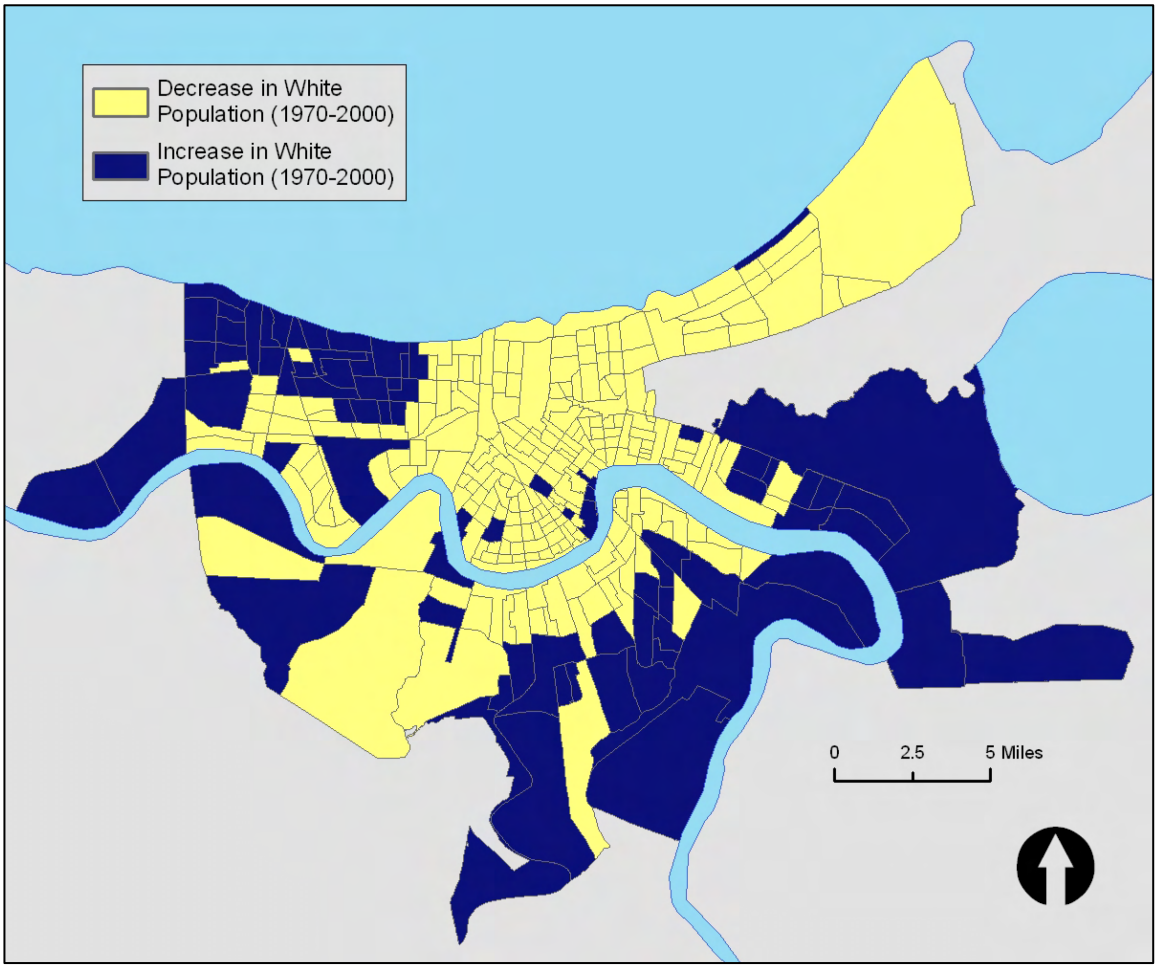

Figure 11: A Graphic Representation of White Flight by Census Tract within the Urbanized Area surrounding New Orleans, 1970-2000.

framework of “contemporary era” employed here controls for the geographic realities of desegregation and white flight that were in place by the 1970s.

Though it would not have as evident an effect on the geography of New Orleans as did desegregation, subsequent developments in the Civil Rights Movement did have important symbolic, legal, and electoral consequences in the

U.S. and New Orleans. The culmination of the Civil Rights Movement came with the passage of the Civil Rights Act of 1964 and the Voting Rights Act of 1965. The Civil Rights Act set up federal mechanisms to field discrimination complaints from minorities, and African-Americans used this political machinery in part to desegregate schools, hospitals, and other public accommodations (Fairclough 1995). In contrast, the Voting Rights Act placed federal voter registrars in problem areas (primarily in the Deep South), solicited complaints of electoral discrimination, and developed a means to reapportion legislative representation that had for many years been biased heavily in favor of whites (Fairclough 1995). These acts did, however, incur resistance from some whites, and minorities continue to struggle to translate this legislation into actual equality. However, the legislation produced by the Civil Rights Movement provided the social, legal, and electoral frameworks with which minorities have employed as they work toward equality.

Many scholars consider the 1970s the “environmental decade,” and the beginning of the “era of environmental regulation” (Merchant 2002, 181). Congress passed the National Environmental Policy Act (NEPA) in 1969, effectively creating a regulatory bureaucracy around the mechanism of Environmental Impact Statements (EIS). NEPA represents a legislative attempt to balance the often competitive interests of development, technology, long term (if not sustainable) resource use, and quality of life (Merchant 2002). NEPA made it impossible for federal agencies or those using federal monies to commit to development projects without first having an EIS approved by federal environmental inspectors. NEPA marks the beginning of the environmental movement in the United States, at least within federal regulatory structures.

Congress passed several groundbreaking environmental laws during the 1970s including the Clean Air Amendments of 1970, the Endangered Species Act of 1973, the Safe Drinking Water Act of 1974, and the Resources Conservation and Recovery Act (RCRA) of 1976 (Merchant 2002). Of all the laws enacted during this period, perhaps most consequential to New Orleans was the Clean Water Act (CWA). Adopted in 1972 and strengthened in 1977, CWA has had a profound effect on New Orleans and its patterns of urban development. At the time of its enactment, CWA, along with NEPA, effectively deterred the further growth of the city into the wetlands that surround it. Environmental groups used the new legislation to halt several development projects around the city, with particular success in the threatened wetlands of Eastern New Orleans (Colten 2005). The developmental patterns of suburbanization common to other cities in the U.S. were no longer possible in New Orleans, as plans for additional causeways or further expansion into the wetlands now ran counter to federal regulations (Colten 2005; Hagelman 2008, pers. comm.). Therefore, following the environmental legislation of the 1970s (most notably NEPA and CWA), the boundaries of Greater New Orleans' urbanized area represented steadfast impediments to peripheral development around the city. In 1985, environmental concerns and the national "oil bust" forced developers to drop plans for a suburb in the so-called New Orleans East (Colten 2002b; Colten 2005), and the area now boasts the "largest urban

National Wildlife Refuge in the United States" (U.S. Fish and Wildlife Service 2008).

NEPA is not without its detractors, however. Critics—some in the U.S. Congress—have claimed that NEPA and other environmental regulations may have slowed the construction of vital hurricane protection infrastructure and therefore increased the vulnerability of New Orleans to Hurricane Katrina (Vartabedian and Schmitt 2005). Yet, an analysis by Kysar and McGarity (2006) roundly disputes these claims. In an attempt to avoid such regulatory obstructions while federal engineers continue to rebuild critical hurricane protection infrastructure in New Orleans, FEMA, in conjunction with the United States Environmental Protection Agency (EPA), has drafted "alternative arrangements" to simultaneously meet New Orleans' emergency infrastructural needs and comply with federal environmental regulations, most notably, NEPA (Federal Emergency Management Agency 2006b).

For the purposes of this research, I argue that the mid-to-late 1960s marked the beginning of the "contemporary era" in New Orleans. The broad-scale development of hurricane protection and suburban infrastructure along with the maturation of the civil rights and environmental movements ushered in contemporary geographic and social realities that were, for the first time, analogous to the current period. This study compares census data across the four decades following the contemporary paradigm shift in New Orleans. In order to maintain empirical integrity, the four decades in question (1970-2000) must be comparable from a scientific perspective. Because these four decades share the geographic, social, and environmental realities of the "contemporary era" discussed above, the time frame referenced here essentially controls for the federal hurricane protection system (in design and perception if not function), equal protection under the law for all racial groups, environmental awareness and regulation, and the modern geographic realities produced by school desegregation, suburbanization, and white flight.

Vulnerability and the Contextualized Study of Hazards

Social scientists trace the origin of the hazards literature to the work of Harlan Barrows (Cutter, Mitchell, and Scott 2000). Barrows (1923) viewed geography in general as “the science of human ecology,” and, within this paradigm, he and his students studied human relationships with the environment. Gilbert F. White used Barrow’s human ecology perspective to study societal adjustments to natural hazards (Cutter, Mitchell, and Scott 2000). White and his students contributed to our understanding of the relationships of human society to flood hazards with several noteworthy studies (e.g., White 1945, 1964; White et al. 1958; Burton, Kates, and White 1993). Perhaps White’s (et al. 1958) most notable contribution came with his finding that, while the United States had spent vast amounts of resources on flood control structures (i.e. dams and levees), losses from floods had risen during this period of technological expansion. White et al. (1958) asserted that, as a society develops technologies to control nature, the society becomes more vulnerable to both nature and its control mechanisms, an observation with obvious implications for the “unnatural metropolis” of New Orleans (Colten 2005).

The work of White and his students led hazards researchers to redefine their approach to hazards research (Burton, Kates, and White 1993; Cutter, Mitchell, and Scott 2000). Cutter, Mitchell, and Scott (2000, 714-715) point out that "hazards research now considers, not only the hazards themselves, but the particular contexts in which they are embedded." While this study follows Gilbert White and his contextualized view of hazards, it makes an original contribution to hazards research by focusing on the temporal context of the social landscape.

A key aspect of the contemporary, contextualized view of hazards research is the concept of vulnerability. Hazards researchers broadly define vulnerability as "the potential for loss" (Mitchell, Devine, and Jagger 1989; Cutter, Mitchell, and Scott 2000; Cutter, Boruff, and Shirley 2003). This general definition, however, represents the limits of the consensus on vulnerability from within the discipline (Cutter 1996; Cutter, Boruff, and Shirley 2003). There are a variety of connotations and definitions of the term within the literature (Mitchell, Devine, and Jagger 1989; Dow 1992; Cutter 1996; Cutter, Mitchell, and Scott 2000; Cutter, Boruff, and Shirley 2003). This myriad of perspectives provides a typology of three major views for conceptualizing vulnerability (Cutter 1996). Cutter (1996) has discussed the varying definitions of vulnerability and identified the three central perspectives on vulnerability as: 1) Vulnerability as pre-existing condition, 2) Vulnerability as tempered response, and 3) Vulnerability as hazard of place.

The first perspective, vulnerability as pre-existing condition, is known as the exposure (or *potential* exposure) model. Also known as biophysical vulnerability, this perspective examines the geographical and biophysical conditions that infer potential exposure to environmental hazards (Burton, Kates, and White 1993; Anderson 2000; Cutter, Boruff, and Shirley 2003). Hazards researchers analyze proximity to a threat and the probability of the threat's occurrence to understand the risk posed by extreme events. Examples include proximity to coastal areas (hurricane risk), proximity to toxic releases, and the probabilities that these threats will materialize (Cutter and Solecki 1989; Cutter and Tiefenbacher 1991; Cutter, Boruff, and Shirley 2003). This approach represents the majority of work on vulnerability in the hazards literature, and is concerned with the delineation and analysis of locationally dependent hazard threats based on proximity and probability (Cutter, Mitchell, and Scott 2000).

The second perspective, resilience, is the ability of a group to resist and/or respond to a hazard event (Blaikie et al. 1994; Cutter 1996; Hewitt 1997; Cutter, Mitchell, and Scott 2000; Cutter, Boruff, and Shirley 2003). This perspective asserts that social and demographic factors influence the ability of a society or a subpopulation to prepare for and react to an extreme event. The term *social vulnerability* is most closely associated with this perspective of vulnerability (Blaikie et al. 1994; Cutter 1996; Hewitt 1997; Cutter, Mitchell, and Scott 2000; Cutter, Boruff, and Shirley 2003). Cutter, Mitchell, and Scott (2000, 715-716), following Blaikie et al. (1994) and Hewitt (1997), have defined social vulnerability as the "susceptibility of social groups to potential losses from hazard events or society's resistance and resilience to hazards." Therefore, social vulnerability represents the social inequalities inherent to a landscape (Cutter and Emrich

2006). Social vulnerability is a theoretical model that assumes social, demographic, historical, political, and economic factors infer vulnerability onto subsets of a population (Chen 1994; Kasperson, Kasperson, and Turner 1995; Cutter 1996). In the resilience model, researchers see proximity to a threat or the probability of a threat's occurrence as constant. Social and demographic attributes help to explain the vulnerability of a subpopulation to potential threats relative to other subpopulations at varying spatial scales (Cutter 1996; Cutter, Mitchell, and Scott 2000; Cutter, Boruff, and Shirley 2003). While the exposure model focuses on the geo-spatial location of a population, the resilience model focuses on the socioeconomic and demographic attributes of subpopulations (Cutter, Mitchell, and Scott 2000; Cutter, Boruff, and Shirley 2003).

The third perspective, vulnerability as hazard of place, integrates facets of the prior two perspectives to offer a holistic understanding of vulnerability (Mitchell, Devine, and Jagger 1989; Longhurst 1995; Cutter 1996; Cutter, Mitchell, and Scott 2000; Cutter, Boruff, and Shirley 2003). The "hazards of place" model combines biophysical vulnerability with social vulnerability to arrive at a comprehensive model of vulnerability. Hazards researchers have used the theoretical model to assess the relative vulnerability of populations and subpopulations at a variety of spatial scales (Kasperson, Kasperson, and Turner 1995; Cutter, Mitchell, and Scott 2000; Heinz Center for Science, Economics, and the Environment 2002; Cutter, Boruff, and Shirley 2003). Officials and experts use these and other studies as tools in planning and mitigation efforts to better prepare communities for the threat of extreme events. Hazards researchers use large-scale hazard of place studies to identify specific individuals, families, or neighborhoods that are likely to suffer the greatest impacts of a hazard event, while small-scale studies are used to prioritize the communities, counties, or regions most in need of economic, physical, or technical assistance (Tiefenbacher 2007, pers. comm.). Vulnerability research enjoys broad practical applicability, as identifying populations and communities particularly vulnerable to hazards is a national priority (Federal Emergency Management Agency 1995).

Masozera, Bailey, and Kerchner (2006) analyzed the vulnerability of the population of New Orleans. Their findings suggest that Katrina caused severe flooding in neighborhoods across the income spectrum, and therefore did not disproportionately affect the poor. However, their findings did suggest that lower income groups “were more vulnerable to Hurricane Katrina during the response and recovery phases” (Masozera, Bailey, and Kerchner 2006, 304). Their study, then, suggests that even as lower income groups shared a proportionate amount of biophysical vulnerability, they maintained higher levels of social vulnerability than groups with higher incomes. In contrast to the study conducted by Masozera, Bailey, and Kerchner (2006), this research tests the biophysical vulnerability of the population by dividing the residents not only into socioeconomic groups, but into racial groups, as well. This approach allows for a more thorough analysis of exposure to Katrina’s floodwaters, but, since its focus is exposure (biophysical vulnerability), this study does not specifically include any direct analysis of social vulnerability or resilience. However, this study does relate to social vulnerability in a tangential manner. Although it is not concerned with quantifying or qualifying social vulnerabilities in the conventional sense, this research measures vulnerability by analyzing the social dimensions of exposure.

With the exception of works by Enfield (2007; Endfield and Tejedo 2006; Endfield, Tejedo, and O'Hara 2004), one general limitation of the contemporary vulnerability-based approach to hazard research is its lack of temporal analysis. Although many vulnerability studies are very useful for reasons related to planning and mitigation, these studies generally focus on a brief or static period, therefore overlooking the effects of history and social change on the present state of the landscape. This lack of temporal context can limit the effectiveness of typical vulnerability research by discounting the evolution of social trends within the landscape and by ignoring the potential foresight afforded by analyses that result in some understanding of the trajectory of social landscape change.

The scarcity of temporal analysis in vulnerability research applies also to hazards research in general, albeit with at least one exception. Colten (1990, 1991, 2002a; Colten and Skinner 1996) has produced several studies employing historical geography as a method for understanding hazardscapes.

Another limitation of contemporary vulnerability science is its reliance on theoretical models. While contemporary vulnerability studies tend to use a prospective and predictive approach in regard to a range of potential hazard events, this study takes a retrospective, empirical approach to measure exposure to an actual event—Hurricane Katrina-induced flooding. While the predictive mode of vulnerability research is informative and germane to considerations of policy and mitigation, it offers little in the way of empirical analysis. This research evaluates an actual event (Katrina) and charts the changes in the social landscape that led to the conditions apparent as the hazard event materialized.

The methods and theories of vulnerability research are powerful tools when used to measure the topographical and social responses to hazard events. However, in recent years, many vulnerability researchers have overlooked the study of tangible hazard events and the role of social landscape change in illuminating hazard exposure. A spatio-temporal analysis of Hurricane Katrina, such as the research described here, can measure the socio-economic and racial dimensions of flood exposure in New Orleans over time, a city with a long history of flood events and a dynamic socio-historical geography. Furthermore, this study contributes to the hazard literature by offering an analysis of exposure to a tangible hazard event, linking the general theories of vulnerability to “real-world” happenings. Instead of relating social attributes to potential hazard threats, this study assesses the social dimensions of exposure to a substantive event, and charts the contemporary changes that led to the state of the social landscape at the time of its occurrence. Therefore, this study stands apart from typical vulnerability research by analyzing the spatial *and* temporal aspects of an *actual* event.

The “Naturalness” of Disaster

The topic of Hurricane Katrina as it relates to race and socioeconomics boasts a litany of reference within the social science, humanities, and popular literatures (Colten 2005, 2006a, 2007; Gabe et al. 2005; Simerman, Ott, and

Mellnick 2005; Cutter 2006; Dyson 2006; Elliot and Pais 2006; Lavelle and Feagin 2006; Logan 2006; Mann 2006; Marable 2006; Ruether 2006; Smith 2006; Young 2006; Sharkey 2007; White et al. 2007; Ford 2008). Yet a relatively small number of studies have empirically analyzed the social landscapes of exposure to Katrina's floodwaters in New Orleans (e.g., Gabe et al. 2005; Simerman, Ott, and Mellnick 2005; Logan 2006; Sharkey 2007). The perspectives offered in this array of studies, as Sharkey (2007) asserts, range from those that view the disaster as a metaphor for social and racial injustice, and those that perceive the storm and its aftermath as merely a "natural" disaster that coincidentally affected an urban area with high concentrations of poor and African-American residents. While some authors argue that Katrina exposed broad racial and social inequities in American society (e.g., Cutter 2006; Dyson 2006; Lavelle and Feagin 2006; Colten 2007), others claim that the hurricane exposed only "racial paranoia" (Simerman, Ott, and Mellnick 2005; Young 2006; Ford 2008). Which of these perspectives is most valid? Did the storm combine with anthropogenic forces to exploit the preexisting social discrepancies within the urban landscape, or are "natural" disasters such as Hurricane Katrina inherently arbitrary? This debate is much larger than its pertinence to Hurricane Katrina, as scholars have given much attention in recent years to the social framework of "natural" disasters. Almost thirty years prior to Katrina, O'Keefe, Westgate, and Wisner (1976) first recommended that we "[take] the naturalness out of natural disasters." Currently, a contemporary consensus among scholars holds that social, cultural, and political processes combine to shape both our conceptualization of nature and our interaction with it (Kasperson et al.1988; Proctor 1998; Cutter, Mitchell, and Scott 2000; Ueland and Warf 2006; Bullard 2007). Therefore, this concept suggests that disasters are not “natural” at all, and that forces engendered from human institutions play an important role in shaping the effects of, and our response to, disaster.

Several scholars have dubbed Hurricane Katrina an “unnatural,” socially constructed disaster (Dyson 2006; Marable 2006; Rodríguez and Dynes 2006; Smith 2006). Since breaches in human-built levees and canal walls caused the flooding in urban New Orleans, the “unnatural disaster” thesis is particularly difficult to argue against in the case of Katrina. Of course, Katrina did cause wind damage and storm surge that affected structures from south-central Louisiana to the Florida panhandle, and these forms of damage may tempt some to deem the destruction, “natural.” However, these seemingly natural forces destroyed human-built homes and infrastructure, again calling into question the concept of “natural disaster.” The wind itself is not inherently disastrous; rather it is the outcome of such wind on humans and their built structures that can cause death and destruction.

In the research presented here, I focus on the urban flooding induced by the breaching and overtopping of levees and canal walls during Hurricane Katrina. Damage caused by wind and water in areas external to the Lake Pontchartrain and vicinity Hurricane Protection zone falls outside of the scope of analysis described here. Therefore, this research focuses on the spatial outcomes of Katrina-induced inundation within the contiguous urbanized area surrounding New Orleans.

The "Science" of Katrina

As previously cited, there are a plethora of publications concerning race, class, and Hurricane Katrina. Because this research centers on the storm as it relates to a positivist social landscape, I review only the empirical contributions made to the social science literature by those studying Katrina.

Logan (2006) provides a statistical breakdown of the social patterns of inundation for most of the storm's affected area. This study is useful in that it offers a percentage-based model of flood exposure for eight Louisiana parishes and three Mississippi counties. The author concludes that the effects of the storm were "disproportionately borne by the region's African American community, by people who rented their homes, and by the poor and unemployed" (Logan 2006, 1). The study, in effect, compares exposure across a range of landscapes, rural and urban, and is thus somewhat diluted geographically. The study presented here focuses only on the contiguous urbanized area surrounding New Orleans, the city that faced the brunt of the extended flooding and the only large urban area inside the storm-affected zone. Logan's (2006) study provides a preliminary baseline analysis of Katrina's impact by offering simple percentages relating the storm's damage to the affected population. This study here employs a more robust statistical methodology, and focuses only on the contiguous urbanized area surrounding the city of New Orleans. Finally, scale is an issue of concern for this research, particularly in comparison to previous studies. Logan's (2006) study uses the tract level as its unit of analysis, while the research described here employs the block group, a unit of analysis higher in resolution, in its initial analysis of the landscape at the time of Katrina, (see Figures 13 and 16).

Gabe et al. (2005), on behalf of the U.S. Congressional Research Service (CRS), issued a report summarizing FEMA-developed hurricane damage data and corresponding U.S. census data from the year 2000. The report offers general demographic and geographic analysis, mostly in the form of population-based cross-tabulations. The CRS developed the report to serve lawmakers as a statistical introduction to the storm and its impacts on the population. In essence, the report compares the hurricane-affected area to the rest of the U.S. This method of comparison essentially juxtaposes the Gulf Coast with the rest of the United States. The outcome of this comparison reveals a populace that is, on average, poorer, more likely to be minority, and less educated than the rest of the nation. These results tell us less about the impacts of Hurricane Katrina than the social composition of the U.S. Gulf Coast when compared to the rest of the nation. Although the report serves as a useful compendium of relevant data for congressional review, it contributes little of meaning to the discussion of Hurricane Katrina as it relates to issues of race or class in New Orleans. Further, the CRS report, like the study by Logan (2006), employs the census tract as its smallest unit of analysis, and therefore fails to harness the most resolute data available, a limitation avoided by the research described here.

Sharkey (2007) uses a georeferenced list of fatalities in New Orleans to conclude that, in terms of deaths, Katrina disproportionately affected African-Americans and the elderly. The author acknowledges the errors evident in his data due to incorrect or difficult to determine locational accuracy, nevertheless, his study contrasts sharply to an earlier study based on a preliminary collection of the same data set. The similar study by Simerman, Ott, and Mellnick (2005) uses an older, preliminary (incomplete) data file of deceased New Orleanians to arrive at an opposing conclusion, that white residents were overrepresented among the deceased, and that the African-American community was underrepresented. Sharkey uses the updated version to suggest that the earlier findings were premature and inaccurate, and that African-Americans in New Orleans bore a disproportionate impact from the storm and its flooding, in terms of recorded fatalities. Sharkey's research makes an important contribution to our understanding of the effects of Katrina, but it makes no comment on the effects of the storm on the landscape itself, analyzing only the people who both chose to remain in the city during the hurricane and subsequently died.

This study takes into account the entire social landscape as it stands in the census records, making no distinction between those who may or may not have been in the city during the flood. While it is important to understand the impact of the storm on those who were unable to evacuate or otherwise chose to stay, it is also important to understand the storm's impact on the city in terms of its *a priori* social geography. The research described here contributes to the social science literature by providing an analysis of New Orleans' social landscape as it related to Hurricane Katrina, and by evaluating the changes in the landscape over time that can help us better understand the city and its interface with disaster.

Social Geography, Quantitative Methods, and GIS

The advent and development of geographic information systems (GIS) and the resulting geographic information science (GIScience) have revolutionized the field of geography (Hamnett 1996; Korte 2001). GIS allows geographers to manipulate and analyze large datasets efficiently and empirically using complex spatial and quantitative methods (Korte 2001). Before GIS, this type of analysis was often tedious and wrought with pitfalls. For instance, large spatial datasets were often exceedingly labor intensive to analyze, and hand calculations of such data are often particularly susceptible to human error. GIS has eased the level of difficulty associated with such analyses (Korte 2001).

Before the revolution in GIScience, geography (just as most of the other Social Sciences) experienced a quantitative revolution within the discipline (Burton 1963; Gould 1969). In the late 1950s and early 1960s, geographers began using inferential statistics and abstract mathematical models to describe and analyze geographic phenomena (Gould 1969). This revolution represented a watershed moment in geography, shifting the methodological foci of many practitioners from aerial differentiation and regional studies to a more positivistic approach (Barnes 2000b). In subsequent years, many geographers began to point out the deficiencies of strictly quantitative research methodologies (Harvey 1973), and today, a tempered view of geographic methodology holds that, while some questions can be answered satisfactorily via quantitative methods, others cannot (Barnes 2000a).

Social geographers have used GIS and GIScience in conjunction with quantitative methods to answer empirically a vast array of questions. For example, Holloway (1998) used GIS and quantitative methods to show a pattern of geographically contingent racial discrimination in mortgage lending in Columbus, Ohio. Ueland and Warf (2006) used GIS to show a positive correlation between minority settlement patterns and low-lying elevations in 146 cities in the Southern United States. Prior interdisciplinary studies that have analyzed the demographics of Katrina's victims rely heavily on GIS and quantitative methods (Gabe et al. 2005; Logan 2006; Sharkey 2007). While quantitative science has its limitations, GIS has emerged as a useful tool in exploring social landscapes when used in conjunction with spatially enabled census data.

The GIS revolution is not without its detractors, however. Goss (1995) comments on the Orwellian nature of so-called "geodemographic" systems, their use by for-profit marketers, and their connections to the broader erosions of personal privacy. The focus of this privacy debate remains, however, on the corporate and governmental utilities of GIS, and thus far has spared those who would harness the technology purely for the purposes of scholarly research.

In recent years, an academic debate has emerged that pits those who view GIS as merely a research tool against those who view the technology as a science in and of itself (Pickles 1997; Wright, Goodchild, and Proctor 1997).

While this debate is only of peripheral importance to this research, it is important to note that, while this study would employ GIS as an indispensible tool in answering research questions, GIS itself has not informed the theoretical underpinnings of this research.

A review of recent literature shows that robust empirical analyses concerning exposure to floodwaters in New Orleans have been sparse, and that geo-historical analyses can inform our interpretation of contemporary social landscapes. This study provides an empirical contribution to our understanding of hazards by assessing the relationship among race, socio-economic status, and exposure to Hurricane Katrina in New Orleans, and by illuminating the evolution of socio-spatial trends that predated the storm. Moreover, this study offers a contribution to the geographic literature by exploring the utility of historical geography as a methodology for exploring the relationship of social geographies and hazard exposure. Government officials at many levels stand to benefit from this study, as it illuminates the complex relationship of race, class, and exposed to flooding in a major U.S. city, and, in doing so, provides a methodology applicable to a broad spectrum of potential socio-spatial research questions. In the research described here, Hurricane Katrina is used as a lens with which to view social landscape change; however, subsequent studies could conceivably employ any number of interesting externalities to provide a unique perspective of social morphology. Therefore, while this research enjoys practical applicability potentially useful to those involved in planning, mitigation, and government, it also provides theoretical insight specific to geography and the study of hazards.

CHAPTER V

DATA

This study employs three core datasets. These data include a digital raster file representing Hurricane Katrina's flood extent and depth in New Orleans, U.S. Census attribute and boundary data at the census block group level for the year 2000 (Summary Files 1 and 3), and Geolytics' (2003) Neighborhood Change Database (NCDB) census variables and census tract boundaries for the years 1970, 1980, 1990, and 2000.

Inundation Data

In a joint effort with the USACE, the United States Geological Survey (USGS) developed a spatially enabled raster dataset depicting the extent and depth of floodwater in New Orleans, Louisiana, for the date 2 September 2005 (Smith and Rowland 2007) (see Figure 12). The Louisiana State University GIS Information Clearinghouse makes this dataset available on the World Wide Web (Computer Aided Design and Geographic Information Systems Research Lab 2005). The file is a Light-Imaging Detection and Ranging (LiDAR) derived flood depth raster with a ten-meter resolution. The dataset depicts the extent of and depth values for floodwaters on September 2, 2005, in the Greater New Orleans area, covering portions of Jefferson, Orleans, and St. Bernard Parishes, Louisiana (Smith and Rowland 2007). On this date, Katrina's floodwaters were at relatively high citywide levels, and were distributed across approximately 80 percent of New Orleans. However, it is impossible to know that the extent of the dataset represents the absolute maximum for New Orleans during Katrina (Smith and Rowland 2007). It is assumed that these data are the best available, and because the topography of the city allows for a relative dispersal of the

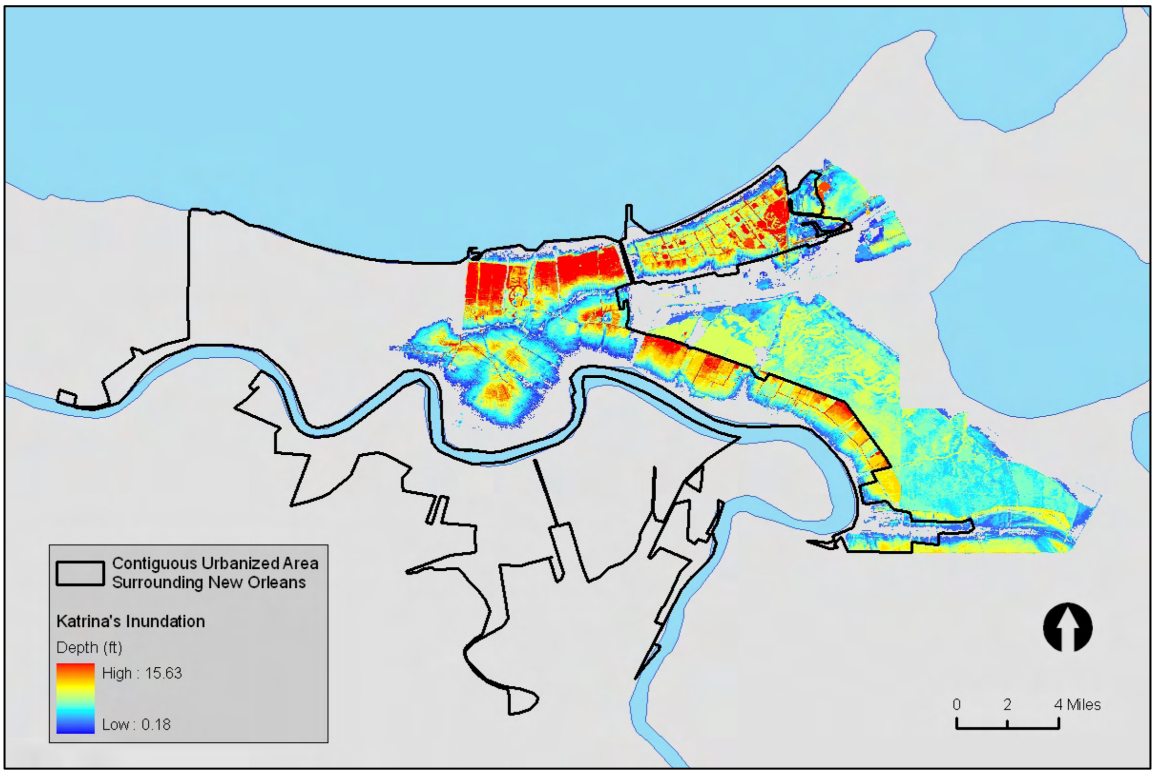

Figure 12: Katrina-induced Flood Depths and Extent for 2 September 2005. Note the urbanized area.

floodwaters throughout its landscape, I assume the data's limitations to be negligible.

Census Data

The U.S. Census Bureau performs fully enumerated counts of the population every ten years. The bureau collects the information contained in these counts from the "short form," and publishes the data in Summary Files 1 and 2. The bureau collects socioeconomic data such as those related to income from the “long form” of the census. Unlike the short form, the bureau administers the long form to only a one in six (16.6 percent) sample of the population and includes the results in its Summary File 3.

The bureau organizes the geography of U.S. Census data into a nested hierarchy. The geographies consist of three divisions below “place,” (i.e. a town or city, etc). These divisions are census blocks, census block groups, and census tracts. Census block groups enable the most detailed level of socioeconomic analysis because they are “the lowest-level geographic entity for which the U.S. Census Bureau tabulates sample data from a decennial census” (United States Census Bureau 2005). According to the online glossary maintained by the U.S. Census Bureau (2005), a census block group is:

> “A statistical subdivision of a census tract (or, prior to Census 2000, a block numbering area)…BGs generally contain between 300 and 3,000 people, with an optimum size of 1,500 people…”

Several block groups are nested in each census tract (see Figure 13 for a visual representation of block groups and tracts in New Orleans).

Until recently, the nature of the U.S. Census made it very difficult to conduct broad scale quantitative analyses of changes in social trends across census collection periods. However, the NCDB grants researchers the power to do just that. The Geolytics corporation took original data from the U.S. Census Bureau and “remapped” them to provide geographic consistency from 1970-2000 (Tatian 2003). In releasing the NCDB, Geolytics (2003) has essentially upgraded the capabilities of the census to support direct comparisons across the four previous decennial periods (1970, 1980, 1990, and 2000). Users of the NCDB can now directly compare socioeconomic and demographic data down to the census tract level for the decennial data collection periods of 1970-2000. This development greatly enhances the power of the census, giving users the ability

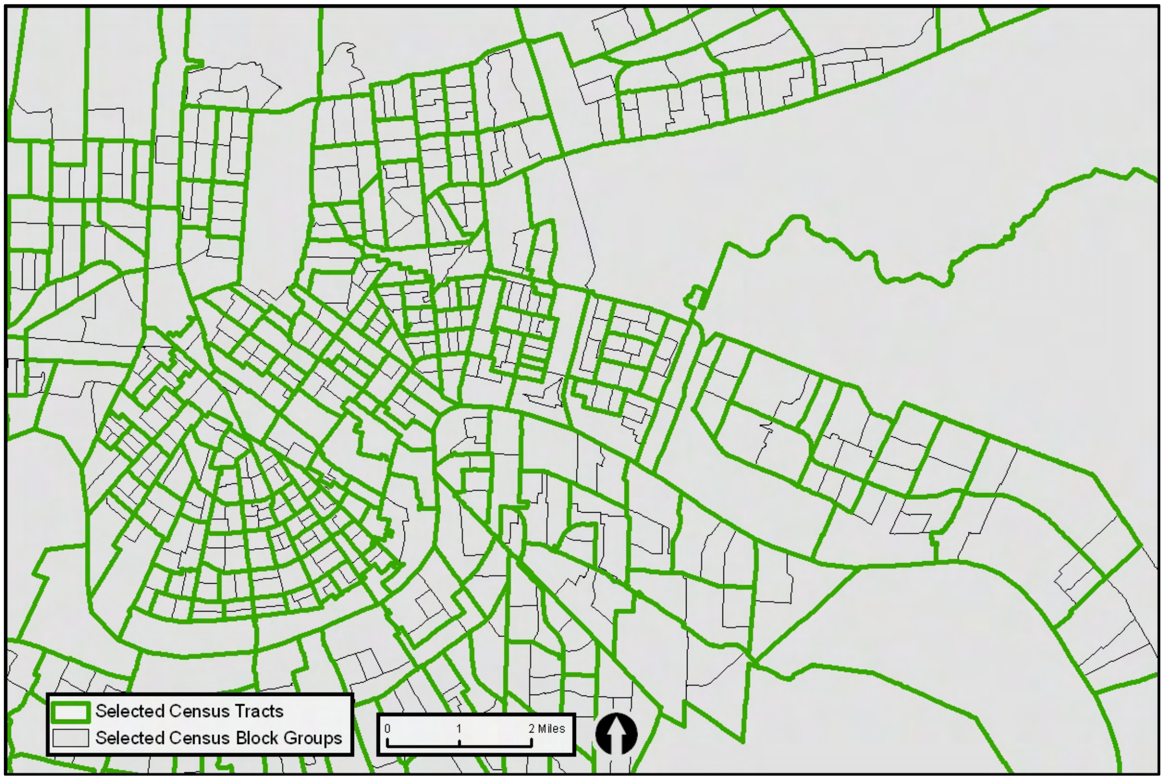

Figure 13: Census Block Groups nested within Census Tracts in New Orleans.

to track demographic, housing, and socioeconomic characteristics over the previous thirty years without controlling for changes in tract boundaries. The NCDB includes the spatial boundary files and their corresponding tabular attribute data for each census period, therefore enabling spatio-temporal analyses such as the study described here (Tatian 2003).

The NCDB contains fully enumerated population and housing data (i.e. “short form”) and sample socioeconomic (i.e. “long form”) data, among others, collected by the U.S. Census Bureau for the years 1970, 1980, 1990, and 2000 (Tatian 2003). The bureau typically collects sample data at a ratio of one in six to one in seven households per census tract (U.S. Census Bureau 2001b). Once the data was collected, the bureau weighted it to reflect the total population of the census tract. I used the census tract resolution for the temporal analysis in this study because it is the smallest resolution within the Census Bureau's nested hierarchy for which the NCDB provides data that can be compared across the collection periods of 1970-2000. The bureau defines a census tract as:

> "A small, relatively permanent statistical subdivision of a county or statistically equivalent entity, delineated for data presentation purposes by a local group of census data users or the geographic staff of a regional census center in accordance with U.S. Census Bureau guidelines. Designed to be relatively homogeneous units with respect to population characteristics, economic status, and living conditions at the time they are established, census tracts generally contain between 1,000 and 8,000 people, with an optimum size of 4,000 people. Census tract boundaries are delineated with the intention of being stable over many decades, so they generally follow relatively permanent visible features. However, they may follow governmental unit boundaries and other invisible features in some instances; the boundary of a state or county (or statistically equivalent entity) is always a census tract boundary…" (United States Census Bureau 2005).

Census tracts are not arbitrary delineations of the landscape. Rather, they represent what many would consider neighborhoods (or relatively homogenous areas) averaging 4,000 inhabitants (Tatian 2003). The census tracts for New Orleans represent smaller, more precise areas than the city's traditionally recognized neighborhoods (see Figure 14) (Greater New Orleans Community Data Center 2007). Because the census tracts are, in most cases, smaller than the neighborhoods in which they are nested, a study of New Orleans that employs the census tract as the unit of analysis (such as the research described here) is more precise and operates within a lower degree of data aggregation than would a comparable study employing a neighborhood level analysis.

By necessity, I used census tracts for the temporal comparison. However, I also employed census block groups for the initial assessment of the social

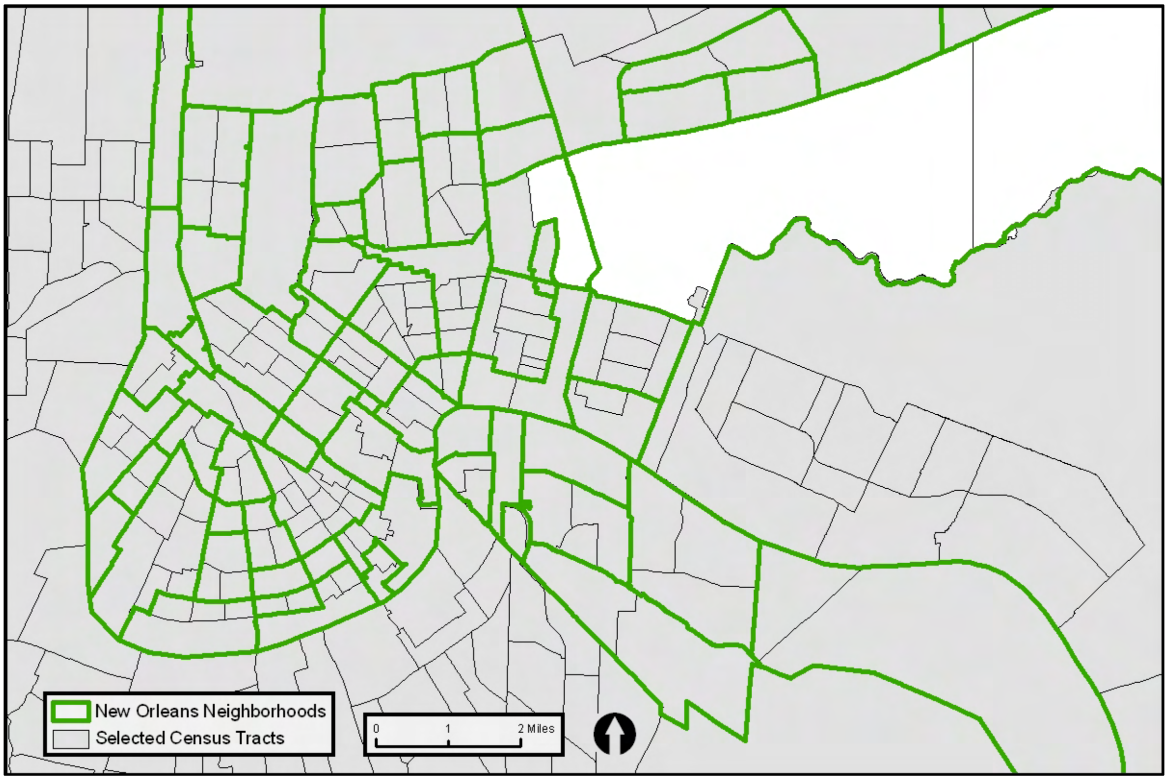

Figure 14: Several Census Tracts fit inside the Conventional Neighborhoods of New Orleans.

landscape at the time of Katrina. Using block groups gives the study a finer geographic resolution, therefore analyzing a greater number of individual units. Further, I compare the block group analysis to the subsequent tract analysis to assess the differences between the two levels of analysis.

The United States Census Bureau releases sample population statistics for “places” and states every year, but a robust enumeration of the population down to the tract and sub-tract levels, is produced only decennially. The most recent decennial census data available for use in this research comes from "Census 2000" (United States Census Bureau 2001a, 2001b). The effort of data collection takes longer than one year, however, and, for Census 2000, the bureau began collecting the data in 1999, and published them beginning in 2001. Because Hurricane Katrina struck in 2005, the most recent decennial data are significantly outdated relative to the event. To slightly complicate this weakness, the Census Bureau reports a decline in the population of 3.2 percent in New Orleans from 2000-2003 (United States Census Bureau 2007). These data limitations notwithstanding, data from Census 2000 represents the best available for use in this study.

By supplying a spatial component to the census attribute data, the census tract boundary files provide a connection between the flood depth raster and the census attribute data. That is, the boundary files provide a geographic location for the socioeconomic and demographic data. The census attribute data represent the *social* data, and the boundary files represent the *landscape*. Using a combination of these data yields a data set analogous to the *social landscape*. I use the boundaries to locate flood values within the strata of census bureau data, and to display census data in graphic form.

Geolytics and The Urban Institute (2003) recognize three important limitations in their NCDB, and Tatian (2003) outlines these limitations in the user guide supplied with the NCDB. First, the procedures in which the Census Bureau collects the data associated with certain variables have changed over time. The Census Bureau collects data associated with certain variables (most notable for this research are the variables concerning race) differently in 2000 than they did for previous census periods. In 2000, the bureau began collecting data on more than one race. That is, they allowed respondents the option of claiming membership in up to four different racial categories. In the year 2000, the Census Bureau tabulated a total population of 1,011,337 residents within Census Block Groups in the study area used in this research. Among these respondents, 996,202 (98.5 percent of the total) indicated membership in one racial group alone. Therefore, I consider the limitations of these data concerning race to be manageable.

Secondly, the NCDB, as with all census products, provides aggregated data. There are no individual level data available; census tracts and census block groups provide an aggregation of individual residents within the census data. Therefore, as in any study that uses census data, ecological fallacy is a concern for this research. Ecological fallacy refers to the erroneous concept that "relationships observed for groups necessarily hold for individuals" (Freedman 1999, 1). Although ecological fallacy is a genuine cause for consideration, social scientists continue to analyze aggregate data with such concerns in mind (Geronimus and Bound 1998; Minot and Baulch 2005). As for this research, where possible, I use the census block group as the unit of analysis. As this is the lowest level of data for which the census bureau provides socioeconomic variables, I employ the data with the lowest degree of aggregation available.

Therefore, I have reduced the undesirable effect of ecological fallacy to its lowest possible amplitude.

The final caveat provided by the NCDB regards the source of the data, the U.S. Census. The bureau collects enumerated population and sample socioeconomic data only once in a decennial period. This method ignores any changes in the data during the nine intervening years between data collection periods. This limitation can be particularly problematic when cyclical or highly volatile variables are used (such as employment variables) (Tatian 2003); however, because I am primarily concerned with the socioeconomic and racial geographies of the landscape itself, and not the population, per se, this limitation has little to no adverse effect on this study.

In addition to the conventional census attribute and boundary data, I use an “Urban Area” feature class developed by the U.S. Census Bureau and made available on the World Wide Web by the National Atlas (United States Department of the Interior 2007) (see Figure 12). Because this feature class distinguishes urbanized land uses from rural land uses, it allows me to discern the urban area of New Orleans from its rural hinterland. This is important, because in New Orleans, urbanized land is essentially analogous with land protected (allegedly) by the system of hurricane protection levees. Because these areas share land inside the levees, they share a relatively equal level of biophysical vulnerability to hurricane-induced flooding due to anthropogenic alterations of the landscape. Areas outside of the levees are vulnerable to storm surge and other hazards regardless of the levees' performance, and thus share different types and levels of vulnerability than areas within the hurricane protection levees. Furthermore, the flood depth raster file accounts only for flooded areas within the hurricane protection levees and does not purport to represent flooded areas outside of the levees. Ergo, to insure scientific integrity, the analysis described here includes only the urbanized areas served by the hurricane protection system.

CHAPTER VI

METHODOLOGY

GIS Data Preparation

The core data were loaded into a Geographic Information System (GIS) software suite developed by Environmental Systems Research Institute (ESRI) (2007) and known as ArcGIS 9.2. To organize the relevant data, I used the GIS to create a *personal geodatabase*. A geodatabase is a collection of spatial and tabular data accessible from a single file structure within a windows-based computing environment (ESRI 2007). The initial data I loaded into the geodatabase included census tract boundaries for Louisiana, census block group boundaries for Louisiana, a polygon feature class delineating the urbanized area surrounding New Orleans, and the USGS/USACE inundation raster file. While importing the data into the geodatabase, I set the processing environment to reproject each spatial dataset to the projection used by the inundation raster—North American Datum 1983, Universal Transverse Mercator Zone 15 North. Having each of the datasets set to the same projection is essential, as it ensured a shared geographic reference among all of the datasets, thereby allowing me to compare the census data directly with the inundation data.

To begin preparations for the initial analysis, I finalized the study area by selecting the block groups to include in the analysis. I included all block groups considered within the contiguous urbanized area surrounding New Orleans. Because there is no official determination of urbanized area available in conventional census geographies (i.e. tracts, block groups or blocks), I used the urban area feature class developed by the U.S. Census Bureau to select block groups for inclusion.

Counter-intuitively, the Census Bureau has generalized the boundary lines for the urban area feature class, therefore the block groups do not fit neatly into the urbanized area polygon. GIS analysis was necessary to determine which block groups should be included for analysis in the study. I first queried the GIS to select all block groups that have their centroid within the urban area feature class. I selected each of the block groups selected in this step for inclusion in the analysis; however, there was a need to include additional block groups based on various geographic factors. Because block groups must account for all of the land and water area within a county or parish, portions of territory within a given block group may fall outside of the urbanized area, but contain no residential land use in the portion of the block group that falls outside of the urbanized area. For example, water features and industrial land uses in a given block group may fall outside of the urbanized area, but all of the residential land use in the block group falls inside the urbanized zone (see Figure 15). Because the land area of the open water or industrial land use is greater than the land area of the residential land use, the centroid for the block group may fall outside of the urbanized area, causing the GIS to exclude the group from the selection. Therefore, I, using remotely sensed, orthorectified imagery (United States

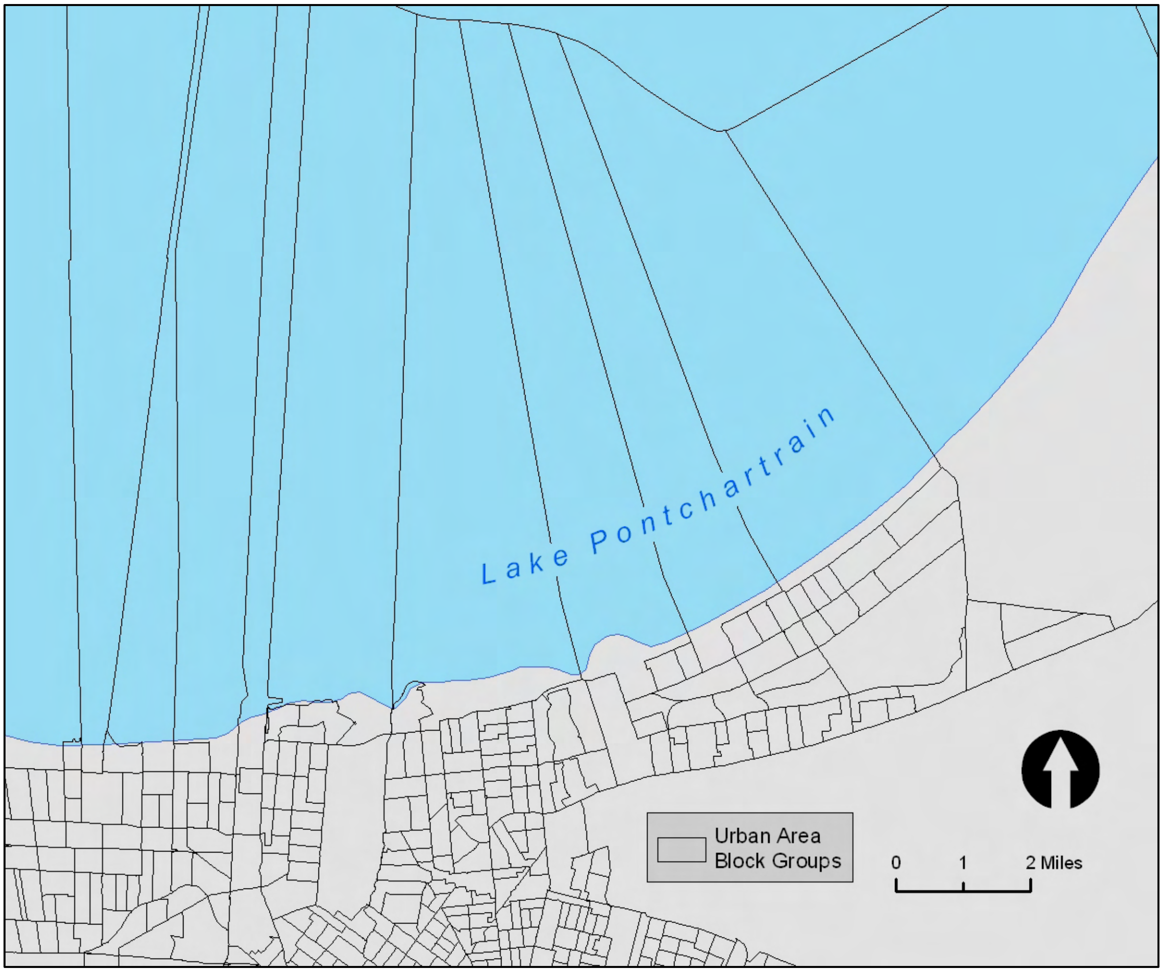

Figure 15: Census Block Groups along the Southern Shore of Lake Pontchartrain. Because the centroids for the block groups along the lakeshore fall in the lake itself, the GIS fails to select these block groups as "inside the urbanized area." Instances such as this make it necessary to analyze all block groups along the periphery of the urbanized area for inclusion in the analysis.

Department of Agriculture 2004), verified that each block group in close proximity to the urban area but excluded from the selection should, indeed, be excluded. I employed GIS aerial calculation techniques when a considerable portion of residential area lies outside of the urbanized area feature class. Upon the completion of the above step, the selected block groups represented a census geography of the contiguous urbanized area surrounding New Orleans at the block group level, and the study area for the initial component of this research was established (see Figure 16).

After verifying the census block groups for inclusion in the study area, I

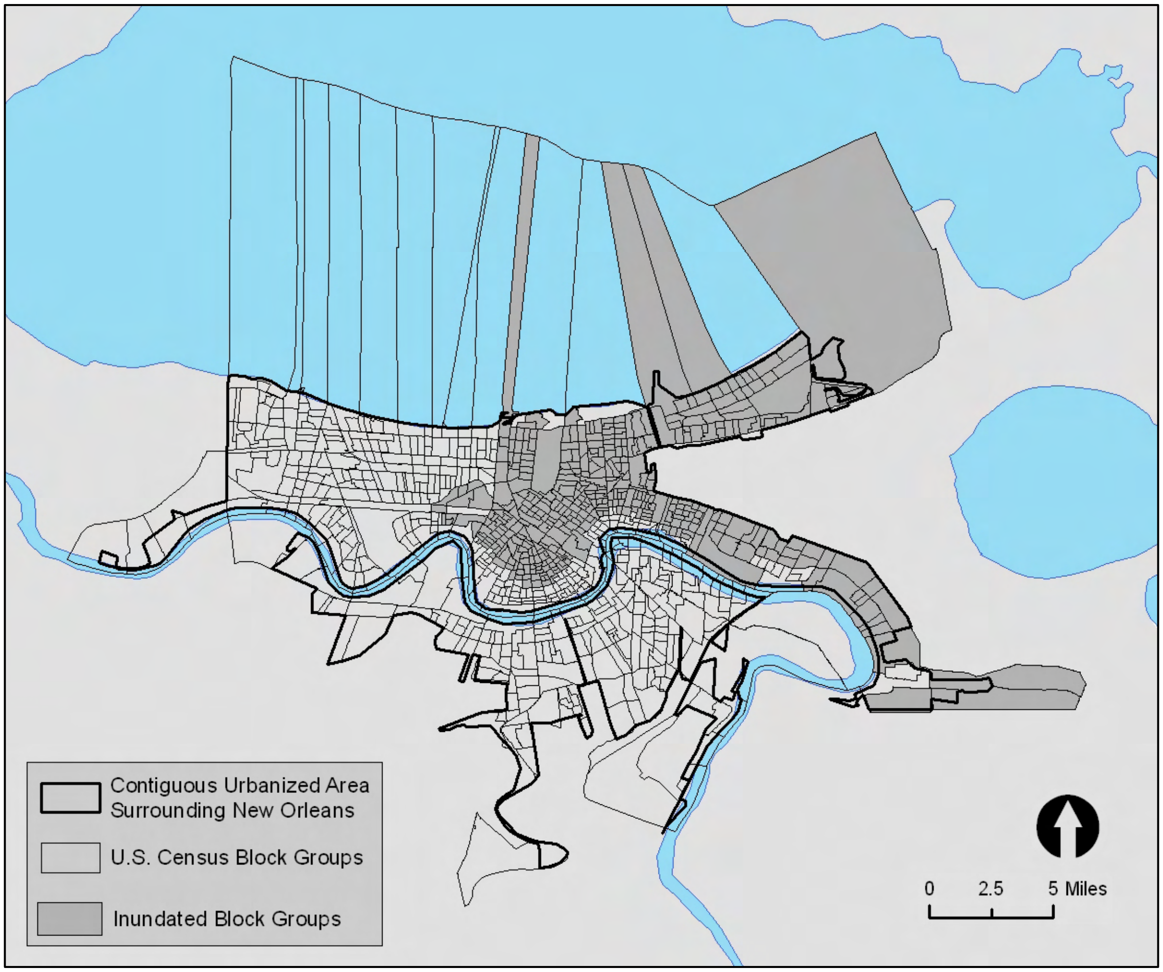

Figure 16: Census Block Groups within the Contiguous Urbanized Area surrounding New Orleans. These block groups comprise the study area for the initial static analysis, and provide the distinction between inundated and non-inundated block groups.

used a similar method as that outlined above to divide the selected block groups into two distinct groups–those within the inundated area and those outside of the inundated area. I dubbed these groups *inundated* and *non-inundated*, respectively (see Figure 16). Because the inundation layer passes through the interior of several census block groups along its boundary, a system for classifying block groups as inundated or non-inundated became necessary.

First, I queried the GIS to select all block groups that intersect the inundation layer, and created a separate layer from the selection. Then, I reclassified the inundation layer into a binary raster with inundated areas signified with a “1,” and the non-inundated areas signified with a “0.” Next, I conducted a *zonal statistics as table* function using the binary inundation layer as the calculation and the urban block groups as “zones.” This function effectively measured the aerial extent of inundation for each block group. Next, I queried the GIS to select only those block groups with more than 50 percent inundation coverage. I then compared the “more than 50 percent” selection to the “intersection” selection performed earlier to find which block groups contained inundation in less than 50 percent of their aerial extent. These block groups were individually verified using orthorectified aerial imagery much as the urban area block groups were verified in the previously described process. For example, as we have previously observed, the block groups along the southern shore of Lake Pontchartrain extend into the lake for approximately 30 Euclidean miles. Because the inundation layer only accounts for land area, the GIS considered all the area inside of the block group, even open water, the same as the land area. Therefore, the GIS failed to select the block groups along the lakeshore because a majority of their aerial extent is composed of open water and does not contain hurricane-induced inundation per the inundation dataset. However, because the people represented by the block groups in question live in the terrestrial portions of the block groups, I redrew the boundaries of the block groups along the lakeshore and added them again to the GIS query.

Once I selected the block groups that constitute the study area, and, in turn, designated which of the block groups I consider inundated and non-inundated, I performed similar steps to select and designate census tracts in a process comparable to that performed for the block groups (see Figure 17). Next, I loaded the relevant census attribute data from Summary Files 1 and 3 and the NCDB into the geodatabase maintained in the GIS.

Upon completion of the GIS data preparations, I had block groups and tracts selected for inclusion in the study, a division among the selected block groups and tracts based on inundated and non-inundated areas (see Figures 16 and 17), and corresponding census block group attribute data from Summary Files 1 and 3 for the year 2000 and census tract data from the NCDB for the years 1970, 1980, 1990, and 2000.

Data Analysis

After loading into and parsing all the relevant data in the GIS, the analysis commenced (see Figure 18). The data analysis was comprised of two major components. In the initial component, I analyzed the social landscape at the time of Hurricane Katrina. In the second component, I conducted a temporal analysis of the social landscape across the period of 1970-2000, using the patterns of inundation produced by Hurricane Katrina as a lens through which historical changes in the city's racial and socioeconomic distributions were viewed.

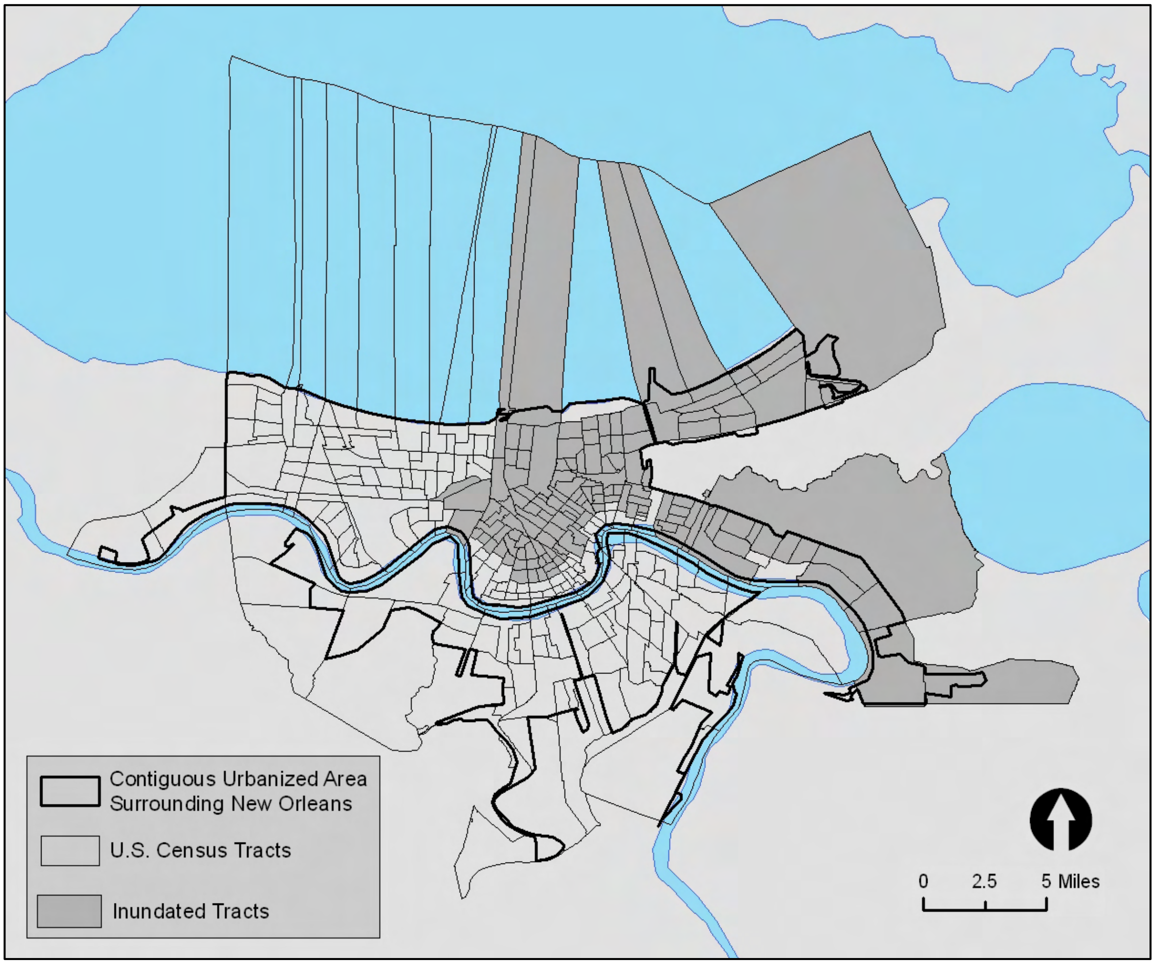

Figure 17: U.S. Census Tracts within the Contiguous Urbanized Area surrounding New Orleans. These tracts comprise the study area for the initial analysis, and provide the distinction between inundated and non-inundated tracts.

The initial analysis assesses the statistical relationship of race, socioeconomics, and Katrina-induced inundation in New Orleans. Essentially, the initial component of this research asks, "What is the relationship among race, socioeconomics, and Katrina-induced inundation?" In an effort to answer this question, I conducted a multivariate regression analysis. Because the census data analyzed in this study are not normally distributed (see Figure 19), and the independent variable (inundation) is binary, a binary logistic regression (logit) is the most appropriate form of regression for the analysis described here (Liao 1994; Menard 2002). Logit is a generalized linear probability model that geographers and other scientists have used to analyze various social and physical data (Faulkner 1998; Pulido 2000; Brewer and Pickle 2002; Wyly and Holloway 2002; Bélange et al. 2006), and the method is appropriate for the research questions analyzed in this research (Liao 1994; Menard 2002). To begin the statistical analysis, I first selected the most appropriate variables for use in the model. Because racial data can be highly correlated, the classical assumptions of regression analysis related to multicollinearity are important to consider. For instance, residents claiming “white” and “African-American” as their racial identity

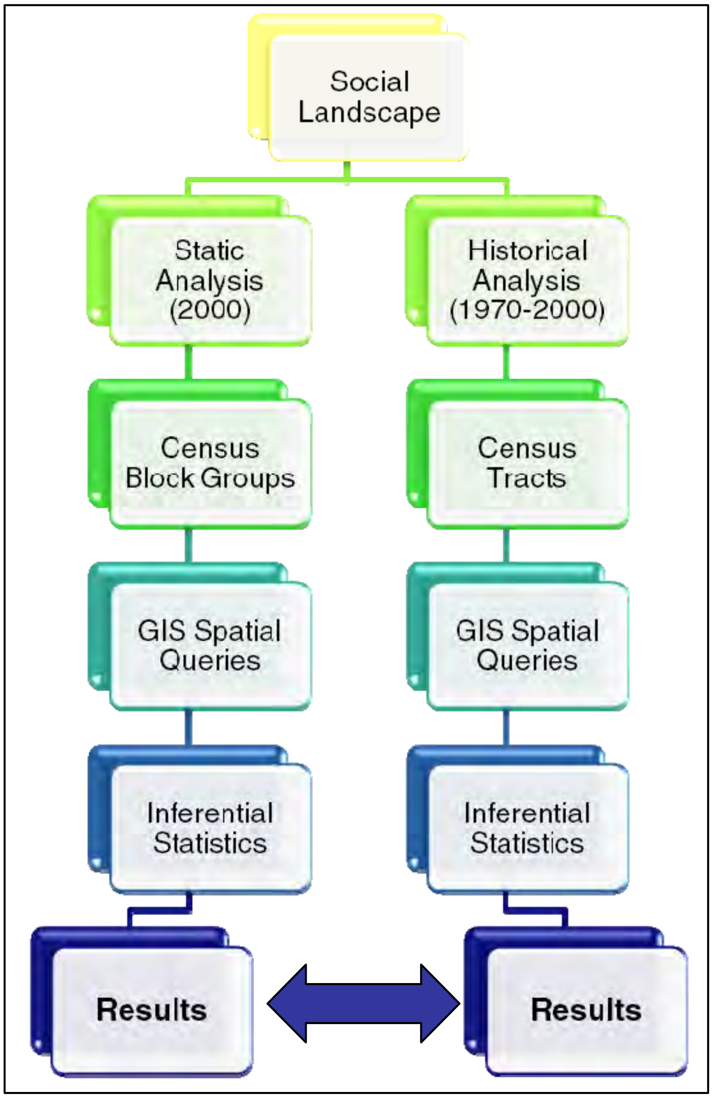

Figure 18: Conceptual Model of the Methodology.

are approaching reciprocity (see Table 1), therefore proportions of both racial categories cannot be used within the same regression analysis because doing so would violate the assumptions of regression analysis related to multicollinearity. Furthermore, residents indicating "white" or "African-American" represent 94.18 percent of the total population and demonstrate racial pluralities within 872 of 873 of the block groups in the study area (see Figure 20). Ergo, these two racial categories dominate the landscape, both statistically and spatially. Because whites and African-Americans represent the dominant racial categories in the study area, and prior studies have found that African-Americans were disproportionately exposed to the inundation induced by Hurricane Katrina (Campanella 2006; Logan 2006; Sharkey 2007), this study uses the proportion of African-Americans within a block group (and census tract in the subsequent temporal analysis) as the specified racial variable in the logit model.

Table 1: Race and Ethnicity within the Study Area.

Entire Urbanized Area (873 Block Groups)		
Population		**% of Total Population**
Total	1,011,337	100%
White	516,429	51.06%
African-American	436,075	43.12%
Asian	25,835	2.55%
Latino/Hispanic*	50,712	5.01%

**Considered an ethnicity; counted as white or African-American in racial tabulations.*

When available, median household income is the income variable preferred by most social scientists (Oliver 1999; Alba, Logan, and Stults 2000; Wyly and Holloway 2002; Peters and MacDonald 2004). While social scientists continue to employ other variables (e.g., those related to poverty and education) to represent socioeconomics in their research, only median household income provides a rich source of continuously scaled data that represents most closely the full spectrum of socioeconomic status. Therefore, in the initial static analysis, I used median household income as the specified socioeconomic variable. However, the census bureau did not offer the variable for median household income for the years 1970 and 1980, and therefore, average household income was used as a substitute in the subsequent temporal analysis. Because of this deficiency, the initial analysis includes two statistical models and their results—one using average household income, and one using median household income—for comparative purposes. The differences between the models were compared, thereby illuminating any potential considerations related to the use of the latter variable in the subsequent analysis.

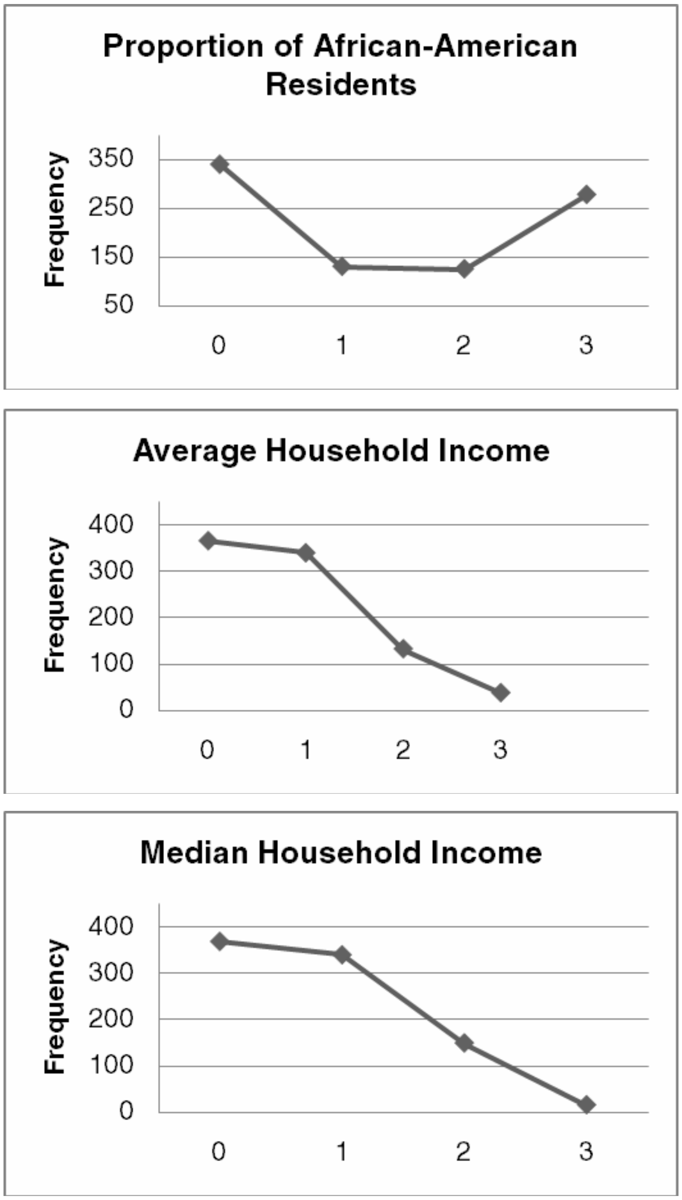

Figure 19: Frequency Distributions for the Independent Variables used in the Initial Analysis.

To begin the logit analysis, I exported the year 2000 census attribute data from Summary Files 1 and 3 to a database file for use in SPSS 14.0 (SPSS 2006) statistical software. Once in SPSS, I began by weighting each block group by its total population. Using this system of frequency weights, the model derives

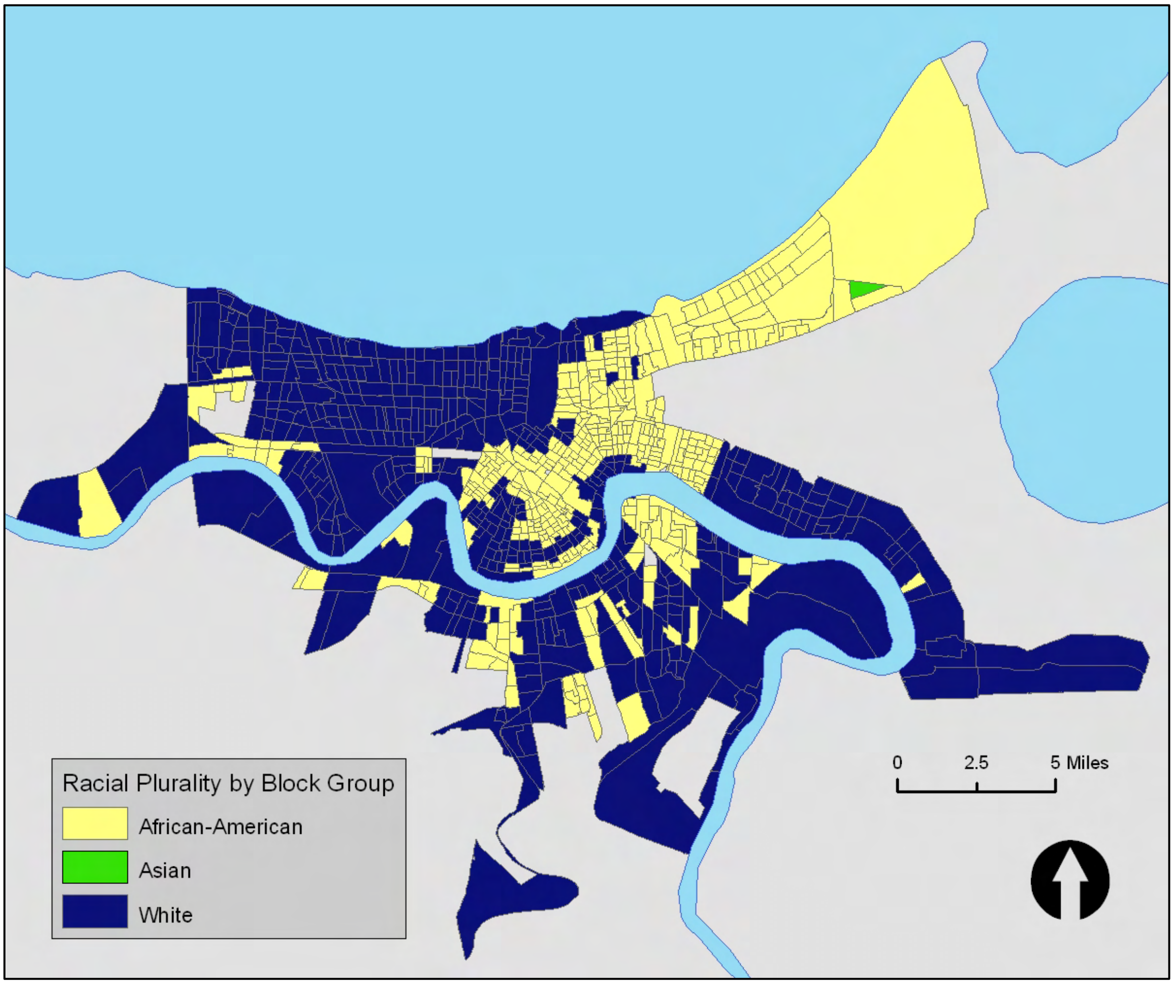

Figure 20: Racial Plurality by Block Group.

the power of each block group from the size of its total population. Therefore, a hypothetical block with a total population of 5000 was allowed ten times more power in the model than would a hypothetical block group with a population of 500. This is an important step, because, without the weighting system, relatively small block groups would have statistical power within the model equal to that of relatively larger block groups.

Next, I conducted a logit regression model using inundation (1=inundated, 0=non-inundated) as the binary dependent variable for the procedure. The independent variables used in the initial analysis represent the statistical effects of race and socioeconomics on the dependent variable—inundation. The variable representing race is the proportion of African-Americans within a block group, and the variable representing socioeconomics is median household income.

A logit model tests to what degree, if at all, a set of independent variables can predict the presence of a dependent variable—in this case inundation. Therefore, in this analysis, logit is used to discern whether race, socioeconomic status, or neither is significantly related to Katrina-induced inundation when the other variables are held constant. This means that the analysis seeks to find out if, when controlling for income, increases in the proportion of African-Americans within a block group affected (positively or negatively) the probability that the block group was flooded. Further, the model also asks if, when controlling for the effects of race, increases in household income within a block group affected (positively or negatively) the probability that the block group was flooded. If the model determines that a significant statistical relationship is apparent, the logit gives us the odds that an increase in each independent variable coincides with inundation or a lack thereof.

Because the logit regression model analyzes changes (increases and decreases) in the independent variables, breaks in the data are particularly important when using this method. Logit measures the effect of an increase in one unit of an independent variable on the dependent variable. Because the proportion of African-Americans and median household income are continuously scaled variables, these data must be parsed into groups (Liao 1994). Otherwise, the logit conducted here would essentially measure the effects of a one percent increase in African-American proportion and a one-dollar increase in median household income. Therefore, failure to parse the data would result in a spurious measurement of the variables. In this research, rather than select arbitrary breaks in the data such as quantiles or equal intervals, I chose to break the data into four classes in accordance with Jenks Natural Breaks (see Figure 19). The breaks for each variable during each decennial period were calculated separately to ensure that the breaks were specific to each distinct array of data. Adhering to the natural breaks in the data allows for a less subjective parsing of the data, therefore permitting the model to preserve the natural, incrementally scaled flow of the independent variables.

For a logit model, SPSS outputs two statistics relevant to this research—*Exponentialized Beta* values (or odds ratios) and *p* values (or levels of statistical significance). The odds ratio for each variable provides the odds that an increase of one unit in the independent variable coincides with an increase or decrease in the dependent variable. In the case of this research, these values were compared against one another to assess which of the independent variables was the more salient variable related to inundation. The *p* value generated for each variable estimates whether its odds ratio is statistically significant, providing the probability that the findings occurred due to chance. These values were used to apply (or, potentially, to disallow) statistical significance to each of the odds ratios.

To begin the temporal analysis, simple proportions for white and African-American residents were tabulated. These tabulations were compared to racial proportions in the zone of the inundation, and differential percentages were calculated. These simple tabulations are useful in exhibiting the proportional changes over time, and allow us to view simple changes in the population through the hypothetical lens of Katrina since 1970.

The temporal logit analysis was conducted in a manner very similar to the initial analysis with the key differences being the addition of temporal scale and a change in the unit of analysis. Once again, SPSS was used to conduct a logit regression, only this time, variables from the NCDB were used rather than the variables from Summary Files 1 and 3 of Census 2000 used in the previous analysis, and, by necessity, the unit of analysis ascended to the level of census tract. The variables used in the temporal analysis were the same as those used in the initial analysis, excluding median household income. As previously mentioned, the census bureau failed to tabulate median household income for the 1970 and 1980 censuses, therefore, only average household income was used in the temporal analysis. A separate logit regression was conducted for each of the censual collection periods of 1970, 1980, 1990, and 2000. Doing so controlled for Katrina’s inundation patterns across the thirty-five years prior to the storm.

CHAPTER VII

RESULTS

This chapter presents and displays the results of both analytical components. While the initial year 2005 analysis assesses the social landscape at the time of the storm, the results of the temporal analysis give us an idea of how the landscape evolved to produce the results derived by the initial analysis. For the years 1970, 1980, 1990, and 2000, each of the four tests represents a decennial benchmark for temporal comparison. Essentially, the temporal analysis takes into account the results of the empirical analysis from the time of Katrina and compares them to hypothetical results indicative of the previous 35 years. This analysis provides a temporal trajectory of the social landscape, illuminating the evolution of New Orleans' social geography through the lens of Hurricane Katrina.

Initial Analysis of 2005 New Orleans

When compared to household income (both median and average), race is the more salient variable in relation to inundation (see Table 2 and Figure 21). In the model employing median household income, the odds ratio [*Exp(B)*] for race is 2.646, while the odds ratio for income is just 1.276. Both variables are statistically significant with p values of less than .001.

These results indicate that, across all 873 block groups in the contiguous urbanized area surrounding New Orleans, an increase in one natural break of the

Table 2: Results of the Initial Analysis for the Year 2005.

Model 1 Independent Variables*	p	Exp(B)	Model 2 Independent Variables*	p	Exp(B)
Race	<.001	2.646	Race	<.001	2.715
Med HH Income	<.001	1.276	Avg HH Income	<.001	1.356
**dependent variable = Inundation*			**dependent variable = Inundation*		

proportion of African-American residents increased the odds of Katrina-induced inundation by a factor of 2.646, or more than 260 percent. Likewise, for block

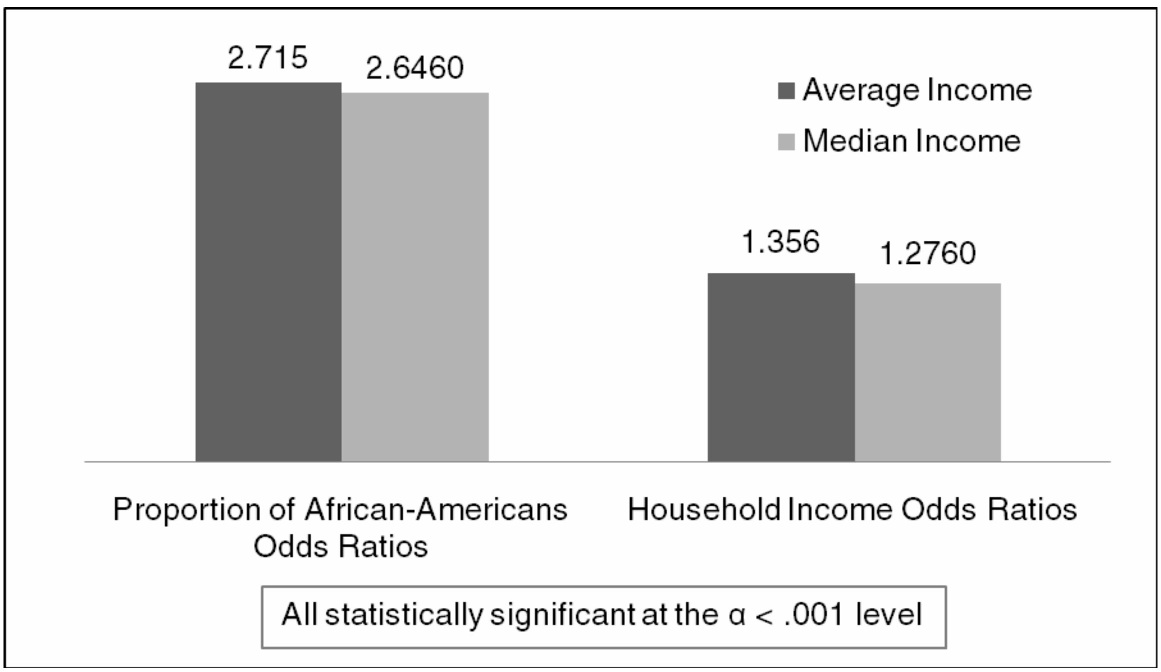

Figure 21: Initial Analysis. These results indicate that, when compared to income, race is the more salient variable in predicting inundation due to Katrina. Further, note the small difference in predictive power between median household income and average household income.

groups in the year 2000, an increase of one natural break in median household income increases the odds of inundation by a factor of 1.276, or almost 130 percent. As in any logistic regression analysis, the odds ratio for each of these variables was rendered while holding the effects of any other independent variables constant. This means that the odds ratio for race was calculated while controlling for the effects of income, and vice versa. In the model employing average household income, the results of both the racial and income variables increase slightly when compared to the results of the model employing median household income. In the model employing average household income, the variable for race increases from 2.646 to 2.715, and the variable for income increases from 1.276 to 1.356. This is a negligible difference because both sets of results are interpreted in practically the same manner, and led me to draw identical conclusions.

Temporal Analysis, 1970-2000

To begin the temporal analysis, I tabulated population figures from 1970-2000 in New Orleans (see Table 3). This tabulation assesses the proportions of whites and African-Americans in the total population for the years in question, as well as their proportions in the Katrina-induced inundation zone. Based on the tabulation, it is clear that African-Americans were overrepresented in the zone of inundation when compared to their proportion in the total population. The tabulation also shows that this disproportionate representation of the African-American community has increased since at least 1970. While the proportions of African-Americans have increased over time, the proportions of white residents within the flooded zone have declined steadily (see Table 3).

This tabulation is similar to census-based analyses conducted by Logan (2006), Campanella (2006, 2007), and Gabe et al. (2005). The figures produced in the tabulation described here, then, can be compared with those derived in previous studies to illuminate the differences in the results related to the chosen scales and units of analyses relative to each study.

Following the simple tabulation of racial proportions, I conducted the logit analysis. In each of the years assessed in the analysis, race is the more salient variable when compared to (and controlling for) income (see Table 4). The

Table 3: Racial Proportions among Whites and African-Americans only within the Study Area. The differential percentage represents the magnitude of under/over representation within the zone of inundation when compared to the total population.

Entire Urbanized Area (319 Census Tracts)			Inundated Area Only (137 Census Tracts)			
1970 Population		**% of Total Population**	**1970 Population**		**% of Total Inundated**	**Differential**
Total	972,151	100%	Total	489,012	100%	
White	658,709	67.76%	White	263,435	53.87%	-13.89%
African-American	310,646	31.95%	African-American	224,015	45.81%	13.86%
1980 Population		**% of Total Population**	**1980 Population**		**% of Total Inundated**	**Differential**
Total	1,077,939	100%	Total	469,740	100%	
White	680,871	63.16%	White	209,830	44.67%	-18.49%
African-American	374,273	34.72%	African-American	251,303	53.50%	18.78%
1990 Population		**% of Total Population**	**1990 Population**		**% of Total Inundated**	**Differential**
Total	1,016,204	100%	Total	431,477	100%	
White	590,425	58.10%	White	164,521	38.13%	-19.97%
African-American	391,226	38.50%	African-American	254,595	59.01%	20.51%
2000 Population		**% of Total Population**	**2000 Population**		**% of Total Inundated**	**Differential**
Total	1,012,560	100%	Total	425,329	100%	
White	524,601	51.81%	White	135,352	31.82%	-19.99%
African-American	440,672	43.52%	African-American	275,200	64.70%	21.18%

temporal analysis exhibits a readily evident trend of increased inundation probabilities within the statistical relationship in regard to both racial proportion and average household income (see Figure 22), with the magnitude of the racial variable increasing to a greater degree and by greater intervals overall when compared to the income variable.

For each year included in the analysis, the odds ratios for race are greater than income, and the intervals of increase among the racial variables are larger over time than the intervals of increase for income. In 1970, an increase of one natural break in African-American proportion increases the odds of inundation by a factor of 1.917, or almost 200 percent. This odds ratio increases steadily overtime, and, by 2000 (the census collection year most relevant to Hurricane Katrina), the same increase in one natural break increases the odds of inundation by a factor of 3.047, or over 300 percent. Conversely, in 1970, an increase of one natural break in average household income increases the odds of inundation by a factor of 1.065, or barely exceeding the constant of 100 percent. Again, the odds ratio increases steadily overtime and, by 2000, the same increase in one natural break increases the odds of inundation by a factor of 1.657, or around 170 percent.

Table 4: Temporal Logit Analysis.

1970		
Independent Variables*	*p*	Exp(B)
Race	<.001	1.9169
Avg HH Income	<.001	1.0646
1980		
Independent Variables*	*p*	Exp(B)
Race	<.001	2.2849
Avg HH Income	<.001	1.0997
1990		
Independent Variables*	*p*	Exp(B)
Race	<.001	2.5893
Avg HH Income	<.001	1.2339
2000		
Independent Variables*	*p*	Exp(B)
Race	<.001	3.0471
Avg HH Income	<.001	1.6565
**dependent variable = Inundation*		

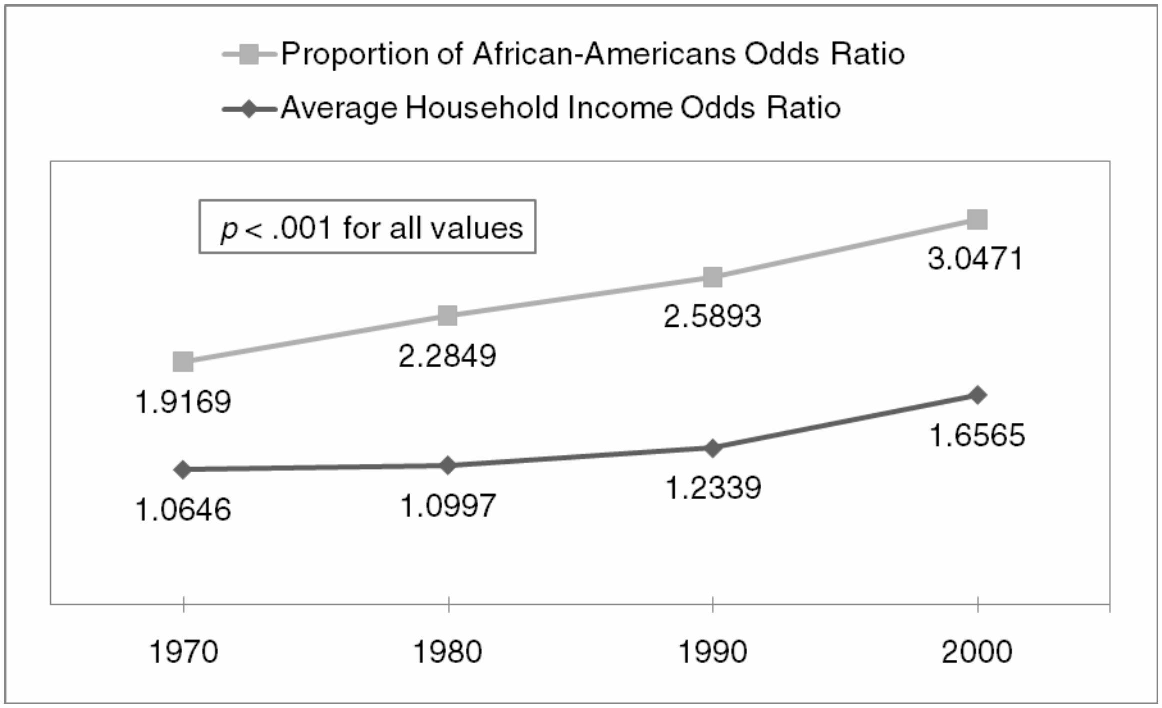

Figure 22: Trends in the Odds Ratios produced by the Temporal Analysis.

CHAPTER VIII

DISCUSSION

The results of the year 2005 analysis described here suggest that African-Americans were disproportionately exposed to the inundation wrought by Hurricane Katrina in the New Orleans area. Further, these results show that, in the case of Katrina, we find a significant relationship among inundation, race, and socioeconomics, and that, relative to these two factors, race demonstrates a more salient linear relationship with inundation. While an increase in median income increases the probability that a given block group would be flooded by a factor of 1.3, an increase in the proportion of African-Americans in a given block group increases the probability of inundation by a factor of 2.6. This means that race exhibits a stronger relationship with exposure to Katrina-induced flooding than does income. These results are similar to findings produced by Campanella (2006, 2007), Logan (2006), and Sharkey (2007) in that they attest to a disproportionate impact on the African-American community. However, the findings described here are the first rendered with a methodology that controls for the effects of the competing independent variables (race and income), and are the first derived from a sub-tract unit of analysis, i.e. block groups.

These results go beyond a mere demonstration of disproportionate exposure. After much speculation on the relationship among race, class, and inundation due to Katrina, these results suggest that race, not income, is the most salient variable related to Katrina's inundation, indicating that areas with relatively high concentrations of African-Americans were, on average, almost three times more likely to have been flooded than those with smaller proportions.

Even as these results emphasize the role of race in understanding the socio-spatial patterns of inundation, they also attest to the importance of socioeconomics in understanding Katrina's social impacts in the New Orleans area. According to these results, an increase in median income in a given block group corresponds with a slight increase (factor of 1.2) in the probability of inundation. Many observers would have perhaps expected a negative association between wealth and inundation in New Orleans, and based on popular assumptions concerning topography and biophysical flood vulnerability in the city (Campanella 2007), the socioeconomic results may ring counter-intuitive for some. However, when taken as a whole, the results of the analyses described here indicate a complex, multifarious relationship among race, class, and Katrina-induced inundation exposure in the New Orleans area, and given previous research into the major agents of social landscape change in New Orleans, these results are indeed intuitive.

A basic understanding of the geographic distribution of African-American proportion in New Orleans gives insight into the results discussed here (see Figure 23). While most of the areas with high concentrations of African-American residents are within the zone of Katrina-induced inundation, most of the areas with high concentrations of white residents are outside of the zone of inundation.

Therefore, the map in Figure 23 provides a clear and concise visual representation of the relationship between race and inundation inferred by the logistic regression.

Notable exceptions to this visible trend include the Lakeview area in western Orleans Parish along the border with Jefferson Parish and the urbanized

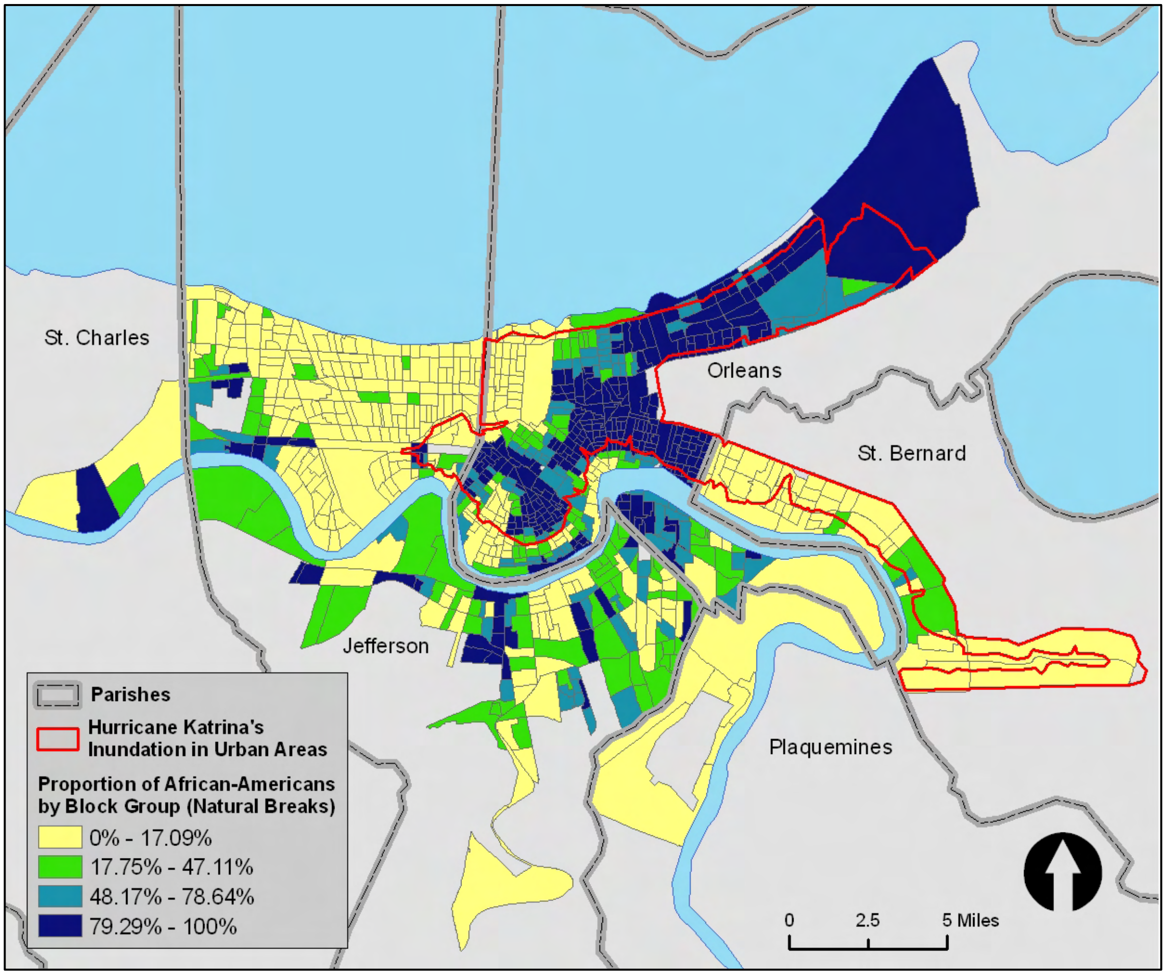

Figure 23: Proportion of African-American Residents with a Generalized Zone of Katrina-induced Inundation and Parish Boundaries.

areas in St. Bernard Parish. These areas contain high concentrations of white residents, and serve to counteract the dominant spatial trend somewhat.

Compared to the distribution of African-American proportions in the city, median income tends to be distributed more consistently across the landscape (see Figure 24). The areas in Orleans and Jefferson Parishes that fall inside the inundation zone contain relatively high population densities compared to areas in the periphery of the traditional urban core. As a result, the logit model weighted these inner city block groups (Orleans Parish and a small area of Jefferson Parish known as "Old Metairie") slightly more heavily due to their higher total populations. Particularly noteworthy in the map are the suburban areas of high relative wealth along the lakeshore, in St. Bernard Parish, and elsewhere within the inundated zone, and areas of low relative wealth outside of the inundated area on the "Westbank," or the southern side of the Mississippi River in Jefferson and Orleans Parishes. This sort of population distribution has dictated the socioeconomic portion of our statistical results.

As the initial year 2005 analysis has produced a snapshot of the social landscape as it relates to the patterns of inundation induced by Hurricane Katrina, the results of the temporal analysis suggest how historical shifts in New Orleans' social geography eventually produced the landscape apparent as the storm came ashore. Put differently, the results of the temporal analysis can help us to interpret and understand the results of the year 2005 analysis by situating New Orleans' social landscape within its historical context, thereby furthering our understanding of the geographic processes that underlay Katrina's human tragedy.

The results of the temporal analysis suggest that, regarding the African-American community and the relatively wealthy, and when patterns of inundation specific to Katrina are held constant, a trend of increasingly disproportionate exposure is evident since the 1970s. These results suggest a complex and alarming tendency. As our initial analysis indicates the existence of spatial segregation among racial and socioeconomic groups within the social landscape, the results of the temporal analysis suggest that, in terms of the patterns of inundation specific to Katrina, the landscape of exposure in New Orleans actually became *less* racially and socioeconomically equitable and increasingly racially

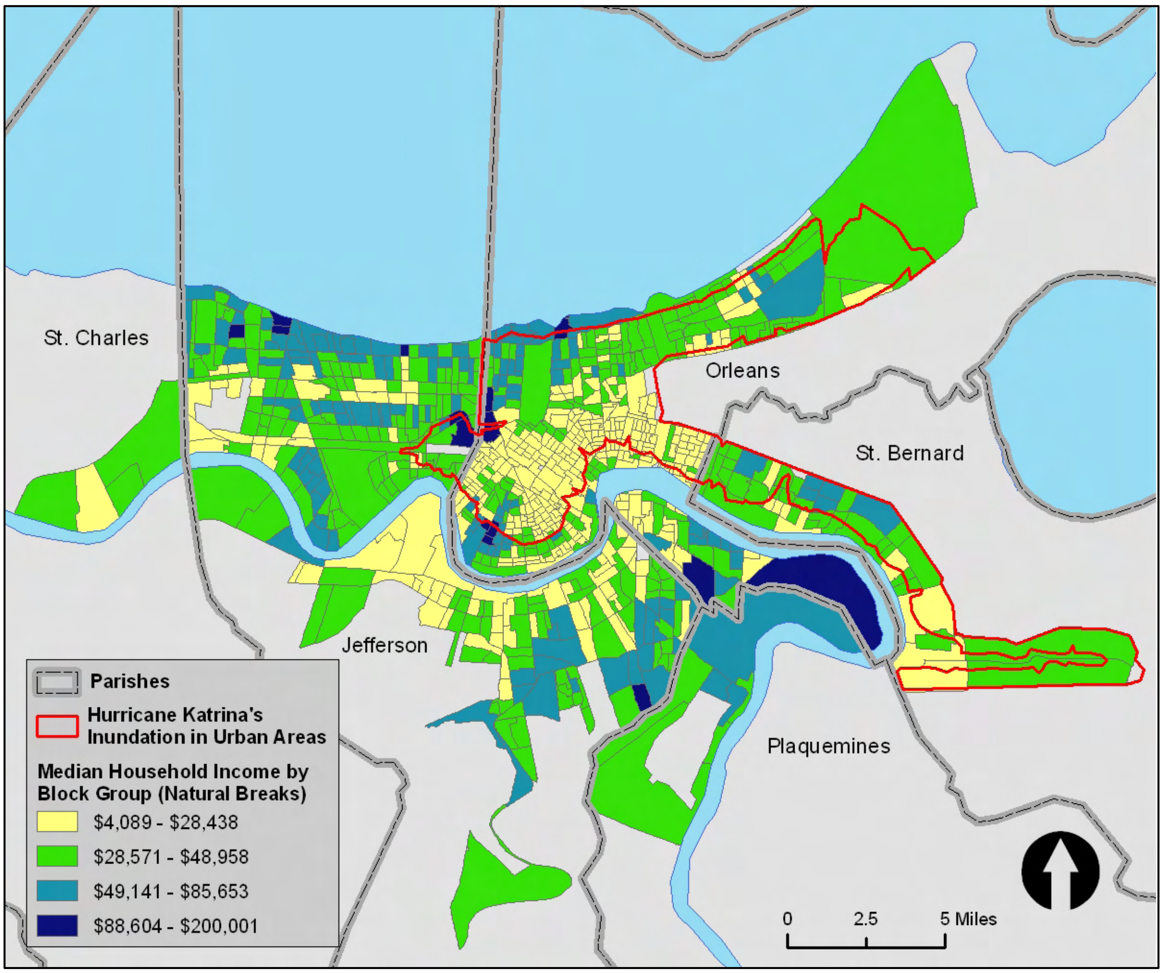

Figure 24: Median Household Income with a Generalized Zone of Katrina-induced Inundation and Parish Boundaries.

segregated from 1970 to 2000. Of course, this temporal analysis is, on its face, hypothetical, and we have no reason to believe that a subsequent Hurricane would produce patterns comparable to those produced by Katrina. However, these hypothetical results illuminate the trajectory of the social landscape as it changed over the contemporary period, and this trajectory can help to clarify our understanding of social landscape change in New Orleans and illuminate how these changes relate to Katrina's social impacts.

Without the results of the temporal analysis, we may be tempted to interpret the results of the initial 2005 analysis related to race as a historical relict embedded in and maintained by the contemporary landscape. That is, many observers may assume that the patterns of disproportionate exposure borne by the African-American community during Katrina were due primarily to the history of racial oppression in the U.S.—e.g., Jim Crow politics and discriminatory housing policies such as "redlining." However, the results of this study suggest that the socio-spatial patterns of racial segregation in New Orleans have increased in magnitude and become quantitatively worse since the climax of the civil rights movement, the advent of equal housing practices, and the implementation of modern hurricane protection infrastructure. If the ideals of racial and ethnic pluralism and desegregation are viewed as meritorious, this trend is certainly cause for concern. Because many assume that the story of post-1960s race relations in the U.S. is primarily one of "progress," findings such as those produced here can run counter to popular assumption. These results suggest that, in terms of geographic segregation, socio-spatial race relations in places like New Orleans are in some ways regressing.

However, the trend of racial segregation and inequity exhibited here is not a uniform or isolated process, and the results of this analysis related to socioeconomics reveal the conflicting nature of social landscape evolution in New Orleans. As these results suggest, what we see in New Orleans is a complex relationship of wealth, race, and geography dependent on patterns of residential development and strategies of environmental management. Therefore, this study demonstrates that the issues of race, class, and inundation in New Orleans are not as simple or as diametric as many commentators have lamented. The social tragedy induced by Katrina was not solely a product of American racial oppression as some have suggested, nor was it an arbitrary “natural disaster” disconnected from racially charged socio-geographic legacies as others have argued. Rather, the socio-spatial impacts of Hurricane Katrina are due to a range of obvious and obscure factors related to climatology, mechanical and structural engineering, land use policies, market trends in real estate and development, cultural idiosyncrasies, and personal preference. Yet, there are three archetypal geographic processes that have coalesced to drive the relationship of race, wealth, and geography evident in contemporary New Orleans. Understanding these processes can help us not only to understand the results of the analysis presented here, but also to reinforce our understanding of social landscape change in New Orleans and beyond. These processes include urban sprawl, White Flight, and Gilbert White’s (et al. 1958) observations on urban floodplain occupance. These processes are interrelated and each has a compelling and distinctly New Orleanian story to tell.

Urban sprawl is a typical urban phenomenon in the U.S. and elsewhere, but it continues to unfold in New Orleans somewhat atypically. Since the city's founding, urban expansion has been contingent on the drainage of wetlands. Therefore, suburbanization in New Orleans has occurred incrementally and more slowly than in most places in the U.S. (Colten 2005). Generally, an expensive array of levees, pumps, and canals are necessary to keep these low-lying former wetlands dry. Notwithstanding these difficulties, land developers and their advocates have managed to expand the city by encroaching upon the wetlands flanking New Orleans, albeit somewhat slowly by comparison.

In the late 1960s, hurricane protection levees implemented in response to Hurricane Betsy made a significant contemporary contribution to the process of wetland-drainage-suburbanization. Though Betsy induced much of the political will in support of the proposed structural mitigation, both federal and municipal boosters economically rationalized these new hurricane protection levees in part due to the expected development of the areas inside the ring of new levees. Despite concerns over land subsidence, federal engineers erected the system of levees, and, in doing so, set in motion a land development process that would rapidly create suburban neighborhoods in low-lying former wetlands along the southern shore of Lake Pontchartrain in Eastern Orleans Parish and in proximity to petro-chemical facilities in St. Bernard Parish, among other areas (Colten 2005). Environmental legislation such as NEPA has slowed the New Orleanian process of sprawl tremendously; however, less aggressive forms of the process continue in peripheral areas such as Harvey and Westwego on the “Westbank” (Guillet 2006; Gordon 2008).

An important byproduct of urban sprawl is White Flight. As sprawl continued to expand the urban area surrounding New Orleans in the 1960s, a surplus of suburban housing combined with the beginnings of school desegregation to initiate a particularly aggressive form of White Flight in the city (Landphair 1999; Lewis 2003). Whites began to leave the traditional urban core in droves (see Figures 8, 9, and 11). Unable to look beyond the potential increases in their tax bases due to new suburban development, local and federal officials promptly obliged would be suburban migrants by implementing expansive transportation and hurricane protection infrastructure projects. Soon the primarily white out migrants settled in various areas surrounding the old city, including areas in Jefferson, St. Tammany, St. Charles, and St. Bernard Parishes.

This emphatically New Orleanian form of White Flight helps to explain the statistical results dealing with race presented here. Katrina’s zone of inundation contains much of New Orleans’ aging urban core. The push factors of the inner city combined with the pull factors of suburban real estate and transportation and hurricane protection infrastructure to influence a heavy out-migration of white residents from the 1950s to the present. Lewis (2003) has previously outlined the process of White Flight in New Orleans and various scholars including Colten (2005) and Campanella (2006) have commented on its causes and effects, but this study is the first to use a robust quantitative methodology to relate White Flight to the social impacts of Katrina.

The process of White Flight is not uniform, and as previously stated, the New Orleanian relationship among race, wealth, and geography is complex. The results of this study suggest that the relatively wealthy and socially mobile became increasingly more likely to live within Katrina's zone of inundation from 1970 to 2000. Therefore, a socioeconomic trend is evident, and sprawl-powered White Flight cannot be the lone factor in accounting for the social patterns of Katrina's inundation.

The connection between structural flood mitigation and economic loss due to flooding is not a new concept to geographers. In 1958, Gilbert White et al. first observed that, as our collective expenditures on flood control infrastructure increase, so do our economic losses due to flooding. White exhibited how structural flood mitigation entices urban development in flood-prone areas newly "protected" by infrastructure. In New Orleans, the process of structural flood mitigation as a harbinger for residential land development has been particularly prominent. After draining wetlands and encircling them with flood control levees, pumping stations, drainage canals, and commuter freeways, middle-to-upper class New Orleanians have migrated into low-lying former wetlands in places like the southern shore of Lake Pontchartrain, New Orleans East, and urban St. Bernard Parish. Though these areas lie outside of New Orleans' aging urban core, they fall inside of the zone of inundation, and help to explain the relationship between income and inundation in the New Orleans metro area suggested by the results presented here. As White et al. (1958) pointed out, though structural mitigation may reduce risk *prima facie*, it often increases long-term hazard by enticing humans to occupy areas that might otherwise be deemed unsafe for residential development. No city owes its continued existence to structural flood mitigation more than New Orleans (Colten 2005). Therefore, the city and its patterns of wetland-drainage-suburbanization development provide a compelling case-in-point for White's observations.

In sum, the results produced by this research suggest that the interrelated forces of urban sprawl, White Flight, and structural hazard mitigation have combined to forge an unsettling trajectory of social landscape evolution in New Orleans (see Figure 25). This trend is unsettling in two key ways: 1) The African-American community found itself not only disproportionately exposed to Katrina's inundation, but within a trend of increasingly disproportionate exposure, and 2) the threat of economic loss has increased due to precarious patterns of land use and development within low-lying former wetlands. Further, the results of the analysis presented here, along with their related geographic processes, reinforce Pierce Lewis' (2003) observation that New Orleans is in some ways unique, but in many ways shares the same social and geographic processes evident in more typical U.S. cities. In my view, the geographic processes evident in New Orleans are comparable to the eclectic people of the city. While New Orleanians are susceptible to many of the same trends apparent in other cities, if they succumb to these external forces, they do so via a distinctly New Orleanian form.

However, even as the research discussed here is rooted firmly in New Orleans, its results are useful to urban areas across the globe. Planners and policymakers in Louisiana and in far-flung regions should perceive the failures of New Orleans' past as warnings of the tragedies that irresponsible land use and

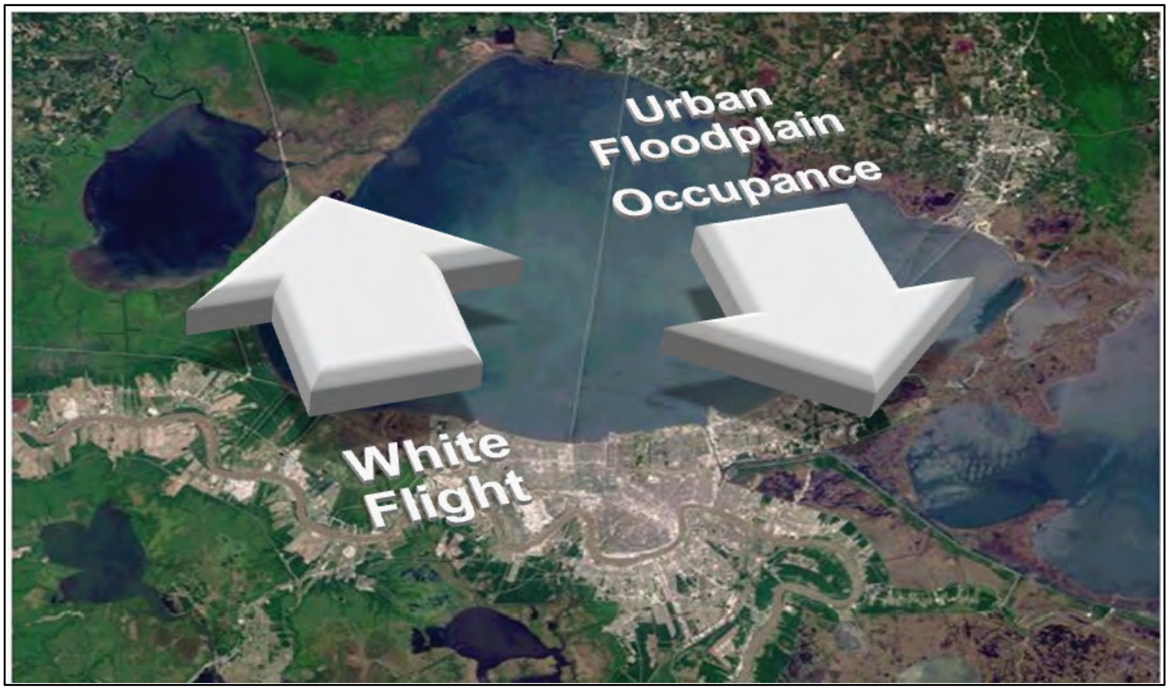

Figure 25: Sprawl-driven White Flight and the Observations of Gilbert White et al. (1958) on Urban Floodplain Occupance. These diverging but interrelated forces have helped to shape the social landscape and its relationship to flood hazard in New Orleans.

development can convey to its human occupants.

Further, the methodology employed here is in no way dependent on New Orleans or even hazard exposure, and could prove useful in explicating patterns of social landscape evolution in other areas. Finally, while this research uses the patterns of inundation produced by Hurricane Katrina as a lens through which it views major shifts in the social landscape, one could potentially employ an array of externalities to illuminate changes in various landscapes over time.

REFERENCES

Alba, Richard D., John R. Logan, and Brian J. Stults. 2000. How segregated are middle-class African Americans? *Social Problems* 47 (4): 543-558.

Anderson, M. B. 2000. Vulnerability to disaster and sustainable development: A general framework for assessing vulnerability. In *Storms (vol. 1)*, ed. R. Pielke, Jr. and R. Pielke, Sr. London: Routledge.

Associated Press. 2005. Hastert questions proposed efforts to rebuild. *Associated Press* 1 September. Available online at http://www.msnbc.msn.com/id/9164727/ (last accessed 7 December 2007).

Austin, D., B. Carriker, T. McGuire, J. Pratt, T. Priest, and A. G. Pulsipher. 2004. History of the offshore oil and gas industry in southern Louisiana: Interim report; Volume I: Papers on the evolving offshore industry. New Orleans, LA: U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region. Available online at http://www.gomr.mms.gov/PI/PDFImages/ESPIS/2/2994.pdf (last accessed 31 January 2008).

Barnes, Trevor. 2000a. Quantitative methods. In *The dictionary of human geography*, ed. R. J. Johnston, Derek Gregory, Geraldine Pratt, and Michael Watts, 663-664. Oxford; Malden, MA: Blackwell Publishers.

———. 2000b. Quantitative revolution. In *The dictionary of human geography*, ed. R. J. Johnston, Derek Gregory, Geraldine Pratt, and Michael Watts, 664-667. Oxford; Malden, MA: Blackwell Publishers.

Barrows, Harlan. 1923. Geography as human ecology. *Annals of the Association of American Geographers* 13 (1): 1-14.

Barry, John M. 1998. *Rising tide: The great Mississippi flood of 1927 and how it changed America*. New York: Simon & Schuster.

———. 2007. Our coast to fix—or lose. *Washington Post* 12 May: Editorial A15.

Baumbach, Richard O. Jr. and William E. Borah. 1981. The second battle of New Orleans : A history of the Vieux Carré riverfront-expressway controversy. Tuscaloosa: Published for the Preservation Press, National Trust for Historic Preservation in the United States by University of Alabama Press.

Behrman, Martin. 1914. Speech, "New Orleans, a history of three great public utilities: Sewerage, water, and drainage, and their influence upon the health and progress of a big city. Presented to the Convention of the League of American Municipalities, Milwaukee, Wisconsin 29 September. Louisiana Collection, Tulane University. Quoted in Juliette Landphair. 1999. Sewerage, sidewalks, and schools: The New Orleans Ninth Ward and public school desegregation. *Louisiana History* 40 (1): 35-62.

Bélanger, Eric, Michael S. Lewis-Beck, Jean Chiche, and Vincent Tiberj. 2006. Party, ideology, and vote intentions: Dynamics from the 2002 French Electoral Panel. *Political Research Quarterly* 59 (4): 503-515.

Blaikie, P., T. Cannon, I. Davis, and B. Wisner. 1994. *At risk: Natural hazards, people's vulnerability, and disasters*. London: Routledge.

Board of Commissioners of the Port of New Orleans. 2008. *Port of New Orleans*. New Orleans, LA: Board of Commissioners of the Port of New Orleans. Available online at http://www.portno.com/ (last accessed 30 January 2008).

Brewer, Cynthia A. and Linda Pickle. 2002. Evaluation of methods for classifying epidemiological data on choropleth maps in a series. *Annals of the Association of American Geographers* 92 (4): 662-681.

Broder, John M., Jodi Wilgoren, and Jeremy Alford. 2005. Amid criticism of federal efforts, charges of racism are lodged. *Washington Post* 5 September: A9.

Brouwer, Greg. 2003. The creeping storm. *Civil Engineering* 73 (6): 46-88.

Bullard, Robert D. 2007. Equity, unnatural man-made disasters, and race: Why environmental justice matters. *Research in Social Problems and Public Policy* 15: 51-85.

Bumiller, Elisabeth. 2005. Gulf coast isn't the only thing left in tatters; Bush's status with blacks takes a hit. *New York Times* 12 September: A17.

Burton, Ian. 1963. The quantitative revolution and theoretical geography. *Canadian Geographer* 7 (4): 151-162.

Burton, Ian, Robert William Kates, and Gilbert F. White. 1993. *The environment as hazard* (2nd ed.). New York: Guilford Press.

Campanella, Richard. 2002. *Time and place in New Orleans: Past geographies in the present day.* Gretna, LA: Pelican.

———. 2006. *Geographies of New Orleans : Urban fabrics before the storm.* Lafayette, LA: Center for Louisiana Studies.

———. 2007. An ethnic geography of New Orleans. *The Journal of American History* 94 (3): 704-715.

Campanella, Richard and Marina Campanella. 1999. *New Orleans then and now*. Gretna, LA: Pelican.

Chen, Robert S. 1994. The human dimension of vulnerability. In *Industrial ecology and global change*, ed. R. Socolow, C. Andrews, F. Berkhout and V. Thomas, 85-105. Cambridge: Cambridge University Press.

Colten, Craig E. 1990. Historical hazards: the geography of relict industrial wastes. *Professional Geographer* 42 (2): 143-56.

———. 1991. A historical perspective on industrial wastes and groundwater contamination. *Geographical Review* 81(2): 215-28.

———. 2002a. Basin Street blues: Drainage and environmental equity in New Orleans, 1890-1930. *Journal of Historical Geography* 28 (2): 237-57.

———. 2002b. Reintroducing nature to the city: Wetlands in New Orleans. *Environmental History* 7 (2): 226-246.

———. 2005. *An Unnatural Metropolis: Wresting New Orleans from Nature*. Baton Rouge: LSU Press.

———. 2006a. Conspiracy of the levees: The latest battle of New Orleans. *World Watch* 19 (5): 8-12.

———. 2006b. The Rusting of the Chemical Corridor. *Technology and Culture* 47 (1): 95-101.

———. 2007. Environmental justice in a landscape of tragedy. *Technology in Society* 29 (2): 173-179.

Colten, Craig E., ed. 2000. *Transforming New Orleans and its environs: Centuries of change.* Pittsburgh: University of Pittsburgh Press.

Colten, Craig E. and Peter N. Skinner. 1996. *The road to Love Canal: Managing industrial wastes before EPA*. Austin: University of Texas Press.

Computer Aided Design and Geographic Information Systems (CADGIS) Research Lab, Louisiana State University, Baton Rouge, LA. 2005. *LSU GIS information clearinghouse*. Available online at http://www.katrina.lsu.edu (last accessed 1 October 2006).

Cowdrey, Albert E. 1977. *Lands end: A history of the New Orleans district, U.S. Army Corps of Engineers, and its life long battle with the lower Mississippi and other rivers wending their way to the sea*. New Orleans, LA: Department of Defense, Department of the Army, Corps of Engineers, New Orleans District.

Coy, Peter. 2005. The big questions about the big easy. *Business Week* 12 September. Available online at http://www.businessweek.com/bwdaily/dnflash/ep2005/nf20050912_8974_db016.htm (last accessed 7 December 2007).

Cutter, Susan L. 1996. Vulnerability to environmental hazards. *Progress in Human Geography* 20 (4): 529-539.

———. 2006. The geography of social vulnerability: Race, class, and catastrophe. In *Understanding Katrina: Perspectives from the Social Sciences,* ed. Social Science Research Council. Available online at http://understandingkatrina.ssrc.org/Cutter/ (last accessed 7 November 2007).

Cutter, Susan L., Bryan J. Boruff, and W. Shirley. 2003. Social vulnerability to environmental hazards. *Social Science Quarterly* 84 (2): 242-261.

Cutter, Susan L. and Christopher T. Emrich. 2006. Moral hazard, social catastrophe: The changing face of vulnerability along the hurricane coasts. *The ANNALS of the American Academy of Political and Social Science* 604 (1): 102-112.

Cutter, Susan, Jerry T. Mitchell, and Michael S. Scott. 2000. Revealing the vulnerability of people and places: A case study of Georgetown County, South Carolina. *Annals of the Association of American Geographers* 90 (4): 713-737.

Cutter, Susan L. and William D. Solecki. 1989. The national pattern of airborne toxic releases. *Professional Geographer* 41(2): 149-161.

Cutter, Susan L. and John Tiefenbacher. 1991. Chemical hazards in urban America. *Urban Geography* 12 (5): 417-430.

Daigle, J. J., G. E. Griffith, J. M. Omernick, P. L. Faulkner, R. P. McCullogh, L. R. Handley, L. M. Smith, and S. S. Chapman. 2006. *Ecoregions of Louisiana* (color poster with map, descriptive text, summary tables, and photographs): Reston, Virginia, U.S. Geological Survey (map scale 1:1,000,000).

Davis, Jack. 2005. Forum: Should New Orleans be rebuilt? Yes. *Pittsburgh Post-Gazette* 11 September. Available online at http://www.post-gazette.com/pg/05254/568906.stm (last accessed 11 December 2007).

Day, John W., Jr., Louis D. Britsch, Suzanne R. Hawes, Gary P. Shaffer, Denise J. Reed, and Donald Cahoon. 2000. Pattern and process of land loss in the Mississippi Delta: A spatial and temporal analysis of wetland habitat change. *Estuaries* 23 (4): 425-438.

Day, John W., Jr., Donald F. Boesch, Ellis J. Clairain, G. Paul Kemp, Shirley B. Laska, William J. Mitsch, Kenneth Orth, Hassan Mashriqui, Denise J. Reed, Leonard Shabman, Charles A. Simenstad, Bill J. Streever, Robert R. Twilley, Chester C. Watson, John T. Wells, and Dennis F. Whigham. 2007. Restoration of the Mississippi Delta: Lessons from Hurricanes Katrina and Rita. *Science* 315 (5819): 1679-1684.

Digital Globe and TerraMetrics. 2008. Photogrammetric image in Google, Inc. 2007. Google Earth for Windows XP (SP 2) (Version 4.2.0205.5730). Mountain View, CA. Information available online at http://earth.google.com/. (Computer software).

Dow, Kirstin. 1992. Exploring differences in our common future(s): The meaning of vulnerability to global environmental change. *Geoforum* 23 (3): 417-436.

Duke, Lynne and Teresa Wiltz. 2005. Katrina blew in, and tossed up reminders of a tattered racial legacy. *Washington Post* 4 September: D1.

Dyson, Michael Eric. 2006. *Come hell or high water: Hurricane Katrina and the color of disaster*. New York: Basic Civitas.

Elliot, James R. and Jeremy Pais. 2006. Race, class, and Hurricane Katrina: Social differences in human responses to disaster. *Social Science Research* 35 (2): 295-321.

Endfield, Georgina H. 2007. Archival explorations of climate variability and social vulnerability in colonial Mexico. *Climatic Change* 83 (1-2): 9-38.

Endfield, Georgina H. and Isabel Fernández Tejedo. 2006. Decades of drought, years of hunger: Archival investigations of multiple year droughts in late colonial Chihuahua. *Climatic Change* 75 (4): 391-419.

Endfield, Georgina H., Isabel Fernández Tejedo, and Sarah L. O'Hara. 2004. Drought and disputes, deluge and dearth: Climatic variability and human response in colonial Oaxaca, Mexico. *Journal of Historical Geography* 30 (2): 249-276.

Environmental Systems Research Institute (ESRI). ArcGIS 9.2. ESRI, Redlands, CA. Information available from http://esri.com. (Computer software).

Fairclough, Adam. 1995. *Race and democracy: The civil rights struggle in Louisiana, 1915-1972*. Athens, GA: University of Georgia Press.

———. 2004. Louisiana: The civil rights struggle*, 1940-1954.* In *Before Brown: Civil rights and white backlash in the modern South,* ed. Glenn Feldman, 144-169. Tuscaloosa, AL: The University of Alabama Press.

Faulkner, Douglas J. 1998. Spatially variable historical alluviation and channel incision in West-Central Wisconsin. *Annals of the Association of American Geographers* 88 (4): 666-685.

Federal Emergency Management Agency (FEMA).1995. *National Mitigation Strategy: Partnerships for Building Safer Communities*. Washington, D.C.: Government Printing Office. Quoted in Cutter, Susan, Jerry T. Mitchell, and Michael S. Scott. Revealing the Vulnerability of People and Places: A Case Study of Georgetown County, South Carolina. *Annals of the Association of American Geographers* 90 (4): p. 713-737.

Federal Emergency Management Agency (FEMA). 2006a. [unnamed press release]. 12 January. Quoted in Hsu, Spencer S. 2006. 2 Million Displaced by Storms. *Washington Post.* 13 January, Friday. 3 (A).

Federal Emergency Management Agency (FEMA). 2006b. NEPA alternative arrangements for critical physical infrastructure in New Orleans. 23 March. Federal Register, Vol. 71(56): 14712-14716 available online at http://www.epa.gov/fedrgstr/EPA-IMPACT/2006/March/Day-23/i4191.htm (last accessed 2 February 2008).

Finch, Susan. 2008. Corps off hook for N.O. canal lapses: But judge blasts agency's failings. *The Times Picayune* (New Orleans). 31 January. Available online at http://www.nola.com/news/tp/frontpage/index.ssf?/base/news-10/1201761402258230.xml&coll=1 (last accessed 31 January 2008).

Fletcher, Michael A. 2005. Katrina pushes issues of race and poverty at Bush. *Washington Post* 12 September: A2.

Fletcher, Michael A. and Richard Morin. 2005. Bush's approval rating drops to new low in wake of storm; He says race didn't affect efforts; Blacks in poll disagree. *The Washington Post* 13 September: A8.

Ford, Richard Thompson. 2008. The race card: How bluffing about bias makes race relations worse. New York : Farrar, Straus and Giroux.

Freedman, David A. 1999. Ecological inference and the ecological fallacy. Prepared for the *International Encyclopedia of the Social & Behavioral Sciences*, Technical Report No. 549. Available online at http://www.stanford.edu/class/ed260/ freedman549.pdf (last accessed 10 December 2007).

Friedman, George. 2005. New Orleans' raison d'être. *Los Angeles Times* 11 September. Available online at http://www.latimes.com/news/printedition/ suncommentary/la-op-neworleans11sep11,1,4449903.story? coll=la-headlines-suncomment (last accessed 7 January 2006).

Gabe, Thomas, Gene Falk, Maggie McCarty, and Virginia W. Mason. 2005. *Hurricane Katrina: Social-demographic characteristics of impacted areas*. Washington, D.C.: Congressional Research Service, The Library of Congress. Available online at http://www.gnocdc.org/reports/crsrept.pdf (last accessed 13 December 2007).

Geronimus, Arline T. and John Bound. 1998. Use of Census-based aggregate variables to proxy for socioeconomic group: Evidence from national samples. *American Journal of Epidemiology* 148 (5): 475-486.

Geolytics, Inc. and The Urban Institute. 2003. Neighborhood Change Database (NCDB) 1970-2000 Tract Data. East Brunswick, NJ. (Computer Software). Information available from http://www.geolytics.com/USCensus, Neighborhood-Change-Database-1970-2000,Products.asp (last accessed 11 December 2007).

Gingrich, Newt and John M. Barry. 2005. Why New Orleans Needs Saving. *Time.* Available online at http://www.time.com/time/magazine/article/ 0,9171,1169133,00.html (last accessed 7 December 2007).

Glaeser, Edward L. 2005. Should the government rebuild New Orleans, or just give residents checks? *Economists' Voice* 2 (4): article 4.

Godfrey, Brian J. 1995. Restructuring and decentralization in a world city. *Geographical Review* 85 (4): 436-457.

Gordon, Meghan. 2008. Contract to make levee larger. *The Times Picayune* (New Orleans). 21 March. Available online at http://www.nola.com/news/t-p/index.ssf?/base/news-27/1206077526230110.xml&coll=1 (last accessed 10 April 2008).

Gould, Peter. 1969. Methodological developments since the fifties. *Progress in Geography* 1: 1-49.

Goss, Jon. 1995. “We know who you are and we know where you live”: The instrumental rationality of geodemographic systems. *Economic Geography* 71 (2): 171-198.

Greater New Orleans Data Center. 2007. http://www.gnocdc.org/. Neighborhood boundaries available online at http://www.gnocdc.org/mapping/docs/Neighborhood.pdf (last accessed 10 December 2007).

Guillet, Jaime. 2006. Tech park set to spark West Bank boom in N.O. *New Orleans City Business.* 1 May. Available online at http://findarticles.com/p/articles/mi_qn4200/is_20060501/ai_n16214455 (last accessed 10 April 2008).

Hagelman, Ron. 2003. Review of *New Orleans: The making of an urban landscape* (2nd ed.), by Pierce F. Lewis, *Geographical Review* 93 (3): 421-424.

———. 2008. Conversation with author. January 17. San Marcos, TX. Personal communication.

Halpern, Stephen C. 1995. *On the limits of the law: The ironic legacy of Title VI of the 1964 Civil Rights Act*. Baltimore: Johns Hopkins University Press.

Hamnett, Chris, ed. 1996. *Social geography: A reader*. London: Arnold.

Hartshorne, Richard. 1939. *The nature of geography*. Lancaster, PA: Association of American Geographers.

Harvey, David. 1973. *Social justice and the city*. London: Edward Arnold.

Heinz Center for Science, Economics, and the Environment. 2002. *Human links to coastal disasters.* Washington, D.C.: The H. John Heinz III Center for Science, Economics, and the Environment.

Hewitt, K. 1997. *Regions of risk: A geographical introduction to disasters*. Essex: Longman.

Holloway, Steven R. 1998. Exploring the neighborhood contingency of race discrimination in mortgage lending in Columbus, OhioTT. *Annals of the Association of American Geographers* 88 (2): 252-276.

Jacob, Klaus. 2005. Time for a tough question: Why rebuild? *Washington Post* 6 September: A25.

Johnson, Peter. 2005. Katrina may unleash a media storm. *USA Today* 6 September: D1.

Kasperson, J. X., R. E. Kasperson, and B. L. Turner, eds. 1995. *Regions at risk: Comparisons of threatened environments*. Tokyo: United Nations University Press.

Kasperson, Roger E., Ortwin Renn, Paul Slovic, Halina S. Brown, Jacque Ernel, Robert Goble, Jeanne X. Kasperson, and Samuel Ratick. 1988. The social amplification of risk: A conceptual framework. *Risk Analysis* 8 (2): 177-187.

Kates, R. W., C. E. Colten, S. Laska, and S. P. Leatherman. 2006. Reconstruction of New Orleans after Hurricane Katrina: A Research Perspective. *Proceedings of the National Academy of Sciences of the United States of America* 103 (40): 14653-14660.

Keim, Barry David. 1990. *Synoptic weather, frequency, and magnitude analyses of heavy rainfall in New Orleans, Louisiana, 1871-1989*. Master's thesis (M.S.), Department of Geography and Anthropology, Louisiana State University, Baton Rouge, LA.

Keim, Barry David and Robert A. Muller. 1992. Temporal fluctuations of heavy rainfall magnitudes in New Orleans, Louisiana: 1871-1991. *Journal of the American Water Resources Association* 28 (4): 721-730.

Kelman, Ari. 2003. *A river and its city: The nature of landscape in New Orleans*. Berkeley, CA: University of California Press.

———. 2007. Boundary issues: Clarifying New Orleans's murky edges. *The Journal of American History* 94 (3): 695-703.

Killian, Lutz. 2006. *Not all oil price shocks are alike: Disentangling demand and supply shocks in the crude oil market*. London: Centre for Economic Policy Research.

Knabb, Richard D., Jamie R. Rhome, and Daniel P. Brown, eds. 2005. Tropical Cyclone Report: Hurricane Katrina. National Oceanic and Atmospheric Administration (NOAA), National Hurricane Center (43): Miami, FL. Available online at http://www.nhc.noaa.gov/pdf/TCR-AL122005_Katrina.pdf (last accessed 12 December 2007).

Korte, George B. 2001. *The GIS book*. Australia; Albany, NY: OnWord Press.

Kysar, Douglas A. and Thomas Owen McGarity. 2006. *Did* NEPA drown New Orleans? The levees, the blame game, and the hazards of hindsight. *Duke Law Journal, 36th Annual Administrative Law Symposium 5*6. Available online at http://ssrn.com/abstract=928869 (last accessed 2 February 2008).

Landphair, Juliette. 1999. Sewerage, sidewalks, and schools: the New Orleans Ninth Ward and public school desegregation. *Louisiana History* 40 (1): 35-62.

———. 2007. "The forgotten people of New Orleans": Community, vulnerability, and the Lower Ninth Ward. *The Journal of American History* 94 (3): 837-845.

Lavelle, Kristen and Joe Feagin. 2006. Hurricane Katrina: The race and class debate. *Monthly Review* 58 (3): 52-66.

Lewis, Pierce F. 2003. *New Orleans: the making of an urban landscape*. 2nd ed. Santa Fe: Center for American Places in association with the University of Virginia Press, Charlottesville, VA: University of Virginia Press.

Liao, Tim Futing. 1994. *Interpreting probability models: Logit, probit, and other generalized linear models*. Thousand Oaks, CA: Sage.

Loevy, Robert D., ed. 1997. *The Civil Rights Act of 1964: The passage of the law that ended racial segregation*. Albany, NY: State University of New York Press.

Logan, John R. 2006. *The impact of Katrina: Race and class in storm-damaged neighborhoods*. Hurricane Katrina project, initiative on spatial structures in the social sciences. Providence, RI: Brown University. Available online at http://www.s4.brown.edu/ Katrina/report.pdf (last accessed 30 March 2007).

Longhurst, R. 1995. The assessment of community vulnerability in hazard prone areas. *Disasters* 19 (3): 269-270.

Louisiana Department of Health and Hospitals. 2006. Report of missing and deceased, August 2, 2006. Available online at http://www.dhh.louisiana.gov/offices/page.asp?ID=192&Detail=5248 (last accessed 11 December 2007).

Mann, Eric. 2006. Race and the high ground in New Orleans. *World Watch* 19 (5): 40-42.

Masozera, Michel, Melissa Bailey, and Charles Kerchner. 2006. Distribution of impacts of natural disasters across income groups: A case study of New Orleans. *Ecological Economics* 63 (1): 299-306.

Marable, Manning. 2006. Race, class, and the Katrina crisis. *WorkingUSA* 9 (2): 155-160.

Martin, François X. 1976. *History of Louisiana from the earliest period* (3rd ed.). New Orleans: Pelican.

Mathewson, Kent and Martin S. Kenzer, eds. 2003. Culture, land, and legacy: Perspectives on Carl O. Sauer and Berkeley School Geography. Baton Rouge, LA: Geoscience Publications (Geoscience and Man, 37).

Meinig, D. W. 1978. The continuous shaping of America: A prospectus for geographers and historians. *The American Historical Review* 83 (5): 1186-1205.

———. 1989. The historical geography imperative. *Annals of the Association of American Geographers* 79 (1): 79-87.

———. 1992. A life of learning. *American Council of Learned Societies, Occasional Paper No. 19.* Available online at http://www.acls.org/uploadedfiles/publications/op/haskins/1992_donaldwmeinig.pdf (last accessed 23 February 2008).

Meinig, D. W., ed. 1979. Introduction. In *The interpretation of ordinary landscapes.* Oxford: Oxford University Press.

Menard, Scott W. 2002. *Applied logistic regression analysis* (2nd ed.). Thousand Oaks, CA: Sage.

Merchant, Carolyn. 2002. *The Columbia guide to American environmental history*. New York : Columbia University Press.

Milloy, Courtland. 2005. The daily crush of poverty, strong as any storm. *Washington Post* 5 September: B01.

Minot, Nicholas and Bob Baulch. 2005. Poverty mapping with aggregate census data: What is the loss in precision? *Review of Development Economics* 9 (1): 5-24.

Mitchell, J.K., N. Devine, and K. Jagger. 1989. A contextual model of natural hazard. *Geographical Review* 79 (4): 391-409.

National Climatic Data Center. 2006. *Comparative climatic data for the United States through 2006.* Asheville, NC: National Climatic Data Center, National Oceanic and Atmospheric Administration (NOAA), United States Department of Commerce. Available online at http://ols.nndc.noaa.gov/plolstore/plsql/olstore.prodspecific?prodnum=C00095-PUB-A0001 (last accessed 28 January 2008).

No Author. 2005a. Hurricane exposes issues of class, race. *USA Today* 2 September: A20.

———. 2005b. Race isn't factor in response to natural disaster. *USA Today* 12 September: A22.

O'Keefe, Phil, Ken Westgate, and Ben Wisner. 1976. Taking the naturalness out of natural disasters. *Nature* 260 (5552): 566-567.

Oliver, J. Eric. 1999. The effects of metropolitan economic segregation on local civic participation. *American Journal of Political Science* 43 (1): 182-212.

Olwig, Kenneth R. 1996. Recovering the substantive nature of landscape. *Annals of the Association of American Geographers* 86 (4): 630-653.

Page, Susan and Maria Puente. 2005. Views of whites, blacks differ starkly on disaster. *USA Today* 13 September: A1.

Peters, Alan and Heather MacDonald. 2004. *Unlocking the census with GIS*. Redlands, CA: ESRI Press.

Piazza, Tom. 2005. *Why New Orleans matters*. New York: ReganBooks.

Pickles, John. 1997. Tool or science? GIS, technoscience, and the theoretical turn. *Annals of the Association of American Geographers* 87 (2): 363-372.

Price, Marie and Martin Lewis. 1993. The reinvention of cultural geography. *Annals of the Association of American Geographers* 83 (1): 1-17.

Proctor, James D. 1998. The social construction of nature: Relativist accusations, pragmatist and critical realist responses. *Annals of the Association of American Geographers* 88 (3): 352-376.

Pulido, Laura. 2000. Rethinking environmental racism: White privilege and urban development in Southern California. *Annals of the Association of American Geographers* 90 (1): 12-40.

Rodríguez, Havidán and Russell Dynes. 2006. Finding and framing Katrina: The social construction of disaster. In *Understanding Katrina: Perspectives from the Social Sciences,* ed. Social Science Research Council. Available online at http://understandingkatrina.ssrc.org/ Dynes_Rodriguez/ (last accessed 15 November 2007).

Romero, Simon. 2005. Port of New Orleans needs its city back. *International Herald Tribune* 6 October: Available online at http://www.iht.com/articles/ 2005/10/06/business/port.php (last accessed 30 January 2008).

Ruether, Rosemary R. 2006. After Katrina: poverty, race, and environmental degradation. *Dialog: A Journal of Theology* 45 (2): 176-183.

Sauer, Carl O. 1963. The morphology of landscape. In *Land and life: A selection from the writings of Carl Ortwin Sauer*, ed. John Leighly. Berkeley: University of California Press.

Scott, Loren C. 2007. *The energy sector: Still a giant economic engine for the Louisiana economy*. Baton Rouge, LA: Louisiana Mid-Continent Oil and Gas Association. Available online at http://www.lmoga.com/information/ erfull.pdf (last accessed 31 January 2008).

Sewerage and Water Board of New Orleans. 2004. *Drainage facts.* Available online at http://www.swbno.org/drainagefacts.html (last accessed 26 January 2008).

Shafer, Jack. 2005. *Don’t refloat: The case against rebuilding the sunken city of New Orleans* 7 September: Available online at http://www.slate.com/id/ 2125810/ (last accessed 7 December 2007).

Sharkey, Patrick. 2007. Survival and death in New Orleans: An empirical look at the human impact of Katrina. *Journal of Black Studies* 37 (4): 482-501.

Simerman, John, Dwight Ott, and Ted Mellnik. 2005. Assumptions about Katrina victims may be incorrect, data reveal. *Knight Ridder Newspapers* 29 December: Available online at http://www.accessmylibrary.com/coms2/ summary_0286-12188761_ITM (last accessed 15 November 2007).

Sluyter, Andrew. 2001. Colonialism and landscape in the Americas: Material/conceptual transformations and continuing consequences. *Annals of the Association of American Geographers* 91 (2): 410-429.

Smith, Neil. 2006. There's no such thing as a natural disaster. *In Understanding Katrina: Perspectives from the Social Sciences, ed. Social Science Research Council.* Available online at http://understandingkatrina.ssrc.org/ Smith/ (last accessed 15 November 2007).

Smith, Jodie and James Rowland. 2007. Temporal analysis of floodwater volumes in New Orleans after Hurricane Katrina. In *Science and the storms: The USGS response to the hurricanes of 2005*, eds. G.S. Farris, G.J. Smith, M.P. Crane, C.R. Demas, L.L. Robbins, and D.L. Lavoie. Reston, VA: U.S. Geological Survey circular 1306.

Souther, J. Mark. 2007. The Disneyfication of New Orleans: The French Quarter as facade in a divided city. *The Journal of American History* 94 (3): 804-811.

Spain, Daphne. 1979. Race relations and residential segregation in New Orleans: Two centuries of paradox. *Annals of the American Academy of Political and Social Science* 441 (1): 82-96.

SPSS, Inc. 2006. SPSS 14.0 for Windows. Chicago, IL. Information available from http://spss.com. (Computer software).

Tatian, Peter A. 2003. Neighborhood Change Database (NCDB) 1970-2000 Tract Data. Data User's Guide, Long Form Release. Available online at http://www.geolytics.com/pdf/NCDB-LF-Data-Users-Guide.pdf (last accessed 11 December 2007).

Tidwell, Mike. 2003. *Bayou farewell: The rich life and tragic death of Louisiana's Cajun coast*. New York: Pantheon Books.

Tiefenbacher, John. 2007. Conversation with author. 18 April. San Francisco, CA. Personal communication.

Ueland, Jeff and Barney Warf. 2006. Racialized topographies: altitude and race in southern cities. *The Geographical Review* 96 (1): 50-78.

United States Army Corps of Engineers (USACE). 1965. Lake Pontchartrain, LA, and vicinity hurricane protection. Map. Office of the District Engineer, New Orleans District, U.S. Army Corps of Engineers. In United States Army Corps of Engineers (USACE). 1965. Report on Hurricane Betsy, 8-11 September 1965, in the U.S. Army Engineer District, New Orleans. New Orleans: United States. Army. Corps of Engineers. New Orleans District.

United States Army Corps of Engineers. 2006. *Katrina: one year later*. Press release # 06-07. 25 August 2006. Available online at http://www.mvd.usace.army.mil/offices/pa/releases/2006/Rel0607.pdf. (last accessed 4 December 2007).

United States Census Bureau. 2001a. United States Census [database on-line]. Available online at http://www.census.gov/ (last accessed 10 October 2006).

United States Census Bureau. 2001b. Census 2000 Summary File 1, Technical documentation. Available online at http://www.census.gov/prod/cen2000/doc/sf1.pdf (last accessed 16 December 2007).

United States Census Bureau. 2005. Glossary of Basic Geographic and Related Terms - Census 2000. Available online at http://www.census.gov/geo/www/tiger/glossary.html #glossary (last accessed 10 December 2007).

United States Census Bureau. 2007. State and county quick facts. Available online at http://quickfacts.census.gov/qfd/states/22/2255000.html (last accessed 16 December 2007).

United States Congress. House of Representatives. Subcommittee on Energy and Water Development, Committee on Appropriations. 2005. *United States Army Corps of Engineers, Lake Pontchartrain and Vicinity Hurricane Protection Project: Testimony before the Subcommittee on Energy and Water Development, Committee on Appropriations*. 109th Cong., 1st sess., 28 September. Available online at http://www.gao.gov/new.items/d051050t.pdf (last accessed 1 February 2008).

United States Department of Agriculture, Aerial Photography Field Office. 2004. Digital Orthophoto (Aerial image) for Orleans Parish, Louisiana. Available online at the USDA Geospatial Data Gateway: http://datagateway.nrcs.usda.gov/ (last accessed 15 December 2007).

United States Department of Commerce. 2006. Service assessment: Hurricane Katrina. 50 [report on-line]. Available online at http://www.weather.gov/os/assessments/pdfs/Katrina.pdf (last accessed 23 April 2007).

United States Department of the Interior. 2007. *National Atlas*. http://www.nationalatlas.gov. (last accessed 7 November 2007).

United States Fish and Wildlife Service. 2008. *Bayou Sauvage National Wildlife Refuge*. Washington, D.C.: U.S. Fish and Wildlife Service. http://www.fws.gov/Refuges/profiles/index.cfm?id=43595 (last accessed 21 January 2008).

United States Geological Survey (USGS). 2007. *National elevation dataset*. Sioux Falls, SD: U.S. Geological Survey, EROS Data Center. http://seamless.usgs.gov/index.php (last accessed 30 January 2008).

Vartabedian, Ralph and Richard B. Schmitt. 2005. Katrina has role in fight over environmental law. *Los Angeles Times* 19 September: Available online at http://seattletimes.nwsource.com/html/nationworld/2002504712_katdisarray19.html (last accessed 27 February 2008).

Weisman, Steven R. 2005. Rice defends Bush's race record and calls for rebuilding fairly. *The New York Times* 13 September: A24.

White, Gilbert F. 1945. Human adjustments to floods. *Department of geography research papers* 29. Chicago: University of Chicago Press.

———. 1964. Choice of adjustments to floods. *Department of geography research papers* 93. Chicago: University of Chicago Press.

White, Gilbert F., W. C. Calef, J. W. Hudson, H. M. Mayer, J. R. Shaeffer, and D. J. Volk. 1958. Changes in urban occupance of flood plains in the United States. *Department of geography research papers* 57. Chicago: University of Chicago.

White, Ismail K., Tasha S. Philpot, Kristin Wylie, and Ernest McGowen. 2007. Feeling the pain of my people: Hurricane Katrina, racial inequality, and the psyche of Black America. *Journal of Black Studies* 37 (4): 523-538.

Wickham, DeWayne. 2005. Blacks suffering over race or class? Some of both. *USA Today* 13 September: A13.

Wright, Dawn J., Michael F. Goodchild, and James D. Proctor. 1997. GIS: Tool or science? Demystifying the persistent ambiguity of GIS as "tool" versus "science." *Annals of the Association of American Geographers* 87 (2): 346-362.

Wyly, Elvin K. and Steven R. Holloway. 2002. The disappearance of race in mortgage lending. *Economic Geography* 78 (2): 129-169.

Young, Cathy. 2006. Katrina's racial paranoia. *Boston Globe* 16 January: A13.

Zukin, Sharon. 2003. Urban lifestyles. In *The consumption reader*, ed. David B. Clarke, Marcua A. Doel, and Kate M. L. Housiaux, 127-132. London; New York: Routledge.

VITA

A. Case Watkins was born in Jefferson Parish, Louisiana, on 15 November 1976, the son of Alan D. Watkins and Libbey M. Watkins. After graduating from Minden High School in Minden, Louisiana, in 1995, Watkins received the Bachelor of General Studies degree from Louisiana State University in May 2002. He entered the Masters program in the Department of Geography at Texas State University-San Marcos in the fall of 2005, and in 2006 began employment with the U.S. Geological Survey in Austin, Texas. He currently resides in Salvador da Bahia, Brazil.

Permanent Address: 1102 Country Club Cir

Minden, Louisiana 71055

This thesis was typed by A. Case Watkins.