RESILIENCY OF NEW ORLEANS FOLLOWING HURRICANE KATRINA: A STUDY OF COMMUNITIES THREE YEARS AFTER THE STORM

A Thesis

Submitted to the Graduate Faculty of the
Louisiana State University and
Agricultural and Mechanical College
in partial fulfillment of the
requirements for the degree of
Master of Science

in

The Department of Environmental Sciences

by
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B.S., Tulane University, 2006
August 2009

ACKNOWLEDGEMENTS

I would like to thank my major advisor Dr. Margaret Reams and the other members of my thesis committee, Dr. Nina Lam and Michael Wascom, for their constructive support. I would also like to thank my fellow students Ariele Baker, Alison Martin, and Helbert Arenas for their help in completing this research. Thank you to my parents and my fiancée for their invaluable encouragement and help by reviewing this document.

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ABSTRACT

In 2005, Hurricane Katrina and subsequent levee failures produced widespread flooding in New Orleans, Louisiana and forced the evacuation of most of the local population. This event allowed for the study of the community's resilience, or the ability of a system to absorb changes or perturbations and still function. Statistical analysis and case studies were used to study resilience and answer the following questions. Can natural community recovery models be used when evaluating the population recovery of a human community following a disturbance? Given that there are variations in population recovery patterns, what factors account for this difference in recovery?

The recovery patterns of zip codes in Orleans Parish were able to be classified by those patterns demonstrated by tree communities following a hurricane, indicating that natural system models may be relevant to social communities. Census tracts of Orleans Parish were compared through discriminant analysis and it was delineated that higher flood depth, high percentage of black population, and low population with a bachelor's degree have the greatest significant impact on population recovery. It was also indicated that flood depth was the most important factor affecting return to the area. Knowledge gained through this study is applied to methods that can improve the resiliency of New Orleans and other communities that face the threat of a disturbance. Through this analysis suggests that maintenance of the physical infrastructure and the natural ecosystem are essential to the resilience of New Orleans communities.

1. INTRODUCTION

1.1 BACKGROUND AND PROBLEM STATEMENT

Orleans Parish communities encountered much devastation following Hurricane Katrina and the subsequent levee failures on August 29, 2005. The mass exodus from New Orleans, Louisiana and gradual repopulation of the city provides a valuable opportunity to study the factors that give communities resilience, known as the ability of a system to absorb changes or perturbations and still function (Adger 2000). Destructive events, either natural or man-made, can occur in all areas of the world and it is important to determine what factors influence the recovery of a community following such a disturbance. Federal, state, and local governments need to know the best way to aid a city in rebuilding and where funding will be the most effective. Through the collection of empirical data and the provision of a theoretical framework to analyze the recovery of a city following a disaster, these problems can be addressed.

Factors influencing the resilience of Orleans Parish following the major natural disaster of Hurricane Katrina will be studied through statistical analysis and case studies at both the zip code and census tract levels. This research answers the following questions. Can natural community recovery models (Figure 3) be useful when evaluating the recovery of a human community following a disturbance? Given that there are variations in community recovery patterns, what factors account for this difference in recovery?

On Monday, August 29, 2005, Hurricane Katrina came onshore near the Mississippi/Louisiana border. Once a category 5 storm, Katrina weakened to a category 3 before making landfall and veered to the east, sparing New Orleans from a direct hit. Immediately after the storm passed, it was thought that the Crescent City had avoided the doomsday scenario that the levees protecting the city would fail, allowing water to flow into New Orleans. But as residents and city officials emerged after the storm, it became apparent that some levees had been breached and New Orleans was flooding.

1.2 HISTORY OF NEW ORLEANS

Frenchman Robert de La Salle laid claim to the area now known as New Orleans in 1682 for French monarch King Louis XIV. In 1718, explorer Jean-Baptiste Le Moyne, sier de Bienville founded the town of La Nouvelle Orleans. Bienville's brother Iberville originally preferred the location of the settlement where Biloxi, MS now stands. The placement of New Orleans in its present location was eventually decided by many factors. Construction of the settlement on high ground at a strategic bend in the Mississippi River allowed one to see enemy ships approaching. This location was also the shortest route between the River and Lake Pontchartrain. In addition, Bienville felt that the nutrient rich soils of New Orleans would greatly benefit agriculture (Campanella and Campanella 1999).

Urban geographer Pierce F. Lewis has described New Orleans as "an inevitable city on an impossible site." Although rich, alluvial soils could be found in New Orleans, the frequent floods that produced these soils provided many difficulties for early settlers. Floods along with hurricanes, fires, and mosquito vector disease epidemics such as malaria and yellow fever greatly deterred early settlers (Bryant 2007).

Presently, metropolitan New Orleans is surrounded by levees protecting the city from the waters of the Mississippi River, Lake Pontchartrain, and the Gulf of Mexico via Lake Borgne. A map of the city is presented in Figure 1. Initially, drainage ditches were built to prevent flooding but as the town grew levees were built along the Mississippi River to serve this purpose. Although the levees were intended to guard the city from floodwaters, these manmade structures cut off the natural sedimentation processes achieved by overflow waters. The sediment carried by the floodwaters was deposited on the land and balanced out subsidence which naturally occurs as the newly deposited alluvial lands dewater and compact. Thus, New Orleans began to develop into a bowl with an average rate of subsidence of 5 mm/year (Campanella 2006).

Figure 1 – A map of New Orleans, Louisiana labeled by zip code. The city is shaded in gray.

Three major weather-related events should be highlighted in order to understand the development of New Orleans today and the reaction of the local government and population to Hurricane Katrina. These events are the Great Mississippi Flood of 1927, Hurricane Betsy in 1965, and Hurricane Camille in 1969. In 1927, heavy rains throughout the Mississippi River Basin produced a spring flood stage at heights never before seen on the leveed River. New Orleans businessmen feared the levees would not be able to hold the water and invented a plan to deal with this contingency. They decided that if the water levels posed an imminent threat, they would dynamite the levees along St. Bernard Parish, therefore alleviating the pressure along the New Orleans levees. Louisiana Governor Oramel Simpson approved the dynamiting of the levee on two conditions: that there was no other choice to save the city of New Orleans and that New Orleanians compensate the victims of the flooding. St. Bernard Parish and surrounding areas were evacuated on April 28 and the levee was dynamited at 2:17 pm on April 29, 1927 (Barry 1997). The intentional destruction of the levee produced much damage to the flooded areas, but perhaps the greatest impact was the belief that the wealthy would do anything to ensure the safety of their property, even if their actions victimized the less fortunate. This notion would be prevalent in later disasters such as when rumors circulated that levees were bombed near the Ninth Ward during Katrina. As a reaction to the 1927 flood, the Flood Control Act of 1928 was passed, charging the U.S. Army Corps of Engineers with building taller, stronger levees and floodwalls along the Mississippi River.

Category 3 Hurricane Betsy came onshore near New Orleans on September 9, 1965. The storm's surge was driven up the Intracoastal Waterway and Industrial Canal, overtopping and collapsing levees. Six to twelve feet of water inundated the Lower Ninth Ward and St. Bernard Parish, leaving the rest of the city fairly intact. Rumors percolated throughout the flooded areas that the levees had again been intentionally destroyed in order to save the wealthier areas of New Orleans. These tales proved false, although the New Orleans Sewage and Water Board did recognize the need for action to protect all citizens (Landphair 2007). Hurricane Betsy was the first storm to cause over a billion dollars in damage (in 1965 U.S. currency) in the United States. The Flood Control Act of 1965 was passed following Betsy, as Congress recognized the need to protect New Orleans. Three hurricane protection projects were authorized: New Orleans to

Venice, Lake Pontchartrain and Vicinity, and West Bank and Vicinity. These projects were built with the intention that the structures erected would withstand a category 3 storm. In 2005 when Katrina came onshore, none of these projects had been completed. The New Orleans to Venice project was approximately 84% complete in 2005 and the Lake Pontchartrain and West Bank projects were scheduled to be completed in 2015 and 2016, respectively (Link et al. 2006).

In 1969, Gulf Coast residents faced their worst fear, that a category 5 hurricane had formed in the Gulf of Mexico. Hurricane Camille came onshore August 17, 1969 following a path similar to the one Hurricane Katrina would take 36 years later, satellite images of the two storms are found in Figure 2. Although New Orleans dodged a direct hit, other areas of the Gulf Coast and Mid-Atlantic were ravaged by Camille. The storm caused approximately $6.8 billion dollars in damage (in 2000 U.S. currency) and 256 deaths (Sheets and Williams 2001).

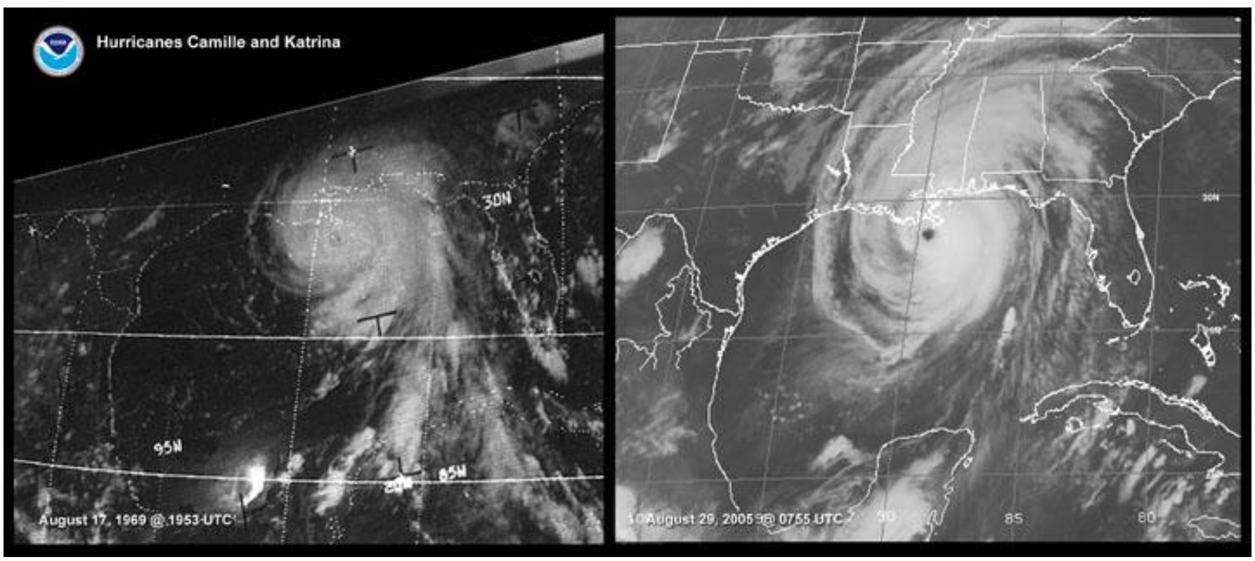

Figure 2 – A comparison of Hurricane Camille (left) and Hurricane Katrina (right). *Courtesy of the National Oceanic Atmospheric Administration/National Climatic Data Center* (Source: http://www1.ncdc.noaa.gov/pub/data/images/hurr-camille&katrina-comparison-10x7.jp).

Hurricane Katrina was weaker than Camille but caused much more devastation in New Orleans because of a variety of factors. Katrina was a larger storm than Camille and lingered over the Gulf Coast area for a longer time. The storm surge generated by Katrina varied from

3.5 – 6 meters which is that of a category 5 storm. Katrina maintained category 5 status while in the Gulf of Mexico and this is likely how the large surge was engendered. There were also no significant levee breaks following Hurricane Camille. Some New Orleanians who survived Hurricane Camille did not think Katrina warranted a significant threat and that they did not need to evacuate for the category 3 storm. This belief may have put more citizens in danger.

1.3 RESILIENCE RESEARCH

Ecosystems are dynamic systems and disturbances of these systems are a natural, sometimes frequent occurrence (Savage 1993). In 1973, C.S. Holling introduced the concept of resilience to explain the behavior of dynamic systems away from equilibrium when they are impacted by a disturbance. Resilience can be defined as the ability of systems to absorb changes or perturbations and still function. Resilience can also be viewed as an antonym to vulnerability (Adger 2000). Two ideas of resilience have developed: engineering resilience and ecological resilience. Engineering resilience is the measure of how quickly a system returns to a steady state following a disturbance (Pimm 1991). Ecological resilience can be defined as a measure of how far a system can be disturbed or the magnitude of the disturbance it can absorb before it shifts to another regime (Walker et al. 2006). Engineering resilience assumes only one stable state or domain for a system, whereas ecological resilience denotes multiple equilibrium domains for the system (Gunderson 2000). For this thesis, we will test elements of both these concepts.

Resilience as a concept was initially used to study ecological systems. Given the frequent linkage of human and ecological communities, the theory of resilience has now been expanded to include social or community resilience. Social-ecological resilience can be defined as the ability of a community to survive a disturbance that impacts both its social infrastructure and the natural system it is built upon. The resilience of a community includes many factors and is tied to its dependence on the ecosystem. Social-ecological resilience factors include demographic, economic, and institutional variables and measures of capital in the community. Human systems are equally vulnerable to environmental changes that can disrupt the stability of the system. The displacement of a significant portion of the population can symbolize a collapse of social-ecological resilience and was seen following Katrina (Adger 2000). For the rest of the paper, the word resilience will indicate social-ecological resilience.

The Resilience Alliance, "a research organization comprised of scientists and practitioners from many disciplines who collaborate to explore the dynamics of social-ecological systems," delineates three key characteristics of resilience: the amount of change a system can experience and still maintain the same controls and/or function; the degree to which a system can self-organize; and the system's ability to build and increase its capacity for adaptation and learning (Carpenter et al. 2001, Holling 1973 and 1996). These three attributes will be fully described in the following paragraphs.

The amount of change that can be absorbed by a community is often directly related to the natural ecosystem. Some modification of the ecosystem and built infrastructure may allow for an increase in resilience, particularly if community awareness of a disturbance is high (Pérez-Maqueo 2007). Along the southern coast of Louisiana, the ecosystem has been drastically changed with the erosion and disappearance of wetlands. Wetlands serve as a buffer to tropical storms, dissipating storm surge and reducing the water level that will reach land. Within New Orleans, the construction of levees around the city is a significant alteration in natural processes. Levees are intended to reduce the vulnerability of New Orleans to flooding and tropical storms, but they also degrade the resilience that the ecosystem can provide by preventing the replenishment of soils due to overflow and expansion of the waters into wetland areas.

According to Abel, the ability to self-organize is the foundation of resilience and can be hindered by excessive external subsidies (Abel et al. 2006). There is a need for local systems to be interconnected and connected to a larger, national system in order to deal with disturbances. It is also important that these local networks maintain self-reliance, or the ability to subsist without the larger system (Baker and Refsgaard 2007). As was obvious following Katrina, the local social networks in New Orleans failed and the dependence of the city on federal assistance was extremely injurious. Federal assistance was initially insufficient given the numerous evacuees and resources needed to provide for these people. Collaboration among networks can greatly improve resilience of a community as does established trust of the population in the networks and institutions, their leaders, and the information disseminated to the community (Nkhata et al. 2008, Longstaff and Yang 2008). This collaboration was lacking prior to and immediately following Hurricane Katrina.

The capacity for adaptation is a crucial method of retaining resilience. Following a disturbance, many methods of reorganization are possible. An institution can take no action and see if the system returns to its previous state; it can manage the system to guide the return back to the initial state; or it can adapt to the new altered system. Adaptive management is an integrated approach to managing a social-ecological system and its resources. In this management structure, policies must be easily and continually modified as experience and additional knowledge is gained over time (Baker and Refsgaard 2007). The management method frequently taken by the New Orleans government was a command and control approach that targets a specific variable and reduces resilience by ignoring other parts of the system (Gunderson 2000). In this instance, the levees were frequently the target variable and other factors such as community networks and a strong evacuation plan were likely overlooked.

According to Walker et al. (2006), adaptability is principally controlled by the amount of all forms of capital and the governance and institutions within the system. Thus, in order to study the resilience of a social-ecological community, an essential component are the capitals of the system which include human, social, financial, physical, and natural capital. Human capital can be defined as the individuals within the system and their ability to adapt to changes and develop solutions to cope with disturbances. Social capital can include interactions among humans and humans with the surrounding environment, as well as community networks, and institutional and cultural capital. Financial capital can be defined as the access of the system to monetary resources. Physical capital is the infrastructure and technological resources of a community. Natural capital includes the ecosystems relied on by the humans of the system. These variables can be aggregated through factors representing the various forms of capital, and a level of resilience within a community can be described. In 2007, Costanza and Farley showed that coastal areas have high concentrations of capital and can maintain resilience by investing in all forms of capital along with sustainably allocating resources. Investment in capital can be crucial in order for a system to return to a steady state following a disturbance (Abel et al. 2006). Independent variables gathered for this analysis were intended to represent the forms of capital described.

The linkage of social and ecological systems has previously been ascertained. It is then reasonable to assume that the pattern of recovery of an ecological system following a disturbance can be comparable to the recovery of a social-ecological system. The graphs in Figure 3 indicate the methods of recovery observed in a tree community following a hurricane.

The tree communities demonstrate various stages of resiliency in their recovery from the hurricane. The susceptible community was devastated by the disturbance and has been unable to fully recover from the event. The resilient community was also ravaged by the hurricane but is able to fully recover from the episode. A community that felt a much smaller impact from the

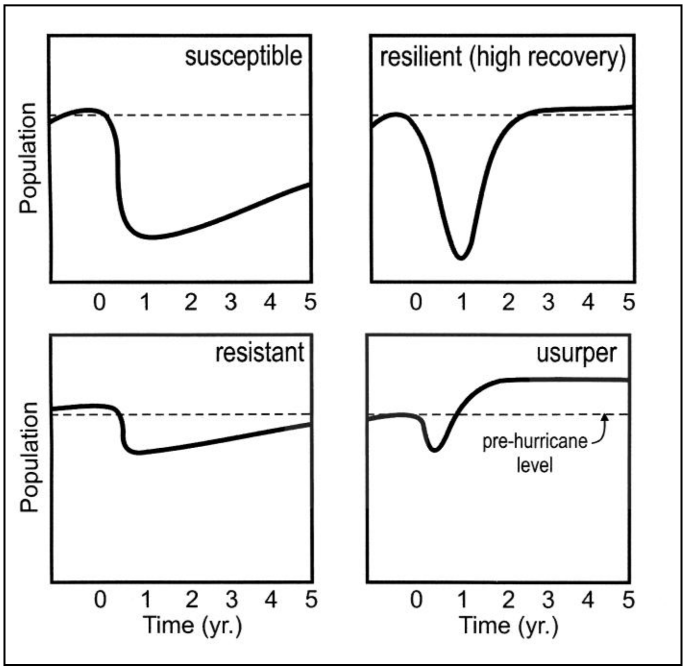

Figure 3 – Patterns of tree community recovery following a hurricane can be used to describe patterns of recovery in a social-ecological community (Liu et al. 2006).

disturbance can be described as resistant. A usurper community is one that is only somewhat influenced by the disruption and exhibits a population increase that exceeds pre-hurricane levels. The patterns denoted in these graphs will be used to study resilience and vulnerability of New Orleans communities following Hurricane Katrina (Liu et al. 2006).

2. DATA AND METHODS

2.1 ZIP CODE ANALYSIS

In order to evaluate the rate of recovery as represented by population return by zip code in Orleans Parish, USPS mail delivery data made available by the Greater New Orleans Community Data Center and Valassis were used. The information obtained presented the number of households receiving mail in each of the 17 zip codes within Orleans Parish and these data were used as an indicator of population. The data reviewed spans from July 2005 to December 2008 with a 13-month gap between July 2005 and August 2006 as data were not collected monthly by the USPS during this time. Percent of July 2005 households presently occupied at each date were calculated and put into the computer program SPSS (Statistical Program for the Social Sciences) for further analysis. A K-Means cluster analysis was then performed to divide the zip codes into four groups to simulate the recovery patterns in Figure 3. Households receiving mail versus time was plotted for each zip code (extrapolating for the missing months) which enabled the groups to be classified as susceptible, resilient, resistant, or usurper based on the tree community model. The recovery rate for each zip code was calculated using the number of households receiving mail for [December 2008 –August 2006]/August 2006. This produced a recovery percentage that could be compared and contrasted for each neighborhood. The recovery rate of communities classified as susceptible were highlighted and four of these zip codes were chosen for further analysis. The following four susceptible neighborhoods were selected for their variation in recovery rates, difference in economic status prior to Katrina, and proximity to levee breaks: New Orleans East (zip code 70127), Gentilly Woods (70126), Lakeview (70124), and Lower Ninth Ward (70117).

The characteristics of each of the chosen communities were examined to ascertain what aspects may lead to a more vulnerable community in the face of a disaster. Independent variables for the susceptible zip codes were compiled to include social, economic, demographic, and environmental factors representing the various types of capital referred to in resilience research. These variables, the form of capital they represent, and the sources of the data are found in Table 1.

Table 1 – Independent variables for susceptible zip codes

Capital	Variable	Source
Human/Social	Median age	2000 U.S. Census
Human/Social	Race: Percent black population	2000 U.S. Census
Human/Social	Number of neighborhood associations	Neighborhoods Partnership Network website
Human/Social	Education: percent population 25 years and older with a bachelor's degree	2000 U.S. Census
Human/Social	Voting percentage	Louisiana Secretary of State Elections Division
Financial	Median household income	2000 U.S. Census
Financial	Number of owner occupied housing units	2000 U.S. Census
Financial	Percent in labor force	2000 U.S. Census
Physical/Natural	Average flood depth	LSU GIS Hurricane Katrina and Rita Clearinghouse Cooperative
Physical/Natural	Average elevation	U.S. Geological Survey National Map Seamless Server National Elevation Dataset

Data about the susceptible zip codes were obtained from the 2000 U.S. Census through the Census Bureau website [http://factfinder.census.gov]. The number of neighborhood associations was obtained from the New Orleans Neighborhoods Partnership Network website [http://www.npnnola.com/]. The Louisiana Secretary of State Elections Division was contacted and provided the number of voters in the 2002 mayoral runoff election. The number of voters was divided by the 2000 census population of 25 years and over to derive the voting percentage presented in the table. The variable of population 25 years and older was used for this equation as it was the closest to voting age obtained when using the census data. All data was obtained in 2008.

2.2 CENSUS TRACT ANALYSIS

Population data were collected through the U.S. Department of Housing and Urban Development (HUD). HUD made available U.S. Postal Service (USPS) data that recorded the number of households actively receiving mail by census tract which was used as an indicator of population. The mail data were opened and filtered in Microsoft Access to eliminate all other information other than the 181 census tracts within Orleans Parish. Only residential addresses were used in the analysis. To obtain the number of occupied addresses, the number of vacancies and addresses with no habitant information, addresses for which the USPS determined were under construction or not active, were subtracted from the number of occupied residential addresses. Data were available for each quarter (March, June, September, December) from December 2005 to December 2008. Although Hurricane Katrina hit in August 2005, it took nearly a year for population loss to be demonstrated in the data, so December 2005 depicts pre-Katrina population numbers. December 2007 data were not available through HUD due to delays associated with separating residential and business addresses and were not used in the analysis.

Households actively receiving mail, or population, served as the dependent variable for analysis. Again, independent variables were compiled to include social, economic, demographic, and environmental factors representing the various types of capital referred to in resilience research. Table 2 below identifies the independent variables with the form of capital they represent and where each variable was obtained. Factors signifying human and social capital were difficult to separate and are classified as both forms of capital. Variables for physical capital characterizing the infrastructure and technological capacity of the census tracts were difficult to discern. The heavy reliance on levees and flood protection infrastructure in Orleans Parish closely links the natural and physical capital and thus the mean elevation and flood depth factors are also an indication of both natural and physical capital.

Table 2 – Independent variables for the census tracts

Capital	Variable	Source
Human/Social	Age	2000 U.S. Census – ESRI
Human/Social	Race: Percent black population	2000 U.S. Census – ESRI
Human/Social	Female headed household with no husband present	2000 U.S. Census – University of Wisconsin-Milwaukee Employment and Training Institute
Human/Social	Education: population 25 years and older with a bachelor's degree	2000 U.S. Census – ESRI
Financial	Median household income	2000 U.S. Census – University of Wisconsin-Milwaukee Employment and Training Institute
Financial	Number of owner occupied housing units	2000 U.S. Census – ESRI
Financial	Unemployment rate	2000 U.S. Census – University of Wisconsin-Milwaukee Employment and Training Institute
Physical/Natural	Average flood depth	LSU GIS Hurricane Katrina and Rita Clearinghouse Cooperative
Physical/Natural	Average elevation	U.S. Geological Survey National Map Seamless Server National Elevation Dataset

U.S. Census data were made available by census tract through the University of Wisconsin-Milwaukee Employment and Training Institute [http://www4.uwm.edu/eti/PurchasingPower/ETIshapefiles.htm] and the ESRI websites [http://www.esri.com/data/download/census2000_tigerline/index.html]. Together these websites provided social, economic, and demographic census information. Environmental factors of elevation and flood depth were recognized as important indicators of resilience for Orleans Parish. These data were created through the use of geographic information systems (GIS) and the GIS program ArcMap, as it was not readily available from a source. A shapefile of the census tracts within Orleans Parish was obtained from the Geography Network website. Elevation data, defined in a 30 meter grid, from the U.S. Geological Survey National Map Seamless Server National Elevation Dataset was overlaid with the census tract and an average elevation for each census tract was acquired. The same GIS procedure was performed with flood depth data, defined in a 25 meter grid, available from the LSU GIS Hurricane Katrina and Rita Clearinghouse Cooperative and an average flood depth for each census tract was achieved. All data for the independent variables was accessed and collected in 2008.

Statistical analysis on the census tract data was performed through SPSS. The independent variables were analyzed with the dependent variable of population in order to determine what factors impact population recovery. First, a cluster analysis was performed to put the 181 census tracts into groups that display similar repopulation rates for easier analysis of the independent variables. K-Means cluster analysis was performed to allow for the selection of the number of clusters into which the tracts would be divided. Without this grouping, analyzing the 181 tracts individually would have been extremely time consuming and prove difficult to obtain significant results to explain the variability among tracts. Initially, four groups were desired for comparison to the tree community recovery patterns. After analysis was performed, a four group division demonstrated a higher margin of error (discriminate analysis showed that 32% of the groups were incorrectly classified) so the tracts were divided into three groups. The input variables for the cluster analysis were exclusively the mail data representing population as the repopulation rate was the dependent variable by which the tracts were to be classified. The variables included in the analysis were the percent of homes occupied in December 2005 for each census tract, along with the calculated percent of December 2005 homes presently occupied for each corresponding time period. Although Hurricane Katrina hit in late August 2005, December 2005 was used as the starting variable because the address changes which occurred as a result of Katrina were not fully processed until nearly a year after the storm. Also, there were no data collected in September 2005 due to the effects of the storm.

Discriminant analysis was then performed to delineate the factor or factors explaining the differences in recovery rates among the census tracts. Discriminant analysis was utilized as it is a method to determine the variables that differentiate among multiple groups and establish which variables are the best predictors of the various rates of repopulation in the census tracts (Liu and Lam 1985). The variables from Table 2 were used with the cluster classification to perform stepwise discriminant analysis with the following criteria: Grouping variable: cluster classification; Independents: variables from Table 2.2; Method: Wilks' lambda. The analysis indicated that the dependent variables of flood depth, percent of black population, and population 25 years and over with a bachelor's degree were the most influential factors on the repopulation rates and these factors will be thoroughly discussed in the next section. The highlighted variables will be used to assess the zip code trends noted in the data as well.

The discriminant analysis also indicated that 22.1% of the tracts may have been incorrectly classified in the cluster analysis. The tracts were mapped through ArcMap to see the wrongly identified clusters and their associated recovery rates which may explain the incorrect classification. GIS was also utilized to demonstrate any neighborhood effects among the tracts. Neighborhood effect is the idea that there is a link between adjacent communities and their characteristics. This effect can also be interpreted to indicate that an area with strong resiliency can increase the resiliency of those areas around it, or that a susceptible area can increase the vulnerability of its surrounding areas (Johnston et al. 2004).

3. RESULTS: ZIP CODE ANALYSIS

Initially, larger community groups were studied through the 17 zip codes of Orleans Parish. The zip codes were divided into groups through the cluster analysis and the results are shown in Table 3 below and in Appendix A. Also included in the table is the classification of each group based on the tree community recovery model.

Table 3 – Results of the K-Means cluster analysis for New Orleans zip codes

	Group	**Number of Zip Codes**	**Classification**
	1	1.000	Usurper
	2	4.000	Resilient
	3	7.000	Resistant
	4	5.000	Susceptible
Valid		17.000	
Missing		.000	

By graphing the population recovery of each zip code, a comparison to Figure 3 can be reviewed. In Figure 4, the recovery curves for four New Orleans zip codes are shown representing the four recovery patterns demonstrated by tree communities following a disturbance. The Central Business District (CBD) represents a usurper community, one that has achieved a higher population than before the disturbance and is theoretically better off now than before the storm. Indeed, the CBD has undergone much revitalization since Katrina and is an area where many young professionals live (Campanella 2006). The CBD was the only zip code found to be a usurper. Zip code 70115, Uptown, is classified as resistant, along with 6 other communities. Uptown is an affluent area that includes portions of St. Charles and Magazine Streets. The financial resources of the area combined with the fact that it received minimal flooding following Katrina, enabled the community to be resistant to the disturbance and steadily recover from a slight drop in population.

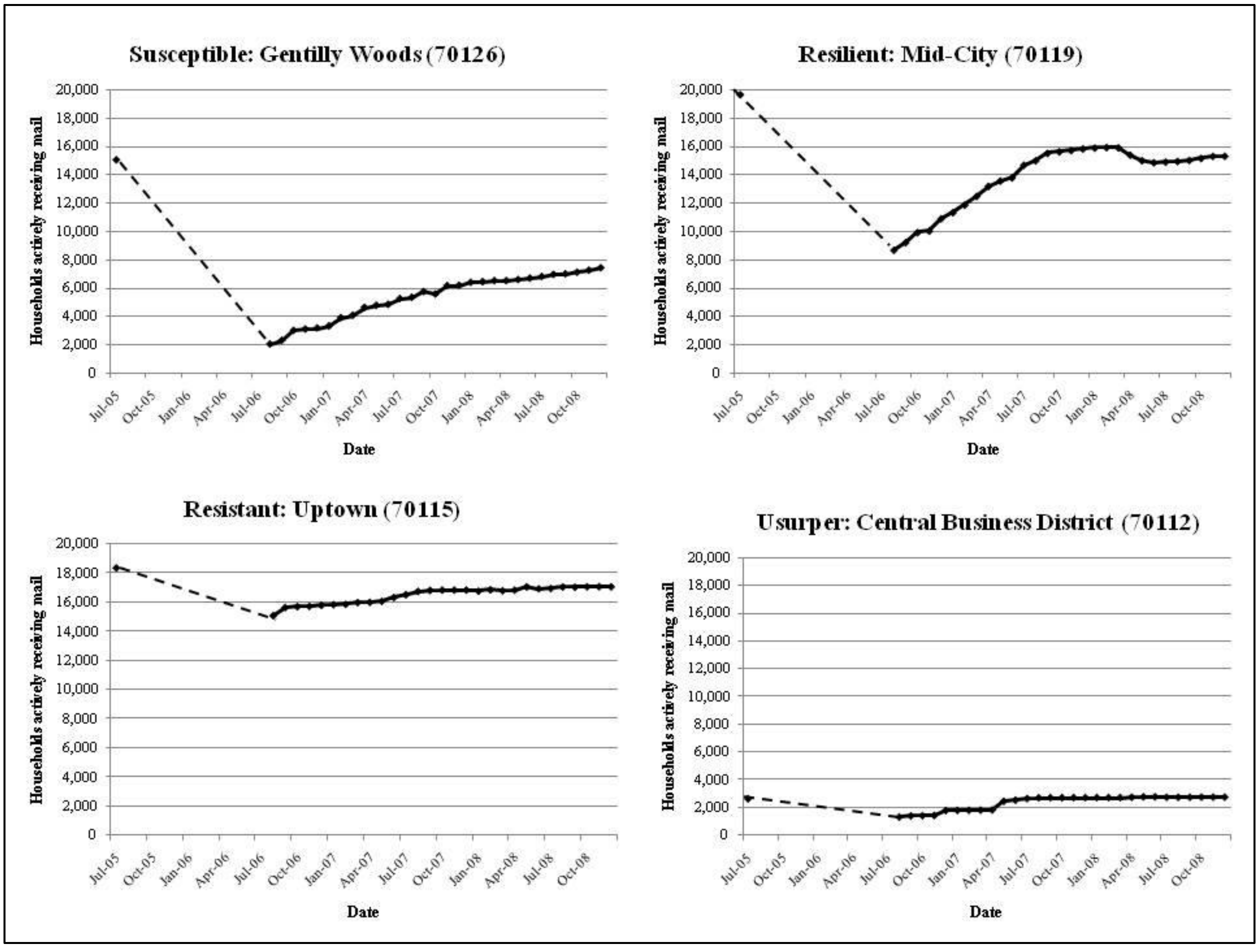

Figure 4 – Households actively receiving mail for four zip codes in Orleans Parish representing patterns of susceptibility, resiliency, resistance, and usurper. All graphs are scaled equally to 20,000 households.

The Mid-City community, zip code 70119, is classified as resilient following Hurricane Katrina. All of Mid-City experienced some flooding from Katrina, ranging from 1 – 6 feet, which explains the loss of over half the population following the storm. Mid-City has seen significant repopulation and revitalization since Katrina and has recovered, gaining over 75% of the population lost following the disturbance. A total of four zip codes were found to be resilient. A map of New Orleans labeled by zip code illustrating flooding following Hurricane Katrina is included in Figure 5.

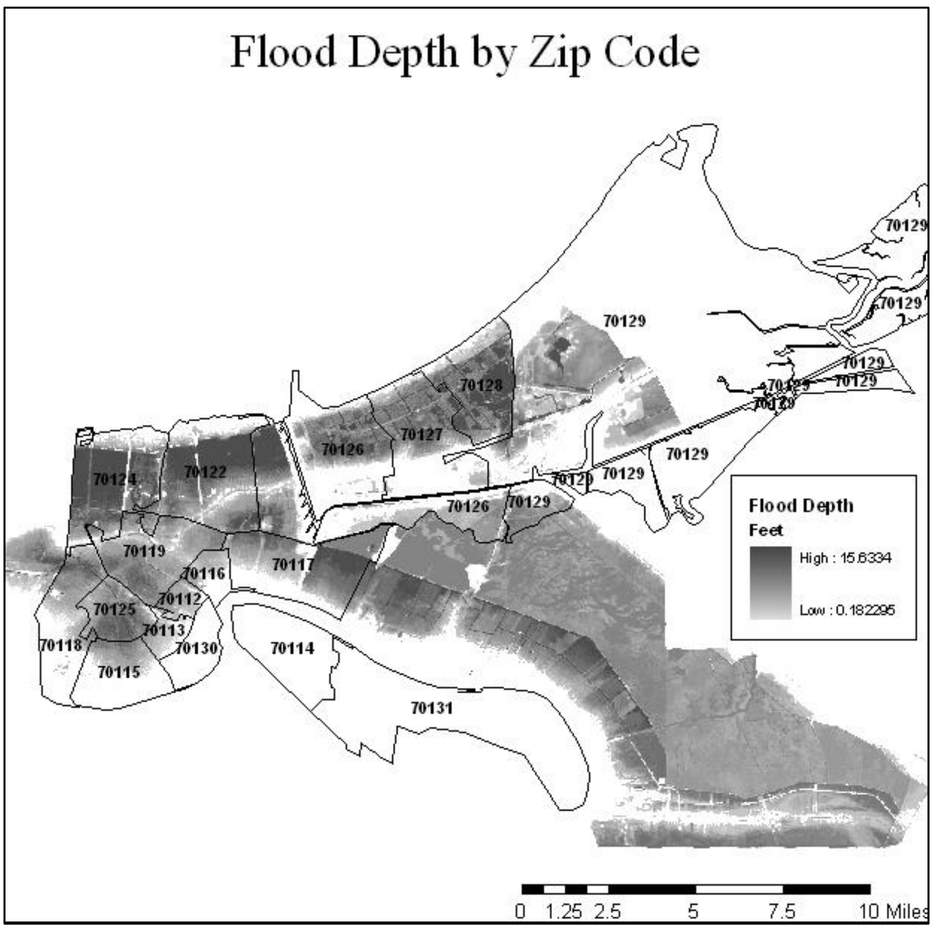

Figure 5 – Map of flooding in Orleans Parish labeled by zip code.

Upon reviewing the five zip codes that demonstrated a susceptible recovery curve, a surprising observation was made. Areas classified as susceptible included a variety of communities with seemingly different socio-economic standings prior to Katrina. Four of the five susceptible communities will be highlighted. The recovery curves for the communities of Lower Ninth Ward (70117), Lakeview (70124), Gentilly (70126), and New Orleans East (70127) are shown in Figure 6. Selected social, economic, and political factors for these four communities are displayed in Table 4. The estimation of neighborhood associations and voting percentage variables are only available at the zip code level. These data were obtained from the 2000 U.S. Census [http://factfinder.census.gov/] and are compared to the 2000 national average.

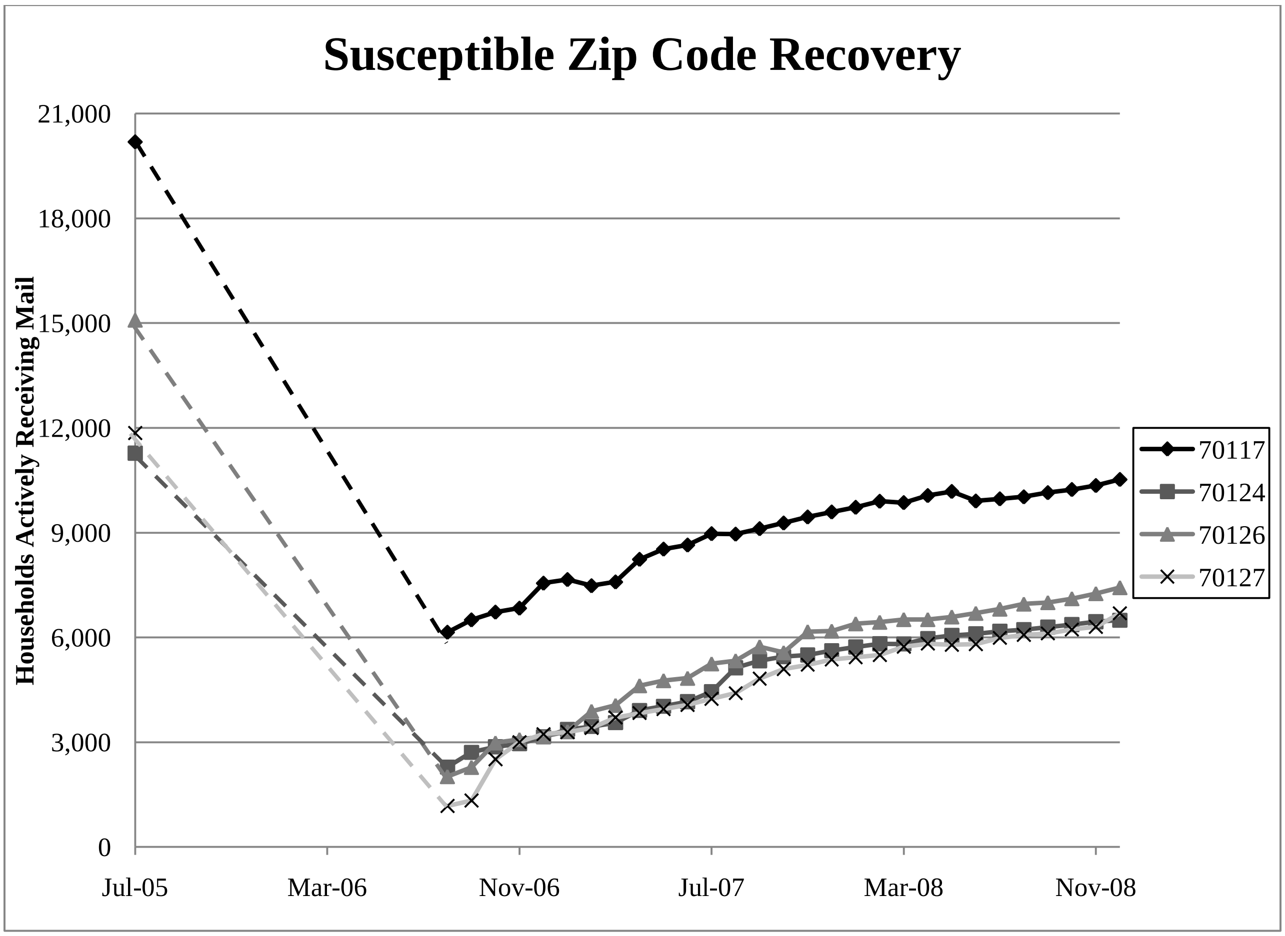

Figure 6 – Percent of population recovery for the four selected susceptible zip codes determined through households actively receiving mail over three years following Hurricane Katrina.

The Lower Ninth Ward is a close, culturally rich black community that has had the greatest difficulty recovering from Hurricane Katrina. The Industrial Canal levee breach flooded the area which was also hard hit by Hurricane Betsy in 1965. As is illustrated in Table 4, the

Ninth Ward is the lowest of the four for variables of education and wealth which significantly impairs the community's ability to recover. Although there was a high number of owner occupied homes in the Ninth Ward, these homes were frequently passed down to family members, often circumventing the requirement that homeowners purchase flood insurance.

Table 4 – Social, economic, and political variables for the four susceptible zip codes

Neighbor-hood	Recovery Rate* (%)	Race: Black (%)	Estimation of Neighbor-hood Assoc.	Population with a Bachelor's Degree or Higher	Voters (%)	House-hold Income	Owner Occupied Housing Units (%)	Elevation Above Sea Level (ft.)	Avg. Flood Depth (ft.)
N.O. East (70127)	470.02	85.6	3	19.6%	35.04	$30,954	48.3	-7.76	3.8
Gentilly (70126)	267.77	87.1	7	21.7%	38.57	$30,627	56.4	-5.70	3.55
Lakeview (70124)	183.74	1.3	9	50.6%	38.52	$51,684	69.6	-6.23	4.7
Ninth Ward (70117)	71.12	88.8	2	10.6%	31.38	$19,567	66.2	-0.19	3.6
National Average	N/A	12.3	N/A	24.4%	N/A	$41,994	66.2	N/A	N/A

*Percent gain in number of households receiving mail from August 2006 – December 2008

Many recovery projects have targeted the Ninth Ward such as the Habitat for Humanity Musician's Village and the Make It Right Foundation, but the community has yet to see a substantial recovery. In order to further explore the factors that may influence the lack of recovery among susceptible zip codes, the New Orleans East and Lakeview communities are described.

4. CASE STUDIES

4.1 NEW ORLEANS EAST

In the 1970s, a suburban style residential development was marketed in the New Orleans East (NOE) area. Previously a swamp, developers saw an opportunity to capitalize on the growth of New Orleans and build up the eastern area of Orleans Parish. Vietnamese refugees were also settled in NOE, through the invitation of the Catholic Church at the end of the Vietnam War, bringing cultural diversity to the predominantly black area. NOE is separated from the rest of New Orleans by the Inner Harbor Navigational Canal, also known as the Industrial Canal, a primary reason for the location of the New Orleans Business and Industrial District (NOBID) within NOE. NOBID is an industrial corridor that adds to the mix of commercial and residential properties located here (Campanella 2006). Like many areas of New Orleans, NOE was experiencing an overall downward trend in population prior to the storm.

The census tract discriminant analysis conveyed that flood depth, black population percentage, and education were the factors that influence the resiliency of a population. As shown in Table 3.5, the 2000 U.S. Census found the percentage of black population in zip code 70127 was 85.6%, percentage of white population was 11.3%, and 1% were Asian. The percentage of population with a bachelor's degree was 19.6%, below the national average of 24.4%. The median home value for NOE at $84,300 was on the higher end for the New Orleans area, although below the nationwide average. Although not subject to a major levee break, NOE did receive a significant amount of flooding due to minor levee breaches and overtopping.

NOE has been classified as susceptible, but it has exhibited a very high rate of repopulation following Hurricane Katrina when compared to the other susceptible communities. What are the potential factors that may explain this recovery compared to Lakeview and the other susceptible areas? Of the susceptible zip codes, NOE has the highest percentage of population in the labor force (64.1%), an indicator of stability. It may be that many jobs held by the citizens of NOE are unique to this area and employment is the main reason for their quick return. Individuals in NOE may have fewer financial resources, preventing them from settling in another area and forcing them to return and rebuild their property faster. Another possibility is that the combination of industry, commercial, and residential opportunities in NOE have enabled individuals to return to the area faster.

4.2 LAKEVIEW

The community of Lakeview was developed in the early 1900s. The majority of land parcels sold were restricted to white citizens through deed covenants. The Lakeview New Basin Canal was closed in 1949 which led to a decrease in industry and a rise of commercial businesses. Prior to Katrina, Lakeview was primarily residential with a large number of churches and schools (Campanella 2006). The 2000 U.S. Census illustrates the ethnic make-up of the area's population: 95.7% white and 1.3% black. Over half of Lakeview residents over 25 have a bachelor's degree and nearly 70% of the housing units are owner occupied. Lakeview also has one of the highest median home values in the city at $184,300.

Although Lakeview exhibits high resiliency through these social and economic variables and those presented in Table 4, it is labeled as susceptible with a recovery rate below those of NOE and Gentilly. The most obvious reason for this grouping is flood depth. Along the east border of Lakeview is the 17th Street Canal which was breached during Katrina as is shown in the picture below (Figure 7). This levee break was one of the largest and most devastating caused by Katrina, producing over 10 feet of flooding in parts of Lakeview. Some homes in the area were completely submerged while others that were built higher escaped with only a few feet of flooding. Even though Lakeview displays high resiliency through socio-economic stability, these factors were overpowered by the massive amounts of flooding that occurred in the area.

Figure 7 – 17th Street Canal levee breach. The flooded Lakeview neighborhood is on the left of the canal. *Courtesy of the U.S. Army Corps of Engineers* (Source: http://www.mvd.usace.army.mil/hurricane/KatrinaImages/Misc/DSC00033.JPG).

This may explain the inability of Lakeview residents to quickly return to the area and recover from Katrina. Another potential explanation could be that the individuals from Lakeview have the means to easily relocate somewhere else and do not plan to return. Also, wealthier Lakeview residents may be comfortably living in another area while their homes are being rebuilt and do not have to rush the process unlike many other New Orleans citizens.

5. RESULTS: CENSUS TRACT ANALYSIS

In order to further explore what factors may influence the resiliency of an area and to have a larger sample size for statistical analysis, the 181 census tracts within Orleans Parish were studied. The tracts were initially divided into groups by the K-Means cluster analysis. The results of this analysis are shown in Table 5 and in Appendix B.

Table 5 – Results of the K-Means cluster analysis for census tracts

	Group	**Number of Tracts**
	1	55.000
	2	52.000
	3	74.000
Valid		181.000
Missing		.000

The groups were then evaluated based on population and environmental, social, economic, and demographic variables. Using these variables, a stepwise discriminant analysis was performed. This analysis showed that 77.9% of the census tracts were correctly classified in the groups they were placed in by the K-Means cluster analysis. The discriminant analysis also indicated that the factors influencing the population return rate of the census tracts were: mean flood depth, percent of black population, and people 25 and over with a bachelor's degree (Table 6).

Table 6 – Standardized canonical discriminant function coefficients from discriminant analysis

	Function	
	1	2
Percent black population	.467	-.687
25 years and older with a bachelor's degree	-.537	.601
Mean flood depth	.999	.366

Additional results from the discriminant analysis can be found in Appendix C. Overwhelmingly, mean flood depth was shown to account for differences in recovery rates among the census tract groups.

When the census tracts were mapped by their corrected cluster classification and overlaid with mean flood depth, it became apparent that the areas which received the least amount of flooding were mainly found in Group 3, whereas the areas that received the greatest amount of flooding were in Group 2 and the majority of tracts with moderate levels of flooding were in Group 1. This is illustrated in the map below, Figure 8.

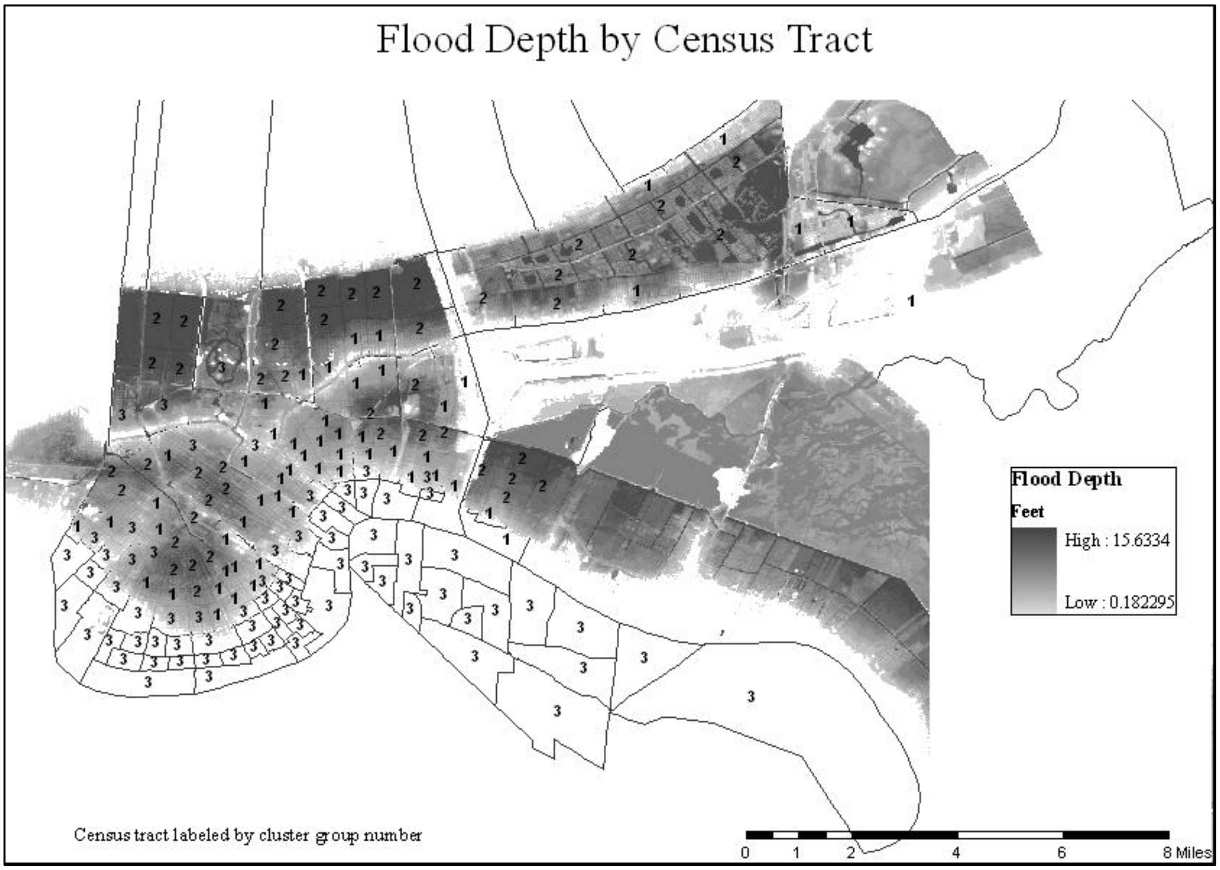

Figure 8 – Map of flood depth labeled by the census tract cluster groupings.

A neighborhood effect with the groupings is also observed when the cluster classifications are mapped. This effect may be because flooding in one tract is likely similar to that of the tracts nearest to it. Although, it can be observed that the social and economic factors accounting for resiliency in one tract may be shared by the areas around it. It is also possible that the strong or weak resiliency of one area affects its surrounding tracts and produces the neighborhood effect seen in the groupings of the census tracts.

An indicator of susceptibility in the analysis was a higher percentage of black population which can be representative of human, social and sometimes financial capital. In New Orleans, poorer areas tend to have a higher percentage of black population with access to fewer economic resources. When compared to the flood depth map, these areas also had a greater amount of flooding. Historically, wealthier white populations settled on the highest ground in the city while black and poor white populations were forced to settle in areas with lower elevation (Landphair 2007; Campanella 2006).

The discriminant analysis showed that a higher percentage of population with a bachelor's degree was inversely related to flood depth and race. These areas, Group 3, depict a higher rate of resiliency and in this case resistance to a disturbance following Hurricane Katrina. Education has also been shown to correlate with wealth and greater access to financial resources, and thus is a symbol of financial, social, and human capital. The availability of funds following a disturbance will affect the ability of individuals to return to an area and in this instance it is shown that the higher educated population was able to return to New Orleans faster than the less educated in most instances.

The recovery rates for the census tracts in each group were averaged to obtain an overall recovery curve for each cluster. The results are shown in Figure 9. By comparing the group recovery curves to those of the ecological system model in 1.3, the groups can be classified as resistant or susceptible. Group 1 demonstrates susceptibility, although when compared with the susceptible curve of Group 2, Group 1 appears to be somewhat more resilient than 2. The census tracts that were classified into Group 3 exhibit resistance.

One year from the storm (between June and September of 2006), the percentage of households receiving mail for each group was at its lowest point. This indicates the severe displacement caused by Katrina and the inability for New Orleanians to return quickly to the areas hardest hit. Two years following the storm in September 2007, the recovery rate for Group 3 was at its highest and the group was almost fully recovered.

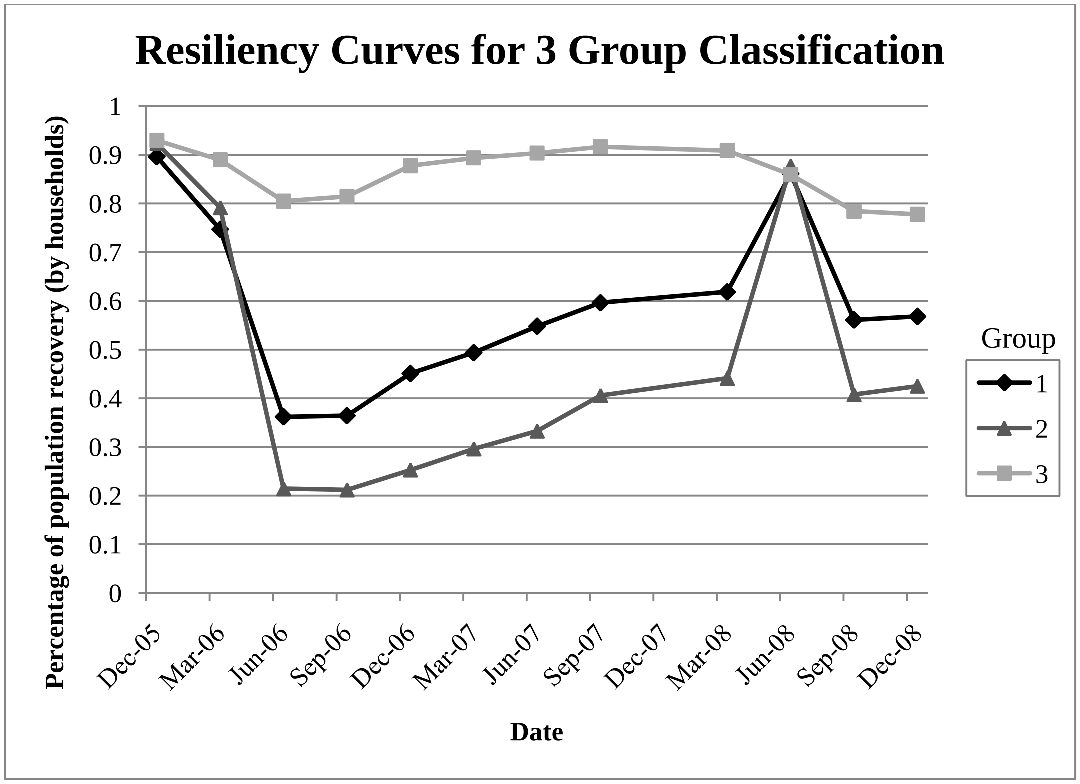

Figure 9 – Percent of population recovery for the three cluster groups determined through households actively receiving mail over three years following Hurricane Katrina.

Groups 1 and 2 illustrated a steady return rate but attained a population level that is nowhere near the original population of these areas. Group 2 achieved a 91% increase in population as compared to September 2006 numbers while Group 1 managed a 64% increase in population. Around June 2008, a spike in population was observed for Groups 1 and 2. Although it appears that all three groups have the same value, there is a slight variation in their averages. Population numbers are higher for all census tracts at June 2008, but no logical explanation for this sudden increase has been determined and the likely conclusion is that it is an anomaly in the data.

In September 2008, three years from the storm, a surprising trend is observed. The population for each group has begun to decrease slightly compared to the previous quarters. There are many explanations for this decrease that can only be mentioned here, as additional data over a longer period of time are needed for a definitive conclusion. It is possible that the data are just now starting to reflect individuals who will not return to the city. It has been suggested that New Orleans will not reach the level of population it maintained before Katrina and this trend could be an indication of a smaller city. This observation can also be due to the fact that perhaps the highest level of population recovery has been reached and the city may now continuing the downward population trend that existed prior to Hurricane Katrina.

6. DISCUSSION

Resilience is the ability of a system to withstand a disturbance and still function. The presence of human, natural, physical, social, and financial capital can increase the resilience of a community. Through statistical analysis, the natural/physical capital and human/social capital have been shown to be the most significant factors when dealing with a disturbance that is in the form of a hurricane. By an overwhelming margin, a large amount of flooding was shown to explain the loss of resilience in an area. This illustrates that natural/physical capital is the most important factor in a community's recovery from a disturbance. An area may be socio-economically stable but if natural/physical capital is lacking, then they will be susceptible to a disturbance. A prime example of this notion is the Lakeview community, one of the most affluent neighborhoods of New Orleans. Although Lakeview had a highly educated, wealthy population, it could not contend with over ten feet of flooding and has had difficulty recovering from the effects of Katrina.

The human and social capital factors of higher education and percentage of black population were highlighted as important factors influencing resilience by the discriminant analysis. A higher percentage of black population can be correlated with poorer neighborhoods in New Orleans, those with fewer resources to contend with natural disasters. The percentage of population with a bachelor's degree was inversely related to black populations, indicating the need for improved education resources in these areas. These two factors demonstrate the necessity for recovery efforts to focus on education and the availability of financial resources for the less fortunate populations in New Orleans.

In order to increase resilience for Orleans Parish, decisionmakers and government need to restore the physical and natural capital of the area as well as decrease the dependence on physical capital like the levees (Gaddis et al. 2007). Although levees are necessary for life in New Orleans, building codes and other regulatory measures can be instituted to ensure that homes are being rebuilt to withstand flooding and hurricane damage. Flood insurance should also be made available and obtained by all homeowners, rich and poor alike.

Adaptive management is a form of government regulation that allows for change in policies as experience and knowledge is gained over time. This form of management is particularly applicable to Orleans Parish and Gulf Coast communities as adaptability is needed to deal with the ever increasing threat from tropical storms and the long-term threat of sea level rise due to climate change. Governments should involve all stakeholders in planning for disasters and recovery to guarantee that no population will be left out of response planning (Baker and Refsgaard 2007). The New Orleans Redevelopment Authority (NORA) has instituted community improvement plans to revitalize neighborhoods throughout the city with stakeholder involvement but the effects of this program remain to be seen. Rebuilding in areas that have received significant flooding after multiple hurricanes such as the Ninth Ward has been allowed without much thought to the future and how to protect the new developments.

Throughout the Gulf Coast, the trend in management has been to invest in disaster response instead of addressing the vulnerabilities of the area to the disaster itself (Masozera et al. 2006). Orleans Parish must address the vulnerabilities of its physical capital, particularly with the levees and other flood prevention structures. The U.S. Army Corps of Engineers (USACE) has closed the Mississippi River Gulf Outlet (MRGO) blamed for much of the flooding in NOE and funneling storm surge into the New Orleans metropolitan area. In August 2007, the USACE announced plans for a $14.7 billion flood-protection system to shield New Orleans from future tropical storms. As with the previous flood-protection systems, this plan will take years to build and is currently projected to be completed by June 1, 2011 (Grissett 2009).

Werner and McNamara in 2007 stated that human and landscape communities should not be seen as separate systems but instead treated as “interweaved, coupled systems.” The loss of wetlands has not been addressed in this analysis but any recovery plan should take into account the importance of this natural capital and the buffering capacity to devastating storms demonstrated by wetlands. If southern Louisiana wetlands had not been eroded by saltwater intrusion and subsidence, among other factors, they would have reduced the storm surge created by Katrina and prevented some flooding. The Louisiana Legislature created the Coastal Protection and Recovery Authority (CPRA) in 2005 as a response to the devastation caused by Hurricanes Katrina and Rita. CPRA is intended to institute Louisiana’s Comprehensive Master Plan for a Sustainable Coast, providing both increased protection for coastal resources like wetlands and development of structures to shield coastal communities. Success or failure of this program cannot yet be determined.

7. AREAS FOR IMPROVEMENT AND FUTURE RESEARCH

In order to study the recovery of New Orleans at the census tract and zip code levels following Hurricane Katrina, households receiving mail was used to indicate population return. There may be problems with these population data including the accuracy of the household count within a census tract and potential variation between the numbers of people in households of different areas. Actual population counts would be ideal but this information has yet to be collected by the U.S. Census or another agency.

There are many other avenues for further research that could not be undertaken by this project. Evaluation of repopulation rates in future years to come will be valuable in demonstrating resiliency in New Orleans communities and the true impact of current recovery efforts. Overall, New Orleans has experienced a significant decrease in population. In July 2005 prior to Hurricane Katrina, 198,232 households in Orleans Parish were receiving mail. The first recording after the storm in August 2006 indicated that 98,141 households were accepting mail delivery. The most recent data in December 2008 specifies that 146,113 households are receiving mail. These numbers can also be compared with the population estimates for all of Orleans Parish from the U.S. Census Bureau: 2000 population – 484,674; 2005 population (prior to Katrina) – 453,726; 2006 population – 210,198; 2007 population – 288,113; and 2008 population – 311,853. The population trend is represented in Figure 11 below.

Although the population in New Orleans has increased over the past few years, it remains to be seen if the city's population will return to pre-Katrina numbers. New Orleans may be shifting to a different state, one that supports a smaller, potentially more resilient population. Current comparisons of the census tract population data between recovery from one, two, and three years after the storm show that after approximately two and a half years, a recovery peak has been reached and population tends to level off or decrease after this point. Only observations in future years will be able to verify these hypotheses and illustrate the presence of a recovery climax.

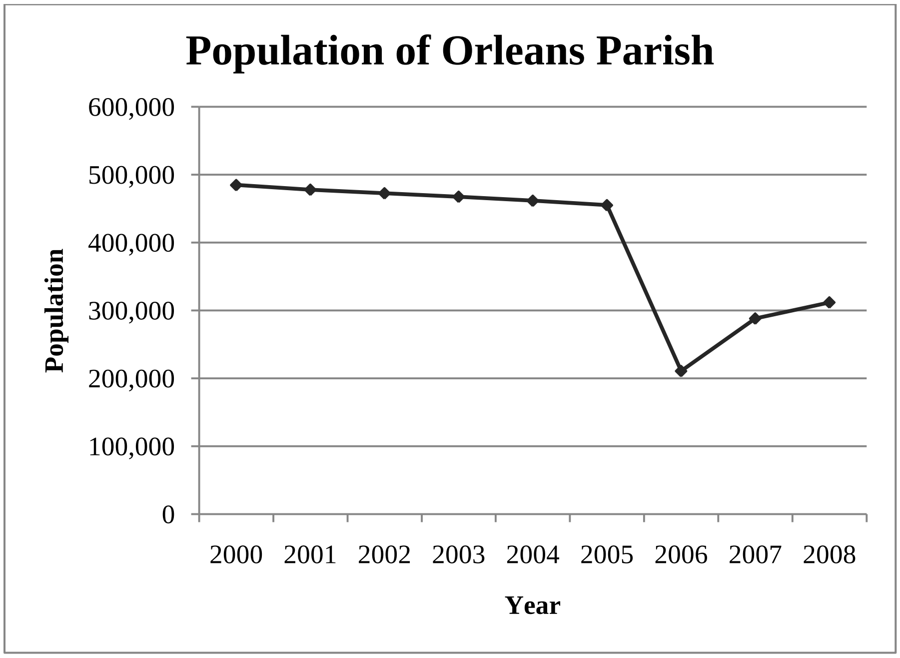

Figure 10 – Population of Orleans Parish from 2000 – 2008.

The influence of environmental management practices and construction practices on resiliency is an unexplored research area that could yield interesting results. Recently, proposed development projects intended to receive recovery development money for part of their budgets have been cancelled due to the inability to secure additional economic support. Thus, another potential aspect to be studied is how the current economic downturn will impact the recovery of New Orleans and its future.

8. SUMMARY OF FINDINGS

The subsequent flooding of the New Orleans area following Hurricane Katrina devastated the city and forced the evacuation of most of the local population. This provided a valuable opportunity to study the various factors that influence the recovery of a major U.S. city following a disturbance. Statistical analysis has shown that flood depth, race, and education will have the greatest significant impact on population recovery. Through this analysis, the amount of flooding was demonstrated to have the most influence on a community's ability to recover from a disturbance. The knowledge of these factors on population recovery can aid in the planning for a disaster and help community leaders improve the resilience of their areas.

New Orleans and the Gulf Coast will continue to face many disturbances including hurricanes and probable sea level rise. The importance of preserving the natural system and maintaining physical capital must be recognized as a method of increasing resiliency, along with ensuring access to education and financial resources. By upholding the physical infrastructure and preserving the natural ecosystem, the vulnerabilities of New Orleans can be minimized.

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APPENDIX A: CLUSTER ANALYSIS FOR ZIP CODES

Appendix Table 1 – Initial Cluster Centers

	Cluster			
	1	2	3	4
pct0806	.503982	.444218	1.003194	.133908
pct0906	.535078	.471318	1.003194	.151409
pct1006	.542283	.507298	1.003278	.197879
pct1106	.549488	.512963	1.003278	.204176
pct1206	.682215	.556854	1.003362	.209413
pct0107	.686765	.578698	.967219	.219092
pct0207	.689420	.605798	.971337	.257872
pct0307	.693212	.636828	.971674	.269075
pct0407	.697763	.672604	.971758	.306397
pct0507	.933257	.691691	.976801	.316009
pct0607	.963974	.703174	.985459	.320517
pct0707	1.005309	.748494	.986215	.347895
pct0807	1.028062	.764111	.979743	.353729
pct0907	1.029579	.790701	.900815	.380312
pct1007	1.031096	.796111	.896360	.369042
pct1107	1.031475	.800602	.896781	.408817
pct1207	1.031854	.806318	.897789	.410010
pct0108	1.032234	.809431	.898462	.423931
pct0208	1.032992	.811371	.878961	.426782
pct0308	1.033750	.810197	.880306	.431952
pct0408	1.041335	.784322	.879129	.431886
pct0508	1.053091	.764418	.880222	.436924
pct0608	1.053091	.757477	.881399	.443752
pct0708	1.040197	.759416	.881483	.451707
pct0808	1.040197	.761815	.882323	.461319
pct0908	1.040956	.765489	.882912	.464103
pct1008	1.045127	.772430	.884004	.471528
pct1108	1.045506	.779933	.885349	.481206
pct1208	1.045885	.780188	.888459	.492476

Appendix Table 2 – Iteration History(a)

Iteration	Change in Cluster Centers			
	1	2	3	4
1	.000	.386	.366	.364
2	.000	.273	.079	.000
3	.000	.000	.000	.000

a Convergence achieved due to no or small change in cluster centers. The maximum absolute coordinate change for any center is .000. The current iteration is 3. The minimum distance between initial centers is 1.166.

Appendix Table 3 – Cluster Membership

Case Number	Zipcode	Cluster	Distance
1	70112	1	.000
2	70113	3	.572
3	70114	3	.401
4	70115	3	.181
5	70116	3	.475
6	70117	4	.219
7	70118	3	.280
8	70119	2	.643
9	70122	4	.391
10	70124	4	.155
11	70125	2	.202
12	70126	4	.364
13	70127	4	.226
14	70128	2	.370
15	70129	2	.391
16	70130	3	.286
17	70131	3	.550

Appendix Table 4 – Final Cluster Centers

	Cluster			
	1	2	3	4
pct0806	.503982	.342514	.819635	.197028
pct0906	.535078	.370458	.831841	.219822
pct1006	.542283	.396282	.843972	.271455
pct1106	.549488	.404399	.846475	.284931
pct1206	.682215	.473749	.915198	.301629
pct0107	.686765	.484657	.914421	.311047
pct0207	.689420	.501562	.916626	.323757
pct0307	.693212	.516307	.919694	.350246
pct0407	.697763	.538663	.939448	.373828
pct0507	.933257	.566036	.940389	.383817
pct0607	.963974	.570084	.944931	.394740
pct0707	1.005309	.587712	.950337	.414296
pct0807	1.028062	.617191	.962507	.431647
pct0907	1.029579	.644834	.951945	.450456
pct1007	1.031096	.641109	.937668	.452268
pct1107	1.031475	.648056	.938838	.465871
pct1207	1.031854	.655441	.929143	.473782
pct0108	1.032234	.661787	.928143	.481939
pct0208	1.032992	.667124	.927399	.487900
pct0308	1.033750	.672141	.927649	.493519
pct0408	1.041335	.667825	.925032	.502244
pct0508	1.053091	.667337	.927155	.506028
pct0608	1.053091	.667717	.927312	.504383
pct0708	1.040197	.670624	.917397	.505143
pct0808	1.040197	.676914	.915649	.510714
pct0908	1.040956	.683908	.916533	.515025
pct1008	1.045127	.688831	.919542	.522001
pct1108	1.045506	.695353	.922257	.530419
pct1208	1.045885	.689097	.922323	.542010

Appendix Table 5 – Distances between Final Cluster Centers

Cluster	1	2	3	4
1		1.762	.920	2.652
2	1.762		1.822	.908
3	.920	1.822		2.703
4	2.652	.908	2.703	

Appendix Table 6 – Number of Cases in each Cluster

Cluster	1	1.000
	2	4.000
	3	7.000
	4	5.000
Valid		17.000
Missing		.000

APPENDIX B: CLUSTER ANALYSIS FOR CENSUS TRACTS

Appendix Table 7 – Initial Cluster Centers

	Cluster		
	1	2	3
Percent presently occupied 1205	.870544	.000000	.960422
Percent of Dec. 05 addresses occupied 0306	.558779	.932257	.962667
Percent of 1205 occupied 0606	.163227	.000000	.980211
Percent of Dec. 05 addresses occupied Sept. 06	.197936	.000000	.981530
Percent of 1205 addresses presently occupied 1206	.358349	.000000	1.029024
Percent of Dec. 05 addresses occupied 0307	.416708	.443495	.994667
Percent of Dec. 05 addresses occupied June 07	.575985	.000000	1.042216
Percent of Dec. 05 addresses occupied Sept. 07	.773921	.000000	1.055409
Percent of Dec.05 occupied March 2008	.838649	.000000	1.062005
Percent of Dec. 05 occupied June 2008	.659475	1.000000	1.009235
Percent of Dec. 05 presently occupied Dec. 2008	.498124	.000000	1.002639

Appendix Table 8 – Iteration History(a)

Iteration	Change in Cluster Centers		
	1	2	3
1	.507	.802	.453
2	.038	.242	.077
3	.054	.108	.007
4	.036	.051	.000
5	.056	.046	.016
6	.050	.019	.031
7	.045	.027	.022
8	.022	.025	.000
9	.015	.016	.000
10	.010	.011	.000

a Iterations stopped because the maximum number of iterations was performed. Iterations failed to converge. The maximum absolute coordinate change for any center is .006. The current iteration is 10. The minimum distance between initial centers is 1.720.

Appendix Table 9 – Cluster Membership

Case Number	geoid	Cluster	Distance
1	22071000100	3	.139
2	22071000200	3	.161
3	22071000300	3	.139
4	22071000400	3	.159
5	22071000601	3	.459
6	22071000602	3	.414
7	22071000603	3	.395
8	22071000604	3	.268
9	22071000605	3	.373
10	22071000606	3	.308
11	22071000607	3	.366
12	22071000608	3	.357
13	22071000611	3	.392

14	22071000612	3	.475
15	22071000613	3	.597
16	22071000614	3	.387
17	22071000701	2	.915
18	22071000702	2	.379
19	22071000800	2	.246
20	22071000901	2	.501
21	22071000902	2	.712
22	22071000903	2	.652
23	22071000904	2	.458
24	22071001100	1	.520
25	22071001200	3	.305
26	22071001301	1	.306
27	22071001302	1	.315
28	22071001303	1	.328
29	22071001304	1	.483
30	22071001401	2	.408
31	22071001402	2	.318
32	22071001500	2	.341
33	22071001600	2	.550
34	22071001701	2	.740
35	22071001702	2	.352
36	22071001703	2	.178
37	22071001706	2	.936
38	22071001714	2	.660

39	22071001720	2	.455
40	22071001722	2	.221
41	22071001723	2	.355
42	22071001724	2	.254
43	22071001725	1	.451
44	22071001726	2	1.187
45	22071001728	2	.844
46	22071001730	2	.845
47	22071001732	1	.520
48	22071001733	1	.452
49	22071001734	2	.880
50	22071001735	2	.323
51	22071001736	2	.452
52	22071001737	2	.296
53	22071001738	1	.360
54	22071001739	2	.299
55	22071001740	2	.534
56	22071001741	1	.368
57	22071001742	1	.359
58	22071001800	3	.174
59	22071001900	1	.447
60	22071002000	1	.309
61	22071002100	2	.236
62	22071002200	2	.217
63	22071002300	2	.383

64	22071002401	1	.251
65	22071002402	1	.216
66	22071002501	2	.388
67	22071002502	2	.370
68	22071002503	1	.237
69	22071002504	1	.439
70	22071002600	3	.151
71	22071002700	1	.402
72	22071002800	1	.247
73	22071002900	1	.363
74	22071003000	2	.419
75	22071003100	1	.218
76	22071003301	2	.253
77	22071003302	1	.474
78	22071003303	2	.445
79	22071003304	2	.238
80	22071003305	2	.466
81	22071003306	2	.402
82	22071003307	1	.426
83	22071003308	1	.293
84	22071003400	1	.379
85	22071003500	1	.195
86	22071003600	1	.310
87	22071003701	3	.362
88	22071003702	3	.293

89	22071003800	3	.159
90	22071003900	3	.153
91	22071004000	1	.434
92	22071004100	3	.409
93	22071004200	3	.383
94	22071004401	1	.510
95	22071004402	2	.404
96	22071004500	1	.357
97	22071004600	3	.383
98	22071004700	3	.577
99	22071004800	1	.833
100	22071004900	1	.417
101	22071005000	1	.514
102	22071005400	3	.479
103	22071005500	1	.441
104	22071005601	2	.315
105	22071005602	2	.346
106	22071005603	2	.378
107	22071005604	2	.352
108	22071005700	3	.726
109	22071005800	3	.821
110	22071005900	3	.999
111	22071006000	1	.524
112	22071006300	2	.560
113	22071006400	1	.326

114	22071006500	1	.197
115	22071006700	3	.398
116	22071006800	3	.213
117	22071006900	2	.837
118	22071007000	2	.319
119	22071007100	1	.441
120	22071007200	1	.372
121	22071007501	1	.354
122	22071007502	1	.195
123	22071007603	2	.276
124	22071007604	1	.432
125	22071007605	1	.367
126	22071007700	1	.497
127	22071007800	3	.218
128	22071007900	3	.302
129	22071008000	1	.834
130	22071008101	3	1.026
131	22071008102	3	.603
132	22071008200	3	.307
133	22071008300	3	.168
134	22071008400	3	.228
135	22071008500	3	.550
136	22071008600	2	.609
137	22071008700	3	.623
138	22071008800	3	.190

139	22071008900	3	.196
140	22071009000	3	.192
141	22071009100	3	.245
142	22071009200	1	.543
143	22071009301	1	.380
144	22071009302	2	.578
145	22071009400	2	.390
146	22071009600	3	.739
147	22071009700	3	.218
148	22071009900	3	.213
149	22071010000	1	.536
150	22071010100	3	.318
151	22071010200	1	.365
152	22071010300	1	.318
153	22071010400	3	.404
154	22071010500	3	.267
155	22071010600	3	.234
156	22071010700	3	.146
157	22071010800	3	.278
158	22071010900	3	.251
159	22071011100	1	.381
160	22071011200	1	.230
161	22071011400	3	.359
162	22071011500	3	.342
163	22071011600	3	.326

164	22071011700	3	.320
165	22071011900	3	.320
166	22071012000	3	.213
167	22071012101	3	.237
168	22071012102	3	.173
169	22071012200	1	.469
170	22071012300	1	.206
171	22071012400	1	.351
172	22071012500	3	.264
173	22071012600	3	.223
174	22071012700	3	.216
175	22071012800	3	.236
176	22071012900	3	.161
177	22071013000	3	.179
178	22071013100	3	.500
179	22071013200	3	.513
180	22071013301	3	.337
181	22071013302	3	.848

Appendix Table 10 – Final Cluster Centers

	Cluster		
	1	2	3
Percent presently occupied 1205	.906468	.890420	.919670
Percent of Dec. 05 addresses occupied 0306	.803912	.736732	.864320
Percent of 1205 occupied 0606	.348635	.218339	.820012
Percent of Dec. 05 addresses occupied Sept. 06	.387862	.168937	.836522
Percent of 1205 addresses presently occupied 1206	.482179	.208507	.895310
Percent of Dec. 05 addresses occupied 0307	.553234	.324187	.831060
Percent of Dec. 05 addresses occupied June 07	.597909	.263392	.922730
Percent of Dec. 05 addresses occupied Sept. 07	.660879	.315346	.935958
Percent of Dec.05 occupied March 2008	.680993	.354643	.924887
Percent of Dec. 05 occupied June 2008	.873185	.857573	.839500
Percent of Dec. 05 presently occupied Dec. 2008	.618051	.358729	.786290

Appendix Table 11 – Distances between Final Cluster Centers

Cluster	1	2	3
1		.776	.972
2	.776		1.698
3	.972	1.698	

Appendix Table 12 – Number of Cases in each Cluster

Cluster	1	55.000
	2	52.000
	3	74.000
Valid		181.000
Missing		.000

APPENDIX C: DISCRIMINANT ANALYSIS OF CENSUS TRACTS

Appendix Table 13 – Analysis Case Processing Summary

Unweighted Cases		N	Percent
Valid		181	100.0
Excluded	Missing or out-of-range group codes	0	.0
	At least one missing discriminating variable	0	.0
	Both missing or out-of-range group codes and at least one missing discriminating variable	0	.0
	Total	0	.0
Total		181	100.0

Appendix Table 14 – Group Statistics

Cluster Number of Case		Mean	Std. Deviation	Valid N (listwise)	
		Unweighted	Weighted	Unweighted	Weighted
1	Female household, no husband present	296.3818182	184.43974133	55	55.000
	Median household income in 1999	25118.3272727	16551.26587982	55	55.000
	Race: black	2244.5090909	1680.03329853	55	55.000
	Age under 5 years	198.4363636	159.60689714	55	55.000
	Age 65 and above	322.4727273	188.44616625	55	55.000
	Median age	33.6236364	4.54548875	55	55.000
	Owner occupied housing units	491.6909091	472.66646579	55	55.000
	Population unemployed	122.2545455	82.24876858	55	55.000
	25 and over:	203.8727273	206.304436	55	55.000

	Bachelor degree		55		
	Mean Flood Depth	2.7889885	1.30901727	55	55.000
	Mean Elevation	-.2065862	.84079048	55	55.000
2	Female household, no husband present	345.7307692	230.22283454	52	52.000
	Median household income in 1999	25594.7307692	13119.81986982	52	52.000
	Race: black	2455.8653846	1705.46436697	52	52.000
	Age under 5 years	244.9807692	162.18066546	52	52.000
	Age 65 and above	355.7884615	218.36310258	52	52.000
	Median age	32.9076923	8.04684437	52	52.000
	Owner occupied housing units	572.6153846	413.50245530	52	52.000
	Population unemployed	144.6346154	125.33485014	52	52.000
	25 and over: Bachelor degree	228.2115385	228.75514237	52	52.000
	Mean Flood Depth	4.4602101	1.98820867	52	52.000
	Mean Elevation	-.8508299	.93896495	52	52.000
3	Female household, no husband present	154.8783784	132.74281991	74	74.000
	Median household income in 1999	33171.4324325	22399.97896347	74	74.000
	Race: black	1010.7297297	986.84403977	74	74.000
	Age under 5 years	133.0135135	118.88275486	74	74.000
	Age 65 and above	275.8918919	198.37259585	74	74.000
	Median age	34.9648649	6.52819874	74	74.000
	Owner occupied housing units	415.8108108	344.16043072	74	74.000
	Population unemployed	80.5135135	56.43428552	74	74.000

	25 and over: Bachelor degree	299.0675676	244.60907201	74	74.000
	Mean Flood Depth	.7057671	.93768887	74	74.000
	Mean Elevation	1.2915326	1.24996874	74	74.000
Total	Female household, no husband present	252.7071823	198.45953241	181	181.000
	Median household income in 1999	28547.6243094	18690.80808765	181	181.000
	Race: black	1800.8121547	1583.21086827	181	181.000
	Age under 5 years	185.0607735	151.76305237	181	181.000
	Age 65 and above	313.0000000	203.08949861	181	181.000
	Median age	33.9662983	6.52671622	181	181.000
	Owner occupied housing units	483.9171271	409.51728872	181	181.000
	Population unemployed	111.6187845	92.29923246	181	181.000
	25 and over: Bachelor degree	249.7845304	231.59851032	181	181.000
	Mean Flood Depth	2.4174147	2.10780167	181	181.000
	Mean Elevation	.2208178	1.39800763	181	181.000

Appendix Table 15 – Tests of Equality of Group Means

	Wilks' Lambda	F	df1	df2	Sig.
Female household, no husband present	.822	19.294	2	178	.000
Median household income in 1999	.957	3.966	2	178	.021
Race: black	.824	18.988	2	178	.000
Age under 5 years	.904	9.425	2	178	.000
Age 65 and above	.973	2.490	2	178	.086
Median age	.982	1.637	2	178	.197
Owner occupied housing units	.975	2.285	2	178	.105
Population unemployed	.912	8.557	2	178	.000
25 and over: Bachelor degree	.967	3.050	2	178	.050
Mean Flood Depth	.448	109.634	2	178	.000
Mean Elevation	.561	69.776	2	178	.000

C.1 STEPWISE STATISTICS

Appendix Table 16 – Variables Entered/Removed(a,b,c,d)

		Wilks' Lambda							
				Exact F					
Step	Entered	df2	df3	Statistic	df1	df2	Sig.	Statistic	df1
1	Mean Flood Depth	.448	1	2	178.000	109.634	2	178.000	.000
2	25 and over: Bachelor degree	.387	2	2	178.000	53.711	4	354.000	.000
3	Race: black	.329	3	2	178.000	43.555	6	352.000	.000

At each step, the variable that minimizes the overall Wilks' Lambda is entered.
a Maximum number of steps is 22.
b Minimum partial F to enter is 3.84.
c Maximum partial F to remove is 2.71.
d F level, tolerance, or VIN insufficient for further computation.

Appendix Table 17 – Variables in the Analysis

Step		Tolerance	F to Remove	Wilks' Lambda
1	Mean Flood Depth	1.000	109.634	
2	Mean Flood Depth	.881	132.448	.967
	25 and over: Bachelor degree	.881	13.890	.448
3	Mean Flood Depth	.869	119.921	.778
	25 and over: Bachelor degree	.845	17.922	.396
	Race: black	.956	15.469	.387

Appendix Table 18 – Variables Not in the Analysis

Step		Tolerance	Min. Tolerance	F to Enter	Wilks' Lambda
0	Female household, no husband present	1.000	1.000	19.294	.822
	Median household income in 1999	1.000	1.000	3.966	.957
	Race: black	1.000	1.000	18.988	.824
	Age under 5 years	1.000	1.000	9.425	.904
	Age 65 and above	1.000	1.000	2.490	.973
	Median age	1.000	1.000	1.637	.982
	Owner occupied housing units	1.000	1.000	2.285	.975
	Population unemployed	1.000	1.000	8.557	.912
	25 and over: Bachelor degree	1.000	1.000	3.050	.967
	Mean Flood Depth	1.000	1.000	109.634	.448
	Mean Elevation	1.000	1.000	69.776	.561
1	Female household, no husband present	.997	.997	11.427	.397
	Median household income in 1999	.927	.927	11.096	.398

	Race: black	.997	.997	11.518	.396
	Age under 5 years	.998	.998	5.634	.421
	Age 65 and above	.874	.874	2.324	.437
	Median age	.956	.956	5.604	.421
	Owner occupied housing units	.904	.904	1.493	.441
	Population unemployed	.988	.988	7.439	.413
	25 and over: Bachelor degree	.881	.881	13.890	.387
	Mean Elevation	.678	.678	5.883	.420
2	Female household, no husband present	.976	.863	13.481	.336
	Median household income in 1999	.668	.636	2.219	.378
	Race: black	.956	.845	15.469	.329
	Age under 5 years	.836	.738	15.221	.330
	Age 65 and above	.530	.530	1.568	.380
	Median age	.889	.819	1.935	.379
	Owner occupied housing units	.332	.324	7.487	.357
	Population unemployed	.982	.867	7.921	.355
	Mean Elevation	.638	.638	9.924	.348
3	Female household, no husband present	.271	.265	.989	.326
	Median household income in 1999	.592	.556	.062	.329
	Age under 5 years	.315	.315	3.450	.317
	Age 65 and above	.468	.468	.413	.328
	Median age	.739	.734	.744	.327
	Owner occupied housing units	.234	.234	.477	.328
	Population unemployed	.565	.550	.959	.326
	Mean Elevation	.558	.558	3.272	.318

Appendix Table 19 – Wilks' Lambda

Step	Number of Variables	Lambda	df1	df2	df3	Exact F			
	Statistic	df1	df2	Sig.	Statistic	df1	df2	Sig.	Statistic
1	1	.448	1	2	178	109.634	2	178	.000
2	2	.387	2	2	178	53.711	4	354	.000
3	3	.329	3	2	178	43.555	6	352	.000

C.2 SUMMARY OF CANONICAL DISCRIMINANT FUNCTIONS

Appendix Table 20 – Eigenvalues

Function	Eigenvalue	% of Variance	Cumulative %	Canonical Correlation
1	1.959(a)	98.7	98.7	.814
2	.026(a)	1.3	100.0	.160

a First 2 canonical discriminant functions were used in the analysis.

Appendix Table 21 – Wilks' Lambda

Test of Function(s)	Wilks' Lambda	Chi-square	df	Sig.
1 through 2	.329	196.567	6	.000
2	.975	4.572	2	.102

Appendix Table 22 – Standardized Canonical Discriminant Function Coefficients

	Function	
	1	2
Race: black	.467	-.687
25 and over: Bachelor degree	-.537	.601
Mean Flood Depth	.999	.366

Appendix Table 23 – Structure Matrix

	Function	
	1	2
Mean Flood Depth	.790(*)	.608
Mean Elevation(a)	-.497(*)	-.239
25 and over: Bachelor degree	-.112	.607(*)
Race: black	.323	-.601(*)
Median household income in 1999(a)	-.120	.565(*)
Female household, no husband present(a)	.280	-.537(*)
Median age(a)	-.118	.497(*)
Population unemployed(a)	.177	-.466(*)
Age under 5 years(a)	.128	-.342(*)
Owner occupied housing units(a)	.078	.298(*)
Age 65 and above(a)	.154	.297(*)

Pooled within-groups correlations between discriminating variables and standardized canonical discriminant functions
Variables ordered by absolute size of correlation within function.
* Largest absolute correlation between each variable and any discriminant function
a This variable not used in the analysis.

Appendix Table 24 – Functions at Group Centroids

Cluster Number of Case	Function	
	1	2
1	.513	-.235
2	1.701	.159
3	-1.576	.063

Unstandardized canonical discriminant functions evaluated at group means

C. 3 CLASSIFICATION STATISTICS

Appendix Table 25 – Classification Processing Summary

Processed		181
Excluded	Missing or out-of-range group codes	0
	At least one missing discriminating variable	0
Used in Output		181

Appendix Table 26 – Prior Probabilities for Groups

Cluster Number of Case	Prior	Cases Used in Analysis	
		Weighted	Unweighted
1	.333	55	55.000
2	.333	52	52.000
3	.333	74	74.000
Total	1.000	181	181.000

Appendix Table 27 – Casewise Statistics

	Case Number	Actual Group	Highest Group				
			Predicted Group	P(D>d | G=g)		P(G=g | D=d)	Squared Mahalanobis Distance to Centroid	Group
			p	df	p	df	p	df
Original	1	3	3	.809	2	.973	.424
	2	3	3	.740	2	.871	.602
	3	3	3	.622	2	.827	.950
	4	3	3	.424	2	.746	1.718
	5	3	3	.333	2	.677	2.201
	6	3	3	.444	2	.766	1.624
	7	3	3	.416	2	.735	1.752
	8	3	3	.220	2	.636	3.026
	9	3	3	.648	2	.851	.867

10	3	3	.225	2	.996	2.987
11	3	3	.161	2	.997	3.655
12	3	3	.232	2	.996	2.918
13	3	3	.126	2	.510	4.146
14	3	3	.868	2	.964	.283
15	3	3	.297	2	.695	2.431
16	3	3	.167	2	.997	3.584
17	2	2	.448	2	.877	1.605
18	2	1(**)	.872	2	.675	.274
19	2	1(**)	.750	2	.695	.576
20	2	2	.388	2	.917	1.895
21	2	2	.061	2	.974	5.605
22	2	2	.588	2	.870	1.060
23	2	2	.869	2	.641	.282
24	1	1	.724	2	.608	.645
25	3	3	.882	2	.954	.250
26	1	1	.478	2	.548	1.478
27	1	1	.680	2	.641	.773
28	1	3(**)	.710	2	.717	.685
29	1	3(**)	.928	2	.848	.149
30	2	2	.622	2	.782	.950
31	2	1(**)	.728	2	.647	.636
32	2	1(**)	.949	2	.677	.105
33	2	2	.804	2	.825	.437
34	2	2	.100	2	.968	4.602
35	2	2	.812	2	.539	.416
36	2	2	.589	2	.654	1.057
37	2	1(**)	.712	2	.559	.680
38	2	1(**)	.945	2	.586	.113
39	2	2	.467	2	.533	1.524
40	2	2	.312	2	.694	2.331
41	2	1(**)	.858	2	.577	.307
42	2	1(**)	.944	2	.620	.116
43	1	1	.807	2	.690	.429
44	2	3(**)	.904	2	.828	.201
45	2	2	.575	2	.773	1.108
46	2	1(**)	.935	2	.630	.134
47	1	2(**)	.807	2	.752	.429
48	1	1	.972	2	.650	.057
49	2	3(**)	.887	2	.960	.239
50	2	2	.746	2	.756	.586
51	2	2	.573	2	.782	1.112
52	2	1(**)	.797	2	.569	.454
53	1	1	.092	2	.741	4.778
54	2	2	.938	2	.767	.128
55	2	2	.944	2	.756	.115

56	1	1	.781	2	.599	.493
57	1	1	.624	2	.705	.943
58	3	3	.874	2	.963	.270
59	1	1	.368	2	.500	2.001
60	1	1	.836	2	.685	.359
61	2	1(**)	.852	2	.509	.319
62	2	2	.988	2	.649	.025
63	2	2	.663	2	.743	.823
64	1	1	.918	2	.552	.171
65	1	1	.949	2	.653	.105
66	2	2	.039	2	.981	6.514
67	2	2	.019	2	.987	7.893
68	1	1	.444	2	.541	1.624
69	1	1	.486	2	.548	1.444
70	3	3	.886	2	.957	.242
71	1	1	.491	2	.581	1.423
72	1	1	.891	2	.642	.231
73	1	1	.742	2	.708	.596
74	2	2	.813	2	.507	.414
75	1	1	.867	2	.525	.286
76	2	2	.106	2	.883	4.494
77	1	2(**)	.874	2	.783	.268
78	2	2	.041	2	.976	6.410
79	2	2	.146	2	.960	3.851
80	2	2	.926	2	.578	.153
81	2	2	.087	2	.690	4.879
82	1	1	.947	2	.573	.110
83	1	1	.959	2	.655	.084
84	1	1	.617	2	.553	.967
85	1	1	.773	2	.662	.515
86	1	1	.896	2	.690	.221
87	3	1(**)	.760	2	.600	.548
88	3	1(**)	.745	2	.638	.588
89	3	3	.373	2	.993	1.974
90	3	3	.588	2	.496	1.063
91	1	1	.717	2	.692	.664
92	3	3	.886	2	.832	.242
93	3	3	.290	2	.992	2.477
94	1	1	.884	2	.645	.246
95	2	1(**)	.757	2	.697	.556
96	1	1	.862	2	.669	.298
97	3	3	.037	2	.443	6.576
98	3	3	.972	2	.841	.057
99	1	1	.638	2	.727	.899
100	1	1	.725	2	.598	.642
101	1	2(**)	.812	2	.510	.417

102	3	3	.434	2	.489	1.671
103	1	1	.067	2	.431	5.399
104	2	2	.008	2	.941	9.570
105	2	2	.003	2	.929	11.483
106	2	2	.134	2	.877	4.019
107	2	2	.108	2	.829	4.450
108	3	3	.825	2	.971	.385
109	3	3	.736	2	.619	.613
110	3	3	.741	2	.621	.599
111	1	1	.810	2	.572	.421
112	2	2	.914	2	.785	.179
113	1	2(**)	.940	2	.625	.125
114	1	1	.687	2	.573	.750
115	3	3	.908	2	.818	.193
116	3	1(**)	.515	2	.627	1.329
117	2	1(**)	.178	2	.518	3.448
118	2	2	.806	2	.555	.431
119	1	2(**)	.022	2	.751	7.644
120	1	1	.908	2	.596	.194
121	1	2(**)	.856	2	.727	.311
122	1	2(**)	.647	2	.644	.871
123	2	2	.003	2	.885	11.943
124	1	1	.132	2	.443	4.045
125	1	2(**)	.996	2	.659	.008
126	1	3(**)	.844	2	.968	.339
127	3	3	.847	2	.968	.332
128	3	3	.985	2	.889	.030
129	1	1	.581	2	.510	1.087
130	3	3	.258	2	.627	2.706
131	3	3	.821	2	.888	.393
132	3	3	.797	2	.974	.455
133	3	3	.887	2	.957	.240
134	3	3	.945	2	.855	.112
135	3	1(**)	.486	2	.557	1.444
136	2	1(**)	.980	2	.614	.041
137	3	3	.764	2	.871	.538
138	3	3	.872	2	.936	.273
139	3	3	.771	2	.883	.521
140	3	3	.189	2	.995	3.337
141	3	3	.927	2	.831	.152
142	1	1	.709	2	.680	.688
143	1	1	.996	2	.652	.008
144	2	1(**)	.761	2	.578	.545
145	2	2	.887	2	.756	.240
146	3	3	.811	2	.898	.420
147	3	3	.815	2	.902	.410

148	3	3	.237	2	.993	2.878
149	1	1	.823	2	.662	.389
150	3	3	.574	2	.673	1.110
151	1	2(**)	.903	2	.648	.205
152	1	2(**)	.415	2	.893	1.759
153	3	3	.883	2	.914	.250
154	3	3	.867	2	.920	.285
155	3	3	.881	2	.931	.254
156	3	3	.915	2	.952	.177
157	3	3	.830	2	.964	.372
158	3	3	.854	2	.821	.316
159	1	1	.839	2	.512	.352
160	1	2(**)	.513	2	.744	1.335
161	3	3	.376	2	.993	1.955
162	3	3	.397	2	.992	1.849
163	3	3	.699	2	.975	.718
164	3	3	.071	2	.994	5.283
165	3	1(**)	.185	2	.483	3.371
166	3	3	.603	2	.808	1.011
167	3	3	.568	2	.752	1.132
168	3	3	.872	2	.786	.274
169	1	3(**)	.129	2	.511	4.101
170	1	2(**)	.595	2	.640	1.037
171	1	1	.763	2	.602	.541
172	3	3	.849	2	.967	.328
173	3	3	.607	2	.979	1.000
174	3	3	.902	2	.946	.205
175	3	3	.608	2	.917	.994
176	3	3	.994	2	.913	.012
177	3	3	.739	2	.641	.606
178	3	1(**)	.553	2	.640	1.187
179	3	1(**)	.964	2	.668	.074
180	3	3	.034	2	.991	6.741
181	3	3	.663	2	.753	.823

** Misclassified case

Appendix Table 2 – Classification Results(a)

		Cluster Number of Case	Predicted Group Membership			Total
			1	2	3	
Original	Count	1	39	12	4	55
		2	15	35	2	52
		3	7	0	67	74
	%	1	70.9	21.8	7.3	100.0
		2	28.8	67.3	3.8	100.0
		3	9.5	.0	90.5	100.0

a 77.9% of original grouped cases correctly classified.

VITA

Lauren DeFrank was born and grew up in League City, Texas, a suburb of Houston. Following her graduation from high school in 2002, she attended Tulane University in New Orleans, Louisiana. While at Tulane she co-majored in environmental biology and environmental science with a minor in history. Lauren relocated to Houston, Texas, for the fall 2005 semester because of Hurricane Katrina. In the spring of 2006, Lauren completed her bachelor's degree at Tulane and graduated in May 2006. After graduation, Lauren moved to Washington, D.C., where she worked as an Events Associate for the Alliance to Save Energy until she returned to Louisiana to begin her degree at Louisiana State University in the spring of 2008. Lauren will graduate in August of 2009 with a master's in environmental science and a concentration in environmental planning and management. She has been selected as a Fellow for the Presidential Management Fellows program and intends to work for the United States Army Corps of Engineers Institute for Water Resources in Alexandria, Virginia, following graduation.