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AN ANALYSIS OF THE PREVALENCE OF THE WEST NILE VIRUS IN RELATION TO HEALTH RESILIENCE ALONG THE GULF OF MEXICO

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 Science

by
Lillian Mata
B.S. & B.A., The University of Texas at Austin, 2011
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Abstract

As the Earth's climate changes, coastal communities are increasingly vulnerable to the natural hazards that are driven by these processes, particularly in regards to the health of these communities. It has been shown that disease patterns can change in response to our environment, putting the health resilience of communities at risk. This study looks at the relationship between natural exposure and traditional resilience index variables in the context of the spread of West Nile Virus along the Gulf of Mexico. Through analysis of 534 counties, the West Nile Virus for 2001-2012 was analyzed as an incidence and incidence rate at three levels of urban and rural classification (metropolitan, micropolitan, and rural) as well as for the entire study area. Regression analysis found that models incorporating both natural and society indicators were more successful at explaining a population's vulnerability to the West Nile Virus. It was seen that short-term climate variability and economic indicators were important measures of a community's health resilience in the context of the prevalence of the West Nile Virus. Socio-economic characteristics proved to be more explanatory in rural environments while natural characteristics explained more variance in metropolitan and micropolitan environments. Increasing temperatures were found to increase the spread of the West Nile Virus, particularly in urban areas. This study is a tangible analysis of health resilience in the context of both the human and natural environments across different levels of human infrastructure on a large spatial scale.

Chapter 1: Introduction

1.1 Problem Statement

Climate changes have long been looked at as having an impact on community health because they can change the way that the environment and community are able to interact and the way that the community is able to adapt when faced with different kinds of hazards (Adger et al., 2005). Average world temperatures are expected to rise which in turn causes the sea level to rise, increasing the amount of vulnerable communities in regards to flooding and coastal hazards (Patz et al., 2005). Long term climate changes and year-to-year variability can also be linked with changes in human health (Patz et al., 2005). In general, climate change can be associated with warming winters that can increase the prevalence of diseases (National Wildlife Federation, 2012). Anthropogenic climate change can lead to extreme variability in climate over short periods of time that can lead to alterations in community health by shifting the way that diseases are spread, the prevalence of diseases, and the vulnerability of a community to health effects from both diseases and changing natural patterns (Ebi, 2011; Patz et al., 2005). As land use changes, industry increases, and populations of communities grow on both large and small scales; the natural environment will be altered and damaged, sometimes irreversibly. These changes can lead to a decrease in the health of the population, making them more vulnerable to diseases and hazards (Patz et al., 2005).

Just prior to the beginning of this century, the West Nile Virus took root in this country. The first outbreak of West Nile in the United States took place the summer of 1999 in New York City (Nash et al., 2001). Since this initial incidence, the disease has spread through the entire continental United States (National Wildlife Federation, 2012). Research has shown that the

spread of West Nile Virus is encouraged by warmer than normal winters followed by summers that are hot and dry (Epstein, 2001). Climate change has led to a trend in winters being warmer, which puts pressure on the natural environment, but also leads to pressure on the human population (Neira et al., 2008). This complicated process trends toward supporting disease transmission cycles between human populations and carriers of diseases such as the West Nile virus, with mosquitoes and birds being the most common carriers (Epstein, 2001). Short term climate variation caused by climate change has a profound effect on the transmission of West Nile Virus; as temperatures increase and as rainfall levels provide ideal breeding sites for mosquitoes, the availability of carriers for the disease increases (Epstein, 2001). Climate change also decreases the variety of bird species within bird populations on a local scale, which has been shown to increase the incidence of West Nile Virus within both the bird and human populations by making bird populations more vulnerable to disease amplification (Keesing et al., 2010). This provides ample access for mosquitoes to reservoirs of West Nile Virus. As the number of carriers of disease in the environment increases, it leads to an increase in the risk that the human population faces in contracting the disease by increasing the exposure potential (National Wildlife Federation, 2012). These connections between climate change and the risk of disease put our human populations at risk not only from a health perspective but also from a community strength perspective.

There is responsibility on the individual level for health, but the community must also be involved in promoting the health of the individuals that make it up. As the old adage goes, we are only as strong as our weakest link, meaning that the health of the individual is important and indicative of the health of the community. Both governmental and non-governmental

organizations on a variety of scales need to be involved in order to increase the resilience - and therefore the health - of the communities they are responsible for serving and protecting (Acosta et al., 2011). From a government perspective, having a resilient community is preferential, because it in turn limits how much financial assistance governments have to dish out following a large scale disaster (Chandra et al., 2010). Governments can also be involved on a smaller scale in promoting health within a community. In the context of the West Nile Virus, advertising that the disease is an issue, providing information on appropriate prevention techniques, and large-scale spraying for mosquitoes improve the chances within the community that people will not contract the disease or that individuals who do contract it will recognize the disease and be able to handle it appropriately (National Wildlife Federation, 2012).

As more is learned about climate change and the effects that it has on human communities, more must be done to combat the effects to our health (Neira et al., 2008). Community resilience has been looked at in recent years as a measure of our ability to "absorb recurrent disturbances" and move forward from them or not being destroyed by them (Adger et al., 2005). There is a body of research about what factors can lead to a community's resilience in regards to different climate change related factors, but there is currently no focus onto what climate change is doing to our health resilience as individuals or as communities on a wider scale. In order to determine the health resilience of a community, the appropriate climate change factors need to be associated with descriptors of the community health. These descriptors of community health need to be reflective of not only the health and status of the individual but also that of the community as a whole. There also needs to be the ability to associate characteristics across communities that lend themselves to either weakness or

strength of community health so that characteristics that promote health and resilience in response to climate change and disease can be promoted.

This study will investigate what relationships are important in the development of a framework for understanding health resilience using West Nile Virus as a study case. The research questions are as follows:

1. How is the spread of the West Nile Virus affected by variations in the natural exposure? Specifically:
    a. Climate variability in temperature and precipitation
    b. Variations in the natural environment between urban and rural areas through the use of MSA classifications
    c. Variation in historical occurrence of thunderstorms, drought, and flooding events
    d. Variations in mean elevation
2. How is the spread of West Nile Virus affected by variations in Socio-Economic Status?
    a. Using traditional resilience indicators
3. How does the combination of the natural exposure and societal factors affect the spread of the West Nile Virus?

1.2 Research Objectives

The main objective of this study is to examine the relationship between West Nile Virus occurrence, climate factors, and socio-economic characteristics in order to develop a set of predictive indicators for patterns of human health resilience across the five states along the

Gulf Coast. Extensive research has been done establishing resilience using socio-economic indicator variables like population change, median income change, and per capita income change. There is not currently a method for establishing resilience based on health. The aim here is to take a two-pronged approach by first looking at how climate variations are affecting health by analyzing the West Nile Virus cyclic epidemic and then looking at how this relationship changes in context with community resilience descriptors across the study area. The results from this two-pronged approach will support the development of a health resilience framework that can be used for analysis, assessment, and management purposes. West Nile Virus data will be used in this context as a health indicator variable since it has a known and traceable history in the United States.

The thought behind using a health indicator variable is that it could be determined how the health of both individuals within the community and the health of the community as a whole are being changed by the effects of coastal and climate hazards. It has been shown that climate change puts both the natural environment and human populations at risk from coastal and climate hazards as weather patterns change (Adger et al., 2005; Keesing et al., 2010). This is important for future development of community resilience because the health of the population is an important risk factor that can have an effect on the other factors, such as socio-economic ones, that have proven so important to determining the resilience of a community (Castleden et al., 2011). In determining what exactly leads to resilience, decisions can then be made in decreasing the effects of climate change induced hazards and the associated health risks (Adger et al., 2005).

Since climate change has been related to community resilience and to health independently in the literature, West Nile Virus presents a unique crossroads at which to bring these two concepts together. Directly affecting health and having been commonly linked with climate variability allows for the use of West Nile Virus in order to take a look at the conceptual development of human health resilience. The ultimate goal would be to unite these different ideas and create a more extensive definition of community resilience in regards to climate change in order to develop a framework of health resilience. In doing so, health can be related to the different aspects of resilience and the different variables that come together to determine a community's true resilience (Castleden et al., 2011).

The study area of the five Gulf of Mexico coastal states in combination with the West Nile Virus as a health indicator presents a chance to look at the combination of resilience in regards to health and climate patterns as caused by climate change. A total of 534 counties create the study area within the states of Alabama, Florida, Louisiana, Mississippi, and Texas-all of the states along the Gulf of Mexico. These states were chosen based on the work already done in looking at resilience within these communities. They were chosen also in that they are subjected to increases in coastal hazards due to climate change and these areas have been affected by the West Nile Virus continuously since the disease came to this country (CDC, 2012; National Wildlife Federation, 2012). The objective in using these counties is to look at the vulnerabilities caused by present day climate variability and how they affect the health of the human communities in these areas. Research has been done in assessing the resilience scores of these communities; therefore, the study area provides a comparative basis for looking at the validity of the process for developing a health resilience index. Through this method, factors

that affect health resilience can be further analyzed and assessed for use in promoting the health of individuals and development of policies to help communities in the future.

Through the course of this study, the following will be accomplished: (1) to develop climate data at the county level for the study area on a monthly basis for the years 2000-2012; (2) compilation of a dataset on the West Nile Virus incidence and incidence rates at a county level and at the state level for this study area and time period; (3) to use visual methods such as mapping in order to determine what sort of trends there are across the study area; (4) to use correlation analysis to determine relationships between West Nile Virus incidence and incidence rates with climate trends and traditional socio-economic resilience indicators; (5) to then use regression analysis to study the relationships between climate factors, socio-economic variables, and West Nile Virus. By accomplishing the aforementioned analysis, the following research hypotheses will be evaluated:

1. As temperature and precipitation levels increase, so will the incidence of West Nile Virus.
2. There is a difference in the way urban and rural environments are affected by the West Nile Virus, with urban environments being more susceptible.
3. A community with stronger socio-economic characteristics will be less affected by the West Nile Virus.
4. A model that incorporates both differences in natural exposure and socio-economics is better in explaining the spread of West Nile Virus.

Chapter 2: Literature Review

2.1 Resilience

2.1.1 Definition

Resilience is a much-studied topic, but there is a lacking consensus of exactly how to define it across disciplines. At a most basic level, it is defined in Webster's as "the capability of a strained body to recover its size and shape after deformation caused especially by compressive stress" or "an ability to recover from or adjust easily to misfortune or change" (Merriam-Webster, 2012). Within the scientific community, there are a multitude of definitions of what resilience means dependent upon what is specifically being looked at in that moment. In 1973, Holling introduced the term in order to describe a "measure of the persistence of systems and their ability to absorb change and disturbance and still maintain the same relationships between populations or state variables" (Holling, 1973). Adger defines it as "the capacity of linked social-ecological systems to absorb recurrent disturbances…as to retain essential structures, processes of feedbacks" (Adger et al., 2005). Some definitions focus on the broad scale ideas of planning and management while other focus on populations or the individual and the way they react to a difficult situation (Castleden et al., 2011; Keim, 2008). In the context of resilience to natural disasters, resilience can be looked at as a community not needing assistance following a large-scale disaster, whether the community is able to initially withstand the disaster or whether it come from being able to recover and improve themselves following a catastrophic disaster (Chandra et al., 2010 & 2011).

A physicist, an engineer, and a psychologist will all use the term resilience in completely different contexts, but all of these different perspectives help form the basis of a community's total resilience (Castleden et al., 2011). It does however pose a problem for the entities trying to come together to promote the resilience within a community, both on a local scale and a national scale (Acosta et al., 2011; Castleden et al., 2011). In order to achieve a high level of resilience, common thought in the literature is that federal government, state and local government officials, and non-governmental agencies must come together and function as a unit in order to promote resilience and in turn deal with the problems within the community following a disaster, whether of man-made or natural origins (Acosta et al., 2011; Chandra et al., 2010). The breakdown in resilience exists because there is a lack of understanding of how to come together and of what specifically drives resilience (Chandra et al., 2010).

2.1.2 Quantifying Resilience

It is commonly accepted that resilience is achieved through the interactions of a plethora of factors and processes that must all work together in order to achieve strength within a community. However, there currently is not a completely persuasive set of descriptors that can be used to quantify resilience (Reams et al., 2012). It can be said that resilience can be broken down into two main components, the portion afforded by the natural environment and that stemming from human activities (Keim, 2008). In a broad sense, human behaviors that lead to a reduction in risk and vulnerability from hazards are the defining component of human community resilience (Cutter et al., 2008; Keim, 2008). Many of the threats that human populations face, particularly within coastal communities, originate through natural processes

that not only can we not control but that we must learn to manage our response as populations grow and change (Reams et al., 2012). This management can be achieved through an understanding of the components that drive human resilience.

There are many categories of descriptors that have been determined to have some influence on the resilience of any given community. On a broad scale, connectivity of the individuals within a community to the social networks existing within the community allow for development of resilience (Castleden et al., 2011; Chandra et al., 2010). This ability to self-organize provides a way for individuals to drive the development of resilience, not just depending on someone else to do it. The capacity of a community to recognize what weaknesses exist amongst them and to develop mechanisms to help manage these during a crisis is very important (Acosta et al., 2011). These interactions occur on a local scale but also on much wider national and global scales, making it quite difficult to quantify community resilience (Olwig, 2012). This is particularly pertinent with coastal communities, whose very existence is linked with processes with a wide reach, i.e. tourism, industry, and economics (Adger et al., 2005).

There are also dimensions of resilience that can come from the natural environment and the built environment and infrastructure within a community (Cutter et al., 2008). The government and the community also interact through the economics and regulations within the community that can lead to changes in how the community is structured; therefore, these interactions can affect how the resilience of the community is structured (Cutter et al., 2008). All of these different components of resilience can come together to reduce risks within a given community system (Adger et al., 2005).

2.2 Health Resilience

2.2.1 Definition

Currently, there is no widely accepted definition for the concept of health resilience. Looking at health resilience requires looking at resilience on a large scale that includes many different contexts (Castleden et al., 2011). In the research context, human health does not just mean a medically defined and diagnosable condition; health is used to describe the intersection of the physical, mental, and social status of an individual or population (Curtis & Oven, 2012). Resilience itself can be looked at in the context of nation-wide, community level, response to disasters, socio-economic factors, infrastructure, and on the individual level (Castleden et al., 2011). And all of these different forms of resilience are relevant to a definition of health resilience. In order to determine the types of protection that might be necessary to be put into place to promote the health of the nation, community, or individual it is necessary to understand all sides of the resilience issue. Health resilience can loosely be defined as the ability of a community to handle a disaster in the context of "preventing, withstanding, and mitigating the stress of a health incident; recovering in a way that restores the community to a state of self-sufficiency and at least the same level of health and social functioning after a health incident; and using knowledge from a past response" moving forward to deal with similar events (Chandra et al., 2011). In looking at the health resilience of a community, the relationship between the physical and mental health of an individual with the broad scale interaction of environmental changes, natural disasters, health events, climate changes,

changes in infrastructure and government policy must be analyzed and united together (Castleden et al., 2011).

2.2.2 Adaptation & the Quantification of Health Resilience

In the context of evolution, adaptation can be defined as any reaction to stress that allows a population to have a greater chance for survival (Berkes & Jolly, 2001). There has been a focus in the study of resilience on the concept of adaptations, i.e. what we do as a population or as individuals in order to develop strategies to reduce the effects of a given situation (Ebi & Semenza, 2008). Adaptations can be at the individual level in response to an event that that individual feels is extreme or can be taken by governing bodies to enact a large-scale change to benefit a large number of people (Adger, 2003). In the context of health, the idea of prevention is equivalent to adaptation in that we want to prevent the negative effects from a disaster or from environmental changes on our health (Ebi & Semenza, 2008). In recent years, the human population has turned from an approach of dealing with disasters after they happen to proactively preparing comprehensive plans to deal with natural disasters that could negatively affect our health and societies (Keim, 2008). These adaptive strategies allow for populations to make changes on both a large and small scale to help protect the structure of both community and individual health (Berkes & Jolly, 2001). Steps are being taken on both local and federal scales in order to better prepare human populations for future large-scale health events (Chandra et al., 2010; Keim, 2008).

Changing population dynamics can have a strong influence on the health of any given community. As technology advances, our societies become more mobile which has led to a

change in disease patterns through the spreading of diseases to places where they formerly were not found (Adger et al., 2005). This puts entire populations at risk for diseases that they would have no exposure to previously, for example West Nile Virus coming to the United States in 1999 when it had not been found in the Western Hemisphere previously (May et al., 2011). Economic factors such as poverty can also determine how diseases are spread. In areas of high poverty, there is not money to support adaptive strategies or treat people that are dealing with poor health (Adger, 2003; Haines et al., 2006). Areas of poverty tend to be in more hazardous areas, in regards to both natural disasters and man-made problems (Adger, 2003; Haines et al., 2006). Other changes, such as urbanization, population and land use changes, travel, and economic expansion can all contribute towards increasing or decreasing the health resilience of a given community (Haines et al., 2006; Lindgren et al., 2012).

2.2.3 Extreme Weather Effects on Health

Definitions of human populations, things like education, health, and infrastructure, will determine what capacity a society has to be resilient to extreme weather variability (Keim, 2008). The socio-economic status of the population will be a determinant of the degree to which any given population can adapt to the effects from climate changes (Haines et al., 2006). Gradual changes in climate conditions can cause society to dismiss measures that can be used to build resilience to extremes because they cannot see the results of such efforts (Adger, 2003). The importance of these factors is not realized until a major event happens and the health of the community suffers greatly (Adger, 2003). Populations that are already struggling or that do not have a strong infrastructure in place will be more affected by extreme and changing weather patterns (Keim, 2008). In order to withstand the coming climate changes,

communities need to be able to anticipate the risks that are coming and make the necessary changes to be prepared to effectively deal with the changes (Ebi, 2011). The problem is that adaptations in any population take time to sink in and become normal practice for any population; extreme natural events can lead to stress because there is no way to anticipate the necessary adaptations (McMichael et al., 2006).

Within recent history we have seen that both health and resilience of communities can be directly and indirectly affected by extreme weather events. Temperature and precipitation variability can lead to changes in the ways that diseases are distributed, changes in sea level can threaten whole communities and infrastructures, and changes in climate can lead to problems in agricultural industries (Haines et al., 2006). Isolated extremes in temperature or excessive or lacking rainfall can all cause individuals with a weakened health resilience to succumb in a way they normally would not have (McMichael et al., 2006). For example, the heat wave of 2003 across Europe proved the point that temperature can exacerabte tenuous health situations (Haines et al., 2006). It is commonly accepted that mortaility increases during extreme temperatures, and during this heat wave more than 16,000 people died from heat related deaths across Europe (Haines et al., 2006). It was said that these were the hottest conditions in Europe since the 1500's (Haines et al., 2006). Existing conditions weaken people in such a way that they cannot deal with the extreme tempeatures (Haines et al., 2006).

Extreme amounts of precipitation can also lead to mortaility. Flooding leads to fatalities directly through drowning but also through increases in diseases (Haines et al., 2006). Hazardous materials can get into the water systems and crowding of populations into smaller than normal areas can increase the spread of both respiratory and diarrhoeal diseases (Haines

et al., 2006). On the other extreme, a lack of precipitation during an extreme drought can cause changes in the availability of water and nutrition and can also lead to forest fires, which can cause air pollution and respiratory problems (Haines et al., 2006).

Vector borne diseases can also be altered by changing weather patterns. Warmer temperatures and changing patterns of rainfall can both lead to an increase in habitat and breeding grounds for vectors like mosquitoes (McMichael et al., 2006). As these activity of these diseases is dependent upon the stength of the vector population, health of a community is then dependent upon what is happening in the natural environment. Increases in or shifts of these diseases to new areas can lead to decreases in health resilience as new populations as that were not previously exposed to diseases are facing changing disease landscapes (Chandra 2010).

2.3 Climate Change Impacts on Health

2.3.1 Climate Change

According to the Environmental Protection Agency, "climate change refers to any significant change in measures of climate lasting for an extended period (EPA, 2012)." These long-term changes in climate that the earth has undergone recently can in large part be attributed to human activities, mainly the production and use of fossil fuels (Weber, 2010). Temperature and precipitation cycles and patterns are commonly used as indicators of climate change (EPA, 2012). These climate measures have historically been shown to change through natural processes, but the concern lies in that there has been a more expedient rate of change in the last 50-100 years (Herbert, 2012; Weber, 2010). In recent years, climate scientists have

come to the consensus that the human caused greenhouse gas emissions are causing changes in the world's climate at rates that have previously been unseen (McMichael et al., 2012).

As the world population continues to grow, climate change becomes an increasingly larger issue due to the rising demand for the use of fossil fuels, leading to "The Greenhouse Effect" (Howat & Stoneham, 2011). The Greenhouse Effect is caused when solar radiation is trapped in the Earth's atmosphere and redistributed to the Earth's surface by greenhouse gas molecules in the atmosphere rather than passing through the atmosphere after reflecting off the Earth's surface (EPA, 2012; NOAA, 2008). Greenhouse gases are molecules in the atmosphere such as water vapor, carbon dioxide, methane, chlorofluorocarbons, and ozone and high concentrations of them can be attributed to anthropogenic sources (IPCC, 2007; NOAA, 2008). The greenhouse effect is a "self-reinforcing cycle" due to the fact that as the earth warms, more emissions occur as humans combat the effects of the warming which in turn leads to more warming, making it difficult to break the cycle (IPCC, 2007). When these gases get into the upper portions of the atmosphere, they cause larger scale changes in temperature compared to if these molecules were trapped near the surface (IPCC, 2007). Often, the term global warming is used in the place of climate change; however these terms are not interchangeable. Global warming specifically references an "average increase in the temperature of the atmosphere near the Earth's surface" (EPA, 2012). This surface warming represents a single kind of climate change that the Earth will go through (NOAA, 2008).

2.3.2 Climate Change Effects on Coastal Communities

There are many ways that coastal communities can feel the brunt of climate change. It is quite costly to build the necessary infrastructure to protect coastal communities from sea level

rise. In areas that cannot afford to build these protections, the threat of sea level rise is quite real and potentially detrimental to them (Haines, et al., 2005). Coastal communities are also poised to feel the effects from stronger hurricanes that are influenced by the warming of the oceans (McMichael et al., 2006). They are located in a prime position to feel the most extreme effects from these different situations, making coastal communities highly vulnerable to the extreme weather events that can be caused by climate change.

2.3.3 Differences in Urban and Rural Environments

Changes in the natural environment such as a change in land cover can exacerbate the effects of climate change on a more localized or regional scale (Patz et al., 2005). The construction of cities can lead to urban heat islands through removal of vegetation and converting open land to roads and buildings (Ebi & Semenza, 2008; EPA, 2012). This decrease in the vegetative cover and increase in impermeable man-made cover leads to an increased heat storage capacity, which lowers the ability of the land to cool through evaporation (Patz et al., 2005). Cities and urban areas have been shown to be anywhere from 1-11^{o}C warmer than the rural areas outside of the city limits (EPA, 2012; Patz et al., 2005). This is caused by materials used to make roofs, roads, and buildings heating to potentially more than 30^{o}C warmer than the current air temperature (Ebi & Semenza, 2008; Patz et al., 2005). Urban heat islands also do not allow for cooling during the evening hours since the materials used to build city infrastructure will continue to release heat into the night long after the sun has set (EPA, 2012). This creates a problem by compromising the health of the city residents through higher temperatures and also leads to higher levels of greenhouse gas emissions and other pollutants

due to the higher levels of fossil fuels being used to combat the higher temperatures as the human population searches for comfort (Ebi & Semenza, 2008; EPA, 2012). These higher temperatures can also provide ideal environments for vectors that can cause rampant spread of disease through closely confined urban populations (Epstein, 2001).

2.3.4 Climate Change Effects on Disease Transmission

Many vector borne diseases are extremely sensitive to climate variability, which could be a result of more long-term climate change (Haines et al., 2006). Changes in temperature, humidity, precipitation, sea level rise, land cover, and available habitat can alter the patterns of many different diseases (Haines et al., 2006; McMichael et al, 2006). These changes in climate and natural environemnt can change the populations of disease vectors by creating conditions that are conducisve to increases in the vector population (NWF 2012). Mosquitoes are a prime example of this. All varieties of mosquito populations are extremely senstive to climate conditions, with the stength of the population being determined by temperature and precipitation levels (CDC 2012; Stobbe 2013).

2.4 West Nile Virus

2.4.1 Introduction & History

West Nile Virus is an RNA virus that belongs to the family Flaviviridae (Murray et al., 2011). This family of diseases includes several others that are dangerous to humans such as St. Louis Encephalitis, which can be found here in the United States and other disease such as Kunjin fever, yellow fever, and dengue which can be found in other parts of the world

(Kilpatrick, 2011; Murray, 2011; PA DOH). Mosquitoes are the main transmitters of the disease into the human population, however there have been instances of transmission through blood transfusion, mother-to-child transmission, and organ transplants (Mayo Clinic, 2012; PA DOH). There is no way for the disease to spread through human-to-human contact (CDC, 2012).

West Nile Virus has long been identified as leading to meningitis and encephalitis, beginning with the first reported outbreak in 1957 in Israel (CDC, 2004; Nash et al., 2001). Historically, outbreaks of the West Nile Virus in humans have reportedly occurred all over the world (May et al., 2011). Epidemics have been reported in Africa, Australia, Russia, Europe, the Middle East, and now the United States (CDC, 2004; May et al., 2011). The virus was originally isolated from an adult female febrile patient in Uganda in 1937 (CDC, 2004; Kilpatrick, 2011; May et al., 2011). Epidemiological studies have shown that the West Nile Virus is endemic to tropical climates in Africa, southern Asia, and the northern coast of Australia (Kilpatrick, 2011). Not much was known about the disease until a major outbreak in Israel in the early 1950's sparked studies into further understanding of the West Nile Virus and where it was located (May et al., 2011). West Nile Virus was so misunderstood when it was originally discovered that in the 1950's it was attempted to use the West Nile Virus as an anticancer therapy (Kilpatrick, 2011).

West Nile Virus was first reported in North America in New York City during the summer of 1999 (Epstein, 2001). The introduction of the West Nile Virus into the Americas was the first time in recent history that an Old World flavivirus has entered the Western Hemisphere (Peterson & Roehrig, 2001). It has been shown through genetic testing that the strain of West Nile Virus that first came into New York City in 1999 is closely related to a strain that is

commonly found in Israel; however, it is still unknown what type of carrier brought the virus to the United States from the Middle East (Epstein, 2001; Peterson & Roehrig, 2001). West Nile Virus has since been reported in Canada and all 48 states in the continental United States since the initial discovery of West Nile Virus in New York City; Alaska and Hawaii both have never had any reported West Nile Virus cases (CDC, 2004, 2010, 2012). After that initial incidence along the Eastern Seaboard of the United States, it only took four years for the West Nile Virus to spread across the United States to the West Coast (Kilpatrick, 2011). Since the West Nile Virus's spread into North America, it has spread across the hemisphere into Central and South America (May et al., 2011).

2.4.2 Transmission Cycle

Since its initial introduction into and detection within the United States, West Nile Virus has caused cyclical epidemics across the Western Hemisphere (CDC, 2010). West Nile Virus has been recognized as causing these seasonal epidemic outbreaks every summer since the first cases of the virus were reported here in the United States (CDC, 2012). Generally the season for West Nile Virus in the United States starts in April and peaks in August (CDC, 2012). The season can extend through October or November depending on climate conditions (CDC, 2012; DeNoon, 2012).

The main vector for the disease into the human population has been shown to be mosquitoes from the genus *Culex* (Gong et al., 2011; Murray et al., 2011). These mosquitoes easily thrive in urban environments and can be influenced by climactic conditions, which has potentially helped spread the disease across the Western Hemisphere (Epstein, 2001; Gong et al., 2011; Kilpatrick, 2011). Urban environments provide ideal breeding locations for the *Culex*

mosquitoes because a built environment creates many places for standing water, which is needed for propagation of a mosquito population (CDC, 2012). Sewers and drainage systems provide ideal breeding locations for these mosquitoes, making urban environemnts ideal for populations of *Culex* mosquitoes (Epstein, 2001). The strength and length of the West Nile Virus season is influenced predominantly by the activity of the mosquito population. When a mosquito population is actively breeding and doing it at high levels, it increases the degree to which the virus can spread-more mosquitoes equals more chances for disease (Stobbe, 2013). When weather conditions are optimal for mosquito breeding, the disease is able to spread more quickly (IDPH, 2007).

The West Nile Virus infects mosquitoes when they feed on the blood of an infected bird (CDC, 2012). The bird population acts as a reservoir for the West Nile Virus in a given environment and it has been shown that birds can quite easily survive a West Nile Virus infection (CDC, 2009; Epstein, 2001). The mosquitoes take the blood of an infected bird and the virus propagates in the mosquito's salivary glands (CDC, 2012). Once the mosquito is carrying the West Nile Virus, it can pass the disease to any animal or human that it may bite in order to feed (CDC, 2012). Horses can also be infected with West Nile Virus, allowing for them to act as an additional reservoir for the disease (CDC, 2009). There have not been any indications that West Nile Virus can spread person-to-person or from an animal to a human (CDC, 2009).

While causing sickness and leading to death in some infected humans, West Nile Virus has also affected other vertebrates including horses and birds (Zielinski-Gutierrez & Hayden, 2006). Since the establishment of the West Nile Virus in this country, tens of thousands of birds have tested positive for the disease post-mortem in both wild and captive populations (La Deau

et al., 2007). The West Nile Virus has been shown to survive long-term by using birds and mammals such as horses as reservoirs because animals such as birds can survive an infection, which allows for the West Nile Virus to exist in a population long-term (CDC, 2009; IDPH, 2007). This is accomplished due to the fact that birds in particular can easily survive the infection, which gives the disease a place to live during the seasons when mosquitoes are not active (CDC, 2009). Over 300 species of birds have been identified as West Nile Virus carriers, which allows for the disease to persist and amplify in a large population (LaDeau et al., 2010).

2.4.3 Human Health Effects

Once someone has been infected with the West Nile Virus, there are several different ways in which the disease can present itself (CDC, 2012). Around 80% of the human population that is affected by the West Nile Virus will not show symptoms or are so mildly affected that they do not ever realize they are sick (CDC, 2012; Mayo Clinic, 2012). Less than 20% of people infected by the West Nile Virus will display the mild symptoms of the West Nile Fever (Mayo Clinic, 2012). The symptoms of the West Nile Fever include: fever, body aches, nausea and vomiting, headaches, swelling of the lymph glands, back pain, and/or a rash that can spread along the core of the body (CDC, 2012; Mayo Clinic, 2012). About 1% of the population that is infected with the West Nile Virus will experience serious illness or death (Mayo Clinic, 2012; PA DOH). When an infected individual beings to display the intense symptoms of a West Nile Virus infection, it can generally be associated with some form of encephalitis or meningitis (Mayo Clinic, 2012). Encephalitis is the inflammation of the brain; meningoencephalitis is the inflammation of the brain and all the associated membranes; meningitis is the inflammation of the membranes around the brain and spinal cord (Mayo Clinic, 2012). The symptoms associated

with these serious infections include: high fevers, vision loss, numbness, tremors, comas, disorientation, stupor, headaches, neck stiffness, convulsions, partial paralysis, and abrupt muscle weakness (CDC, 2012; Mayo Clinic, 2012). In the most serious of cases, West Nile Virus Encephalitis can lead to death and the neurological symptoms and effects can be long lasting and even permanent (CDC, 2012; Mayo Clinic, 2012).

Currently, there is no vaccine for West Nile Virus nor are there any real treatment options for someone infected with the West Nile virus; the only real available option is for symptomatic treatment (Zielinski-Gutierrez & Hayden, 2006). Hospitalization and treatment of the symptoms is generally the only option (PA DOH). Because of this, prevention becomes the most promoted option when dealing with the West Nile Virus (CDC, 2012; National Wildlife Federation, 2012; Zielinski-Gutierrez & Hayden, 2006). These methods include protecting oneself from mosquitoes when it is unavoidable to go out in areas where they are abundant and destroying sites where mosquitoes could potentially breed (Austin, 2013; CDC, 2012).

2.4.4 West Nile Virus & Climate

It has long been established that vector-borne diseases are quite sensitive to climate changes (McMichael et al., 2006). Mosquitoes are affected by temperature-warmer temperatures lead to an increase in the breeding rates of mosquitoes and also increases the speed with which West Nile Virus can develop within the mosquitoes (Epstein, 2001). As winters are getting warmer and warmer, it also allows for the mosquito populations to survive longer and allows the West Nile Virus to endure from season to season (Maxmen, 2012). Warmer temperatures can also decrease the number of mosquitoe predators, which allows for larger populations of mosquitoes (Epstein, 2001). Changing rainfall patterns can also increase

the amount of available habitat by providing standing water that allows for mosquitoes to breed at higher levels (Gong et al., 2011). West Nile Virus incidence increases have been attributed to higher than normal temperatures, especially as winters are more and more mild (National Wildlife Federation, 2012). However, both higher and lower levels of precipitation have been associated with the spread of West Nile Virus (Walsh, 2012).

It is possible that some portion of the spread of the disease throughout the Western Hemisphere could be attributed to bird migration and changes in their migratory patterns as climatic changes are felt more strongly in the environment (Fuller, 2012). Birds are quite sensitive to climate changes and will change their migratory patterns based on changes in temperature and precipitation cycles, and as these patterns change the birds can spread the disease into areas that it previously was not located (Fuller et al., 2012). Even without changes in their migration patterns it has been established that birds can transmit and carry diseases long distances during migration (Fuller et al., 2012). Part of this sensitivity to climate can also increase the ease with which the disease spreads through bird populations. Drought can cause birds to congregate in high numbers when there are low water resources for them to choose from, which allows the disease to move quickly through the population (Epstein, 2001).

2.4.5 West Nile Virus Relevance to Health Resilience

West Nile Virus is poised at a very interesting intersection to be used in the development of a conceptual health resilience framework. West Nile Virus has a traceable history within this country since it was not found here until 1999. Being able to track the spread of a health indicator gives a certain amount of control over the analysis. It has also been established that there is some relationship between climate conditions and the spread of the

West Nile Virus. There has been a lot of research into the tenuous relationship that climate change and human health have with each other. By using an indicator, such as West Nile Virus, to develop this framework in combination with traditional resilience indicators will allow for the opportunity to study how climate can influence human health resilience.

Chapter 3: Study Area & Data

3.1 Study Area

Working within the established framework for determining coastal resilience would allow for using the current model to resolve how to incorporate health exposure into the description of community resilience. Also, West Nile Virus is a disease that is associated with urban-dwelling mosquito species, making it a potential indicator between urban and rural

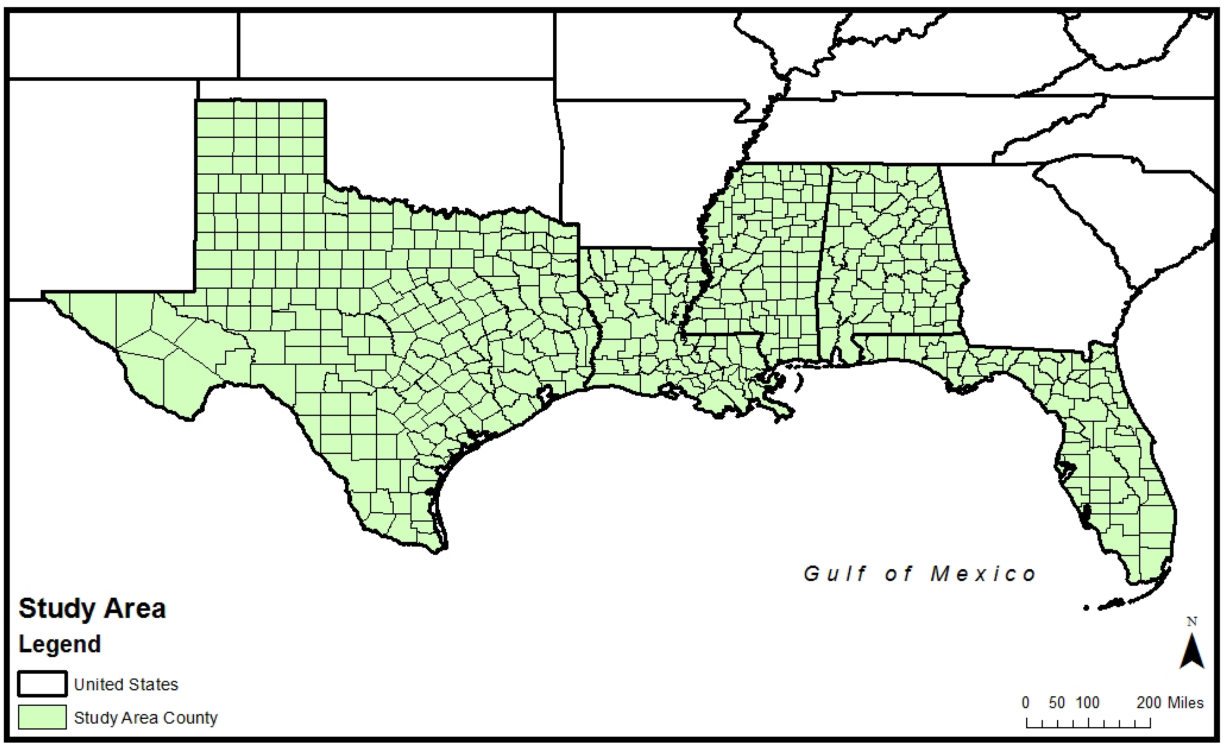

Figure 1: Study Area

population resilience (Epstein, 2001). Due to its cyclic nature, West Nile Virus has also been thought to be influenced by climate variability (Kilpatrick, 2011).

The area used for this study includes all 534 counties across the states of Alabama, Florida, Louisiana, Mississippi, and Texas and are represented in Figure 1. These states were chosen based on their proximity to each other and their use within previous resilience research (Reams et al., 2012). A compilation of West Nile Virus incidence has been put together based on data provided through the Centers for Disease Control and USGS (CDC, 2013). The total reported West Nile Virus incidence per year by county for the years 2001-2012 was then converted into West Nile Virus incidence rates per 100,000 individuals for use in this study. This study begins in 2001 due to that being the year the West Nile Virus was first reported in this study area. Each calendar year represents one West Nile season based on the fact that West Nile Virus starts becoming active in April and runs until October or November depending on a variety of factors (CDC, 2012; DeNoon, 2012). West Nile Virus incidence and incidence rates in a time series will be mapped to examine the patterns of the spread throughout the study area of the West Nile Virus. In looking at areas with a consistent occurrence of West Nile Virus, external factors that are potentially linked with increases or decrease in West Nile Virus from year to year can then be looked at.

3.2 Data

A combination of climate factors will be used in the analysis of the spread of West Nile Virus, as there is evidence that it is affected by changing climate conditions (Epstein, 2001). For the purposes of this study, precipitation and temperature data were used as climate indicators. Currently, there is no county level climate data readily available. Hence, a weather station for each county was chosen as a representation of that county based on the station with the most

complete dataset for 2000-2012. Data for the year 2000 was collected for use in the analysis of relationships with climate conditions from previous years. The map in Figure 2 details the location of each weather station used to collect the data for this study. In a situation where there was a choice of stations, the one chosen was that which was closest to the center of the county in order to best characterize the area. To view a list of these stations please see the county characterization in Appendix 1.

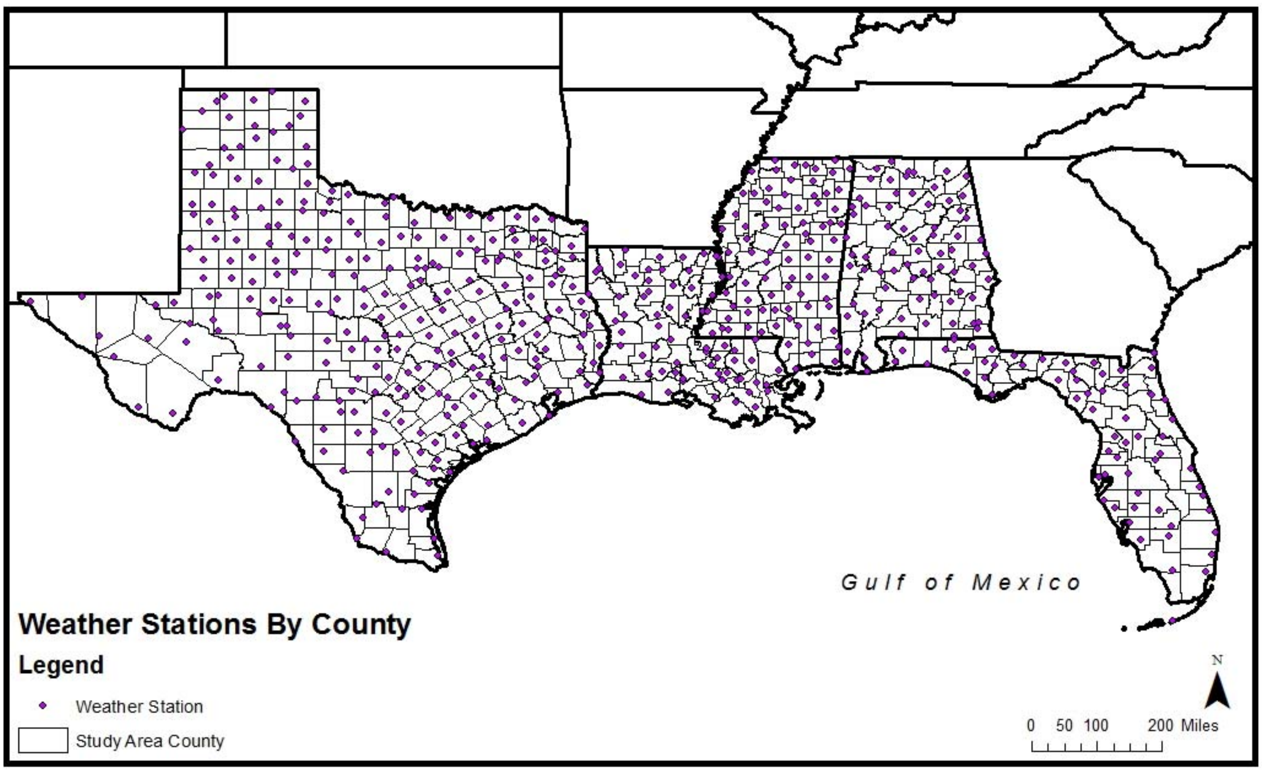

Figure 2: Weather Stations by County

The Monthly Summaries were downloaded for each of the chosen weather stations within the study area from January 2000 to August 2012, the most recent data available at the time of this study. From this data set, the Average Monthly Precipitation and Average Monthly

Temperature data for each county within the study area were compiled in a master dataset. This separation by type, month, and year allows for the calculation and analysis of different

Table 1: Natural Exposure Variables

West Nile Virus	
West Nile Virus Total Incidence Per Year	WNI_t
West Nile Virus Incidence Rate Per Year Per 100,000 Individuals	WNR_t
Natural Exposure	
Average Precipitation For a Given Month Per Year	$PXXX_t$
Average Precipitation Per Year	$PAVG_t$
Average Precipitation West Nile Season	PWN_t
Average Precipitation Non-West Nile Season	PNS_t
Average Temperature For a Given Month Per Year	$TXXX_t$
Average Temperature Per Year	$TAVG_t$
Average Temperature West Nile Season	TWN_t
Average Temperature Non-West Nile Season	TNS_t
Average Precipitation For a Given Month from a Previous Year	$PXXX_{t-n}$
Average Precipitation from a Previous Year	$PAVG_{t-n}$
Average Precipitation from a Previous West Nile Season	PWN_{t-n}
Average Precipitation from a Previous Non-West Nile Season	PNS_{t-n}
Average Temperature For a Given Month from a Previous Year	$TXXX_{t-n}$
Average Temperature from a Previous Year	$TAVG_{t-n}$
Average Temperature from Previous West Nile Season	TWN_{t-n}
Average Temperature from a Previous Non-West Nile Season	TNS_{t-n}
Historical Total of Thunderstorms from 1995-2010	THSTRM
Historical Total of Drought Events from 1995-2010	DRGHT
Historical Total of Flooding Events from 1995-2010	FLDING
Mean Elevation	MELEV

climate relationships. This data compilation allowed for the calculation of yearly averages, the averages for both the West Nile active season and off-season, and seasonal averages in addition to the monthly data themselves (Herbert, 2012). For the purposes of this study, West Nile Season was considered April to October and Non-West Nile Season was considered November (from the previous year) to March. Table 1 details each of the West Nile Virus and climate variables that were collected. Climate variables were used for n=1, 2, 3, and 4 in order to characterize climate relationships through time. These relationships are categorized in Table 1. The use of different climate variables is important because it allows for the analysis of how long-term and short-term climate conditions can affect the variability in the spread of the West Nile Virus.

There have been studies that have shown that there are many components that determine health resilience (Castleden et al., 2011). Social, economic, and demographic characteristics of a community can be related to a community's susceptibility to West Nile Virus and climate conditions, and can lead to changes within a community's health resilience. Variables such as the number of elderly, the number of children, the number of people with diseases such as diabetes, alcoholism, hypertension, coronary disease, and immunosuppression can affect the vulnerability of a community to West Nile Virus (Nash et al., 2001). A wide range of indicators has been related to community resilience and can be used to evaluate the resilience of a community (Cutter et al., 2008;Reams et al., 2012). Based on the established research, Table 2 details the socio-economic variables used in this study. These variables are classified into Demographics, Social Capital, Economics, Government, and Health in order to try and capture the wide range of factors that can determine resilience.

Table 2: Socio-Economic Variables

Demographics	
Population Density, 2010	POPDEN
Percent of the Population that is African American, 2010	PCTBLK
Percent of the Population that is Hispanic, 2010	PCTHIS
Percent of the Population that is Under 5 years old, 2010	PCTKID
Average Number of Individuals Per Household, 2010	AVGPERHH
Percent of Population Over Age of 65, 2010	PCTOLD
Social Capital	
Percent of the Population Over 25 With No High School Diploma, 2010	PTNOHS
Percent of Homes That Are Mobile Homes, 2010	PCTMOB
Total Housing Units Per Square Mile, 2010	HOUDEN
Percent of the Civilian Labor Force That is Female, 2010	FEMLBR
Percent of Female Headed Households, 2010	PCTFHH
Percent of the Population That Rents, 2010	PCTRENT
Percent of the Population Living Below Poverty, 2010	PCTPOV
Economics	
Per Capita Income, 2010	PCINC
Median Income, 2010	MEDINC
Percent of the Civil Labor Force That is Employed, 2010	PCTCVLBRF
Percent of Employment in Agricultural Services, 2010	PCTAG
Median Rent, 2010	MEDRENT
Median Value of Owner Occupied Housing, 2010	MVALOO
Percent Rural Farm Population, 2000	PCTFMPOP
Unemployment Rate, Per 10,000 Labor Forces, 2008	UNEMPL
Government	
Percent of Population That Voted in the Presidential Election, 2008	PCTVOT
Health	
3-year Average of Chronic Illness Deaths Per 10,000 Individuals, 2006	CHRILL
Non-federal Active Medical Doctors Per 10,000 Individuals, 2009	MD
3-year Total Low Birth Weight Babies Per 10,000 Births, 2006	LBWB

In order to properly compare between urban and rural environments, the dataset was divided into subsets. The study area was classified into Rural, Micropolitan, or Metropolitan

areas. Figure 3 depicts these classifications across the study area. In accordance with the United States Metropolitan Statistical Area guidelines, a Metropolitan area is classified as one with a core greater than 50,000 people (US Census, 2013). A Micropolitan area is classified as one with an urban core of greater than 10,000 but less than 50,000 people (US Census, 2013). Therefore, for the purposes of this study Rural areas were classified as less than 10,000 people in a core. To see each county's individual classification, please see the county characterization in Appendix 1.

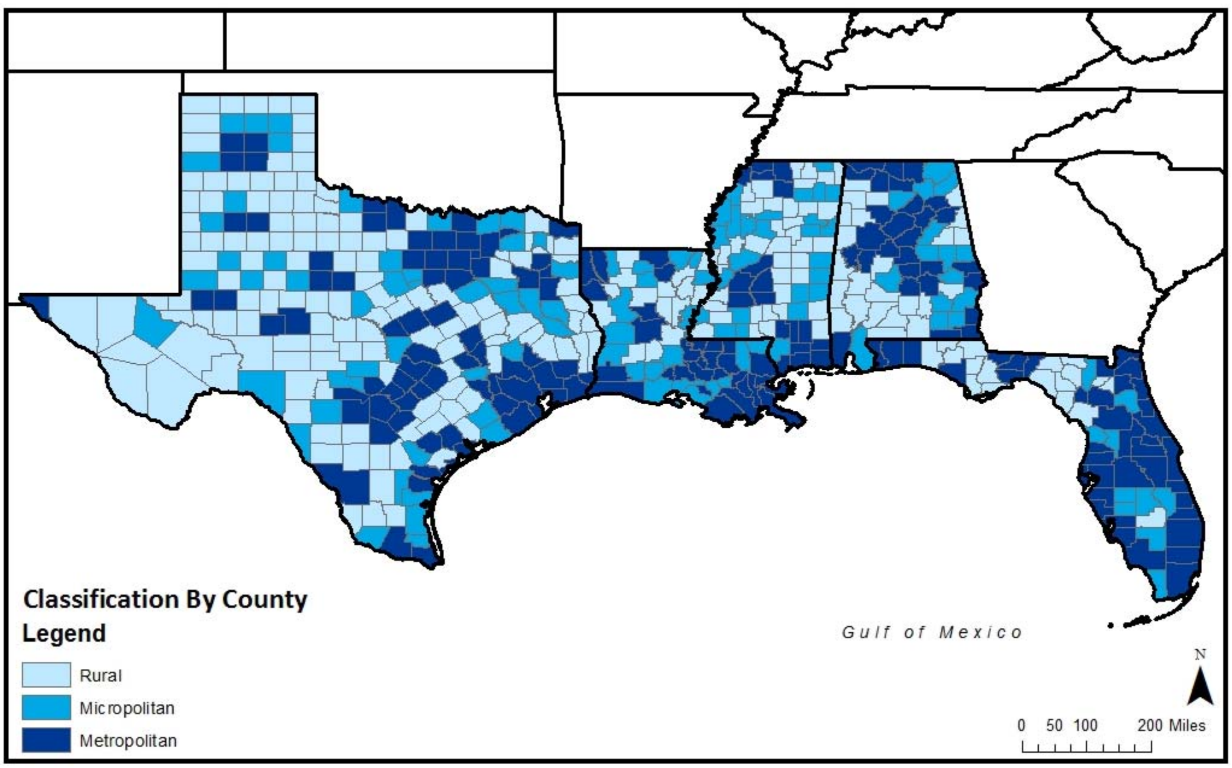

Figure 3: Metropolitan Statistical Area Classification

Climate data was downloaded from the National Climate Data Center, which is run by the National Oceanic and Atmospheric Administration (NOAA, 2013). The Demographic, Social Capital, Economic, and Government variables were obtained through the United States Census

for each county in the study based on the 2010 census (US Census, 2010). Health variables and the Unemployment Rate variable were compiled using the Bureau of Health Professions in U.S Department of Health and Human Services: Area Resource File (ARF) database. Historical natural hazards data was downloaded and tallied from the Spatial Hazard Events and Losses Database for the United States (SHELDUS) database and was used based on the fact that there is an association between weather trends and the West Nile Virus and that these patterns can be reflective of climate change (Harley et al., 2011; Keim, 2008; SHELDUS, 2012). Metropolitan Statistical Area Classification data was gathered using the 2010 US Census classifications and definitions (US Census, 2013). Boundary files for use in mapping were downloaded from the US Census TIGER/Line products (US Census, 2011).

Chapter 4: Analysis of the West Nile Virus

4.1 Comparison of the United States of America and the Study Area

There has been a large amount of coverage of the West Nile Virus in the media in recent years. As our population realize the long-term impacts of being infected with West Nile Virus, a focus on prevention and protection in necessary since there is nothing that can be done to treat a West Nile Virus infection. In the short time that West Nile Virus has had a presence in this country, it has managed to spread not only across the country but across the entire continent and into the southern hemisphere.

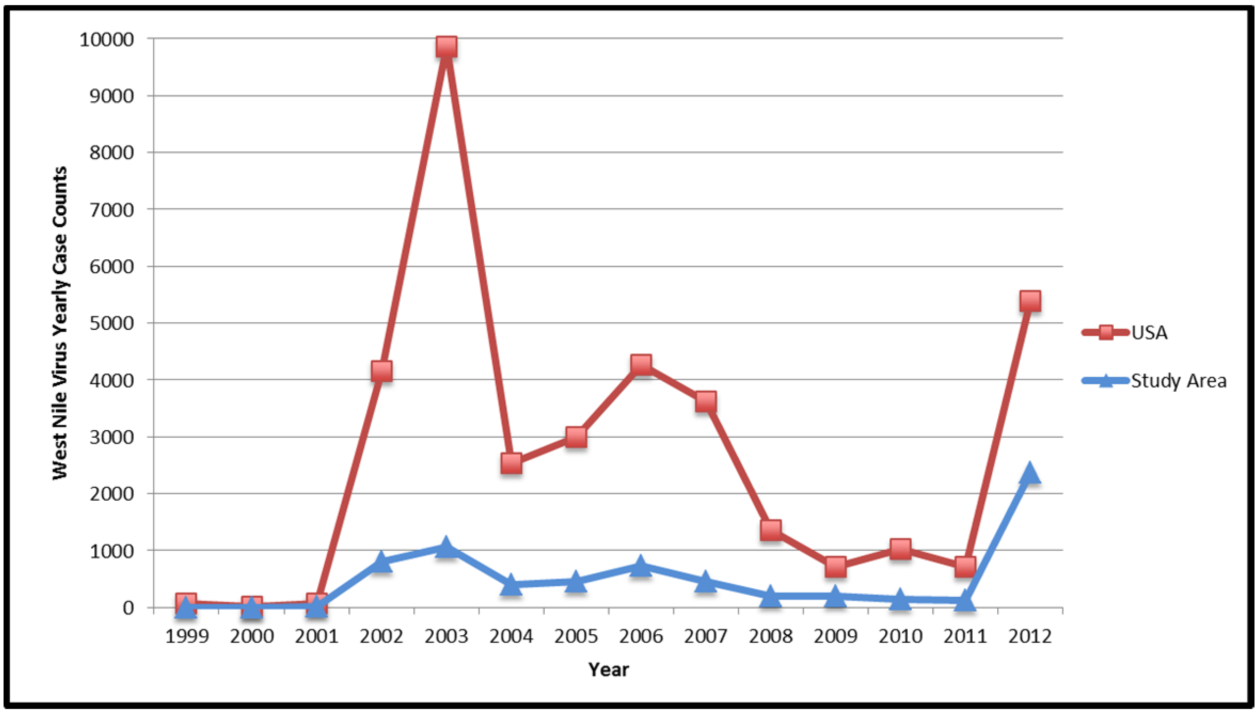

Figure 4: West Nile Virus Incidence USA vs. Study Area

The graph in Figure 4 shows a comparison between the number of cases across the United States of America and the Gulf Coast states used in this study. The study area follows a similar pattern to the country as a whole, with peaks in 2003, 2006, and 2012. The study area was not active for West Nile Virus infections until 2001, but since then the study area has had West Nile Virus infections consistently each year. On average, the study area accounts for about 20% of the West Nile Virus cases in the United States; this is higher than the 18% of the population that the study area accounts for. However, the incidence percentages range from 10-45%, meaning that this area has a tendency to be more susceptible to this disease than other areas in the country.

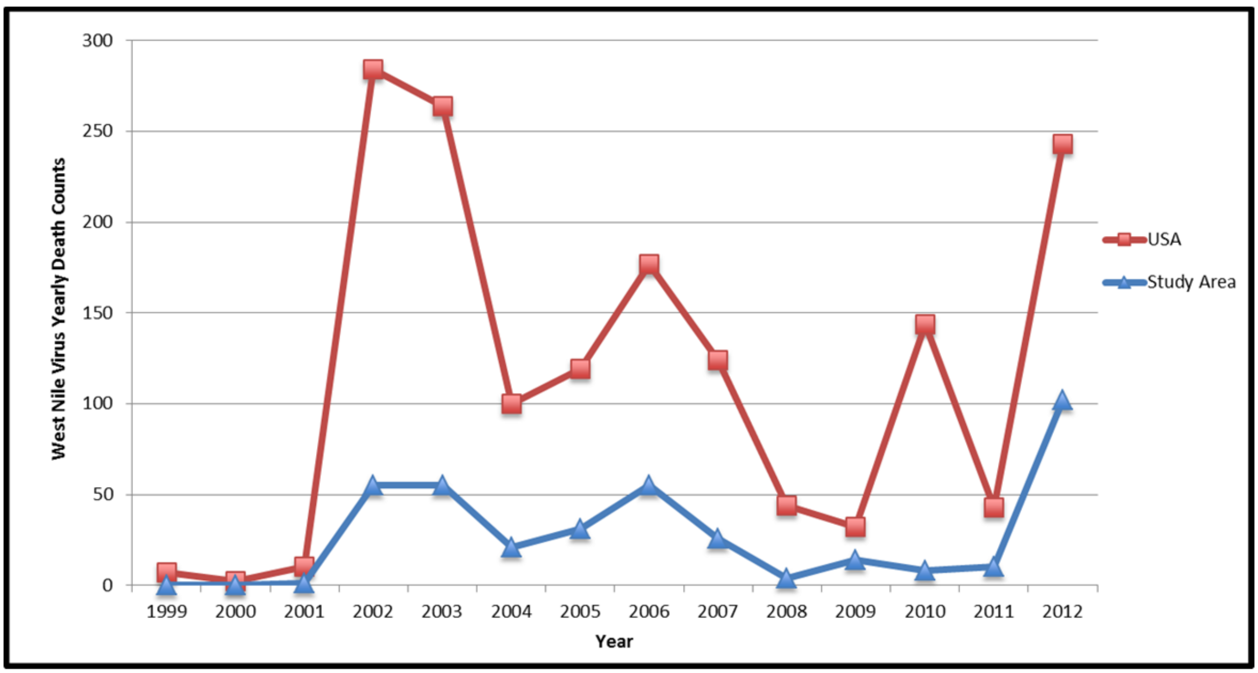

Figure 5: West Nile Virus Fatalities USA vs. Study Area

In further analysis of this susceptibility, a comparison between the number of fatalities from the West Nile Virus for the United States was compared to those from the study area, as

detailed in Figure 5. Similar to the incidence, fatalities for the study area follow a similar pattern when compared to the United States as a whole. This study area averages 22% of the deaths from West Nile Virus in the United States, with a range from 5-42%. During six of the 12 years that are analyzed, the study area has a greater percentage of the total fatalities for the United States than it does for the total number of cases. This disproportionate amount of fatalities further supports the susceptibility of this study area.

This study area has a higher level of susceptibility to the West Nile Virus due to the fact that this study area accounts for 18% of the population and 5 out of 50 states but has contained almost 25% of the deaths caused by West Nile Virus since the first incidence of the disease in the United States in 1999. In comparison, the Gulf Coast states account for 19% of the West Nile Virus cases since 1999, which is quite close to the population representation of these states. That this area accounts for a greater share of the deaths from this disease than the incidence makes it important to understand the conditions in the natural and human exposure that exacerbate the levels of this disease in order to further develop our health resilience.

4.2 West Nile Virus Incidence vs. West Nile Virus Incidence Rate

4.2.1 Methods

The total number of reported cases of West Nile Virus for each West Nile Virus season was totaled at the county level based on available data provided through the CDC (CDC, 2012). This dataset was then transformed into a rate per 100,000 individuals for each county for each year using the following formula. $Incidnce\ Rate\ Per\ Capita = \frac{WestNileVirusCases}{Population} * 100{,}000$

The total incidence and incidence rate of West Nile Virus for each county was also calculated.

The entire study area of 534 counties was considered in the context of this analysis for all twelve of the years in which West Nile Virus has been present in the study area, from 2001 to 2012. In order to track the spread of West Nile Virus through the study area, visual representation through mapping provides the easiest context with which to view the spread of the disease across the study area and also to look for geographic trends within the disease patterns. All the maps were assembled into a time series to allow for analysis chronologically to follow the disease pattern within the study area. The mean, minimum, and maximum West Nile Virus Rate and Incidence were determined for each MSA classification and across the study area. A breakdown of West Nile Virus cases by state and for each year was also compiled in order to follow the trends of the disease across the study area.

County level analysis was used based on the available data. Census boundary files were used in order to link the West Nile Virus cases for each year spatially with the appropriate county. This analysis was completed by also using both the West Nile Virus incidence rate per 100,000 Individuals and the total reported West Nile Virus incidence for 2001-2012 along with each county's total for the whole study period. This not only allows for a determination of areas where the disease has historically never been reported within this study area but also will allow for a direct comparison of the incidence rate and the total incidence of infection. This is an important distinction due to the theoretical idea that West Nile Virus is an urban disease (Elliot et al., 2008; Epstein, 2001). When translated into an incidence rate, the disease pattern can be skewed away from the urban areas due to the high levels of population relative to the number of cases; likewise, a rural area with a smaller population and fewer cases can have a much higher rate with a low level of incidence. Analysis of the West Nile Virus as both a rate and a

straight total has been seen in the literature, so both types were included in this analysis in order to compare how the two different views of the disease can affect what trends are seen across the study area (CDC, 2012; Nolan et al., 2013).

4.2.2 Results

The descriptive statistics for the total amount of West Nile Virus infection incidence and West Nile Virus incidence rate are outlined in Table 3. When looking at the West Nile Virus incidence, it can be seen clearly that the Rural subset has the lowest mean and maximum, followed by the Micropolitan, and that the Metropolitan to has the highest mean and

Table 3: Descriptive Statistics for the Study Area for West Nile Virus Infections 2001-2012

West Nile Virus Incidence				**West Nile Virus Rate Per 100,000 Individuals**			
Classification	**Mean**	**Min**	**Max**	**Classification**	**Mean**	**Min**	**Max**
Rural	2.41	0	26	Rural	25.89	0	349.65
Micropolitan	7.70	0	73	Micropolitan	21.66	0	162.32
Metropolitan	28.92	0	627	Metropolitan	18.24	0	297.08
Study Area	13.01	0	627	Study Area	22.23	0	349.65

maximum. In terms of incidence rate of the West Nile Virus, the Rural subset of the study area actually had the highest mean and maximum rate per 100,000 individuals. The Micropolitan area came in with the second highest mean but the lowest maximum and the Metropolitan area had the lowest mean incidence rate but a maximum rate in between the Rural and Micropolitan. In both cases, the study area mean was between the higher two of the three

means. Furthermore, there were counties that historically never reported any West Nile Virus infections in all three levels of classification.

Of the 534 counties included in the Gulf of Mexico study area, 127 of these counties never had any reported cases of West Nile Virus infections. This is approximately 23% of the counties in the study area that have never reported any cases of the West Nile Virus. In the Rural subset, 77 of the 225 counties never experienced any West Nile Virus. These counties account for approximately 61% of the counties that never have had reported cases of the West Nile Virus across the entire study area. The Micropolitan and Metropolitan areas respectively contained 14% and 25% of the counties without any reported West Nile Virus infections across the Gulf of Mexico states.

Table 4: Study Area Yearly and State West Nile Virus Case Breakdown

Year	Alabama	Florida	Louisiana	Mississippi	Texas	Totals
2001	2	12	1	0	0	15
2002	49	30	329	192	202	802
2003	37	94	124	87	720	1062
2004	16	41	109	51	176	393
2005	5	21	171	70	194	461
2006	8	3	180	183	354	728
2007	24	3	40	136	259	462
2008	18	3	49	65	64	199
2009	0	3	20	53	115	191
2010	3	12	26	8	89	138
2011	5	24	10	52	27	118
2012	48	63	311	245	1712	2379
Totals	215	309	1370	1142	3912	

A yearly and state breakdown of the reported number of West Nile Virus infections is

displayed in Table 4. Texas has the highest number of cases of any state in this study area with about 57% of the cases for this study. Louisiana has the second highest number of cases with about 20% of the total number of West Nile Virus cases. Mississippi has about 16% and Alabama and Florida have 3% and 4% respectively. The years 2003, 2006, and 2012 are all cyclic peaks and have the highest number of West Nile Virus cases across this study period in this study area. These peaks match the trends across the country, as seen in Figure 4. It was also seen that the fatalities caused by the West Nile Virus followed these same cyclic trends. Alabama is the only state to experience no reported West Nile Virus cases during a West Nile Virus season after the virus was initially reported within the state. It can also be noted that every year since the West Nile Virus entered the Gulf of Mexico study area, there were reported cases within the study area.

The next step in this analysis was to analyze the spread of West Nile Virus through the study area both visually and statistically. A series of maps were created, with one set of maps representing each year. These maps were created using ArcMap software and are assembled chronologically, with the totals map at the end of the series. Each Figure includes two maps, one indicating the West Nile Virus incidence rate per 100,000 individuals and one indicating the West Nile Virus incidence by county for that particular year. Figures 6-17 dictate this objective. A standard scale breakdown was used across all incidence rate and all incidence maps, adjusted to each set of data using natural breaks. The same color scale was used across all maps to allow for comparison of the different levels of activity across time and by method of analysis. Furthermore, the set of maps in Figure 18 indicate the total incidence rate and the total incidence of the West Nile Virus for the entire study period.

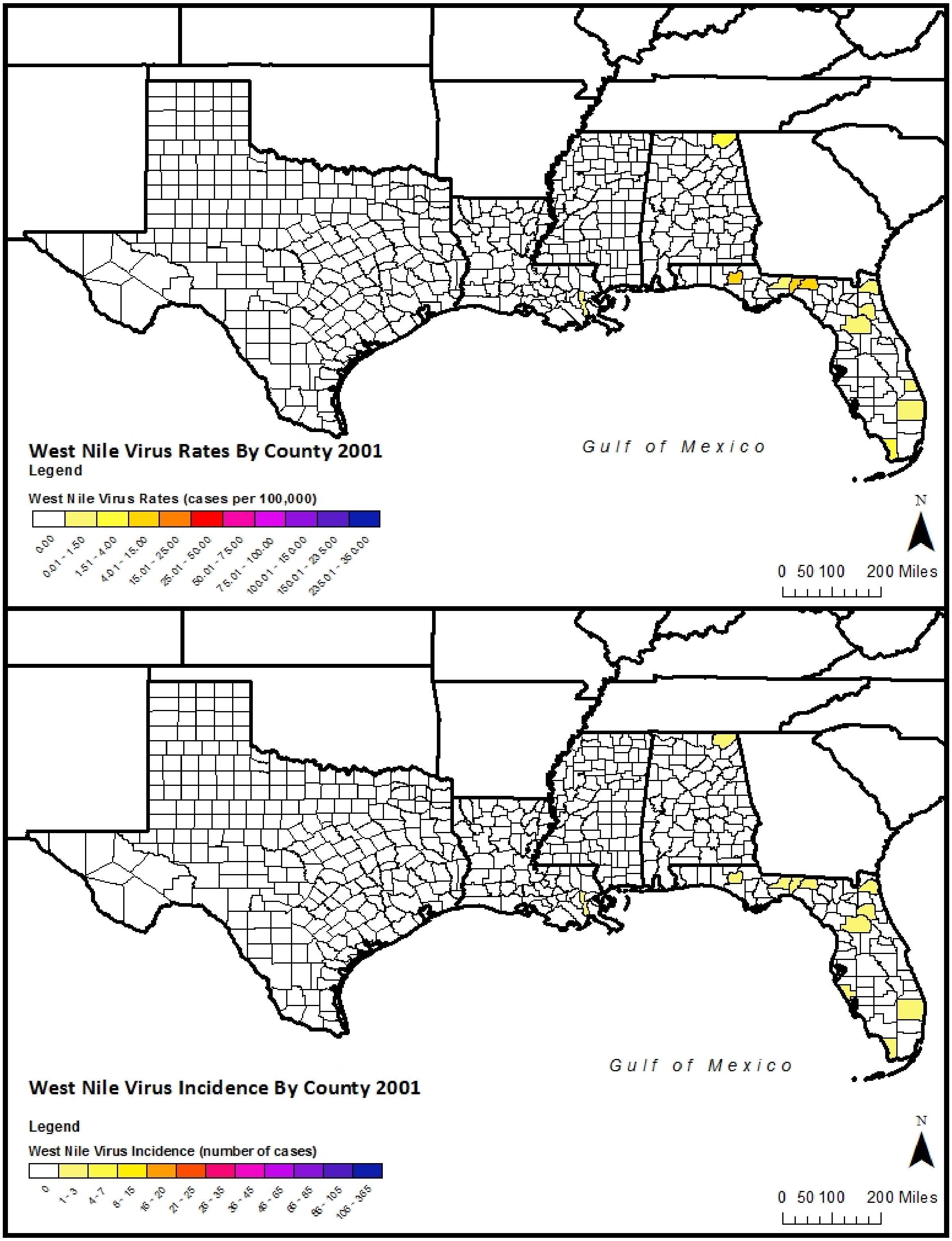

Figure 6: West Nile Virus Incidence Rate vs. Incidence 2001

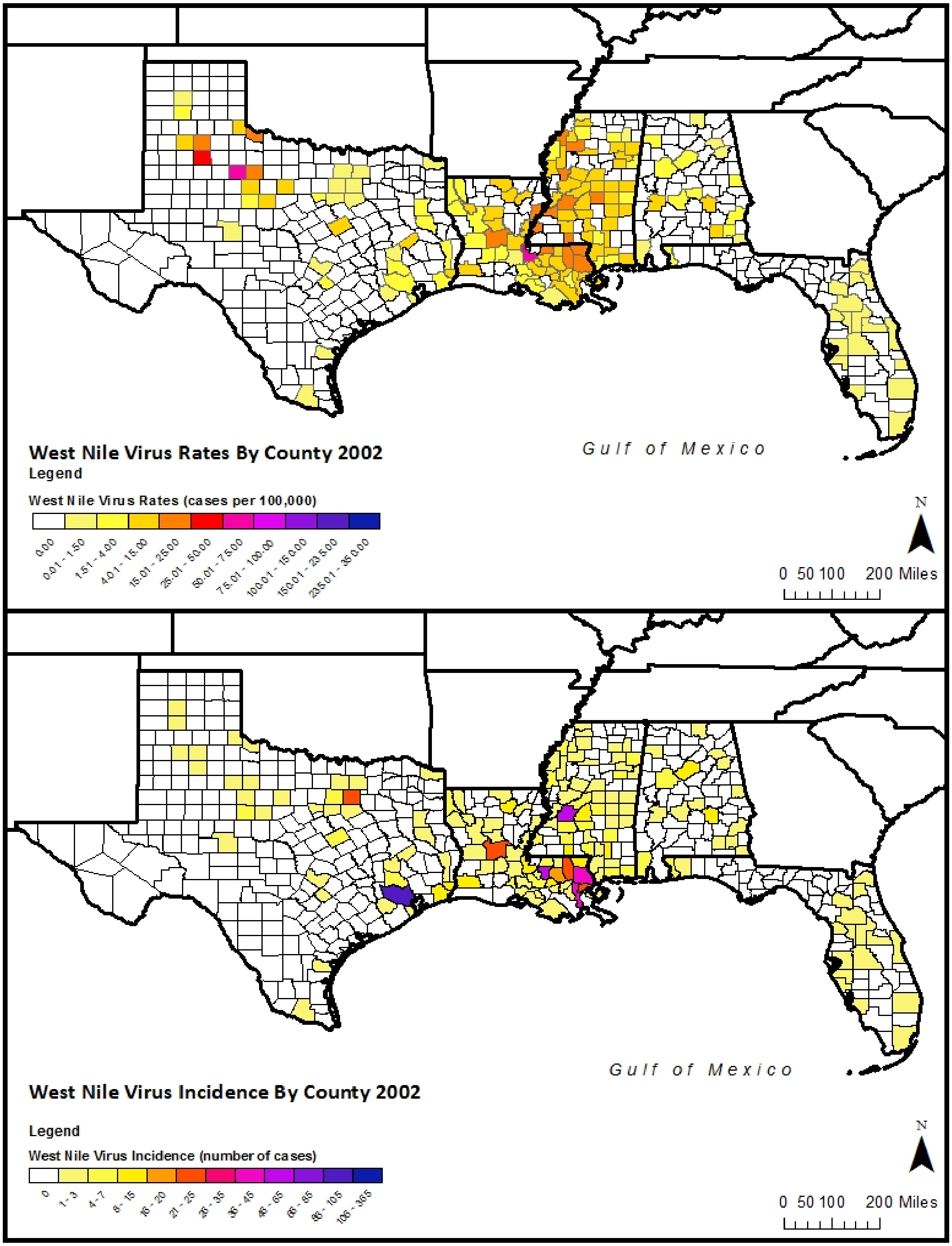

Figure 7: West Nile Virus Incidence Rate vs. Incidence 2002

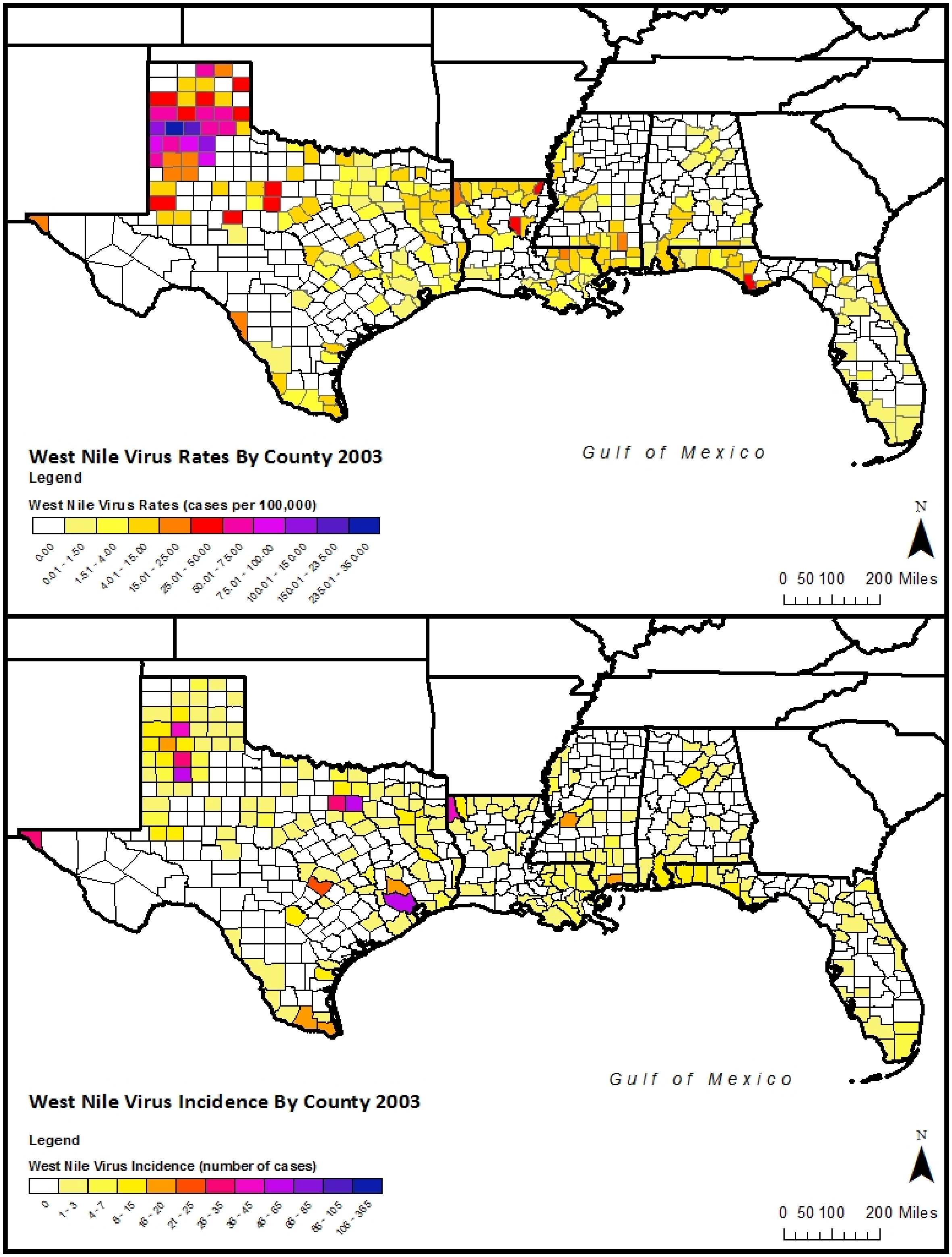

Figure 8: West Nile Virus Incidence Rate vs. Incidence 2003

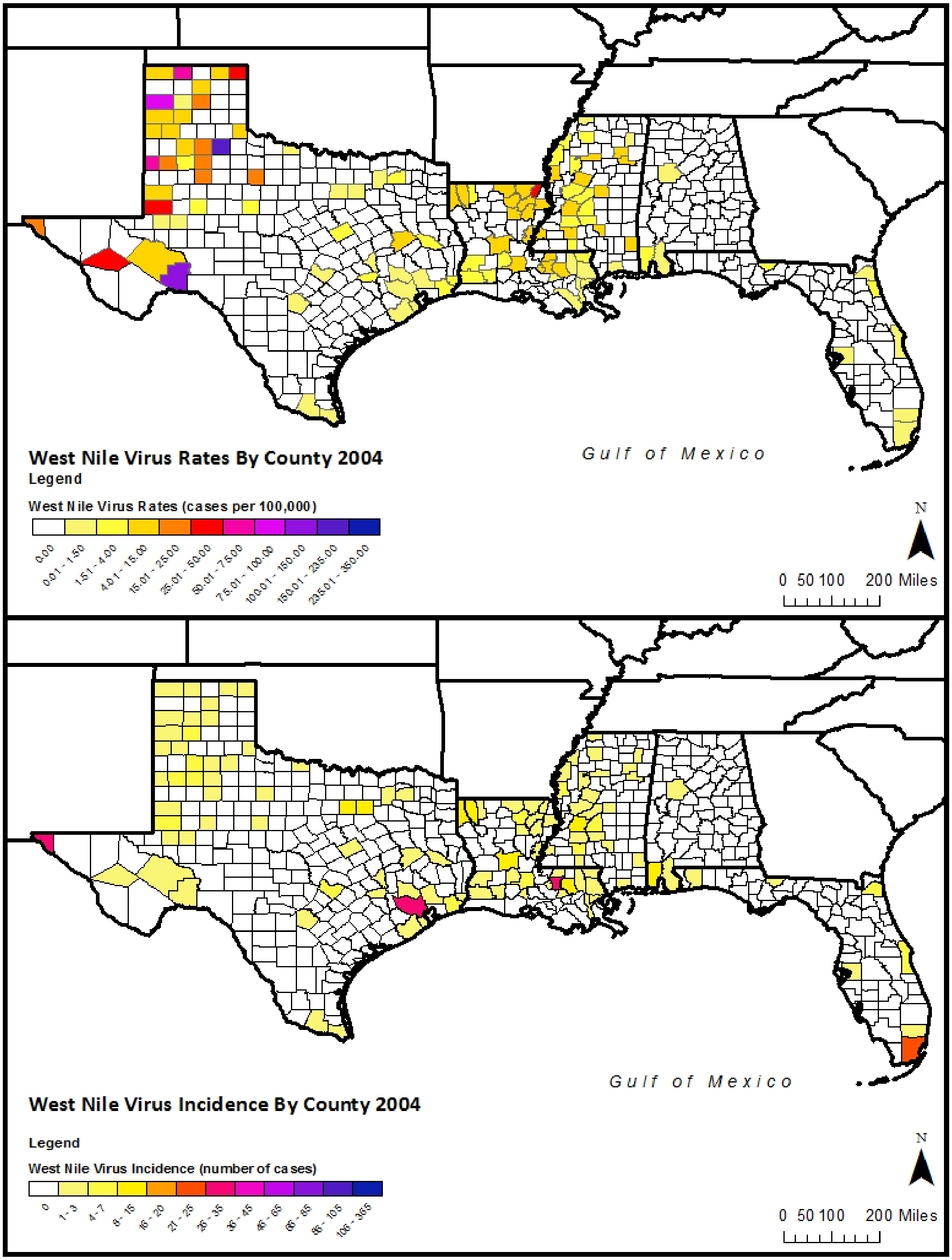

Figure 9: West Nile Virus Incidence Rate vs. Incidence 2004

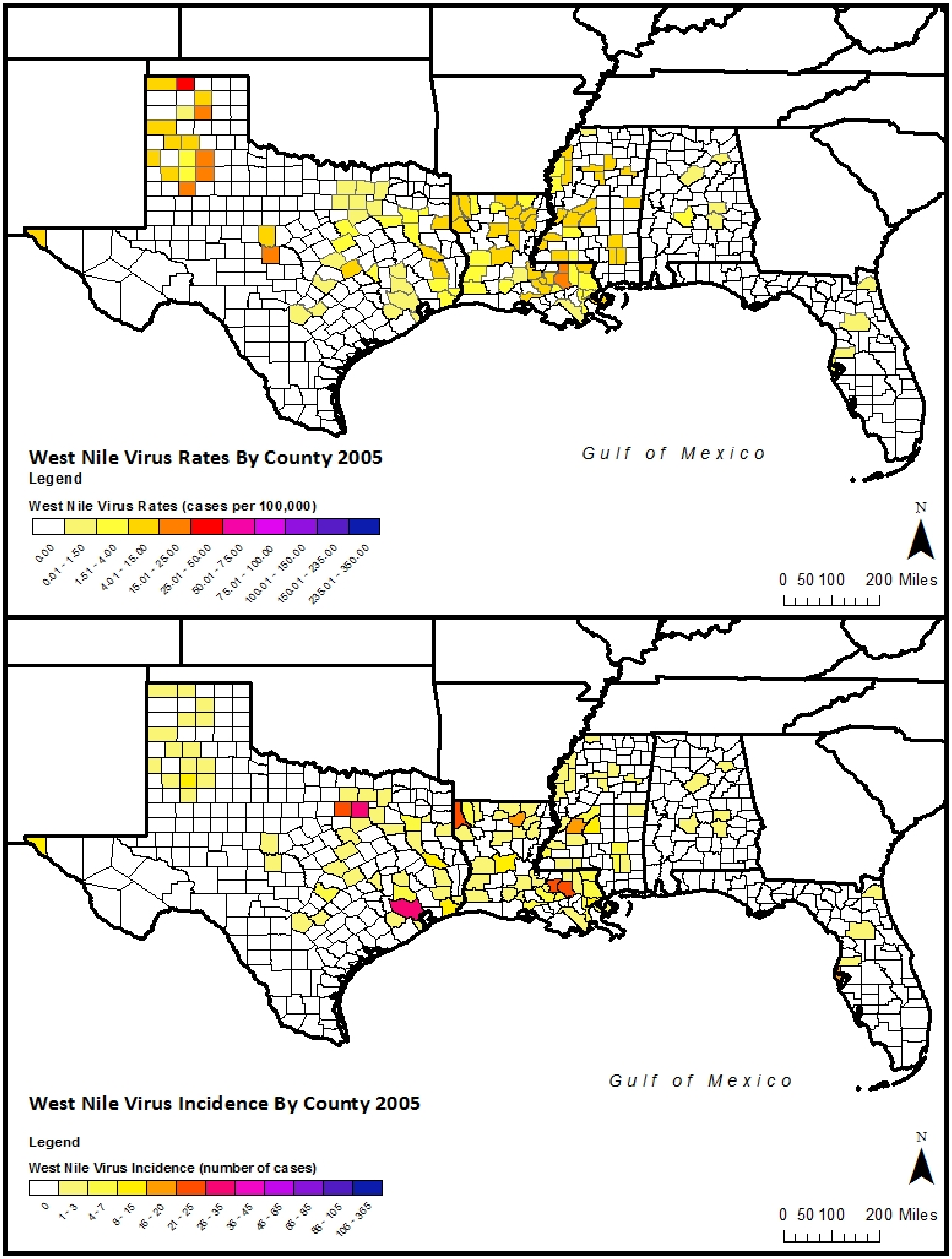

Figure 10: West Nile Virus Incidence Rate vs. Incidence 2005

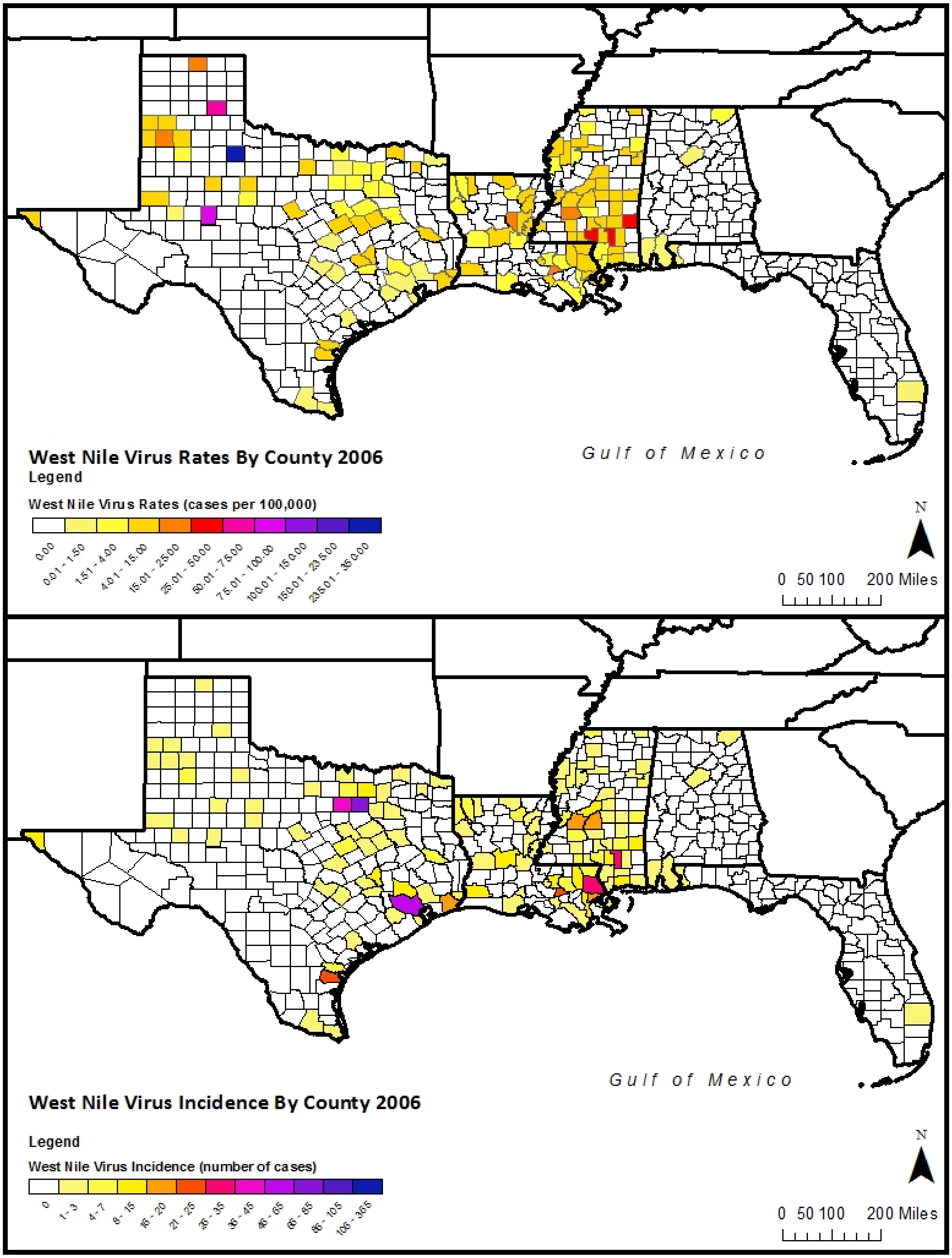

Figure 11: West Nile Virus Incidence Rate vs. Incidence 2006

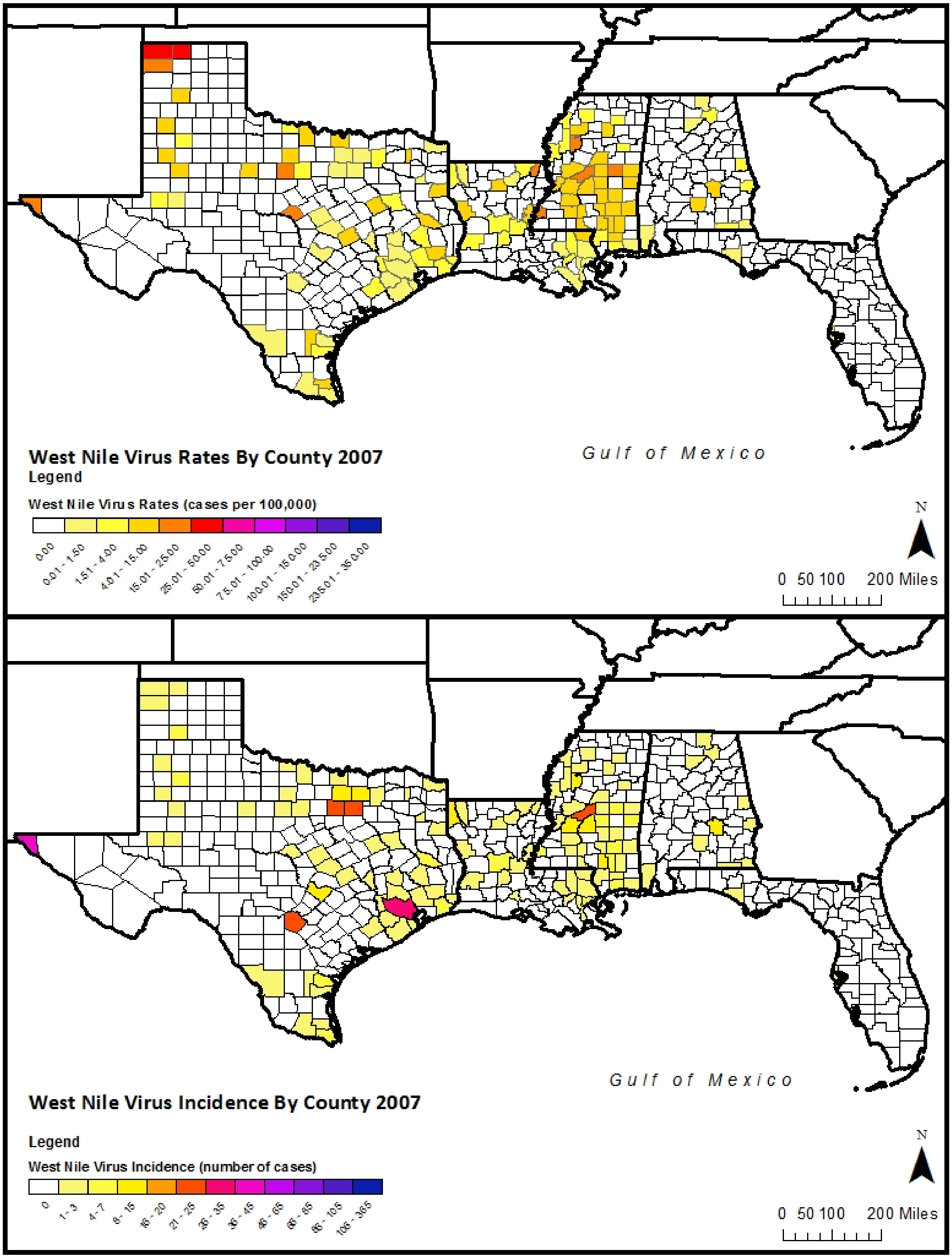

Figure 12: West Nile Virus Incidence Rate vs. Incidence 2007

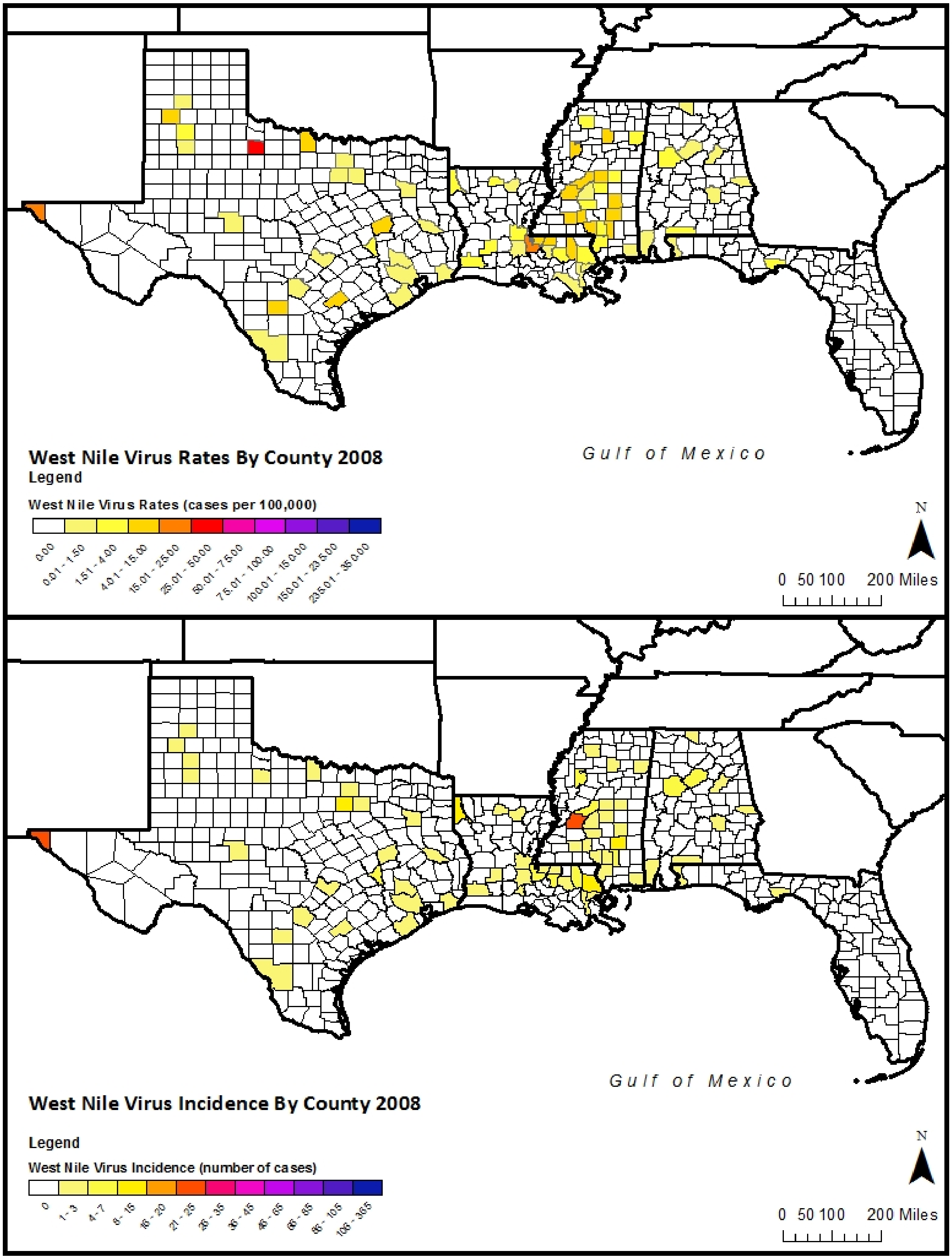

Figure 13: West Nile Virus Incidence Rate vs. Incidence 2008

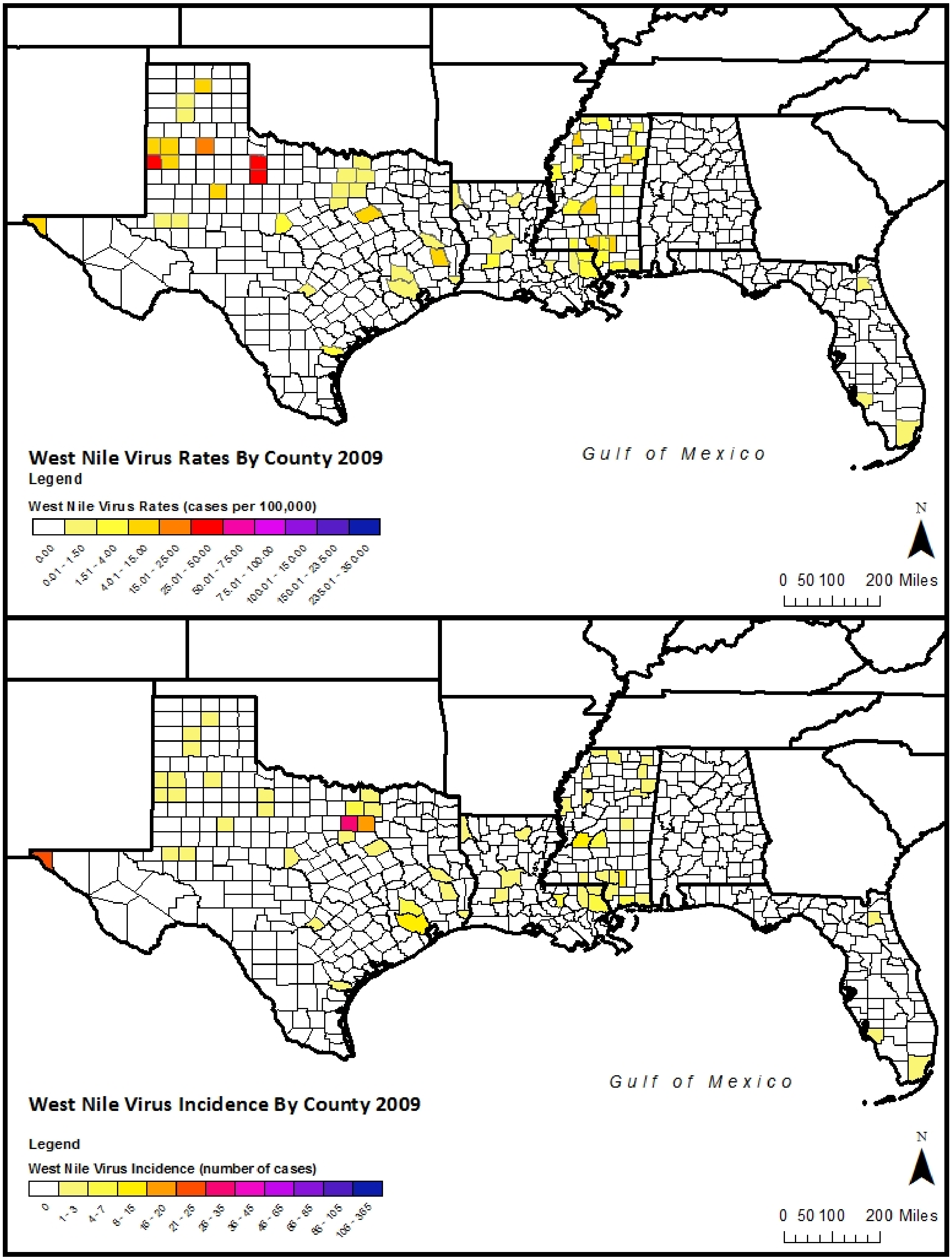

Figure 14: West Nile Virus Incidence Rate vs. Incidence 2009

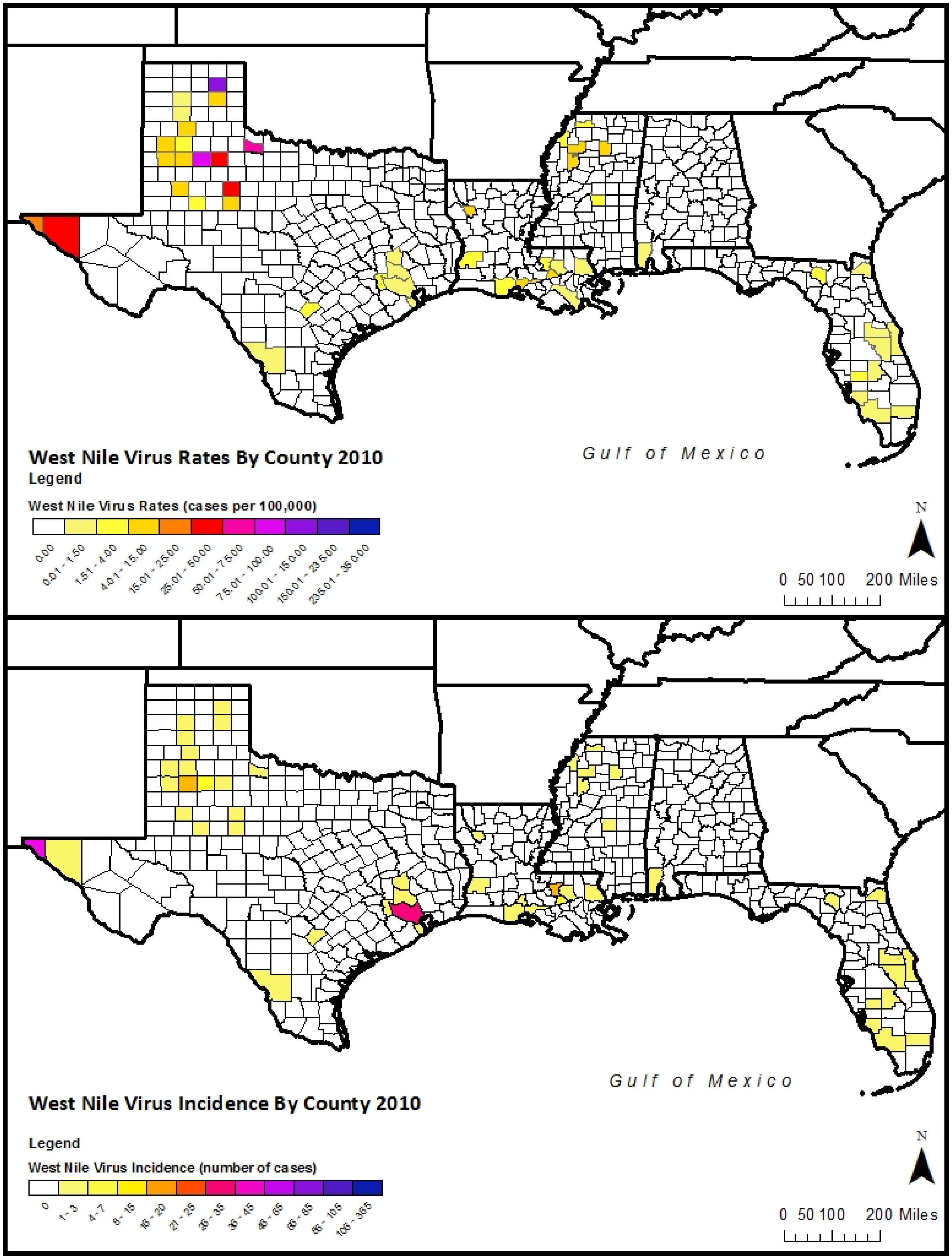

Figure 15: West Nile Virus Incidence Rate vs. Incidence 2010

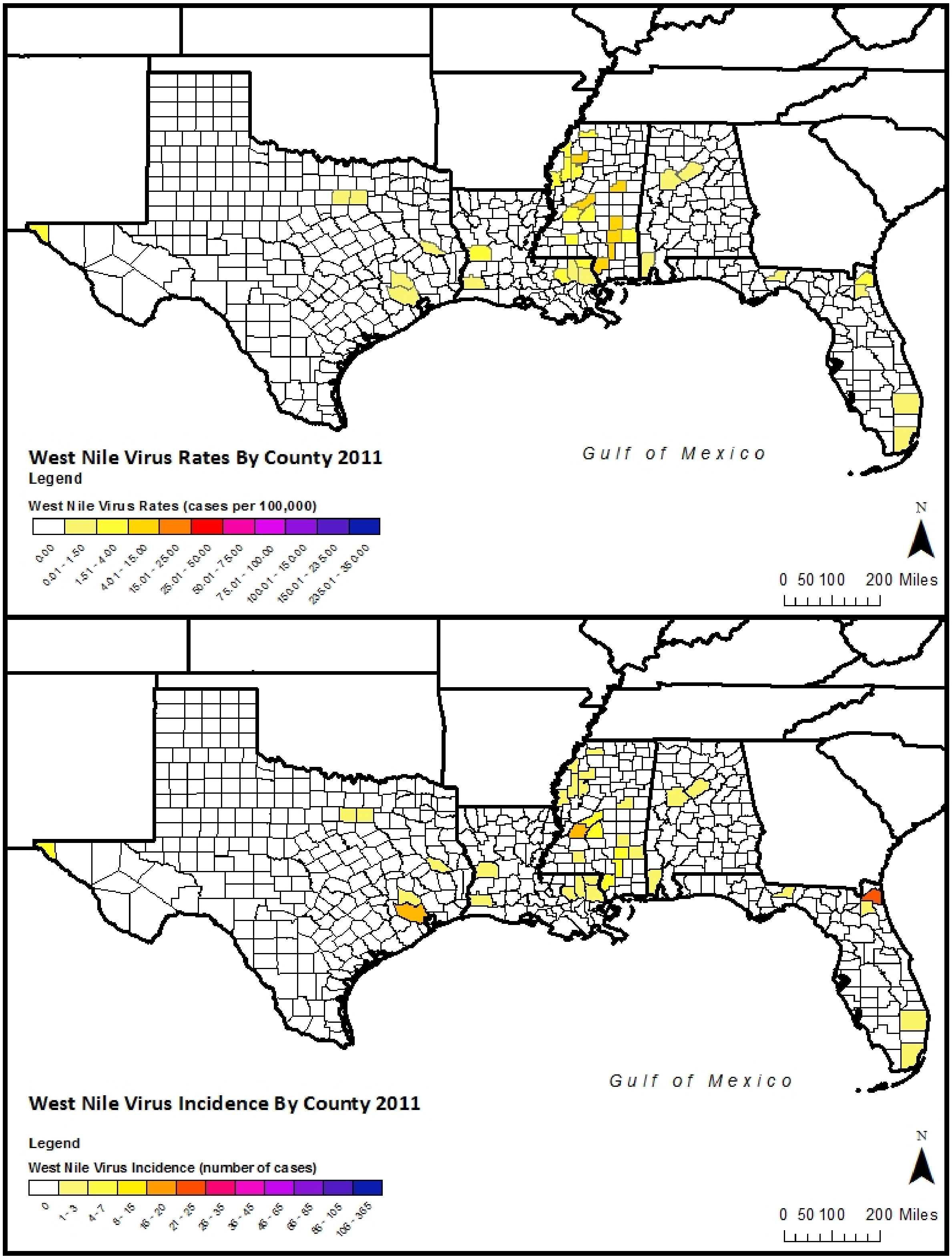

Figure 16: West Nile Virus Incidence Rate vs. Incidence 2011

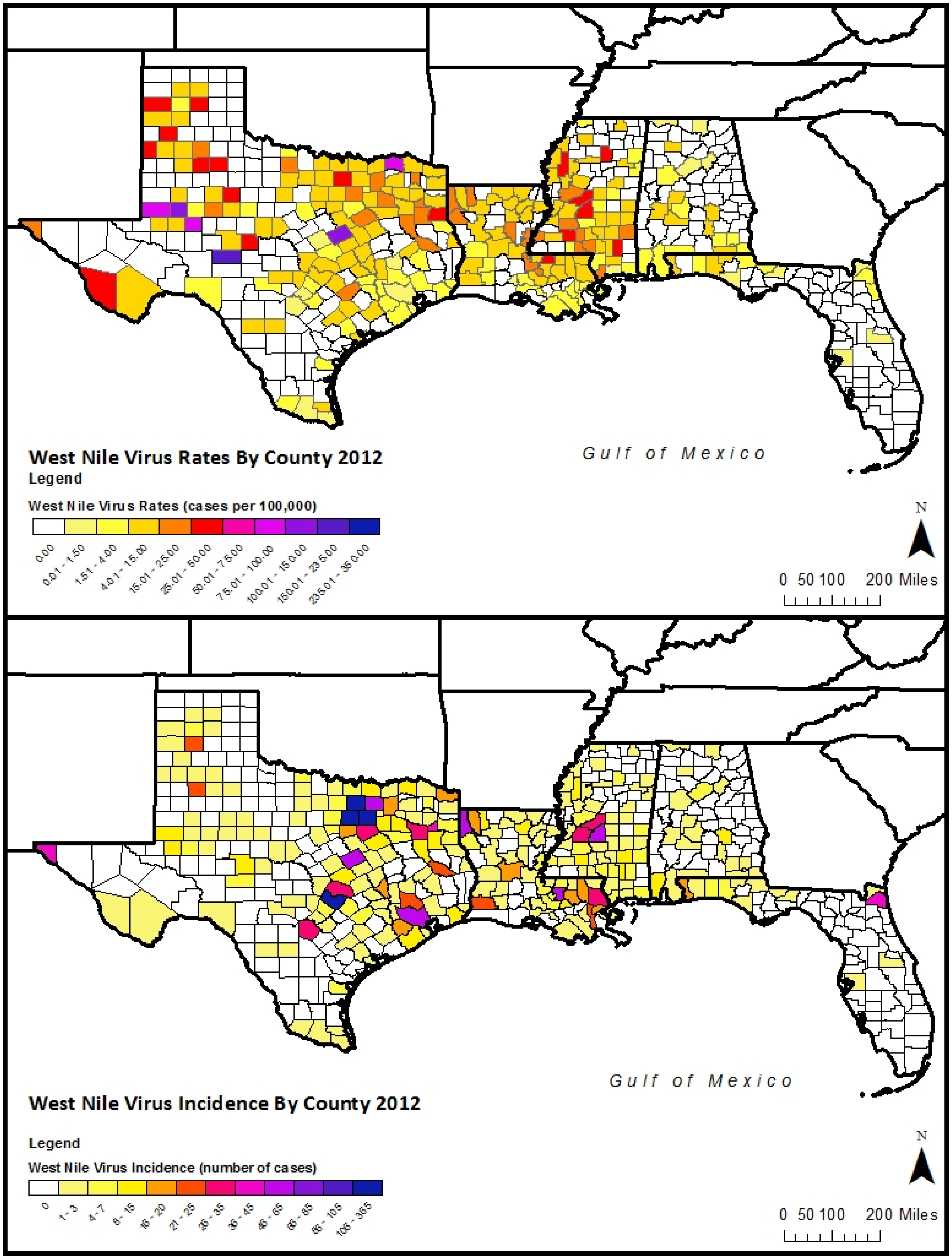

Figure 17: West Nile Virus Incidence Rate vs. Incidence 2012

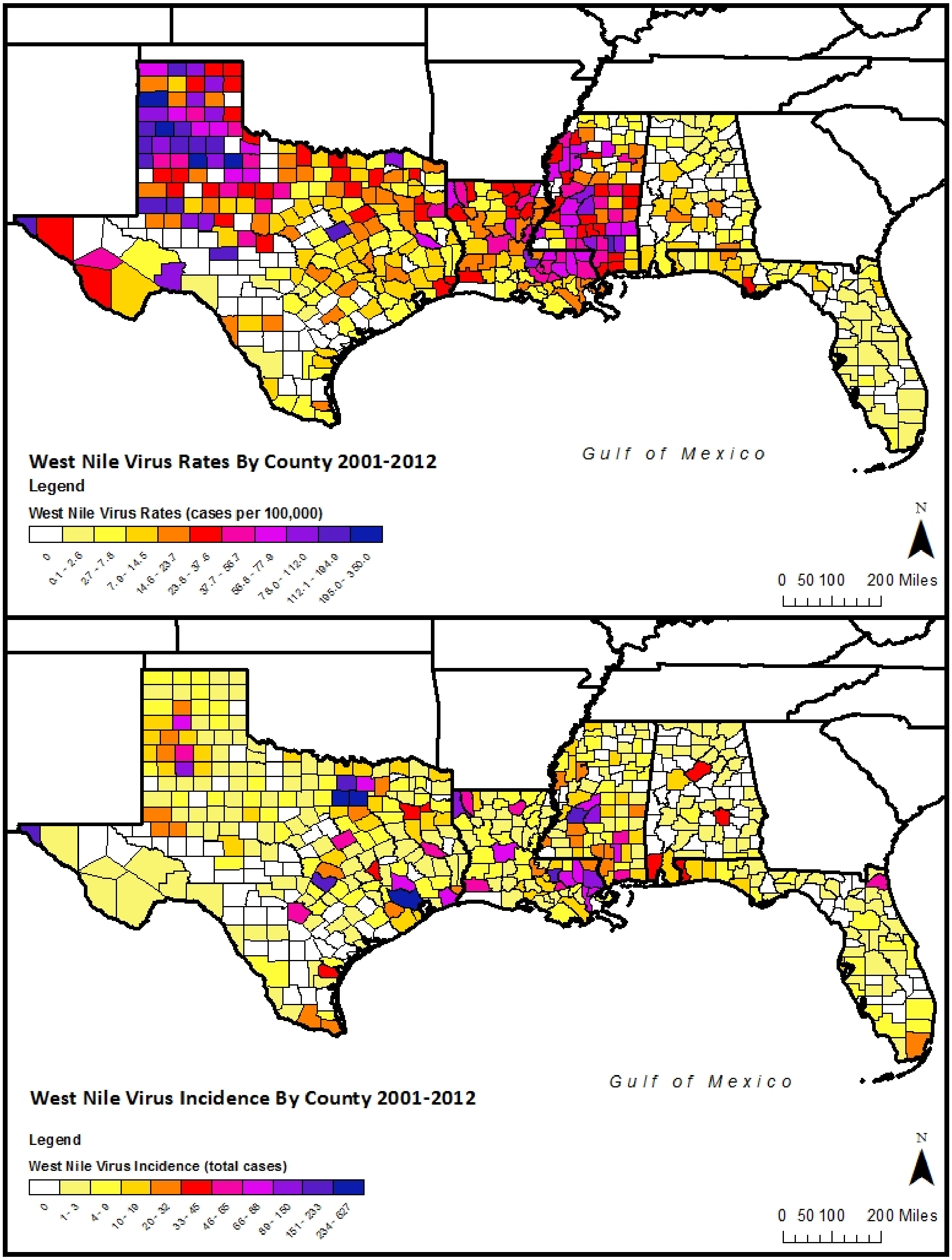

Figure 18: West Nile Virus Incidence Rate vs. Incidence 2001-2012

4.2.3 Analysis of Incidence vs. Incidence Rate

A difference between urban and rural patterning of the West Nile Virus can clearly be seen when looking at the incidence of the West Nile Virus across time. In looking at this perspective, West Nile Virus clearly follows a pattern of being most active in Metropolitan areas. This can be seen over time as the counties that are consistently active with the West Nile Virus are included in the Metropolitan subset of the study area. Even in years where there is a low level of West Nile Virus activity, these areas are still the most active in continuing to report infections. However, the patterning that is seen in the West Nile Virus incidence rate maps in not as clearly defined between urban and rural environments. These maps show areas recognized as being more rural as being the most active for the West Nile virus at the county scale. Analyzing the incidence rate distorts the theoretical image of the West Nile Virus as an urban disease and allows for analysis of the virus across spatial scales. The study level analysis of the West Nile Virus showed that when analyzed as a rate the pattern of West Nile Virus activity is spread across a wider area that reaches beyond urban or rural classification. From the panhandle of Texas across to Mississippi there is a wide area that has experienced a higher level of West Nile Virus activity. This activity level across classifications is supported by the descriptive statistics in Figure 3; the average activity within each area is quite similar.

There are clear belts of counties when visually analyzing Figure 18 where there have not historically been any diagnoses of the West Nile Virus, and statistically 61% of these counties are in the Rural subset. This can visually be confirmed by comparing Figures 3 and 18, where it can be seen that many of these areas without West Nile Virus being reported can be matched up to the Rural subset of this study area. What is interesting is in the analysis of Figure 18, there

are many areas with high incidence rates of the West Nile Virus that are in the Rural area. There is some innate difference between these areas that is altering the activity of the West Nile Virus. It can be seen in terms of total incidence rate that these high levels of activity of West Nile Virus have a much wider spread than originally thought. It can also be seen in looking at the total West Nile virus activity in Figure 18, there are areas that have lower activity in term of the West Nile Virus. The state of Florida in terms of total West Nile Virus has very low incidence and incidence rates but is a highly metropolitan state in terms of classification. There is something differentiating the other urban areas, such as in the Western portion of the study area, that have experienced a much high levels of West Nile Virus from these areas with low levels of activity.

Incidence rate is a standard scientific practice when studying the epidemiology of any given disease. By transforming the West Nile Virus incidence into a rate of incidence allows for adjustment of the activity of the virus for comparisons between different size populations on the same playing field by taking the population size out of the equation. For example, in Figure 11 the incidence rate map shows one county in the deep purple, which is a rural county. This county has a population of 286 people and one reported case in the year 2006, which translates to an incidence rate of 349.65 cases per 100,000 people. In that same figure, in the incidence map there is a purple county along the Texas coastline that is part of the Metropolitan subset with a reported 54 cases in 2006. This county however, has an incidence rate of 1.32 cases per 100,000 people. Taking the population size out of the comparison, the rural area has a rate of 349.65 while the metropolitan area has a rate of 1.32 cases.

In the case of this analysis, the incidence rate shows us that there is some component of the rural environment that can make those populations either very susceptible to the West Nile Virus or very resilient to the disease. This idea of the West Nile Virus being most active in rural areas goes against the grain that the West Nile Virus is an urban specific disease and provides support for the fact that West Nile Virus is a specific threat to the health and health resilience of the human population that must be recognized across environments. There are some Metropolitan areas that are still quite active for the West Nile Virus, which supports the relationship with the urban areas, but confuses what relationship exists between the spread of the West Nile Virus and the natural environment. What the incidence rate maps do show us conclusively, is that there is a potential for the West Nile Virus in a variety of natural environments, reinforcing the point that prevention and research into the West Nile Virus cannot be solely focused on urban areas.

Chapter 5: Model Development

5.1 Framework

Understanding the spread and prevalence of a disease is a complicated process. There are many factors that can determine the resilience a community has when faced with a new disease and can dictate the way that a population is able to respond to a new health threat. In order to determine what these factors are, the influences of Natural Exposure and the Socio-Economic factors that describe the human population are analyzed independently and in tandem. This supports the idea that human resilience can be influenced in through two avenues; it can be influenced by the human environment and also by the natural environment (Keim, 2008). For this model precipitation and temperature data, historical weather hazards data, and mean elevation defined the Natural Exposure, a list of these variables can be seen in Table 1. Breaking down the dataset into subsets further supported this model and allowed for analysis of the differences between the different environments of each MSA classification. The Socio-Economic model was defined by a variety of traditional resilience indicators in the categories of demographics, social capital, economics, government, and health, these variables are listed in Table 2. By then combining these two initial models into a combination model allows for a broader analysis of the factors that determine community resilience and susceptibility to the West Nile Virus.

5.2 Variable Determination

The first step towards developing a model for understanding health resilience is to look at the relationship between traditional socio-economic population indicators that are

associated with community resilience and the health indicator variable, in this case West Nile Virus. For this specific study, bivariate correlation was used in order to identify patterns of significant relationships. These variables were determined from previous resilience research (Cutter et al., 2008; Reams et al., 2012). A bivariate correlation looks at the relationships between two specific variables and is reflected by the Pearson's Correlation Coefficient (Devore & Peck, 2005; Field, 2009). There can either be a positive relationship, as one value increases so does the other; there can also be a negative relationship where the variables have an inverse relationship (Field, 2009). SPSS Statistics was used for this analysis.

Due to the cyclic nature of the health variable, this analysis was done for each West Nile Virus season with consideration that each season can be contained within a single calendar year. Each variable was correlated to each West Nile Virus Incidence and each West Nile Virus Rate for each year. This allows for a determination of a set of variables that can be used at Rate and Incidence levels of analysis. This was accomplished by using the Rural, Micropolitan, and Metropolitan subsets for the analysis as well as the study area. Since there is evidence supporting the idea that climate conditions have an effect on the virulence of West Nile Virus, correlation was also done on a variety of climate relationships (Epstein, 2001; Gong et al., 2011; Walsh, 2012). This is also an important step towards developing a united idea of health resilience since there is an extensive body of work related to how climate variability can affect patterns of health across communities (McMichael, 2006). This climate data analysis included correlation of the West Nile Virus to different relationships with precipitation and temperature. This study looked at in particular: monthly averages, seasonal averages (including West Nile season and Non-West Nile season), yearly averages, and relationships with data from previous

years. All yearly and seasonal averages were derived using monthly averages. This comparison allows for an exploration of the relationship that exists between West Nile Virus and indicators of the natural environment in order to understand how climate variability can affect the spread of the disease.

Included in the running of this analysis, all of the chosen predictive variables were tested for multicollinearity. Multicollinearity exists when the relationship between two predictive variables is too strongly correlated, generally a correlation coefficient with a magnitude of greater than 0.9 (Field, 2009). None of the relationships between any of the predictive variables presented a strong enough correlation to warrant being excluded from the model either due to being insignificantly correlated or to a low magnitude of a significant correlation when directly correlated to each other.

5.3 Methods for Model Development

In order to understand what dynamics within the study area are influencing the spread of West Nile Virus, several models were developed. The variables used in each model were those that were determined to have significant relationships to the West Nile Virus. First, the Natural Exposure model was developed using precipitation, temperature, and historical weather hazards data as defined in Table 1. In terms of precipitation and temperature data, monthly data was transformed into Yearly, West Nile season, and West Nile non-season averages. For this Natural Exposure model, monthly data from March through August was used for both temperature and precipitation for the year being studied and then the monthly data from July to September from the previous year were also included. Yearly and seasonal averages were used for the year being studied along with the previous four years. West Nile

Virus seasonal averages for the year being studied were not included. The Socio-Economic model was developed using traditional resilience indicators identified as significant in the variable determination. In order to look at the relationship that these different indicators have when combined, a model was created using the indicators from the Natural Exposure and the Socio-Economic Models. The independt variables used in this analysis to create the models can be found in Table 1 and Table 2.

In the development of a model explaining health resilience in the context of West Nile Virus, multiple linear regression analysis was used to try and explain the relationship between the variables found to be significant in the correlation and literature analysis portion of this study. In the context of this study, multiple linear regressions was run on the three different models to look for how much of the variability in the spread of West Nile Virus can be explained by the different sets of variables. The output of linear regression, R^2, can be used to explain the magnitude of how much of the variability within the population of the model is explained by the set of predictive variables that were tested (Field, 2009). Each model was run using West Nile Virus incidence rate per 100,000 individiuals and West Nile Virus incidence as the dependent variable for the data from years 2003, 2006, 2009, and 2012. Additionally, these models were analzyed with the total incidence rate of the West Nile Virus for 2001-2012. This analysis was performed within each of the identified Rural, Micropolitan, and Metropolitan classifcaitons, as well as for the entire study area in order to allow for analysis of what drives the West Nile Virus in different environments. This set of models was used in order to examine the hypothesis that combined categories of indicators will be more descriptive than any

individual set of indicators. This analysis was performed using SPSS Statistics and is referenced in shorthand as the ‘Direct Models.’

Additionally, stepwise linear regression used to analyze the total West Nile Virus incidence rate across the different classifications and the study area using the indicators found in Table 1 and Table 2. Stepwise linear regression develops a model by adding and removing variables to determine the most influential and important indicators in explaining the dependent variable (Fields, 2009). This process was used in order to determine what variables were the most important within each classification and as well as across the study area. It also explained how much of the variability in the spread of the West Nile Virus those variables accoutned for. Total incidence rate was used for this problem since it gets rid of any potential small number problems since it is a total over 12 years. Stepwise linear regression allowed for determination of the direction of the relationship between variables. SPSS Statistics was used for this analysis and is referenced as ‘Stepwise.’

5.4 Regression Results

Table 5 displays the R^2 value for each test for each year, separated by model and dependent variable type. Each value represents the amount of variance in West Nile Virus cases that is caused by the variables used within each model for that given year. For the Rural subset, there was an n equals 226, for the Micropolitan subset there was an n equal to 118, for the Metropolitan subset there was an n equal to 190. The Study Area has an n equal to 534. Any R^2 value that is shaded in Table 5 indicates that there was something that prevented that model from being significant. This generally happens in the year 2009, which could be caused in part

by the lower number of cases of West Nile Virus when compared to other years. It also is seen in the Micropolitan subset more commonly than any other classification.

Table 5: Regression Results (R^2) West Nile Virus Incidence vs. Incidence Rate (Direct Models)

Incidence	Natural Exposure				Socio-Economic				Combination			
Year	**2003**	**2006**	**2009**	**2012**	**2003**	**2006**	**2009**	**2012**	**2003**	**2006**	**2009**	**2012**
Rural	0.387	0.400	0.205	0.452	0.223	0.138	0.105	0.350	0.606	0.541	0.290	0.718
Mircopolitan	0.618	0.670	0.480	0.736	0.174	0.297	0.209	0.277	0.849	0.855	0.800	0.884
Metropolitan	0.460	0.412	0.461	0.536	0.409	0.425	0.328	0.451	0.734	0.663	0.718	0.743
Study Area	0.277	0.273	0.361	0.289	0.333	0.389	0.303	0.387	0.486	0.510	0.554	0.573
Rate	**Natural Exposure**				**Socio-Economic**				**Combination**			
Year	**2003**	**2006**	**2009**	**2012**	**2003**	**2006**	**2009**	**2012**	**2003**	**2006**	**2009**	**2012**
Rural	0.468	0.200	0.155	0.321	0.277	0.518	0.159	0.273	0.669	0.825	0.353	0.538
Micropolitan	0.611	0.721	0.424	0.781	0.248	0.315	0.193	0.306	0.915	0.908	0.738	0.960
Metropolitan	0.605	0.407	0.449	0.505	0.404	0.205	0.127	0.182	0.799	0.544	0.689	0.678
Study Area	0.334	0.111	0.537	0.230	0.186	0.258	0.083	0.119	0.434	0.472	0.688	0.275

The Natural Exposure model explained 27-73% of the variability of the incidence of the West Nile Virus and 11-78% when analyzing the incidence rate of the West Nile Virus. When analyzing incidence, the Socio-Economic model accounted for 13-53% of the variability. The Socio-Economic model accounted for 8-51% of the variability within the incidence rate of West Nile Virus. The Natural Exposure model accounted for more of the variability of both West Nile Virus incidence and incidence rate, with higher R^2 values in almost every case. The combination incidence model explained 49-88% of the variability in the West Nile Virus spread. In terms of the incidence rate, the combination model can explain 28-96% of the spread of the West Nile Virus. When used in the combination model, the combined set of variables explained a higher level of the variance of the West Nile Virus in each year across all classifications of the dataset when looking at both incidence and incidence rate.

Table 6 displays the results from the multiple linear regressions and the stepwise linear regression that were performed on the total incidence rate. The linear regression explained more variability in the West Nile Virus incidence rate in each model and in each classification. This is expected since the stepwise linear regression is not required to use all the available variables into the model, but is focused on highlighting those indicators that are most influential on the dependent variable.

Table 6: Regression Results (R^2) West Nile Virus Total Incidence Rate

Total Rate	**Natural Exposure**		**Socio-Economic**		**Combination**	
Classification	**Direct**	**Stepwise**	**Direct**	**Stepwise**	**Direct**	**Stepwise**
Rural	0.496	0.306	0.487	0.448	0.754	0.554
Micropolitan	0.809	0.607	0.477	0.372	0.953	0.749
Metropolitan	0.621	0.373	0.351	0.221	0.756	0.473
Study Area	0.385	0.296	0.272	0.238	0.509	0.372

The total incidence rate linear regression followed the same pattern as those analyses performed in the yearly analysis, with the Natural Exposure explaining more of the variability than the Socio-Economic model and the Combination model explaining more than either component individually. In the Rural classification, the stepwise linear regression Socio-Economic model explained 45% of the variability compared to the 31% of the Natural Exposure model. This was the only case across any of the different scenarios where the Socio-Economic model was more predictive of the variability of the West Nile Virus than the Natural Exposure model. The Natural Exposure model explained 30-60% of the variability when analyzing incidence rate through a stepwise linear regression and the Socio-Economic explained 22-45% of the variability. The Combination model explained 37-75% of the variability of the total

incidence rate. As with the multiple linear regression models, the stepwise linear regression models also showed across classifications that more variability in the West Nile Virus can be explained when analyzing both natural and societal factors.

5.5 Natural Exposure Model Results

Table 7 displays the 2012 variable significance for the Natural Exposure model. It is broken down by classification and then each incidence (Inc) and incidence rate (Rate) is indicated for each classification. Highlighted variables are significant at a $p < 0.05$ significance level. The tables for 2003, 2006, and 2009 Natural Exposure variable significance can be found in Appendix 2. Any time a variable was excluded by SPSS Statistics, it is indicated by a '***' symbol.

Table 7: 2012 Natural Exposure Model Variable Significance

Variable	RuralInc	RuralRate	MicroInc	MicroRate	MetroInc	MetroRate	StudyInc	StudyRate
MELEV	0.887	0.346	0.456	0.960	0.256	0.672	0.604	0.301
THSTRM	0.245	0.862	0.844	0.764	0.092	0.703	0.018	0.004
DRGHT	0.001	0.543	0.340	0.159	0.052	0.002	0.615	0.485
FLDING	0.044	0.392	0.481	0.963	0.591	0.139	0.000	0.161
$PAVG_t$	0.110	0.382	0.428	0.357	0.082	0.191	0.082	0.768
$TAVG_t$	0.397	0.101	0.050	0.280	0.611	0.121	0.044	0.450
PNS_t	0.198	0.542	0.232	0.339	0.048	0.149	0.053	0.949
TNS_t	0.302	0.069	0.114	0.284	0.475	0.875	0.018	0.745
$PAVG_{t-1}$	0.776	0.793	0.048	0.128	0.021	0.062	0.078	0.413
$TAVG_{t-1}$	0.814	0.558	***	***	***	***	0.078	0.170
PWN_{t-1}	0.629	0.680	0.040	0.089	0.012	0.041	0.055	0.365
TWN_{t-1}	0.501	0.459	0.442	0.177	0.746	0.970	0.079	0.168
PNS_{t-1}	0.759	0.980	0.134	0.111	0.030	0.307	0.223	0.513
TNS_{t-1}	0.379	0.561	0.542	0.747	0.160	0.854	0.775	0.010
$PAVG_{t-2}$	0.390	0.726	0.033	0.007	0.112	0.295	0.370	0.239
$TAVG_{t-2}$	0.288	0.689	0.030	0.006	0.031	0.260	0.244	0.148
PWN_{t-2}	0.255	0.484	0.835	0.050	0.074	0.238	0.067	0.003
TWN_{t-2}	0.546	0.427	0.560	0.271	0.006	0.163	0.031	0.139

(Table 7 Continued)

Variable	RuralInc	RuralRate	MicroInc	MicroRate	MetroInc	MetroRate	StudyInc	StudyRate
PNS_{t-2}	0.511	0.400	0.068	0.009	0.150	0.242	0.451	0.296
TNS_{t-2}	0.300	0.234	0.596	0.385	0.791	0.359	0.631	0.236
$PAVG_{t-3}$	0.471	0.503	0.326	0.045	0.256	0.531	0.796	0.312
$TAVG_{t-3}$	0.851	0.336	0.717	0.297	0.429	0.750	0.721	0.905
PWN_{t-3}	0.562	0.594	0.280	0.032	0.346	0.401	0.776	0.240
TWN_{t-3}	0.863	0.356	0.511	0.278	0.435	0.761	0.722	0.885
PNS_{t-3}	0.080	0.124	0.311	0.021	0.369	0.981	0.630	0.132
TNS_{t-3}	0.147	0.006	0.437	0.638	0.123	0.312	0.545	0.239
$PAVG_{t-4}$	0.177	0.050	0.639	0.300	0.396	0.710	0.971	0.225
$TAVG_{t-4}$	0.575	0.389	0.845	0.084	***	***	0.712	0.316
PWN_{t-4}	0.190	0.093	0.444	0.453	0.449	0.908	0.830	0.445
TWN_{t-4}	0.588	0.387	0.733	0.484	0.981	0.505	0.723	0.313
PNS_{t-4}	0.468	0.475	0.486	0.556	0.316	0.325	0.697	0.822
TNS_{t-4}	0.300	0.409	0.446	0.037	0.144	0.319	0.459	0.571
$TMAR_{t}$	0.416	0.320	0.143	0.487	0.727	0.027	0.280	0.065
$TAPR_{t}$	0.411	0.748	0.178	0.868	0.666	0.529	0.057	0.245
$TMAY_{t}$	0.595	0.083	0.160	0.800	0.012	0.318	0.035	0.606
$TJUN_{t}$	0.985	0.021	0.073	0.398	0.229	0.979	0.913	0.912
$TJUL_{t}$	0.638	0.404	0.089	0.611	0.413	0.336	0.471	0.576
$TAUG_{t}$	0.576	0.336	0.311	0.329	0.565	0.384	0.077	0.909
$PMAR_{t}$	0.882	0.344	0.339	0.874	0.792	0.078	0.940	0.443
$PAPR_{t}$	0.105	0.610	0.678	0.547	0.412	0.721	0.155	0.189
$PMAY_{t}$	0.112	0.555	0.350	0.553	0.164	0.133	0.154	0.756
$PJUN_{t}$	0.167	0.353	0.411	0.251	0.067	0.309	0.091	0.815
$PJUL_{t}$	0.313	0.445	0.686	0.450	0.229	0.240	0.226	0.716
$PAUG_{t}$	0.043	0.144	0.373	0.328	0.050	0.109	0.072	0.811
$TJUL_{t-1}$	0.841	0.276	0.273	0.825	0.939	0.049	0.058	0.505
$TAUG_{t-1}$	0.531	0.841	0.751	0.659	0.648	0.097	0.087	0.770
$TSEP_{t-1}$	0.050	0.058	0.913	0.296	0.452	0.953	0.633	0.386
$PJUL_{t-1}$	0.536	0.666	0.061	0.126	0.730	0.478	0.525	0.445
$PAUG_{t-1}$	0.724	0.796	0.769	0.727	0.456	0.935	0.938	0.324
$PSEP_{t-1}$	0.356	0.597	0.441	0.707	0.257	0.396	0.369	0.735

Table 8 displays the 2012 variable significance for the Natural Exposure model when analyzing for total incidence rate. It is broken down by classification. Highlighted variables are significant at a $p < 0.05$ significance level. Any time a variable was excluded by SPSS Statistics, it is indicated by a '***' symbol.

Table 8: Natural Exposure Total West Nile Virus Incidence Rate Variable Significance

Variable	Rural	Micropolitan	Metropolitan	Study Area
MELEV	0.267	0.644	0.001	0.015
THSTRM	0.602	0.463	0.244	0.015
DRGHT	0.893	0.029	0.031	0.769
FLDING	0.425	0.383	0.277	0.790
$PAVG_t$	0.452	0.438	0.226	0.257
$TAVG_t$	0.138	0.276	0.234	0.480
PNS_t	0.598	0.386	0.436	0.327
TNS_t	0.093	0.348	0.564	0.559
$PAVG_{t-1}$	0.529	0.253	0.324	0.404
$TAVG_{t-1}$	***	***	***	0.389
PWN_{t-1}	0.717	0.224	0.226	0.555
TWN_{t-1}	0.412	0.867	0.945	0.400
PNS_{t-1}	0.456	0.160	0.788	0.307
TNS_{t-1}	0.454	0.741	0.814	0.229
$PAVG_{t-2}$	0.420	0.389	0.982	0.133
$TAVG_{t-2}$	0.623	0.410	0.938	0.225
PWN_{t-2}	0.493	0.155	0.109	0.661
TWN_{t-2}	0.661	0.464	0.081	0.668
PNS_{t-2}	0.666	0.242	0.455	0.201
TNS_{t-2}	0.904	0.258	0.133	0.700
$PAVG_{t-3}$	0.740	0.078	0.852	0.339
$TAVG_{t-3}$	0.892	0.049	0.357	0.647
PWN_{t-3}	0.706	0.033	0.708	0.544
TWN_{t-3}	0.874	0.058	0.365	0.644
PNS_{t-3}	0.63	0.104	0.713	0.887
TNS_{t-3}	0.329	0.670	0.064	0.666
$PAVG_{t-4}$	0.172	0.247	0.127	0.352
$TAVG_{t-4}$	0.734	0.673	***	0.529
PWN_{t-4}	0.272	0.503	0.403	0.869
TWN_{t-4}	0.732	0.396	0.700	0.537
PNS_{t-4}	0.216	0.303	0.047	0.297
TNS_{t-4}	0.980	0.051	0.072	0.893
$TMAR_t$	0.331	0.774	0.020	0.128
$TAPR_t$	0.327	0.381	0.675	0.078
$TMAY_t$	0.268	0.860	0.231	0.337
$TJUN_t$	0.062	0.154	0.145	0.264
$TJUL_t$	0.561	0.155	0.106	0.518
$TAUG_t$	0.230	0.985	0.634	0.912
$PMAR_t$	0.691	0.744	0.435	0.575

(Table 8 Continued)

Variable	Rural	Micropolitan	Metropolitan	Study Area
$PAPR_t$	0.638	0.250	0.907	0.120
$PMAY_t$	0.835	0.255	0.146	0.656
$PJUN_t$	0.361	0.475	0.328	0.208
$PJUL_t$	0.358	0.663	0.207	0.154
$PAUG_t$	0.415	0.518	0.268	0.305
$TJUL_{t-1}$	0.388	0.998	0.125	0.669
$TAUG_{t-1}$	0.191	0.676	0.113	0.142
$TSEP_{t-1}$	0.390	0.973	0.920	0.290
$PJUL_{t-1}$	0.599	0.846	0.423	0.286
$PAUG_{t-1}$	0.839	0.141	0.274	0.356
$PSEP_{t-1}$	0.142	0.505	0.109	0.032

5.6 Socio-Economic Model Results

Table 9 displays the 2012 variable significance for the Socio-Economic model. It is broken down by classification and then each incidence (Inc) and incidence rate (Rate) is indicated for each classification. Highlighted variables are significant at a $p < 0.05$ significance level. The tables for 2003, 2006, and 2009 Socio-Economic variable significance can be found in Appendix 2.

Table 9: 2012 Socio-Economic Model Variable Significance

Variable	RuralInc	RuralRate	MicroInc	MicroRate	MetroInc	MetroRate	StudyInc	StudyRate
POPDEN	0.000	0.698	0.034	0.005	0.000	0.149	0.000	0.250
PCTBLK	0.823	0.215	0.899	0.810	0.415	0.145	0.128	0.831
PCTHIS	0.406	0.385	0.907	0.309	0.933	0.375	0.575	0.968
PCTKID	0.578	0.877	0.443	0.500	0.107	0.027	0.068	0.198
PCTOLD	0.755	0.954	0.453	0.265	0.705	0.136	0.863	0.604
AVGPERHH	0.786	0.540	0.940	0.793	0.517	0.134	0.183	0.770
PTNOHS	0.956	0.843	0.072	0.156	0.046	0.317	0.665	0.185
PCTMOB	0.921	0.542	0.991	0.389	0.649	0.392	0.329	0.806
HOUDEN	0.999	0.701	0.081	0.007	0.176	0.160	0.002	0.184
FEMLBR	0.089	0.967	0.624	0.647	0.891	0.977	0.481	0.553

(Table 9 Continued)

Variable	RuralInc	RuralRate	MicroInc	MicroRate	MetroInc	MetroRate	StudyInc	StudyRate
PCTFHH	0.873	0.639	0.244	0.813	0.265	0.214	0.245	0.896
PCTRENT	0.510	0.895	0.310	0.365	0.108	0.068	0.036	0.491
PCTPOV	0.362	0.090	0.678	0.997	0.507	0.262	0.357	0.162
PCINC	0.641	0.028	0.242	0.060	0.026	0.854	0.042	0.793
MEDINC	0.647	0.226	0.644	0.354	0.755	0.950	0.214	0.576
PCTCVLBRF	0.387	0.525	0.910	0.499	0.771	0.114	0.672	0.758
PCTAG	0.136	0.000	0.476	0.068	0.084	0.111	0.077	0.004
MEDRENT	0.041	0.004	0.495	0.899	0.991	0.324	0.106	0.186
MVALOO	0.838	0.421	0.637	0.915	0.028	0.595	0.038	0.103
PCTFRMPOP	0.178	0.033	0.771	0.437	0.730	0.614	0.987	0.014
UNEMPL	0.436	0.035	0.840	0.658	0.703	0.077	0.471	0.024
PCTVOT	0.493	0.040	0.096	0.166	0.627	0.337	0.425	0.807
CHRILL	0.370	0.252	0.793	0.910	0.052	0.280	0.120	0.099
MD	0.864	0.023	0.407	0.257	0.231	0.710	0.066	0.030
LBWB	0.978	0.838	0.936	0.411	0.748	0.424	0.377	0.653

Table 10 displays the 2012 variable significance for the Socio-Economic model when analyzing for total incidence rate. It is broken down by classification and highlighted variables are significant at a $p < 0.05$ significance level.

Table 10: Socio-Economic Model Total West Nile Virus Incidence Rate Variable Significance

Variable	Rural	Micropolitan	Metropolitan	Study Area
POPDEN	0.415	0.439	0.031	0.109
PCTBLK	0.962	0.371	0.030	0.046
PCTHIS	0.348	0.131	0.361	0.617
PCTKID	0.388	0.019	0.001	0.030
PCTOLD	0.888	0.588	0.481	0.919
AVGPERHH	0.035	0.906	0.271	0.007
PTNOHS	0.004	0.057	0.009	0.000
PCTMOB	0.034	0.451	0.050	0.000
HOUDEN	0.047	0.581	0.056	0.084
FEMLBR	0.704	0.575	0.538	0.378
PCTFHH	0.006	0.628	0.126	0.000
PCTRENT	0.002	0.587	0.008	0.578
PCTPOV	0.139	0.434	0.079	0.338

(Table 10 Continued)

Variable	Rural	Micropolitan	Metropolitan	Study Area
PCINC	0.007	0.892	0.105	0.294
MEDINC	0.000	0.304	0.849	0.001
PCTCVLBRF	0.414	0.961	0.000	0.156
PCTAG	0.000	0.186	0.050	0.000
MEDRENT	0.264	0.295	0.304	0.051
MVALOO	0.000	0.239	0.083	0.005
PCTFRMPOP	0.575	0.360	0.819	0.060
UNEMPL	0.337	0.398	0.217	0.420
PCTVOT	0.069	0.043	0.275	0.907
CHRILL	0.700	0.148	0.059	0.686
MD	0.861	0.273	0.604	0.953
LBWB	0.348	0.007	0.730	0.005

5.7 Natural Exposure and Socio-Economic Combination Model Results

Table 11 displays the 2012 variable significance for the Combination model. It is broken down by classification and then each incidence (Inc) and incidence rate (Rate) is indicated for each classification. Highlighted variables are significant at a $p < 0.05$ significance level. The tables for 2003, 2006, and 2009 Combination variable significance can be found in Appendix 2. Any time a variable was excluded by SPSS Statistics, it is indicated by a '***' symbol.

Table 11: 2012 Combination Model Variable Significance

Variable	RuralInc	RuralRate	MicroInc	MicroRate	MetroInc	MetroRate	StudyInc	StudyRate
MELEV	0.653	0.149	0.621	0.541	0.909	0.286	0.190	0.461
THSTRM	0.415	0.934	0.719	0.595	0.494	0.876	0.047	0.003
DRGHT	0.951	0.307	0.619	0.367	0.193	0.002	0.003	0.603
FLDING	0.017	0.354	0.532	0.548	0.015	0.528	0.022	0.635
$PAVG_t$	0.076	0.493	0.930	0.631	0.560	0.590	0.141	0.879
$TAVG_t$	0.594	0.049	***	***	0.985	0.054	0.022	0.289
PNS_t	0.094	0.629	0.911	0.518	0.408	0.630	0.062	0.792
TNS_t	0.295	0.021	0.484	0.070	0.545	0.935	0.011	0.796
$PAVG_{t-1}$	0.102	0.744	0.484	0.312	0.218	0.335	0.057	0.349

(Table 11 Continued)

Variable	RuralInc	RuralRate	MicroInc	MicroRate	MetroInc	MetroRate	StudyInc	StudyRate
$TAVG_t$	0.594	0.049	***	***	0.985	0.054	0.022	0.289
PNS_t	0.094	0.629	0.911	0.518	0.408	0.630	0.062	0.792
TNS_t	0.295	0.021	0.484	0.070	0.545	0.935	0.011	0.796
$PAVG_{t-1}$	0.102	0.744	0.484	0.312	0.218	0.335	0.057	0.349
$TAVG_{t-1}$	0.876	0.713	***	***	***	***	0.269	0.277
PWN_{t-1}	0.159	0.736	0.697	0.314	0.293	0.445	0.091	0.324
TWN_{t-1}	0.681	0.624	0.719	0.853	0.987	0.866	0.268	0.263
PNS_{t-1}	0.069	0.407	0.883	0.642	0.354	0.818	0.233	0.478
TNS_{t-1}	0.791	0.724	0.411	0.301	0.292	0.422	0.684	0.022
$PAVG_{t-2}$	0.279	0.454	0.694	0.498	0.519	0.754	0.459	0.262
$TAVG_{t-2}$	0.384	0.337	0.675	0.561	0.326	0.639	0.240	0.186
PWN_{t-2}	0.770	0.504	0.948	0.015	0.072	0.882	0.168	0.003
TWN_{t-2}	0.634	0.453	0.614	0.111	0.038	0.496	0.116	0.119
PNS_{t-2}	0.367	0.730	0.597	0.327	0.483	0.728	0.218	0.289
TNS_{t-2}	0.732	0.078	0.753	0.031	0.857	0.873	0.760	0.200
$PAVG_{t-3}$	0.367	0.498	0.902	0.452	0.319	0.576	0.130	0.444
$TAVG_{t-3}$	0.307	0.305	0.315	0.068	***	***	0.413	0.430
PWN_{t-3}	0.355	0.289	0.938	0.603	0.397	0.454	0.156	0.961
TWN_{t-3}	0.342	0.322	0.246	0.298	0.239	0.369	0.395	0.953
PNS_{t-3}	0.911	0.385	0.995	0.293	0.234	0.730	0.284	0.321
TNS_{t-3}	0.037	0.068	0.751	0.362	0.705	0.284	0.170	0.398
$PAVG_{t-4}$	0.258	0.373	0.907	0.685	0.359	0.920	0.447	0.447
$TAVG_{t-4}$	0.171	0.572	0.756	0.443	0.600	0.333	0.376	0.970
PWN_{t-4}	0.394	0.510	0.886	0.507	0.600	0.644	0.748	0.636
TWN_{t-4}	0.170	0.562	0.507	0.285	0.591	0.324	0.356	0.931
PNS_{t-4}	0.412	0.806	0.419	0.572	0.374	0.436	0.448	0.871
TNS_{t-4}	0.665	0.667	0.781	0.631	0.230	0.898	0.042	0.402
$TMAR_t$	0.772	0.782	0.889	0.106	0.675	0.083	0.053	0.027
$TAPR_t$	0.887	0.330	0.608	0.746	0.743	0.101	0.110	0.173
$TMAY_t$	0.640	0.195	1.000	0.566	0.166	0.041	0.087	0.486
$TJUN_t$	0.583	0.024	0.652	0.141	0.206	0.988	0.659	0.482
$TJUL_t$	0.710	0.065	0.865	0.036	0.696	0.506	0.870	0.588
$TAUG_t$	0.693	0.268	0.125	0.014	0.781	0.166	0.089	0.974
$PMAR_t$	0.912	0.572	0.333	0.846	0.755	0.419	0.298	0.571
$PAPR_t$	0.176	0.849	0.860	0.584	0.941	0.789	0.269	0.449
$PMAY_t$	0.143	0.593	0.867	0.742	0.443	0.484	0.082	0.795
$PJUN_t$	0.198	0.629	0.938	0.837	0.555	0.803	0.156	0.937
$PJUL_t$	0.162	0.852	0.899	0.394	0.793	0.561	0.359	0.955
$PAUG_t$	0.025	0.159	0.981	0.577	0.392	0.370	0.114	0.918
$TJUL_{t-1}$	0.727	0.373	0.924	0.661	0.961	0.107	0.175	0.877
$TAUG_{t-1}$	0.571	0.826	0.960	0.992	0.782	0.300	0.162	0.805
$TSEP_{t-1}$	0.448	0.075	0.993	0.896	0.704	0.634	0.896	0.744

(Table 11 Continued)

Variable	RuralInc	RuralRate	MicroInc	MicroRate	MetroInc	MetroRate	StudyInc	StudyRate
$PJUL_{t-1}$	0.904	0.916	0.131	0.178	0.996	0.962	0.792	0.612
$PAUG_{t-1}$	0.869	0.546	0.613	0.573	0.633	0.921	0.191	0.383
$PSEP_{t-1}$	0.019	0.458	0.719	0.889	0.994	0.918	0.903	0.561
POPDEN	0.497	0.655	0.138	0.001	0.024	0.939	0.000	0.267
PCTBLK	0.734	0.385	0.302	0.153	0.310	0.925	0.093	0.436
PCTHIS	0.399	0.133	0.437	0.171	0.837	0.383	0.736	0.020
PCTKID	0.967	0.178	0.861	0.918	0.161	0.363	0.199	0.223
PCTOLD	0.925	0.032	0.451	0.014	0.856	0.048	0.611	0.246
AVGPERHH	0.663	0.054	0.630	0.862	0.765	0.129	0.374	0.711
PTNOHS	0.876	0.417	0.675	0.178	0.677	0.404	0.199	0.333
PCTMOB	0.044	0.417	0.529	0.058	0.456	0.755	0.015	0.820
HOUDEN	0.302	0.453	0.217	0.001	0.546	0.842	0.089	0.118
FEMLBR	0.391	0.921	0.275	0.613	0.973	0.821	0.483	0.205
PCTFHH	0.744	0.505	0.706	0.843	0.230	0.825	0.221	0.773
PCTRENT	0.633	0.571	0.143	0.655	0.640	0.115	0.084	0.779
PCTPOV	0.250	0.784	0.498	0.722	0.201	0.394	0.937	0.751
PCINC	0.062	0.034	0.887	0.099	0.610	0.660	0.046	0.282
MEDINC	0.900	0.839	0.777	0.218	0.162	0.742	0.912	0.616
PCTCVLBRF	0.124	0.180	0.754	0.063	0.700	0.754	0.591	0.934
PCTAG	0.954	0.628	0.355	0.969	0.236	0.006	0.424	0.524
MEDRENT	0.036	0.070	0.148	0.086	0.761	0.851	0.970	0.368
MVALOO	0.665	0.393	0.707	0.744	0.781	0.937	0.608	0.210
PCTFMPOP	0.922	0.332	0.729	0.206	0.344	0.303	0.161	0.753
UNEMPL	0.761	0.482	0.749	0.094	0.184	0.148	0.071	0.660
PCTVOT	0.310	0.951	0.615	0.746	0.470	0.328	0.870	0.305
CHRILL	0.309	0.059	0.907	0.597	0.603	0.747	0.222	0.666
MD	0.567	0.126	0.702	0.005	0.913	0.514	0.345	0.740
LBWB	0.280	0.213	0.458	0.501	0.818	0.355	0.366	0.680

Table 12 displays the 2012 variable significance for the Combination model when analyzing for total incidence rate. It is broken down by classification. Highlighted variables are significant at a $p < 0.05$ significance level. Any time a variable was excluded by SPSS Statistics, it is indicated by a '***' symbol.

Table 12: Combination Model Total West Nile Virus Incidence Rate Variable Significance

Variable	Rural	Micropolitan	Metropolitan	Study Area
MELEV	0.140	0.665	0.008	0.237
THSTRM	0.647	0.142	0.665	0.107
DRGHT	0.282	0.365	0.065	0.351
FLDING	0.109	0.110	0.363	0.762
$PAVG_t$	0.258	0.207	0.210	0.380
$TAVG_t$	0.999	***	0.420	0.993
PNS_t	0.371	0.202	0.521	0.403
TNS_t	0.541	0.393	0.404	0.339
$PAVG_{t-1}$	0.203	0.114	0.270	0.329
$TAVG_{t-1}$	0.536	***	***	0.343
PWN_{t-1}	0.426	0.119	0.268	0.530
TWN_{t-1}	0.794	0.194	0.579	0.352
PNS_{t-1}	0.089	0.134	0.691	0.186
TNS_{t-1}	0.980	0.237	0.987	0.270
$PAVG_{t-2}$	0.263	0.307	0.774	0.138
$TAVG_{t-2}$	0.484	0.395	0.749	***
PWN_{t-2}	0.454	0.031	0.237	0.513
TWN_{t-2}	0.344	0.226	0.114	0.239
PNS_{t-2}	0.419	0.440	0.691	0.183
TNS_{t-2}	0.784	0.013	0.987	0.942
$PAVG_{t-3}$	0.633	0.406	0.448	0.311
$TAVG_{t-3}$	0.729	0.022	***	0.740
PWN_{t-3}	0.621	0.301	0.352	0.523
TWN_{t-3}	0.704	0.105	0.692	0.760
PNS_{t-3}	0.995	0.391	0.704	0.904
TNS_{t-3}	0.585	0.339	0.610	0.718
$PAVG_{t-4}$	0.859	0.884	0.274	0.301
$TAVG_{t-4}$	0.539	0.877	0.643	0.786
PWN_{t-4}	0.959	0.902	0.615	0.555
TWN_{t-4}	0.530	0.559	0.654	0.757
PNS_{t-4}	0.680	0.672	0.140	0.562
TNS_{t-4}	0.489	0.893	0.191	0.570
$TMAR_t$	0.785	0.291	0.062	0.227
$TAPR_t$	0.508	0.143	0.717	0.539
$TMAY_t$	0.284	0.924	0.523	0.453
$TJUN_t$	0.826	0.867	0.421	0.574

(Table 12 Continued)

Variable	Rural	Micropolitan	Metropolitan	Study Area
$TJUL_t$	0.762	0.425	0.187	0.785
$TAUG_t$	0.686	0.008	0.938	0.613
$PMAR_t$	0.583	0.609	0.876	0.922
$PAPR_t$	0.345	0.130	0.676	0.302
$PMAY_t$	0.413	0.201	0.109	0.881
$PJUN_t$	0.312	0.287	0.319	0.317
$PJUL_t$	0.307	0.700	0.189	0.206
$PAUG_t$	0.217	0.237	0.265	0.346
$TJUL_{t-1}$	0.967	0.412	0.308	0.996
$TAUG_{t-1}$	0.486	0.131	0.330	0.029
$TSEP_{t-1}$	0.900	0.067	0.888	0.142
$PJUL_{t-1}$	0.685	0.679	0.787	0.382
$PAUG_{t-1}$	0.696	0.291	0.646	0.731
$PSEP_{t-1}$	0.017	0.959	0.430	0.015
POPDEN	0.315	0.120	0.477	0.083
PCTBLK	0.582	0.480	0.456	0.108
PCTHIS	0.505	0.641	0.512	0.334
PCTKID	0.637	0.317	0.188	0.570
PCTOLD	0.703	0.986	0.311	0.242
AVGPERHH	0.602	0.208	0.390	0.001
PTNOHS	0.141	0.152	0.066	0.001
PCTMOB	0.223	0.555	0.403	0.904
HOUDEN	0.312	0.223	0.368	0.080
FEMLBR	0.077	0.262	0.920	0.537
PCTFHH	0.786	0.554	0.883	0.091
PCTRENT	0.064	0.902	0.118	0.173
PCTPOV	0.227	0.416	0.382	0.244
PCINC	0.031	0.087	0.760	0.999
MEDINC	0.001	0.101	0.710	0.002
PCTCVLBRF	0.249	0.164	0.054	0.670
PCTAG	0.017	0.416	0.263	0.011
MEDRENT	0.123	0.528	0.368	0.240
MVALOO	0.000	0.774	0.541	0.000
PCTFRMPOP	0.765	0.496	0.423	0.922
UNEMPL	0.226	0.906	0.073	0.507
PCTVOT	0.903	0.685	0.641	0.609
CHRILL	0.523	0.916	0.615	0.980
MD	0.733	0.010	0.613	0.339
LBWB	0.562	0.208	0.321	0.129

5.8 Stepwise Linear Regression Model Results

Each stepwise linear regression that was performed creates a model using the provided variables that best describes the variability of the dependent variable, in this case the total incidence rate of the West Nile Virus. Table 13 shows the variables that were found to be significant for each model when the Rural subset was analyzed for West Nile Virus total incidence rate. Following that, Table 14 shows the variables that were found to be significant for each model when the Micropolitan subset was analyzed for West Nile Virus total incidence rate. Table 15 shows the variables that were found to be statistically significant for each model when the Metropolitan subset was analyzed for West Nile Virus total incidence rate. Table 16 shows which of the provided variables were found to be significant for each model when the entire Gulf of Mexico coastal study area was analyzed for the West Nile Virus total incidence rate.

The variables listed in each category make up the model using that best describes the Natural Exposure, Socio-Economics, and the Combined for each of the subsets and then the study area. For each variable, the significance level is indicated and all variables that were found to be significant at a $p < 0.05$ level of significance are shaded. It should be noted that each variable chosen by each stepwise linear regression is included in the model was deemed to be significant through statistical analysis. Additionally, the Beta coefficient for each variable included in these models is noted. This coefficient is used to determine the direction of the relationship between that variable and the dependent variable, in this case the total incidence rate of the West Nile Virus.

Table 13: Rural Total West Nile Virus Incidence Rate Variable Significance

Variable	Significance	Beta
Natural Exposure		
TMAR12	0.000	-0.515
PMAY12	0.004	-0.223
PJUN12	0.041	0.162
Socio-Economic		
AVGPERHH	0.000	0.388
PCTNOHS	0.000	-0.341
PCTMOB	0.026	-0.146
PCTFHH	0.000	-0.521
PCTRENT	0.000	0.257
PCINC	0.001	-0.286
MEDINC	0.000	-0.474
PCTAG	0.000	0.488
MVALOO	0.000	0.269
PCTVOT	0.002	0.229
Combination		
TMAR12	0.000	-0.490
PMAY12	0.008	-0.158
AVGPERHH	0.000	0.272
PCTPOV	0.002	-0.296
MEDINC	0.000	-0.594
PCTAG	0.000	0.335
MVALOO	0.000	0.493

Table 14: Micropolitan Total West Nile Virus Incidence Rate Variable Significance

Variable	Significance	Beta
Natural Exposure		
DRGHT	0.019	0.206
TAVG10	0.002	-0.300
TWN10	0.000	-1.133
TNS10	0.016	-0.450
PWN09	0.000	-0.590
PWN08	0.000	0.640
TMAR12	0.000	0.972
TAUG11	0.000	0.459
Socio-Economic		
PCTKID	0.000	0.348
PCTMOB	0.042	-0.164
MEDINC	0.006	0.224
LBWB	0.000	0.430
Combination		
DRGHT	0.000	0.331
TNS12	0.032	-0.836
PWN11	0.000	-0.230
TWN10	0.000	-0.952
TAVG09	0.001	-0.204
TWN09	0.007	1.242
TWN08	0.000	-1.306
TNS08	0.000	2.649
TMAY12	0.000	0.619
PJUL12	0.002	0.254
TAUG11	0.001	0.342
PCTFHH	0.000	0.511
MEDRENT	0.013	0.199

Table 15: Metropolitan Total West Nile Virus Incidence Rate Variable Significance

Variable	Significance	Beta
Natural Exposure		
MELEV	0.000	0.922
PAVG08	0.000	0.329
TMAY12	0.000	0.386
PMAR12	0.000	0.384
Socio-Economic		
PCTKID	0.000	0.338
AVGPERHH	0.033	-0.225
PCTCVLBRF	0.000	0.379
PCTAG	0.004	0.200
UNEMPL	0.032	0.195
LBWB	0.007	0.223
Combination		
MELEV	0.000	0.734
DRGHT	0.028	0.170
PWN08	0.002	0.257
TMAY12	0.001	0.284
PMAR12	0.000	0.325
PSEP11	0.008	0.219
PCTPOV	0.015	0.163
PCTAG	0.001	0.260

Table 16: Study Area Total West Nile Virus Incidence Rate Variable Significance

Variable	Significance	Beta
Natural Exposure		
MELEV	0.000	0.594
DRGHT	0.001	0.163
PAVG12	0.007	0.190
PWN08	0.004	0.161
PMAY12	0.000	-0.195
Socio-Economic		
PCTKID	0.000	0.283
PCTNOHS	0.000	-0.307
PCTMOB	0.000	-0.193
PCTFHH	0.014	-0.156
PCINC	0.000	-0.356
PCTAG	0.000	0.289
MEDRENT	0.024	-0.168
MVALOO	0.000	0.327
PCTFMPOP	0.000	0.216
LBWB	0.002	0.168
Combination		
MELEV	0.000	0.593
DRGHT	0.002	0.142
PAVG12	0.000	0.265
PWN08	0.010	0.153
PMAY12	0.000	-0.197
PAUG11	0.003	-0.131
PCTBLK	0.080	0.096
PCTMOB	0.005	-0.144
PCINC	0.001	-0.259
PCTAG	0.026	0.128
MVALOO	0.000	0.353
PCTFMPOP	0.016	0.128

5.9 Analysis of Significant Variables in the Stepwise Models

The Natural Exposure models specifically highlight that there are a variety of different natural variables that can affect the spread of the West Nile Virus. Monthly temperature and precipitation averages proved to be significant across all classification levels within this study area. More long-term seasonal and yearly averages were seen to be significant in the urban classifications and in the context of the entire study area and they generally indicated that higher levels of temperature and precipitation were conducive to the spread of West Nile Virus along the Gulf Coast. This analysis showed that characterization of the land and long-term weather hazards were also influential on the spread of the West Nile Virus across the study area and in urban classifications specifically.

In the Socio-Economic models it was seen that even populations with more resilient characteristics can be susceptible to changes in disease patterns. Demographics showed that when there is a susceptible population can indicate West Nile Virus activity across all classifications. Interestingly, the social capital variables had negative relationships with the total West Nile Virus incidence rate across all study areas, indicating there is more social capital in the areas being affected by the West Nile Virus. The economic characteristics were a mixed bunch in terms of indicating resilience. Employment in agricultural services and percent of rural farm population both had a positive relationship in all classifications. This result reinforces that there is some component to the spread of the West Nile Virus that is happening in a more rural environment and that activity is not solely located in urbanized areas. Income level had a negative relationship in the study area and the Rural environment, which indicates a less resilient community; however higher incomes were seen in the Micropolitan area. Higher

values of housing but lower median rents were seen to be associated with the West Nile Virus in the study area. These are conflicting ideas as higher values of housing can indicate a wealthier population but lower rents do not. Higher values of housing were also seen in the Rural areas, indicating a more resilient economy when there were other factors to indicate a less resilient economy. The Metropolitan area also saw conflicting economic indicators. A higher percentage of the labor force being employed and higher unemployment rates were both seen to be correlated to the incidence rate of the West Nile Virus. There were more low birth weight babies in areas that with higher incidence rates of the West Nile Virus, indicating that areas that are already weak in terms of health are more susceptible to the spread of the West Nile Virus.

The combination models proved to be the most significant of the models since across all classifications they were able to explain more variability in the total West Nile Virus incidence rate than either natural or human factors could independently. The study area saw both natural exposure variables and socio-economic indicators as important to the spread of the West Nile Virus. The Rural classification saw predominately socio-economic variables that were significant in the regression model. This is supported by the R^2 values for the two different independent models. This can be associated with the fact that the natural environment is less altered in rural areas, which allows for differences within the socio-economic status of the populations to stand out as the most influential. The urban environments saw that natural exposure variables were more significant in terms of the combination models. This was further supported by the R^2 values in the independent stepwise models, where natural exposure explained more variance

than the socio-economic indicators could. The natural environment can be quite altered in the urban environment, which could lead to these trends.

In the combination models, there were differences between urban and rural areas in terms of the relationship that were seen with the natural exposure variables. The Rural subset regression model saw exclusively negative relationships with natural exposure variables; this is indicative of lower levels of precipitation and temperature were influential in the spread of the West Nile Virus in rural areas. The Metropolitan regression model saw positive relationships with the natural exposure variables, indicating warmer temperatures being more indicative of the West Nile Virus in urban areas. There is a positive relationship with historical weather hazards in the urban areas and across the study area, potentially indicating that there is innate lower health resilience in areas that are historically dealing with high levels of weather hazards.

It was also seen in the combination models that there are trends that indicate a community with a less resilient population will be more vulnerable to the West Nile Virus. The analysis suggests that in the urban environments and the study area there is still a rural component that increases a community's vulnerability to West Nile Virus. This was supported by a positive relationship with percent employment in agricultural services and with the percent of rural farm population. These variables are indicative of not only rural areas, but also populations that are at a higher risk of exposure by having a higher level of outdoor activity. Indicators of a weaker economy in urban areas were indicative of a community that is less resilient to the West Nile Virus; this was shown through a larger, positive beta coefficient with the percent of the population living in poverty in these areas. Additionally, relationships indicating that lower levels of income were associated with West Nile Virus further support this.

In the course of this analysis, characteristics of a more resilient community in rural areas were seen. The regression model for the Rural area provided evidence that populations more susceptible to West Nile Virus in rural areas had less poverty and had higher values of housing, which both support the concept of a more resilient community. It was seen that there was a lower level of income, which contradicts this and is indicative of a community with a lower level of resilience.

5.10 Analysis of Model Development & Evaluation of Hypotheses

Hypothesis 1 was stated as "As temperature and precipitation levels increase, so will the incidence of West Nile Virus;" the results showed that this was not exclusively true across all levels of classification within the study areas. The relationship between temperature and precipitation and the West Nile Virus was not as clearly defined as it is theoretically in the literature. Different classifications saw different patterns of specific climate relationships. The Rural subset saw more negative beta coefficient relationships with temperature and precipitation and the Micropolitan area saw both positive and negative beta relationships with temperature and precipitation. This indicates that it is not just extremes in temperature and precipitation that are driving the spread of the West Nile Virus and that in areas with a rural component there are additional factors at play with the spread of the virus. It was seen in the Metropolitan area and in the entire study area that there is a clear positive relationship with temperature and the West Nile Virus in the context of this study area. The relationship between precipitation in these areas is a little more fluid, they were generally positive but in a few cases

they were negative. In terms of the urban areas and the study area, this hypothesis holds true, but was not found to be true in the rural environments of this study area.

"A community with stronger socio-economic characteristics will be less affected by the West Nile Virus. was the second hypothesis, and the results showed that this was true. It was generally seen that indicators of lower socio-economic community resilience are predictive of a more susceptible community to the West Nile Virus in this study area. A community that is innately less resilient will struggle to deal with changing health patterns in the face of climate change. These communities generally do not have the access to medical care or the resources to deal with extremes in climate variability. Indicators of lower socio-economic resilience were seen at all levels of classification within the study area. Some indicators of a higher socio-economic resilience were also seen, indicating that even in a more resilient society there is still weakness in terms of health resilience in the face of changing health patterns.

The third hypothesis of this study, "A model that incorporates both natural exposure and socio-economic characteristics is better in explaining the spread of the West Nile Virus" was supported as true by the results of this study. It was seen that a model incorporating both natural exposure and socio-economic indicators explains more variability of the spread of the West Nile Virus. This was supported through both the multiple and stepwise linear regression analyses and model results; this was true across all classifications of the study area in the course of this analysis. In analyzing the health of a community, combinations of the natural and human environment are important in characterizing the patterns of resilience because these forces interact with each other and cannot be isolated from each other.

This final hypothesis of this study was that "There is a difference in the way urban and rural environments are affected by the West Nile Virus, with urban environments being more susceptible," and the results supported mixed results on this. The analysis of the West Nile Virus in the study area showed that there is susceptibility regardless of differences in built environments, particularly in terms of incidence rate. It was seen through the model development however, that there is a difference between the urban and rural environments individually and when they are combined into the study area. Different relationships between both natural and socio-economic indicators exist with the West Nile Virus total incidence rate at all levels of classification of the study area. There are some trends in indicators that are common across all classifications however, showing that there is a commonality to a county's susceptibility to the West Nile Virus, regardless of land characterization. This hypothesis overall was disprove; urban environments are not necessarily more susceptible than rural areas. However, there are differences in what potentially drives the susceptibility in each specific environment. Urban environments were seen to have their susceptibility driven by natural factors while more rural environments were driven by socio-economic factors.

Chapter 6: Conclusions

6.1 Study Conclusions

A very complicated relationship exists between disease, climate, and resilience. There is an intricate balance that must be maintained in order to keep a community healthy and strong both at an individual level and on a community wide level. As we change the world around us, as individuals and as a nation we need to be prepared to deal with the consequences. We are already feeling the effects of extreme weather events and changing patterns of disease. Through the course of this study there were multiple objectives that were met on the course to more fully understand the relationship that our health has with the world around us.

There is a noticeable difference between the level of susceptibility between urban and rural environments in the context of the West Nile Virus incidence. It is clearly seen that the West Nile Virus incidence follows an urban pattern as it spread throughout the study area since the virus first became active along the Gulf Coast. Statistically, West Nile Virus is most active in urban areas when looking at incidence. When the virus is analyzed from the perspective of an incidence rate, it becomes clear that there is susceptibility across different built and natural environments. This analysis showed that in terms of the scientific standard of rate, there were similar levels of activity across different classifications of urban and rural environments. Spatial analysis through mapping revealed that there was a susceptibility to the West Nile Virus across the study area with levels of high activity more grouped together and cover larger areas. Additionally, it was seen through the model development that there is a difference between the urban and rural environments individually and when they are combined into the study area

in terms of significant characteristics. Analysis revealed that indicators of the natural exposure were more significant in urban environments while in the rural environments socio-economic indicators proved to be the most significant.

The establishment of a climate dataset at the county level allows for a community level analysis across a wide area. This provides an ability to analyze the data for trends over time but also to look at climactic factors in relation to population characteristics to determine the kinds of things that can bring strength into a community. Large-scale weather patterns can affect the ability of a community or individual to respond to stressors in health, making them solid influences in how the patterns of disease can change. The Natural Exposure models made it clear that there are a variety of climate relationships that are influencing the spread of the West Nile Virus. It was seen that higher temperatures lead to higher incidence rates of the West Nile Virus particularly in urban areas while in rural areas lower temperatures and levels of precipitation were associated with the spread of the West Nile Virus. Climate activity at the beginning of the West Nile Virus season and in the peak months of the season proved to be influential in the spread of the West Nile Virus.

This study saw that a community with stronger socio-economic characteristics was generally more resilient to West Nile Virus. Traditional resilience population indicators proved important in this analysis in describing the variability in West Nile Virus incidence and incidence rate. Demographic and economic descriptors proved to have a strong presence when explaining the variability of the spread of the West Nile Virus. These indicators and those describing health and social capital are reflective of the infrastructure that a community has in place. These will be important in the development of a health resilience framework as they are factors that can

be influenced by policy and both federal and local government decisions and they are also reflective of how the structure of a community can influence patterns in health and disease. It is important to build up the local resilience through community education and educated policy decisions.

Through the analysis performed in this study, it was seen that a model that incorporates both differences in natural exposure and socio-economic indicators will be more comprehensive in explaining the spread of West Nile Virus than either type could be independently. This was true across all levels of classification within the study area and was true over time as the disease activity increased within the study area. This analysis showed that there are components of the natural environment and the human infrastructure that can affect the variability in the spread of the West Nile Virus and it is important to consider combinations of these factors in order to properly capture exactly what is happening in terms of a community's or individual's health.

What this study has additionally shown through meeting these different objectives is that in the development of a framework for health resilience there is a wide range of factors that need to be considered. It is potentially very important to have a health indicator that has a traceable history in order to be able to study the effects of different indicators. Being able to trace a disease allows for analysis and identification of the factors that are most important in influencing the spread of a disease. Descriptors of the population at any level of analysis need to be diverse in order to best capture what is driving either the promotion or destruction of health. It is also necessary to consider what type of effect climate change has not only in the context of an individual disease but to the overall structure of our society and infrastructure.

6.2 Implications and Future Research

This study has shown that there is a need to keep working on developing ways to protect the health of both individuals and communities. Through the course of this study, it has been established that in order to fully understand a community's health resilience a wide variety of different kinds of indicators must be analyzed and it is important to characterize both natural and society factors. As our society faces the inevitable extremes in weather patterns due to climate change and we see more changing patterns in disease, it only puts us more at risk. Diseases will move into areas where they were never previously located. These changes are not going to go away, and we may not be able to do anything to prevent them. But it is important that we be prepared to deal with them. It becomes important to promote economic growth and stability, environmentally conscious policies, and community education in order to ensure that both individuals and local governments have the resources necessary to mitigate the effects of climate change and the risk it poses to our health.

There were several limitations that dictated the direction of this research. First was the availability of a properly descriptive climate variable. A dataset was created in order to perform this analysis. Also, in some cases there were gaps in the existing data availability for temperature and precipitation. Secondly, this is a disease that has not been active in this country for very many years, so there is a limited amount of data available. It will take future research in order to truly understand the dynamics of this disease. However, this study has made several contributions towards to future research and development in this field. A dataset for a variety of different climate variables was created at the county level. This dataset provided proof that there is a relationship between climate and health resilience, providing direction

towards the development of a health resilience framework. This study also supported that in moving forward with a health resilience framework, both the natural and human environment need to be characterized. Through the classification of counties into urban and rural, this study showed that West Nile Virus is active in rural areas as well as urban ones, indicating susceptibility across classifications of the human infrastructure.

Future development of an encompassing set of indicators is the first necessary step in establishing a framework for predicting health resilience. By determining what factors are truly reflective of our health, as a community and as an individual we can ensure that protections are being put in place to protect that delicate balance. It has been shown through this study that a complete model of health resilience will require both natural factors and descriptors of the human infrastructure. Policies and programs need to be established to support strengthening communities on local levels in order to ensure they are properly prepared as our health risks change. Simultaneous long-term study of climate conditions and disease and health trends will allow for further analysis of the delicate balance that we must balance with our environment in order to maximize our health resilience.

The next step in analyzing the West Nile Virus will be to analyze it at a more specific scale. By looking at a large spatial area that is broken down into smaller pieces, a more accurate depiction of the natural environment and socio-economic characteristics can be analyzed to further understand the spread of the West Nile Virus. Additionally, analyzing other diseases in a similar method will lead to a better understanding of health resilience. The analysis in this study has shown that there is a need to focus the West Nile Virus research and prevention efforts into

both rural and urban environments, as there is a susceptibility to this health threat that can be felt across all classifications of the build environment.

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Appendix 1: Study Area County Characterization

COUNTY	STATE	FIPS CODE	Weather Station	MSA Classification
Autauga	AL	01001	Plantersville	3
Baldwin	AL	01003	Fairhope/Bay Minette	2
Barbour	AL	01005	Clayton	2
Bibb	AL	01007	Centreville	3
Blount	AL	01009	Oneonta	3
Bullock	AL	01011	Union Springs	1
Butler	AL	01013	Greenville	1
Calhoun	AL	01015	Jacksonville	3
Chambers	AL	01017	West Point	2
Cherokee	AL	01019	Centre	1
Chilton	AL	01021	Thorsby Experimental Station	3
Choctaw	AL	01023	Coffeville Lock and Dam	1
Clarke	AL	01025	Thomasville	1
Clay	AL	01027	Ashland	1
Cleburne	AL	01029	Heflin	1
Coffee	AL	01031	Enterprise	2
Colbert	AL	01033	Muscle Shoals Regional Airport	3
Conecuh	AL	01035	Evergreen Middleton Field	1
Coosa	AL	01037	Rockford	2
Covington	AL	01039	Open Pond/Andalusia	1
Crenshaw	AL	01041	Highland Home	1
Cullman	AL	01043	Cullman NAHS	2
Dale	AL	01045	Dothan Regional Airport	2
Dallas	AL	01047	Marion Junction	2
DeKalb	AL	01049	Valley Head	2
Elmore	AL	01051	Wetumpka/Millbrook	3
Escambia	AL	01053	Brewton	1
Etowah	AL	01055	Gadsden	3
Fayette	AL	01057	Winfield	1
Franklin	AL	01059	Russellville	1
Geneva	AL	01061	Geneva	3
Greene	AL	01063	Gainesville	3
Hale	AL	01065	Warrior Lock and Dam	3
Henry	AL	01067	Headland	3
Houston	AL	01069	Dothan	3
Jackson	AL	01071	Scottsboro	2
Jefferson	AL	01073	Bessemer	3
Lamar	AL	01075	Sulligent	1
Lauderdale	AL	01077	Anderson	3
Lawrence	AL	01079	Moulton	3
Lee	AL	01081	Auburn	3
Limestone	AL	01083	Belle Mina	3
Lowndes	AL	01085	Jones Bluff Lock and Dam	3
Macon	AL	01087	Milstead	2

COUNTY	STATE	FIPS CODE	Weather Station	MSA Classification
Madison	AL	01089	Huntsville International Airport Jones Field	3
Marengo	AL	01091	Demopolis Lock and Dam	1
Marion	AL	01093	Hamilton	1
Marshall	AL	01095	Guntersville	2
Mobile	AL	01097	Mobile Regional Airport	3
Monroe	AL	01099	Claiborne Lock and Dam	1
Montgomery	AL	01101	Montgomery Airport	3
Morgan	AL	01103	Decatur	3
Perry	AL	01105	Uniontown	1
Pickens	AL	01107	Aliceville Lock and Dam	1
Pike	AL	01109	Troy	2
Randolph	AL	01111	Rock Mills	1
Russell	AL	01113	Seale	3
St. Clair	AL	01115	Logan Martin Dam	3
Shelby	AL	01117	Alabaster Shelby Co Airport	3
Sumter	AL	01119	Livingston	1
Talladega	AL	01121	Childersburg Water Plant	2
Tallapoosa	AL	01123	Alexander City	2
Tuscaloosa	AL	01125	Bankhead Lock and Dam	3
Walker	AL	01127	Jasper	3
Washington	AL	01129	Chatom	1
Wilcox	AL	01131	Millers Ferry Lock and Dam	1
Winston	AL	01133	Addison	1
Alachua	FL	12001	High Springs	3
Baker	FL	12003	Glen St. Mary	3
Bay	FL	12005	Panama City	3
Bradford	FL	12007	Starke	1
Brevard	FL	12009	Melbourne Weather Forecast Office	3
Broward	FL	12011	Fort Lauderdale Executive Airport	3
Calhoun	FL	12013	Clarksville	1
Charlotte	FL	12015	Punta Gorda Charlotte Co Airport	3
Citrus	FL	12017	Inverness	2
Clay	FL	12019	Not Available	3
Collier	FL	12021	Oasis Ranger Station	3
Columbia	FL	12023	Lake City	2
DeSoto	FL	12027	Arcadia	2
Dixie	FL	12029	Cross City	1
Duval	FL	12031	Jacksonville Craig Municipal Airport	3
Escambia	FL	12033	Pensacola Regional Airport	3
Flagler	FL	12035	Palm Coast	3
Franklin	FL	12037	Apalachicola Airport	1
Gadsden	FL	12039	Quincy	3
Gilchrist	FL	12041	Bell	3
Glades	FL	12043	Moore Haven Lock	1
Gulf	FL	12045	Wewahitchka	1
Hamilton	FL	12047	White Springs	1

COUNTY	STATE	FIPS CODE	Weather Station	MSA Classification
Hardee	FL	12049	Wauchula	2
Hendry	FL	12051	Devils Garden	2
Hernando	FL	12053	Brooksville Hernando Co Airport	3
Highlands	FL	12055	Archibold Bio Station	2
Hillsborough	FL	12057	Tampa International Airport	3
Holmes	FL	12059	New Hope	1
Indian River	FL	12061	Vero Beach	3
Jackson	FL	12063	Marianna	1
Jefferson	FL	12065	Monticello WTP	3
Lafayette	FL	12067	Dowling Park	1
Lake	FL	12069	Leesburg Municipal Airport	3
Lee	FL	12071	Fort Myers SW Florida Regional Airport	3
Leon	FL	12073	Tallahassee Regional Airport	3
Levy	FL	12075	Usher Tower	1
Liberty	FL	12077	Bristol	1
Madison	FL	12079	Madison	1
Manatee	FL	12081	Sarasota Bradenton Airport	3
Marion	FL	12083	Ocala	3
Martin	FL	12085	Stuart	3
Miami-Dade	FL	12086	Miama International Airport	3
Monroe	FL	12087	Marathon Airport	2
Nassau	FL	12089	Fernandina Beach	3
Okaloosa	FL	12091	Destin Fort Walton Beach Airport	3
Okeechobee	FL	12093	Not Available	2
Orange	FL	12095	Orlando International Airport	3
Osceola	FL	12097	Kissimmee	3
Palm Beach	FL	12099	West Palm Beach International Airport	3
Pasco	FL	12101	Saint Leo	3
Pinellas	FL	12103	St. Petersburg Clearwater International Airport	3
Polk	FL	12105	Lakeland	3
Putnam	FL	12107	Federal Point	2
Santa Rosa	FL	12113	Whiting Field NAS	3
Sarasota	FL	12115	Myakka River State Park	3
Seminole	FL	12117	Sanford	3
St. Johns	FL	12109	Hastings	3
St. Lucie	FL	12111	Fort Pierce St. Lucie Co International Airport	3
Sumter	FL	12119	Bushnell	2
Suwannee	FL	12121	Mayo	1
Taylor	FL	12123	Perry Foley Airport	1
Union	FL	12125	Not Available	1
Volusia	FL	12127	Daytona Beach International Airport	3
Wakulla	FL	12129	Not Available	3
Walton	FL	12131	De Funiak Springs	1
Washington	FL	12133	Chipley	1
Acadia	LA	22001	Crowley	2
Allen	LA	22003	Oberlin Fire Tower	1

COUNTY	STATE	FIPS CODE	Weather Station	MSA Classification
Ascension	LA	22005	Gonzales	3
Assumption	LA	22007	Donaldsonville	2
Avoyelles	LA	22009	Bunkie	1
Beauregard	LA	22011	De Ridder	2
Bienville	LA	22013	Bienville	1
Bossier	LA	22015	Shreveport Downtown Airport	3
Caddo	LA	22017	Shreveport Regional Airport	3
Calcasieu	LA	22019	Lake Charles Regional Airport	3
Caldwell	LA	22021	Columbia Lock	1
Cameron	LA	22023	Rockefellr WL Refuge	3
Catahoula	LA	22025	Jonesville Locks	1
Claiborne	LA	22027	Haynesville	1
Concordia	LA	22029	Vidalia	2
De Soto	LA	22031	Logansport	3
East Baton Rouge	LA	22033	Baton Rouge Ryan Airport	3
East Carroll	LA	22035	Lake Providence	1
East Feliciana	LA	22037	Clinton	3
Evangeline	LA	22039	Beaver Fire Tower	1
Franklin	LA	22041	Winnsboro	1
Grant	LA	22043	Catahoula FTS Louisiana	3
Iberia	LA	22045	New Iberia Acadiana Regional Airport	2
Iberville	LA	22047	Carville	3
Jackson	LA	22049	Jonesboro	2
Jefferson	LA	22051	New Orleans International Airport	3
Jefferson Davis	LA	22053	Jennings	2
La Salle	LA	22059	Jena	3
Lafayette	LA	22055	Lafayette	3
Lafourche	LA	22057	Galliano	1
Lincoln	LA	22061	Ruston	2
Livingston	LA	22063	Livingston	3
Madison	LA	22065	Tallulah Vicksburg Regional Airport	2
Morehouse	LA	22067	Bastrop	2
Natchitoches	LA	22069	Kisatchie FTS Louisiana	2
Orleans	LA	22071	New Orleans Algiers	3
Ouachita	LA	22073	Calhoun Res Station	3
Plaquemines	LA	22075	New Orleans Alvin Callender Field	3
Pointe Coupee	LA	22077	New Roads	3
Rapides	LA	22079	Alexandria	3
Red River	LA	22081	Hanna	1
Richland	LA	22083	Rayville	1
Sabine	LA	22085	Hodges Gardens	1
St. Bernard	LA	22087	Not Available	3
St. Charles	LA	22089	Paradis	3
St. Helena	LA	22091	Pine Grove Fire tower	3
St. James	LA	22093	Lutcher	2
St. John the Baptist	LA	22095	Reserve	3

COUNTY	STATE	FIPS CODE	Weather Station	MSA Classification
St. Landry	LA	22097	Grand Coteau	2
St. Martin	LA	22099	St. Martinville	3
St. Mary	LA	22101	Morgan City	2
St. Tammany	LA	22103	Slidell	3
Tangipahoa	LA	22105	Hammond	2
Tensas	LA	22107	St Joseph	1
Terrebonne	LA	22109	Houma	3
Union	LA	22111	Farmerville	3
Vermilion	LA	22113	Leland Bowman Lock	2
Vernon	LA	22115	Leesville	2
Washington	LA	22117	Mount Hermon	2
Webster	LA	22119	Minden	2
West Baton Rouge	LA	22121	Brusly/Port Allen	3
West Carroll	LA	22123	Oak Grove	2
West Feliciana	LA	22125	St. Francisville	3
Winn	LA	22127	Winona Fire Tower	1
Adams	MS	28001	Natchez	2
Alcorn	MS	28003	Corinth	2
Amite	MS	28005	Gloster	2
Attala	MS	28007	Kosciusko	1
Benton	MS	28009	Ashland	1
Bolivar	MS	28011	Cleaveland	2
Calhoun	MS	28013	Calhoun City	1
Carroll	MS	28015	Greenwood Leflore Airport	2
Chickasaw	MS	28017	Van Vleet	1
Choctaw	MS	28019	Ackerman	1
Claiborne	MS	28021	Port Gibson	1
Clarke	MS	28023	Shubuta	2
Clay	MS	28025	Tibbee	2
Coahoma	MS	28027	Clarksdale	2
Copiah	MS	28029	Hazlehurst	3
Covington	MS	28031	Collins	1
DeSoto	MS	28033	Olive Branch	3
Forrest	MS	28035	Hattiesburg	3
Franklin	MS	28037	Meadville	1
George	MS	28039	Lucedale	3
Greene	MS	28041	Leakesville	1
Grenada	MS	28043	Grenada	2
Hancock	MS	28045	Waveland	3
Harrison	MS	28047	Saucier Experimental Forest	3
Hinds	MS	28049	Oakley Experimental Station	3
Holmes	MS	28051	Pickens	1
Humphreys	MS	28053	Belzoni	1
Issaquena	MS	28055	Rolling Fork	1
Itawamba	MS	28057	Fulton	2
Jackson	MS	28059	Pascagoula Lott International Airport	3

COUNTY	STATE	FIPS CODE	Weather Station	MSA Classification
Jasper	MS	28061	Bay Springs/Paulding	2
Jefferson	MS	28063	Union Church	1
Jefferson Davis	MS	28065	Prentiss	1
Jones	MS	28067	Laurel	2
Kemper	MS	28069	Kipling/Dekalb	2
Lafayette	MS	28071	Abbeville	3
Lamar	MS	28073	Sumrall	3
Lauderdale	MS	28075	Meridian Key Field	2
Lawrence	MS	28077	Monticello,MS	1
Leake	MS	28079	Carthage	1
Lee	MS	28081	Verona Experimental Station	2
Leflore	MS	28083	Not Available	2
Lincoln	MS	28085	Brookhaven City	2
Lowndes	MS	28087	Columbus	2
Madison	MS	28089	Canton	3
Marion	MS	28091	Columbia	1
Marshall	MS	28093	Holly Springs	3
Monroe	MS	28095	Aberdeen	1
Montgomery	MS	28097	Winona	1
Neshoba	MS	28099	Philadelphia	1
Newton	MS	28101	Newton Experimental Station	1
Noxubee	MS	28103	Macon	1
Oktibbeha	MS	28105	State University	2
Panola	MS	28107	Batesville	1
Pearl River	MS	28109	Poplarville Experimental Station	2
Perry	MS	28111	Beaumont Experimental Station	3
Pike	MS	28113	McComb Pike County John E. Lewis Field Airport	2
Pontotoc	MS	28115	Pontotoc Experimental Station	2
Prentiss	MS	28117	Booneville	1
Quitman	MS	28119	Lambert	1
Rankin	MS	28121	Jackson International Airport	3
Scott	MS	28123	Forest	1
Sharkey	MS	28125	Rolling Fork	1
Simpson	MS	28127	D Lo	3
Smith	MS	28129	Raleigh/Mize	1
Stone	MS	28131	Wiggins	3
Sunflower	MS	28133	Moorhead	2
Tallahatchie	MS	28135	Charleston	1
Tate	MS	28137	Independence	3
Tippah	MS	28139	Ripley	1
Tishomingo	MS	28141	Iuka	1
Tunica	MS	28143	Tunica	3
Union	MS	28145	New Albany	1
Walthall	MS	28147	Tylertown	1
Warren	MS	28149	Vicksburg Military/City	2
Washington	MS	28151	Greenville	2

COUNTY	STATE	FIPS CODE	Weather Station	MSA Classification
Wayne	MS	28153	Waynesboro	1
Webster	MS	28155	Eupora	1
Wilkinson	MS	28157	Woodville	1
Winston	MS	28159	Louisville	1
Yalobusha	MS	28161	Water Valley	1
Yazoo	MS	28163	Yazoo City	2
Anderson	TX	48001	Palestine	2
Andrews	TX	48003	Andrews	2
Angelina	TX	48005	Lufkin	2
Aransas	TX	48007	Rockport	3
Archer	TX	48009	Scotland	3
Armstrong	TX	48011	Amarillo International Airport	3
Atascosa	TX	48013	Charlotte	3
Austin	TX	48015	Bellville	3
Bailey	TX	48017	Muleshoe	1
Bandera	TX	48019	Medina	3
Bastrop	TX	48021	Elgin	3
Baylor	TX	48023	Seymour	1
Bee	TX	48025	Beeville	2
Bell	TX	48027	Stillhouse Hollow Dam	1
Bexar	TX	48029	San Antonio Stinson Municipal Airport	3
Blanco	TX	48031	Blanco	1
Borden	TX	48033	Gail	1
Bosque	TX	48035	Whitney Dam	1
Bowie	TX	48037	Texarkana	3
Brazoria	TX	48039	Angleton Lake Jackson Brazoria Co Airport	3
Brazos	TX	48041	College Station Easterwood Field	3
Brewster	TX	48043	Panther Junction	1
Briscoe	TX	48045	Silverton	1
Brooks	TX	48047	Falfurrias	1
Brown	TX	48049	Brownwood	2
Burleson	TX	48051	Somerville Dam	3
Burnet	TX	48053	Burnet Municipal Airport	2
Caldwell	TX	48055	Lockhart	3
Calhoun	TX	48057	Point Comfort	3
Callahan	TX	48059	Putnam	3
Cameron	TX	48061	Port Isabel Cameron Co Airport	3
Camp	TX	48063	Pittsburg	1
Carson	TX	48065	Panhandle	3
Cass	TX	48067	Linden	1
Castro	TX	48069	Dimmitt	1
Chambers	TX	48071	Anahuac	3
Cherokee	TX	48073	Dialville	2
Childress	TX	48075	Childress	1
Clay	TX	48077	Charlie	3
Cochran	TX	48079	Morton	1

COUNTY	STATE	FIPS CODE	Weather Station	MSA Classification
Coke	TX	48081	Water Valley 11	1
Coleman	TX	48083	Hords Creek Dam	1
Collin	TX	48085	Mckinney Municipal Airport	3
Collingsworth	TX	48087	Wellington	1
Colorado	TX	48089	Columbus	1
Comal	TX	48091	Canyon Dam	3
Comanche	TX	48093	Proctor Reservoir	1
Concho	TX	48095	Concho Park Ivie Reservoir	1
Cooke	TX	48097	Gainesville	2
Coryell	TX	48099	Gatesville	3
Cottle	TX	48101	Paducah	1
Crane	TX	48103	Crane	1
Crockett	TX	48105	Action Ranch	1
Crosby	TX	48107	White River Reservoir	3
Culberson	TX	48109	Van Horn	1
Dallam	TX	48111	Conlen	1
Dallas	TX	48113	Dallas Love Field	3
Dawson	TX	48115	Lamesa	2
Deaf Smith	TX	48117	Hereford	2
Delta	TX	48119	Cooper	3
Denton	TX	48121	Denton Municipal Airport	3
DeWitt	TX	48123	Yoakum	1
Dickens	TX	48125	Spur	1
Dimmit	TX	48127	Carrizo Springs	1
Donley	TX	48129	Clarendon	1
Duval	TX	48131	Benavides	1
Eastland	TX	48133	Rising Star/Ranger	1
Ector	TX	48135	Odessa Schlemeyer Field	3
Edwards	TX	48137	Carta Valley	1
El Paso	TX	48141	El Paso International Airport	3
Ellis	TX	48139	Bardwell Dam	3
Erath	TX	48143	Chalk Mountain	2
Falls	TX	48145	Rosebud	1
Fannin	TX	48147	Bonham	2
Fayette	TX	48149	Flatonia	1
Fisher	TX	48151	Rotan	1
Floyd	TX	48153	Floydada	1
Foard	TX	48155	Crowell	1
Fort Bend	TX	48157	Sugar Land	3
Franklin	TX	48159	Mount Vernon	1
Freestone	TX	48161	Oakwood/Fairfield	1
Frio	TX	48163	Pearsall	1
Gaines	TX	48165	Seminole	1
Galveston	TX	48167	Galveston Scholes Field	3
Garza	TX	48169	Lake Alan Henry	1
Gillespie	TX	48171	Gold	2

COUNTY	STATE	FIPS CODE	Weather Station	MSA Classification
Glasscock	TX	48173	Garden City	1
Goliad	TX	48175	Goliad	3
Gonzales	TX	48177	Jeddo	1
Gray	TX	48179	Pampa	2
Grayson	TX	48181	Sherman	3
Gregg	TX	48183	Longview E Texas Regional Airport	3
Grimes	TX	48185	Richards	1
Guadalupe	TX	48187	New Braunfels Muninicpal Airport	3
Hale	TX	48189	Abernathy	2
Hall	TX	48191	Memphis	1
Hamilton	TX	48193	Hamilton	1
Hansford	TX	48195	Gruver	1
Hardeman	TX	48197	Quanah	1
Hardin	TX	48199	Lumberton	3
Harris	TX	48201	Houston Intercontinental Airport	3
Harrison	TX	48203	Hallsville	2
Hartley	TX	48205	Dalhart Municipal Airport	1
Haskell	TX	48207	Haskell	1
Hays	TX	48209	Dripping Springs	3
Hemphill	TX	48211	Canadian	1
Henderson	TX	48213	Athens	2
Hidalgo	TX	48215	La Joya	3
Hill	TX	48217	Hillsboro	1
Hockley	TX	48219	Levelland	2
Hood	TX	48221	Cresson/Grandbury	2
Hopkins	TX	48223	Sulphur Springs	2
Houston	TX	48225	Crockett	1
Howard	TX	48227	Big Springs	2
Hudspeth	TX	48229	Dell City	1
Hunt	TX	48231	Greenville KGVL Radio	3
Hutchinson	TX	48233	Borger Hutchinson Co Airport	2
Irion	TX	48235	Mertzon	3
Jack	TX	48237	Jacksboro	1
Jackson	TX	48239	Edna	1
Jasper	TX	48241	Sam Rayburn Dam	1
Jeff Davis	TX	48243	Valentine	1
Jefferson	TX	48245	Port Arthur Regional Airport	3
Jim Hogg	TX	48247	Hebbronville	1
Jim Wells	TX	48249	Mathis	2
Johnson	TX	48251	Burleson	3
Jones	TX	48253	Stamford	3
Karnes	TX	48255	Runge	1
Kaufman	TX	48257	Terrell Municipal Airport	3
Kendall	TX	48259	Boerne	3
Kenedy	TX	48261	Sarita	2
Kent	TX	48263	Jayton	1

COUNTY	STATE	FIPS CODE	Weather Station	MSA Classification
Kerr	TX	48265	Kerrville	2
Kimble	TX	48267	Junction	1
King	TX	48269	Paducah 15	1
Kinney	TX	48271	Brackettville	1
Kleberg	TX	48273	Kingsville	2
Knox	TX	48275	Truscott	1
La Salle	TX	48283	Fowlerton	1
Lamar	TX	48277	Paris	2
Lamb	TX	48279	Littlefield	1
Lampasas	TX	48281	Lampasas	3
Lavaca	TX	48285	Hallettsville	1
Lee	TX	48287	Lexington	1
Leon	TX	48289	Centerville	1
Liberty	TX	48291	Cleveland	3
Limestone	TX	48293	Thornton	1
Lipscomb	TX	48295	Lipscomb	1
Live Oak	TX	48297	Choke Canyon Dam	1
Llano	TX	48299	Llano	1
Loving	TX	48301	Mentone	1
Lubbock	TX	48303	Lubbock International Airport	3
Lynn	TX	48305	Tahoka	1
Madison	TX	48313	Madisonville	1
Marion	TX	48315	Jefferson	1
Martin	TX	48317	Lenorah	1
Mason	TX	48319	Mason	1
Matagorda	TX	48321	Palacios Municipal Airport	2
Maverick	TX	48323	Eagle Pass	2
McCulloch	TX	48307	Brady	1
McLennan	TX	48309	Waco Regional Airport	3
McMullen	TX	48311	Cross	1
Medina	TX	48325	Hondo Municipal Airport	3
Menard	TX	48327	Menard	1
Midland	TX	48329	Midland International Airport	3
Milam	TX	48331	Rockdale	1
Mills	TX	48333	Goldthwaite	1
Mitchell	TX	48335	Colorado City/Lazy H Ranch	1
Montague	TX	48337	Bowie	1
Montgomery	TX	48339	New Caney	3
Moore	TX	48341	Dumas	2
Morris	TX	48343	Daingerfield	1
Motley	TX	48345	Matador	1
Nacogdoches	TX	48347	Nacogdoches	2
Navarro	TX	48349	Corsicana Campbell Field	2
Newton	TX	48351	Newton/Kirbyville	1
Nolan	TX	48353	Roscoe	2
Nueces	TX	48355	Corpus Chrisit International Airport	3

COUNTY	STATE	FIPS CODE	Weather Station	MSA Classification
Ochiltree	TX	48357	Perryton	1
Oldham	TX	48359	Bravo	1
Orange	TX	48361	Orange	3
Palo Pinto	TX	48363	Gordon	2
Panola	TX	48365	Carthage, TX	1
Parker	TX	48367	Weatherford	3
Parmer	TX	48369	Friona	1
Pecos	TX	48371	Fort Stockton Pecos Co Airport	1
Polk	TX	48373	Livingston, TX	1
Potter	TX	48375	Bushland	3
Presidio	TX	48377	Big Bend Ranch	1
Rains	TX	48379	Lake Tawakoni	1
Randall	TX	48381	Canyon, TX	3
Reagan	TX	48383	Cope Ranch	1
Real	TX	48385	Camp Wood	1
Red River	TX	48387	Avery/Clarksville	1
Reeves	TX	48389	Balmothea	2
Refugio	TX	48391	Refugio	1
Roberts	TX	48393	Miami	2
Robertson	TX	48395	Franklin	3
Rockwall	TX	48397	Rockwall	3
Runnels	TX	48399	Ballinger	1
Rusk	TX	48401	Henderson	3
Sabine	TX	48403	Pineland/Sabine	1
San Augustine	TX	48405	San Augustine	1
San Jacinto	TX	48407	Coldspring	3
San Patricio	TX	48409	Welder W Life Found	3
San Saba	TX	48411	Taylor Ranch/Colorado Bend	1
Schleicher	TX	48413	El Dorado	1
Scurry	TX	48415	Snyder	2
Shackelford	TX	48417	Albany	1
Shelby	TX	48419	Center, TX	1
Sherman	TX	48421	Stratford	1
Smith	TX	48423	Tyler,Tx	3
Somervell	TX	48425	Rainbow	2
Starr	TX	48427	Falcon Dam	2
Stephens	TX	48429	Breckenridge	1
Sterling	TX	48431	Sterling City	1
Stonewall	TX	48433	Aspermont	1
Sutton	TX	48435	Sonora	1
Swisher	TX	48437	Tulia	1
Tarrant	TX	48439	Benbrook Dam	3
Taylor	TX	48441	Abilene Regional Airport	3
Terrell	TX	48443	Dryden Terrell Co Airport	1
Terry	TX	48445	Brownfield	1
Throckmorton	TX	48447	Throckmorton	1

COUNTY	STATE	FIPS CODE	Weather Station	MSA Classification
Titus	TX	48449	Mount Pleasant	2
Tom Green	TX	48451	Knickerbocker	3
Travis	TX	48453	Austin Camp Mabry	3
Trinity	TX	48455	Groveton	1
Tyler	TX	48457	Town Bluff Dam	1
Upshur	TX	48459	Gilmer	3
Upton	TX	48461	McCamey	1
Uvalde	TX	48463	Utopia/Sabinal	2
Val Verde	TX	48465	Amistad Dam	2
Van Zandt	TX	48467	Wills Point	1
Victoria	TX	48469	Victoria Regional Airport	3
Walker	TX	48471	Huntsville	2
Waller	TX	48473	Brookshire	3
Ward	TX	48475	Grandfalls	1
Washington	TX	48477	Brenham	2
Webb	TX	48479	Encinal	3
Wharton	TX	48481	Danevang	2
Wheeler	TX	48483	Shamrock	1
Wichita	TX	48485	Wichita Falls Municipal Airport	3
Wilbarger	TX	48487	Vernon	2
Willacy	TX	48489	Port Mansfield	2
Williamson	TX	48491	Granger Dam	3
Wilson	TX	48493	Floresville	3
Winkler	TX	48495	Winkler Co Airport	1
Wise	TX	48497	Bridgeport	3
Wood	TX	48499	Lake Fork Reservoir	1
Yoakum	TX	48501	Denver City	1
Young	TX	48503	Graham	1
Zapata	TX	48505	Escobas/Zapata	1
Zavala	TX	48507	La Pryor	1

Appendix 2: Regression Results 2003, 2006, and 2009

2003NE	RuralInc	RuralRate	MicroInc	MicroRate	MetroInc	MetroRate	StudyInc	StudyRate
MELEV	0.093	0.157	0.070	0.189	0.011	0.000	0.028	0.010
THSTRM	0.908	0.951	0.747	0.614	0.244	0.660	0.475	0.121
DRGHT	0.286	0.470	0.354	0.136	0.963	0.974	0.000	0.758
FLDING	0.584	0.977	0.658	0.811	0.450	0.391	0.008	0.445
$PAVG_t$	0.964	0.883	0.946	0.574	0.249	0.663	0.831	0.466
$TAVG_t$	0.719	0.886	0.014	0.034	0.799	0.324	0.268	0.587
PNS_t	0.920	0.875	0.711	0.331	0.345	0.907	0.340	0.559
TNS_t	0.305	0.524	0.177	0.443	0.597	0.090	0.517	0.961
$PAVG_{t-1}$	0.595	0.841	0.429	0.512	0.456	0.752	0.517	0.677
$TAVG_{t-1}$	0.989	0.911	0.061	0.018	0.693	0.331	0.600	0.713
PWN_{t-1}	0.752	0.821	0.594	0.507	0.406	0.871	0.100	0.789
TWN_{t-1}	0.587	0.647	0.269	0.696	0.916	0.024	0.585	0.620
PNS_{t-1}	0.911	0.878	0.492	0.555	0.620	0.902	0.284	0.859
TNS_{t-1}	0.374	0.410	0.550	0.485	0.315	0.117	0.848	0.935
$PAVG_{t-2}$	0.775	0.875	0.578	0.571	0.545	0.587	0.270	0.583
$TAVG_{t-2}$	0.930	0.804	0.017	0.003	0.906	0.863	0.657	0.440
PWN_{t-2}	0.708	0.743	0.476	0.710	0.508	0.346	0.411	0.672
TWN_{t-2}	0.943	0.821	0.049	0.004	0.816	0.979	0.923	0.708
PNS_{t-2}	0.682	0.831	0.365	0.751	0.396	0.984	0.462	0.816
TNS_{t-2}	0.184	0.293	0.160	0.709	0.992	0.626	0.641	0.228
$PAVG_{t-3}$	0.534	0.659	0.117	0.783	0.393	0.593	0.349	0.491
$TAVG_{t-3}$	0.784	0.825	0.777	0.748	0.857	0.522	0.917	0.333
PWN_{t-3}	0.511	0.653	0.148	0.768	0.408	0.644	0.630	0.601
TWN_{t-3}	0.438	0.308	0.867	0.680	0.779	0.851	0.979	0.106
PNS_{t-3}	0.699	0.884	0.151	0.754	0.706	0.479	0.993	0.881
TNSt-3	0.707	0.961	0.380	0.945	0.655	0.570	0.490	0.821
$TMAR_t$	0.738	0.971	0.015	0.117	0.738	0.172	0.217	0.536
$TAPR_t$	0.164	0.378	0.827	0.244	0.569	0.461	0.506	0.424
$TMAY_t$	0.043	0.027	0.349	0.218	0.901	0.148	0.450	0.292
$TJUN_t$	0.185	0.116	0.741	0.840	0.883	0.458	0.069	0.273
$TJUL_t$	0.701	0.873	0.676	0.824	0.108	0.385	0.267	0.566
$TAUG_t$	0.254	0.183	0.176	0.166	0.642	0.348	0.325	0.726
$PMAR_t$	0.952	0.526	0.975	0.948	0.561	0.825	0.258	0.771
$PAPR_t$	0.442	0.437	0.950	0.805	0.205	0.905	0.449	0.968
$PMAY_t$	0.809	0.906	0.308	0.956	0.239	0.055	0.566	0.684
$PJUN_t$	0.233	0.140	0.092	0.756	0.338	0.319	0.950	0.016
$PJUL_t$	0.873	0.999	0.754	0.678	0.867	0.815	0.642	0.489
$PAUG_t$	0.577	0.565	0.730	0.991	0.250	0.532	0.395	0.834
$TJUL_{t-1}$	0.094	0.033	0.110	0.589	0.390	0.053	0.002	0.001
$TAUG_{t-1}$	0.296	0.063	0.107	0.155	0.184	0.727	0.152	0.370

2003NE	RuralInc	RuralRate	MicroInc	MicroRate	MetroInc	MetroRate	StudyInc	StudyRate
$TSEP_{t-1}$	0.249	0.419	0.715	0.740	0.216	0.128	0.200	0.291
$PJUL_{t-1}$	0.600	0.942	0.103	0.438	0.722	0.238	0.512	0.570
$PAUG_{t-1}$	0.384	0.290	0.599	0.861	0.621	0.396	0.576	0.644
$PSEP_{t-1}$	0.912	0.983	0.782	0.974	0.788	0.907	0.877	0.418

2003SOCECO	RuralInc	RuralRate	MicroInc	MicroRate	MetroInc	MetroRate	StudyInc	StudyRate
POPDEN	0.795	0.920	0.163	0.183	0.000	0.362	0.000	0.733
PCTBLK	0.087	0.116	0.515	0.293	0.853	0.463	0.382	0.011
PCTHIS	0.968	0.959	0.801	0.357	0.612	0.349	0.533	0.314
PCTKID	0.123	0.073	0.194	0.087	0.141	0.001	0.118	0.001
PCTOLD	0.231	0.296	0.713	0.357	0.375	0.430	0.216	0.250
AVGPERHH	0.061	0.071	0.880	0.919	0.854	0.345	0.310	0.086
PTNOHS	0.858	0.575	0.797	0.999	0.219	0.012	0.550	0.489
PCTMOB	0.408	0.204	0.571	0.850	0.673	0.013	0.818	0.004
HOUDEN	0.109	0.088	0.104	0.171	0.014	0.512	0.000	0.884
FEMLBR	0.758	0.984	0.991	0.879	0.893	0.281	0.496	0.940
PCTFHH	0.004	0.000	0.889	0.604	0.519	0.131	0.203	0.000
PCTRENT	0.148	0.070	0.987	0.526	0.393	0.122	0.062	0.630
PCTPOV	0.472	0.449	0.456	0.310	0.320	0.196	0.764	0.274
PCINC	0.013	0.010	0.537	0.765	0.024	0.032	0.216	0.022
MEDINC	0.089	0.012	0.900	0.588	0.970	0.875	0.147	0.032
PCTCVLBRF	0.995	0.928	0.718	0.708	0.767	0.005	0.503	0.765
PCTAG	0.220	0.658	0.548	0.949	0.119	0.081	0.106	0.882
MEDRENT	0.410	0.150	0.883	0.147	0.497	0.853	0.527	0.375
MVALOO	0.103	0.423	0.612	0.271	0.009	0.241	0.088	0.475
PCTFRMPOP	0.829	0.875	0.508	0.678	0.717	0.007	0.782	0.503
UNEMPL	0.069	0.197	0.384	0.820	0.669	0.692	0.290	0.210
PCTVOT	0.677	0.418	0.143	0.068	0.620	0.835	0.682	0.423
CHRILL	0.950	0.916	0.768	0.840	0.045	0.225	0.068	0.934
MD	0.192	0.138	0.719	0.624	0.133	0.982	0.009	0.927
LBWB	0.465	0.249	0.536	0.314	0.503	0.054	0.390	0.014

2003COMBO	RuralInc	RuralRate	MicroInc	MicroRate	MetroInc	MetroRate	StudyInc	StudyRate
MELEV	0.105	0.147	0.726	0.107	0.000	0.000	0.168	0.175
THSTRM	0.497	0.514	0.097	0.105	0.668	0.291	0.518	0.140
DRGHT	0.308	0.490	0.192	0.181	0.819	0.263	0.253	0.335
FLDING	0.327	0.516	0.858	0.463	0.758	0.863	0.764	0.042
$PAVG_t$	0.849	0.664	0.355	0.503	0.466	0.495	0.647	0.262
$TAVG_t$	0.916	0.907	0.414	0.265	0.109	0.160	0.726	0.452
PNS_t	0.614	0.703	0.353	0.698	0.564	0.714	0.631	0.325
TNS_t	0.122	0.249	0.912	0.851	0.133	0.144	0.263	0.724
$PAVG_{t-1}$	0.237	0.246	0.963	0.880	0.790	0.718	0.727	0.486
$TAVG_{t-1}$	0.741	0.818	0.190	0.210	0.786	0.699	0.278	0.543
PWN_{t-1}	0.570	0.541	0.782	0.563	0.532	0.535	0.856	0.465
TWN_{t-1}	0.380	0.353	0.340	0.500	0.083	0.046	0.091	0.963
PNS_{t-1}	0.308	0.196	0.689	0.584	0.465	0.617	0.516	0.871
TNS_{t-1}	0.287	0.235	0.143	0.039	0.675	0.616	0.139	0.827
$PAVG_{t-2}$	0.363	0.255	0.732	0.210	0.686	0.848	0.963	0.604
$TAVG_{t-2}$	0.446	0.351	0.040	0.013	0.222	0.869	0.250	0.149
PWN_{t-2}	0.402	0.299	0.889	0.577	0.741	0.978	0.703	0.779
TWN_{t-2}	0.283	0.236	0.050	0.011	0.220	0.862	0.217	0.236
PNS_{t-2}	0.843	0.514	0.929	0.851	0.414	0.685	0.818	0.500
TNS_{t-2}	0.485	0.404	0.848	0.511	0.506	0.595	0.541	0.310
$PAVG_{t-3}$	0.887	0.633	0.909	0.493	0.326	0.569	0.694	0.220
$TAVG_{t-3}$	0.253	0.139	0.599	0.458	0.945	0.607	0.635	0.333
PWN_{t-3}	0.951	0.543	0.923	0.897	0.291	0.714	0.777	0.169
TWN_{t-3}	0.193	0.123	0.936	0.878	0.546	0.767	0.597	0.057
PNS_{t-3}	0.790	0.729	0.922	0.857	0.136	0.325	0.639	0.453
TNS_{t-3}	0.540	0.251	0.353	0.753	0.936	0.961	0.587	0.378
$TMAR_t$	0.086	0.206	0.313	0.393	0.645	0.749	0.514	0.520
$TAPR_t$	0.094	0.268	0.598	0.286	0.227	0.174	0.800	0.476
$TMAY_t$	0.031	0.022	0.731	0.199	0.135	0.348	0.494	0.575
$TJUN_t$	0.175	0.084	0.677	0.477	0.782	0.970	0.989	0.716
$TJUL_t$	0.978	0.902	0.841	0.342	0.380	0.665	0.742	0.439
$TAUG_t$	0.250	0.158	0.640	0.387	0.470	0.929	0.795	0.997
$PMAR_t$	0.240	0.429	0.897	0.264	0.705	0.811	0.265	0.212
$PAPR_t$	0.309	0.272	0.662	0.688	0.525	0.710	0.232	0.725
$PMAY_t$	0.991	0.699	0.136	0.430	0.009	0.026	0.360	0.931
$PJUN_t$	0.208	0.138	0.323	0.556	0.769	0.705	0.926	0.013
$PJUL_t$	0.638	0.531	0.351	0.615	0.882	0.793	0.598	0.521
$PAUG_t$	0.599	0.574	0.346	0.213	0.421	0.693	0.394	0.834
$TJUL_{t-1}$	0.180	0.130	0.175	0.867	0.156	0.392	0.034	0.011
$TAUG_{t-1}$	0.187	0.081	0.338	0.195	0.797	0.681	0.621	0.322
$TSEP_{t-1}$	0.923	0.719	0.607	0.364	0.172	0.021	0.629	0.299
$PJUL_{t-1}$	0.673	0.747	0.845	0.295	0.493	0.176	0.334	0.815

2003COMBO	RuralInc	RuralRate	MicroInc	MicroRate	MetroInc	MetroRate	StudyInc	StudyRate
$PAUG_{t-1}$	0.653	0.607	0.978	0.776	0.828	0.388	0.738	0.655
$PSEP_{t-1}$	0.910	0.841	0.527	0.871	0.310	0.834	0.989	0.831
POPDEN	0.760	0.915	0.955	0.665	0.177	0.841	0.000	0.722
PCTBLK	0.148	0.223	0.583	0.385	0.807	0.830	0.794	0.388
PCTHIS	0.018	0.023	0.522	0.084	0.778	0.183	0.429	0.328
PCTKID	0.972	0.985	0.295	0.150	0.291	0.084	0.525	0.068
PCTOLD	0.051	0.067	0.780	0.142	0.238	0.275	0.017	0.256
AVGPERHH	0.160	0.211	0.818	0.423	0.621	0.739	0.211	0.257
PTNOHS	0.288	0.272	0.530	0.479	0.075	0.008	0.597	0.323
PCTMOB	0.815	0.586	0.584	0.485	0.436	0.633	0.080	0.057
HOUDEN	0.441	0.716	0.930	0.778	0.973	0.614	0.008	0.835
FEMLBR	0.856	0.842	0.526	0.019	0.289	0.772	0.115	0.164
PCTFHH	0.144	0.213	0.285	0.086	0.791	0.745	0.432	0.233
PCTRENT	0.755	0.648	0.264	0.305	0.477	0.601	0.223	0.508
PCTPOV	0.117	0.050	0.229	0.220	0.292	0.244	0.969	0.326
PCINC	0.381	0.204	0.218	0.097	0.035	0.268	0.545	0.743
MEDINC	0.015	0.002	0.481	0.725	0.193	0.952	0.103	0.001
PCTCVLBRF	0.634	0.497	0.263	0.210	0.007	0.827	0.681	0.533
PCTAG	0.729	0.694	0.484	0.324	0.099	0.095	0.264	0.627
MEDRENT	0.987	0.468	0.960	0.978	0.640	0.674	0.682	0.262
MVALOO	0.179	0.316	0.879	0.573	0.211	0.627	0.635	0.274
PCTFRMPOP	0.094	0.117	0.398	0.412	0.203	0.001	0.729	0.158
UNEMPL	0.073	0.068	0.831	0.746	0.403	0.387	0.961	0.414
PCTVOT	0.196	0.417	0.352	0.187	0.258	0.727	0.976	0.504
CHRILL	0.872	0.836	0.571	0.075	0.033	0.705	0.063	0.307
MD	0.199	0.204	0.516	0.694	0.039	0.206	0.003	0.468
LBWB	0.008	0.009	0.559	0.282	0.308	0.909	0.782	0.035

2006NE	RuralInc	RuralRate	MicroInc	MicroRate	MetroInc	MetroRate	StudyInc	StudyRate
MELEV	0.989	0.996	0.747	0.032	0.943	0.717	0.716	0.725
THSTRM	0.022	0.827	0.002	0.012	0.082	0.338	0.921	0.083
DRGHT	0.287	0.160	0.264	0.037	0.660	0.551	0.040	0.679
FLDING	0.189	0.825	0.890	0.532	0.896	0.778	0.000	0.561
$PAVG_t$	0.528	0.695	0.891	0.954	0.758	0.895	0.170	0.059
$TAVG_t$	0.248	0.318	0.741	0.737	0.613	0.368	0.893	0.399
PNS_t	0.503	0.784	0.543	0.499	0.842	0.570	0.098	0.198
TNS_t	0.289	0.603	0.272	0.394	0.808	0.578	0.687	0.534
$PAVG_{t-1}$	0.585	0.500	0.338	0.999	0.709	0.470	0.207	0.223
$TAVG_{t-1}$	0.643	0.581	0.099	0.227	0.255	0.366	0.472	0.703
PWN_{t-1}	0.597	0.398	0.414	0.957	0.717	0.626	0.166	0.231
TWN_{t-1}	0.505	0.208	0.160	0.234	0.251	0.364	0.468	0.700
PNS_{t-1}	0.734	0.927	0.481	0.902	0.469	0.609	0.348	0.439
TNS_{t-1}	0.029	0.708	0.628	0.661	0.282	0.607	0.587	0.596
$PAVG_{t-2}$	0.216	0.924	0.347	0.876	0.857	0.506	0.694	0.751
$TAVG_{t-2}$	0.026	0.670	0.052	0.001	0.902	0.944	0.590	0.567
PWN_{t-2}	0.371	0.906	0.283	0.835	0.834	0.525	0.521	0.592
TWN_{t-2}	0.025	0.664	0.756	0.395	0.930	0.885	0.568	0.555
PNS_{t-2}	0.671	0.861	0.463	0.821	0.903	0.746	0.789	0.905
TNS_{t-2}	0.027	0.702	0.221	0.257	0.281	0.944	0.561	0.583
$PAVG_{t-3}$	0.199	0.380	0.296	0.920	0.565	0.663	0.150	0.248
$TAVG_{t-3}$	0.047	0.935	0.504	0.396	0.732	0.580	0.751	0.943
PWN_{t-3}	0.143	0.401	0.256	0.999	0.403	0.750	0.118	0.280
TWN_{t-3}	0.033	0.847	0.162	0.106	0.575	0.376	0.725	0.513
PNS_{t-3}	0.655	0.331	0.371	0.820	0.358	0.419	0.074	0.226
TNS_{t-3}	0.434	0.837	0.662	0.845	0.659	0.895	0.645	0.684
$PAVG_{t-4}$	0.613	0.555	0.532	0.208	0.355	0.788	0.113	0.270
$TAVG_{t-4}$	0.450	0.892	0.412	0.157	0.450	0.813	0.739	0.550
PWN_{t-4}	0.916	0.574	0.685	0.383	0.536	0.638	0.151	0.303
TWN_{t-4}	0.338	0.307	0.910	0.815	0.938	0.728	0.844	0.625
PNS_{t-4}	0.189	0.248	0.987	0.768	0.373	0.060	0.743	0.101
TNS_{t-4}	0.839	0.535	0.517	0.236	0.274	0.720	0.460	0.151
$TMAR_t$	0.695	0.569	0.884	0.392	0.693	0.996	0.809	0.789
$TAPR_t$	0.264	0.323	0.278	0.007	0.644	0.404	0.891	0.405
$TMAY_t$	0.658	0.831	0.454	0.093	0.700	0.469	0.960	0.571
$TJUN_t$	0.208	0.016	0.418	0.260	0.119	0.173	0.597	0.001
$TJUL_t$	0.299	0.050	0.951	0.403	0.095	0.203	0.514	0.012
$TAUG_t$	0.263	0.324	0.432	0.102	0.876	0.813	0.901	0.408
$PMAR_t$	0.350	0.337	0.483	0.995	0.327	0.895	0.206	0.370
$PAPR_t$	0.930	0.203	0.483	0.270	0.790	0.972	0.092	0.176
$PMAY_t$	0.017	0.312	0.812	0.675	0.150	0.929	0.749	0.173
$PJUN_t$	0.398	0.627	0.166	0.146	0.329	0.582	0.534	0.020

2006NE	RuralInc	RuralRate	MicroInc	MicroRate	MetroInc	MetroRate	StudyInc	StudyRate
$PJUL_t$	0.001	0.774	0.119	0.243	0.875	0.332	0.846	0.890
$PAUG_t$	0.404	0.889	0.108	0.291	0.394	0.844	0.244	0.720
$TJUL_{t-1}$	0.933	0.469	0.887	0.341	0.308	0.562	0.660	0.112
$TAUG_{t-1}$	0.222	0.292	0.685	0.746	0.708	1.000	0.688	0.388
$TSEP_{t-1}$	0.457	0.347	0.191	0.097	0.668	0.943	0.410	0.723
$PJUL_{t-1}$	0.375	0.332	0.768	0.705	0.898	0.890	0.643	0.569
$PAUG_{t-1}$	0.436	0.541	0.375	0.627	0.958	0.005	0.625	0.252
$PSEP_{t-1}$	0.211	0.378	0.798	0.382	0.944	0.982	0.871	0.512

2006SOCIO	RuralInc	RuralRate	MicroInc	MicroRate	MetroInc	MetroRate	StudyInc	StudyRate
POPDEN	0.091	0.503	0.079	0.179	0.000	0.253	0.000	0.375
PCTBLK	0.816	0.374	0.629	0.364	0.277	0.960	0.088	0.870
PCTHIS	0.161	0.894	0.365	0.213	0.174	0.240	0.257	0.280
PCTKID	0.251	0.634	0.244	0.215	0.682	0.320	0.220	0.268
PCTOLD	0.847	0.355	0.178	0.331	0.364	0.535	0.468	0.364
AVGPERHH	0.455	0.459	0.503	0.451	0.557	0.382	0.906	0.013
PTNOHS	0.457	0.064	0.577	0.577	0.577	0.024	0.977	0.005
PCTMOB	0.440	0.966	0.782	0.481	0.380	0.432	0.859	0.747
HOUDEN	0.561	0.252	0.307	0.417	0.108	0.229	0.000	0.404
FEMLBR	0.580	0.069	0.912	0.871	0.459	0.694	0.217	0.007
PCTFHH	0.961	0.813	0.921	0.864	0.723	0.377	0.589	0.486
PCTRENT	0.369	0.004	0.096	0.097	0.983	0.021	0.897	0.007
PCTPOV	0.427	0.571	0.873	0.677	0.838	0.264	0.432	0.042
PCINC	0.541	0.880	0.655	0.776	0.065	0.759	0.212	0.688
MEDINC	0.275	0.159	0.951	0.969	0.282	0.679	0.782	0.021
PCTCVLBRF	0.038	0.455	0.653	0.557	0.503	0.102	0.233	0.447
PCTAG	0.524	0.000	0.901	0.300	0.283	0.599	0.326	0.000
MEDRENT	0.565	0.001	0.392	0.955	0.500	0.352	0.446	0.000
MVALOO	0.747	0.000	0.755	0.766	0.050	0.177	0.108	0.000
PCTFRMPOP	1.000	0.939	0.306	0.561	0.828	0.855	0.681	0.093
UNEMPL	0.384	0.047	0.671	0.754	0.654	0.139	0.335	0.065
PCTVOT	0.152	0.339	0.453	0.195	0.189	0.006	0.067	0.654
CHRILL	0.522	0.968	0.343	0.475	0.080	0.468	0.114	0.372
MD	0.869	0.149	0.441	0.382	0.706	0.345	0.174	0.170
LBWB	0.607	0.699	0.308	0.117	0.769	0.422	0.862	0.831

2006COMBO	RuralInc	RuralRate	MicroInc	MicroRate	MetroInc	MetroRate	StudyInc	StudyRate
MELEV	0.624	0.075	0.243	0.555	0.606	0.765	0.055	0.833
THSTRM	0.033	0.232	0.745	0.477	0.438	0.516	0.909	0.821
DRGHT	0.544	0.991	0.915	0.619	0.812	0.996	0.513	0.533
FLDING	0.115	0.973	0.350	0.218	0.143	0.541	0.010	0.076
$PAVG_t$	0.702	0.667	0.328	0.892	0.903	0.714	0.859	0.070
$TAVG_t$	0.549	0.507	0.521	0.917	0.661	0.338	0.421	0.698
PNS_t	0.667	0.981	0.882	0.623	0.727	0.521	0.159	0.195
TNS_t	0.750	0.822	0.907	0.536	0.826	0.938	0.773	0.797
$PAVG_{t-1}$	0.878	0.261	0.930	0.762	0.237	0.494	0.034	0.175
$TAVG_{t-1}$	0.585	0.202	***	***	0.594	0.767	0.349	0.393
PWN_{t-1}	0.934	0.352	0.806	0.759	0.317	0.761	0.037	0.113
TWN_{t-1}	0.715	0.417	0.867	0.358	0.589	0.766	0.352	0.405
PNS_{t-1}	0.323	0.179	0.973	0.813	0.190	0.511	0.098	0.561
TNS_{t-1}	0.082	0.743	0.900	0.237	0.808	0.757	0.817	0.795
$PAVG_{t-2}$	0.063	0.098	0.928	0.915	0.381	0.416	0.359	0.961
$TAVG_{t-2}$	0.073	0.745	0.100	0.017	0.977	0.930	0.766	0.784
PWN_{t-2}	0.097	0.133	0.888	0.855	0.327	0.441	0.312	0.922
TWN_{t-2}	0.072	0.736	0.309	0.293	0.745	0.969	0.761	0.755
PNS_{t-2}	0.350	0.158	0.953	0.990	0.350	0.949	0.159	0.843
TNS_{t-2}	0.075	0.807	0.409	0.727	0.530	0.862	0.783	0.829
$PAVG_{t-3}$	0.204	0.636	0.807	0.831	0.359	0.793	0.052	0.530
$TAVG_{t-3}$	0.265	0.924	0.688	0.996	0.658	0.758	0.078	0.333
PWN_{t-3}	0.134	0.775	0.741	0.874	0.219	0.674	0.023	0.559
TWN_{t-3}	0.365	0.682	0.500	0.274	0.544	0.468	0.076	0.096
PNS_{t-3}	0.727	0.747	0.867	0.818	0.381	0.815	0.090	0.352
TNS_{t-3}	0.972	0.646	0.637	0.811	0.976	0.811	0.640	0.833
$PAVG_{t-4}$	0.824	0.485	0.511	0.633	0.418	0.811	0.240	0.517
$TAVG_{t-4}$	0.268	0.572	0.454	0.961	0.114	0.531	0.654	0.610
PWN_{t-4}	0.870	0.434	0.436	0.483	0.840	0.930	0.509	0.416
TWN_{t-4}	0.387	0.392	0.500	0.928	0.685	0.758	0.584	0.177
PNS_{t-4}	0.242	0.770	0.906	0.939	0.762	0.982	0.892	0.864
TNS_{t-4}	0.534	0.342	0.721	0.990	0.130	0.897	0.126	0.651
$TMAR_t$	0.374	0.059	0.361	0.080	0.912	0.842	0.552	0.180
$TAPR_t$	0.573	0.514	0.117	0.400	0.656	0.594	0.412	0.709
$TMAY_t$	0.529	0.470	0.511	0.880	0.825	0.485	0.375	0.152
$TJUN_t$	0.973	0.000	0.885	0.768	0.561	0.193	0.594	0.000
$TJUL_t$	0.222	0.000	0.819	0.397	0.195	0.132	0.184	0.000
$TAUG_t$	0.589	0.569	0.358	0.745	0.516	0.466	0.409	0.795
$PMAR_t$	0.312	0.240	0.529	0.877	0.289	0.955	0.134	0.375
$PAPR_t$	0.788	0.617	0.321	0.965	0.826	0.984	0.455	0.148
$PMAY_t$	0.014	0.041	0.426	0.834	0.968	0.809	0.916	0.349
$PJUN_t$	0.284	0.198	0.206	0.594	0.185	0.703	0.576	0.286

2006COMBO	RuralInc	RuralRate	MicroInc	MicroRate	MetroInc	MetroRate	StudyInc	StudyRate
$PJUL_t$	0.007	0.124	0.731	0.120	0.490	0.794	0.146	0.636
$PAUG_t$	0.569	0.853	0.187	0.918	0.349	0.881	0.955	0.478
$TJUL_{t-1}$	0.516	0.744	0.411	0.874	0.708	0.583	0.879	0.184
$TAUG_{t-1}$	0.632	0.365	0.720	0.664	0.221	0.693	0.103	0.216
$TSEP_{t-1}$	0.150	0.526	0.731	0.342	0.181	0.824	0.054	0.352
$PJUL_{t-1}$	0.439	0.818	0.453	0.467	0.588	0.833	0.749	0.684
$PAUG_{t-1}$	0.136	0.176	0.820	0.899	0.764	0.037	0.330	0.552
$PSEP_{t-1}$	0.819	0.571	0.565	0.436	0.761	0.622	0.871	0.579
POPDEN	0.820	0.186	0.685	0.716	0.013	0.809	0.000	0.743
PCTBLK	0.790	0.725	0.578	0.427	0.364	0.223	0.137	0.948
PCTHIS	0.946	0.794	0.290	0.808	0.814	0.490	0.553	0.438
PCTKID	0.875	0.265	0.884	0.680	0.519	0.985	0.795	0.008
PCTOLD	0.636	0.235	0.565	0.353	0.066	0.674	0.016	0.541
AVGPERHH	0.905	0.140	0.332	0.548	0.633	0.331	0.356	0.000
PTNOHS	0.399	0.598	0.715	0.248	0.590	0.309	0.587	0.054
PCTMOB	0.001	0.000	0.065	0.384	0.742	0.382	0.201	0.029
HOUDEN	0.855	0.083	0.597	0.719	0.482	0.688	0.010	0.896
FEMLBR	0.657	0.306	0.705	0.961	0.945	0.808	0.486	0.036
PCTFHH	0.611	0.251	0.589	0.404	0.744	0.387	0.388	0.413
PCTRENT	0.989	0.021	0.927	0.739	0.764	0.299	0.153	0.000
PCTPOV	0.444	0.389	0.842	0.608	0.389	0.527	0.809	0.005
PCINC	0.589	0.384	0.672	0.511	0.337	0.748	0.203	0.415
MEDINC	0.250	0.007	0.796	0.357	0.524	0.737	0.248	0.005
PCTCVLBRF	0.063	0.718	0.869	0.491	0.541	0.395	0.577	0.681
PCTAG	0.050	0.005	0.600	0.869	0.512	0.962	0.570	0.000
MEDRENT	0.814	0.048	0.907	0.349	0.899	0.081	0.296	0.000
MVALOO	0.539	0.000	0.790	0.493	0.586	0.383	0.884	0.000
PCTFMPOP	0.574	0.598	0.842	0.864	0.580	0.324	0.600	0.522
UNEMPL	0.833	0.177	0.543	0.732	0.939	0.122	0.995	0.017
PCTVOT	0.095	0.177	0.255	0.389	0.504	0.033	0.357	0.260
CHRILL	0.646	0.695	0.733	0.969	0.251	0.719	0.228	0.328
MD	0.223	0.270	0.767	0.381	0.553	0.927	0.745	0.358
LBWB	0.079	0.040	0.987	0.197	0.612	0.039	0.930	0.165

2009NE	RuralInc	RuralRate	MicroInc	MicroRate	MetroInc	MetroRate	StudyInc	StudyRate
MELEV	0.442	0.541	0.860	0.539	0.158	0.001	0.250	0.341
THSTRM	0.294	0.568	0.411	0.424	0.078	0.281	0.101	0.059
DRGHT	0.140	0.154	0.385	0.745	0.908	0.964	0.287	0.149
FLDING	0.518	0.795	0.571	0.408	0.324	0.600	0.730	0.811
$PAVG_t$	0.678	0.922	0.973	0.978	0.323	0.114	0.184	0.365
$TAVG_t$	0.590	0.596	0.773	0.887	0.335	0.698	***	***
PNS_t	0.765	0.630	0.662	0.537	0.278	0.088	0.290	0.553
TNS_t	0.802	0.595	0.861	0.744	0.464	0.054	0.107	0.048
$PAVG_{t-1}$	0.624	0.907	0.307	0.987	0.305	0.031	0.206	0.383
$TAVG_{t-1}$	0.497	0.796	0.469	0.678	***	***	***	***
PWN_{t-1}	0.291	0.884	0.450	0.902	0.200	0.029	0.211	0.330
TWN_{t-1}	0.374	0.525	0.921	0.952	0.448	0.969	0.672	0.885
PNS_{t-1}	0.706	0.876	0.326	0.880	0.430	0.047	0.447	0.741
TNS_{t-1}	0.483	0.751	0.203	0.413	0.349	0.015	0.554	0.441
$PAVG_{t-2}$	0.624	0.985	0.388	0.960	0.249	0.055	0.495	0.650
$TAVG_{t-2}$	0.747	0.755	0.191	0.252	***	***	0.360	0.568
PWN_{t-2}	0.685	0.929	0.522	0.824	0.373	0.101	0.524	0.638
TWN_{t-2}	0.450	0.513	0.166	0.201	0.998	0.899	0.648	0.581
PNS_{t-2}	0.656	0.910	0.089	0.542	0.161	0.026	0.932	0.852
TNS_{t-2}	0.385	0.656	0.586	0.424	0.613	0.391	0.885	0.229
$PAVG_{t-3}$	0.954	0.856	0.075	0.445	0.320	0.025	0.943	0.965
$TAVG_{t-3}$	0.611	0.896	0.369	0.523	0.212	0.894	0.863	0.546
PWN_{t-3}	0.695	0.992	0.060	0.416	0.340	0.025	0.762	0.734
TWN_{t-3}	0.603	0.896	0.447	0.831	0.891	0.213	0.851	0.560
PNS_{t-3}	0.904	0.885	0.069	0.379	0.473	0.118	0.661	0.459
TNS_{t-3}	0.300	0.552	0.362	0.395	0.018	0.091	0.643	0.510
$PAVG_{t-4}$	0.997	0.990	0.395	0.346	0.376	0.231	0.830	0.411
$TAVG_{t-4}$	0.843	0.856	0.500	0.324	0.583	0.730	0.735	0.552
PWN_{t-4}	0.951	0.925	0.356	0.291	0.360	0.506	0.924	0.579
TWN_{t-4}	0.842	0.858	0.499	0.325	0.593	0.744	0.659	0.410
PNS_{t-4}	0.857	0.892	0.528	0.371	0.222	0.031	0.224	0.156
TNS_{t-4}	0.759	0.758	0.382	0.188	0.229	0.067	0.264	0.213
$TMAR_t$	0.902	0.751	0.994	0.819	0.568	0.942	0.296	0.878
$TAPR_t$	0.750	0.948	0.829	0.358	0.218	0.154	0.836	0.593
$TMAY_t$	0.649	0.905	0.801	0.893	0.346	0.072	0.938	0.508
$TJUN_t$	0.322	0.133	0.545	0.228	0.835	0.624	0.442	0.726
$TJUL_t$	0.588	0.594	0.770	0.622	0.338	0.692	0.550	0.572
$TAUG_t$	0.818	0.688	0.940	0.696	0.450	0.789	0.466	0.587
$PMAR_t$	0.520	0.674	0.597	0.787	0.389	0.154	0.945	0.973
$PAPR_t$	0.429	0.671	0.136	0.656	0.288	0.933	0.133	0.206
$PMAY_t$	0.440	0.892	0.705	0.730	0.577	0.181	0.143	0.320
$PJUN_t$	0.504	0.360	0.707	0.287	0.685	0.011	0.562	0.522

2009NE	RuralInc	RuralRate	MicroInc	MicroRate	MetroInc	MetroRate	StudyInc	StudyRate
$PJUL_t$	0.770	0.655	0.805	0.700	0.033	0.020	0.023	0.126
$PAUG_t$	0.267	0.227	0.818	0.989	0.942	0.887	0.637	0.591
$TJUL_{t-1}$	0.800	0.613	0.917	0.844	0.605	0.187	0.947	0.885
$TAUG_{t-1}$	0.531	0.557	0.624	0.687	0.980	0.738	0.232	0.151
$TSEP_{t-1}$	0.726	0.641	0.606	0.687	0.067	0.955	0.388	0.342
$PJUL_{t-1}$	0.480	0.734	0.992	0.944	0.260	0.445	0.364	0.372
$PAUG_{t-1}$	0.181	0.617	0.531	0.682	0.666	0.752	0.694	0.953
$PSEP_{t-1}$	0.653	0.948	0.403	0.878	0.242	0.506	0.015	0.044

2009SOCIO	RuralInc	RuralRate	MicroInc	MicroRate	MetroInc	MetroRate	StudyInc	StudyRate
POPDEN	0.701	0.961	0.787	0.179	0.000	0.014	0.000	0.142
PCTBLK	0.497	0.879	0.831	0.364	0.588	0.692	0.426	0.892
PCTHIS	0.023	0.318	0.871	0.213	0.219	0.188	0.288	0.264
PCTKID	0.914	0.926	0.233	0.215	0.933	0.793	0.398	0.397
PCTOLD	0.885	0.701	0.575	0.331	0.312	0.738	0.323	0.833
AVGPERHH	0.365	0.457	0.275	0.451	0.398	0.915	0.387	0.659
PTNOHS	0.766	0.573	0.174	0.577	0.961	0.245	0.615	0.114
PCTMOB	0.022	0.031	0.224	0.481	0.943	0.632	0.619	0.002
HOUDEN	0.686	0.979	0.923	0.417	0.004	0.010	0.000	0.094
FEMLBR	0.081	0.036	0.316	0.871	0.834	0.795	0.484	0.058
PCTFHH	0.468	0.974	0.569	0.864	0.962	0.319	0.925	0.978
PCTRENT	0.328	0.322	0.058	0.097	0.550	0.750	0.639	0.077
PCTPOV	0.296	0.294	0.581	0.677	0.770	0.480	0.737	0.743
PCINC	0.494	0.158	0.704	0.776	0.133	0.771	0.290	0.180
MEDINC	0.018	0.001	0.613	0.969	0.558	0.604	0.810	0.027
PCTCVLBRF	0.439	0.077	0.816	0.557	0.983	0.595	0.751	0.039
PCTAG	0.289	0.035	0.592	0.300	0.504	0.881	0.655	0.027
MEDRENT	0.820	0.809	0.916	0.955	0.940	0.858	0.580	0.788
MVALOO	0.848	0.829	0.818	0.766	0.183	0.613	0.158	0.740
PCTFRMPOP	0.217	0.217	0.419	0.561	0.690	0.435	0.924	0.205
UNEMPL	0.823	0.598	0.160	0.754	0.816	0.560	0.992	0.630
PCTVOT	0.344	0.116	0.118	0.195	0.214	0.026	0.104	0.097
CHRILL	0.362	0.592	0.595	0.475	0.249	0.834	0.237	0.963
MD	0.325	0.306	0.134	0.382	0.452	0.725	0.439	0.424
LBWB	0.540	0.686	0.965	0.117	0.819	0.692	0.949	0.852

2009COMBO	RuralInc	RuralRate	MicroInc	MicroRate	MetroInc	MetroRate	StudyInc	StudyRate
MELEV	0.369	0.315	0.818	0.803	0.264	0.000	0.337	0.211
THSTRM	0.565	0.446	0.271	0.442	0.028	0.029	0.060	0.074
DRGHT	0.334	0.345	0.286	0.606	0.322	0.364	0.780	0.762
FLDING	0.457	0.859	0.893	0.888	0.954	0.164	0.190	0.337
$PAVG_t$	0.992	0.888	0.359	0.587	0.193	0.441	0.460	0.836
$TAVG_t$	0.746	0.759	0.895	0.681	0.871	0.770	***	***
PNS_t	0.761	0.946	0.856	0.638	0.069	0.074	0.925	0.672
TNS_t	0.586	0.620	0.355	0.715	0.945	0.322	0.297	0.360
$PAVG_{t-1}$	0.435	0.706	0.521	0.774	0.039	0.023	0.608	0.787
$TAVG_{t-1}$	0.932	0.803	0.227	0.773	***	***	***	***
PWN_{t-1}	0.244	0.613	0.516	0.858	0.005	0.016	0.527	0.582
TWN_{t-1}	0.667	0.881	0.953	0.970	0.652	0.589	0.559	0.401
PNS_{t-1}	0.407	0.566	0.420	0.884	0.175	0.078	0.708	0.897
TNS_{t-1}	0.631	0.989	0.811	0.993	0.325	0.006	0.273	0.338
$PAVG_{t-2}$	0.397	0.518	0.228	0.859	0.094	0.180	0.561	0.572
$TAVG_{t-2}$	0.970	0.744	0.425	0.491	***	***	0.789	0.581
PWN_{t-2}	0.446	0.512	0.260	0.882	0.140	0.243	0.537	0.567
TWN_{t-2}	0.970	0.820	0.645	0.756	0.824	0.663	0.784	0.576
PNS_{t-2}	0.476	0.546	0.182	0.764	0.087	0.083	0.931	0.892
TNS_{t-2}	0.388	0.461	0.173	0.527	0.455	0.520	0.588	0.504
$PAVG_{t-3}$	0.637	0.670	0.142	0.561	0.215	0.074	0.920	0.714
$TAVG_{t-3}$	0.848	0.610	0.098	0.329	0.637	0.804	0.714	0.282
PWN_{t-3}	0.518	0.642	0.123	0.525	0.250	0.047	0.808	0.602
TWN_{t-3}	0.838	0.612	0.527	0.894	0.589	0.142	0.714	0.282
PNS_{t-3}	0.724	0.522	0.140	0.539	0.271	0.471	0.686	0.300
TNS_{t-3}	0.413	0.795	0.262	0.620	0.080	0.815	0.540	0.348
$PAVG_{t-4}$	0.653	0.478	0.725	0.835	0.253	0.281	0.510	0.147
$TAVG_{t-4}$	0.865	0.937	**	**	0.463	0.628	0.397	0.130
PWN_{t-4}	0.655	0.424	0.885	0.965	0.688	0.675	0.867	0.338
TWN_{t-4}	0.864	0.931	0.255	0.206	0.467	0.638	0.364	0.094
PNS_{t-4}	0.982	0.826	0.945	0.856	0.392	0.574	0.081	0.046
TNS_{t-4}	0.933	0.960	0.916	0.710	0.058	0.018	0.976	0.922
$TMAR_t$	0.556	0.261	0.181	0.435	0.524	0.659	0.859	0.232
$TAPR_t$	0.891	0.872	0.809	0.738	0.788	0.834	0.710	0.638
$TMAY_t$	0.563	0.922	0.474	0.730	0.284	0.072	0.370	0.262
$TJUN_t$	0.643	0.290	0.935	0.416	0.087	0.015	0.993	0.791
$TJUL_t$	0.742	0.751	0.256	0.349	0.776	0.772	0.404	0.350
$TAUG_t$	0.871	0.989	0.783	0.965	0.235	0.270	0.223	0.232
$PMAR_t$	0.972	0.777	0.212	0.343	0.390	0.139	0.539	0.410
$PAPR_t$	0.579	0.628	0.735	0.140	0.143	0.565	0.661	0.860
$PMAY_t$	0.709	0.940	0.581	0.833	0.295	0.208	0.416	0.708
$PJUN_t$	0.735	0.826	0.574	0.385	0.004	0.001	0.778	0.811

2009COMBO	RuralInc	RuralRate	MicroInc	MicroRate	MetroInc	MetroRate	StudyInc	StudyRate
$PJUL_t$	0.874	0.815	0.205	0.862	0.019	0.186	0.175	0.594
$PAUG_t$	0.453	0.191	0.933	0.859	0.202	0.523	0.336	0.293
$TJUL_{t-1}$	0.963	0.537	0.770	0.833	0.311	0.829	0.920	0.549
$TAUG_{t-1}$	0.485	0.459	0.274	0.444	0.525	0.444	0.825	0.895
$TSEP_{t-1}$	0.945	0.632	0.675	0.359	0.002	0.515	0.767	0.971
$PJUL_{t-1}$	0.468	0.645	0.085	0.043	0.072	0.090	0.337	0.254
$PAUG_{t-1}$	0.240	0.562	0.713	0.743	0.075	0.752	0.567	0.710
$PSEP_{t-1}$	0.509	0.512	0.899	0.916	0.070	0.601	0.021	0.084
POPDEN	0.865	0.758	0.473	0.645	0.001	0.054	0.531	0.333
PCTBLK	0.984	0.751	0.580	0.744	0.913	0.648	0.433	0.297
PCTHIS	0.400	0.767	0.630	0.328	0.915	0.123	0.972	0.397
PCTKID	0.722	0.687	0.722	0.915	0.073	0.030	0.858	0.744
PCTOLD	0.781	0.762	0.085	0.217	0.993	0.784	0.401	0.238
AVGPERHH	0.422	0.560	0.565	0.367	0.291	0.653	0.401	0.204
PTNOHS	0.331	0.371	0.624	0.470	0.500	0.166	0.142	0.171
PCTMOB	0.500	0.668	0.669	0.631	0.503	0.605	0.878	0.833
HOUDEN	0.811	0.640	0.307	0.528	0.091	0.047	0.965	0.829
FEMLBR	0.420	0.435	0.732	0.509	0.856	0.715	0.577	0.449
PCTFHH	0.560	0.910	0.282	0.756	0.178	0.003	0.617	0.512
PCTRENT	0.409	0.161	0.213	0.233	0.707	0.736	0.965	0.746
PCTPOV	0.515	0.600	0.720	0.706	0.769	0.424	0.925	0.699
PCINC	0.867	0.224	0.889	0.557	0.470	0.276	0.768	0.895
MEDINC	0.215	0.013	0.509	0.819	0.102	0.596	0.736	0.922
PCTCVLBRF	0.297	0.063	0.805	0.597	0.487	0.766	0.929	0.944
PCTAG	0.364	0.065	0.503	0.679	0.336	0.575	0.443	0.822
MEDRENT	0.598	0.445	0.190	0.221	0.209	0.680	0.098	0.205
MVALOO	0.800	0.761	0.570	0.905	0.539	0.069	0.454	0.360
PCTFMPOP	0.653	0.381	0.651	0.669	0.869	0.140	0.717	0.725
UNEMPL	0.577	0.335	0.874	0.735	0.126	0.092	0.883	0.694
PCTVOT	0.426	0.610	0.962	0.809	0.355	0.036	0.072	0.052
CHRILL	0.917	0.736	0.828	0.507	0.220	0.240	0.590	0.816
MD	0.790	0.638	0.382	0.390	0.483	0.216	0.124	0.014
LBWB	0.769	0.538	0.307	0.376	0.050	0.009	0.605	0.724

Vita

Lillian Mata was born in Houston, Texas and she spent most of her childhood living in the city of Friendswood, Texas. In 2006, Lillian furthered her education through attending the University of Texas at Austin. While at the University of Texas, she majored in Biology with a focus in Ecology, Evolution, and Behavior and also in Geography & the Environment. She spent several summers working at the Texas Commission on Environmental Quality. After graduating in May of 2011, Lillian moved to Baton Rouge, Louisiana and began attending Louisiana State University in the Fall of 2011 to pursue a Master's of Environmental Science degree. As a graduate student in the Department of Environmental Sciences, Lillian was an active member of the Coast and Environment Graduate Organization, serving as the social chair for 2012-2013. She will graduate from Louisiana State University in May of 2013.