CHOOSING A REGIONAL RESILIENCE PARTNER: A COMPARATIVE STUDY OF URBAN, SUBURBAN, AND RURAL NATURAL HAZARD PREPAREDNESS CONDITIONS

by

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A dissertation submitted to the faculty of
The University of North Carolina at Charlotte
in partial fulfillment of the requirements
for the degree of Doctor of Philosophy in
Public Policy

Charlotte

2021

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ABSTRACT

CHRISTINA M. DANIS Choosing a Regional Resilience Partner: A comparative study of urban, suburban, and rural natural hazard preparedness conditions (Under the direction of DR. SUZANNE LELAND)

Whether urban, suburban, or rural or from different United States (US) geographic regions, communities expect public officials to guide them to better prepare for and adapt to changing conditions and recurring natural hazard threats. Natural hazard preparedness conditions characterize the compilation of resilience and vulnerability conditions and incorporate prior response decisions into state and local natural hazard planning, policies, and practices. Many different options are available to empower vulnerable regions with the right resiliency tools; what is essential to understand is these communities' capacity to influence natural hazard resiliency planning effectiveness. The literature suggests when rural, suburban, and urban communities understand why a resilient region inhibits disaster impacts and supports the restoration of local economic, social, and ecosystem services, there is greater participation in the preparedness process.

My research provides context and insight about how regional natural hazard preparedness conditions may bolster community planning and capital across the urban-rural continuum. This study evaluates contiguous US county-level natural hazard resilience and vulnerability with a measurement tool developed at the University of Missouri entitled the Missouri Transect Project (MTP). It reflects a gap in the peer-reviewed research as the MTP has yet to be field-tested. I examine the MTP via a mixed-method approach. My two quantitative analyses, a categorical regression, and a spatial cluster/outlier statistic inform my qualitative interview questions with the 10 Federal Emergency Management Agency (FEMA) region Community Preparedness Officers (CPO) about the value of the MTP.

My findings validate the MTP as a community natural hazard preparedness tool to promote urban-rural patterns of resilience and vulnerability. My MTP economic variable model findings indicate counties with increased building insurance risk values have slightly increased preparedness odds than lower building risk counties. The MTP infrastructure resilience and vulnerability spatial cluster/outlier for rural counties found them less prepared than suburban and urban counties. The MTP social vulnerability spatial cluster/outlier for rural counties found them to be less prepared than suburban and urban counties. The MTP economic resilience spatial cluster/outlier for rural counties found them to be less prepared than suburban and urban counties.

The CPO interviews indicate the need to bolster education and outreach for rural areas about FEMA preparedness documents, mobile applications, virtual disaster preparedness videos, disaster simulation board games, and context-sensitive social media outreach measures. My findings support establishing social resilience policies and procedures within FEMA, states, and counties to bolster regional and community resilience through enhanced education and coordination of state and local hazard mitigation planning mechanisms, particularly for under-resourced rural areas. My research serves as a useful heuristic to understand why natural hazards do not just bring damages but provide pre-disaster planning insight and the ability to examine post-disaster aid as a community-building versus property re-building opportunity.

ACKNOWLEDGMENTS

I would like to express my appreciation and respect to my committee chair, Dr. Suzanne Leland. She was there for me no matter how much life interfered with this dissertation journey, she taught me the value of asking important and practical questions about my research and why resilience matters to policy decision makers. I am also grateful to my committee for contributing their time, knowledge, and expertise to benefit my work. Dr. Isabelle Nilsson, for her dedicated reading of drafts and for enlightening my mind about regional economic theory and practices, Dr. William Graves, for providing me with an opportunity to work together to understand why a region's history and development decisions matter for resilience, and Dr. Wei-Ning Xiang for his commitment and teaching of why social resilience is essential if communities are to evolve from resilient to sustainable.

I would like to thank the Federal Emergency Management Agency (FEMA) Community Preparedness Officers for their commitment to Zoom interviews during the pandemic and the insight they shared with me about community resilience in their regions. Without their wealth of knowledge and experiences, my research would not be as rich with potential. I am grateful for the research of Dr. Brian Dabson and the University of Missouri, Rural Policy Research Institute (RUPRI) for developing a user-friendly community resilience tool that specifically includes the perspectives of rural areas. I would like to acknowledge the cartography expertise of Vance

Harris, who’s creativity informs his M.S. Environmental Science from The University of Colorado Denver and my state and FEMA region map series.

I would like to acknowledge Jeff Michael, Executive Director, and the team at the UNCC - Urban Institute for providing me with the opportunity to conduct important and relevant research for Charlotte and the North Carolina Piedmont region and beyond as part of my dissertation journey. I would also like to recognize the assistance and support of the Public Policy Program and the directors, Dr. Martha Kropf, Dr. Cherie Maestas, and Dr. Stephanie Moller, for providing access to interesting research opportunities.

DEDICATION

To **R** for Ross for always believing in me.

To **E** for each of my children who make the world more fabulous each day.

To **S** for Siblings and Seaside Chicks, the wind beneath my wings.

To **I,** in the words of Rumi, out beyond wrongdoing and right doing, there is a field, I will meet you there.

To **L** for enough love to heal our planet.

To **I** for the intellectual curiosity provided by family and community.

To **E** for each of my grandchildren who deserve a healthy and safe world to grow up in.

To **N** for Nick and Norma, my parents who I miss every day.

To **C** for my PPOL cohort for always taking care of each other, especially Titiksha.

To **E** for every resilient person who helped clear the path to making this journey possible.

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LIST OF ABBREVIATIONS

ACS	American Community Survey
APA	American Planning Association
BCR	benefit-cost ratio
BRIC	Building Resilient Infrastructure and Communities
CPO	Community Preparedness Officer
DMA	Disaster Mitigation Act 2000
DV	dependent variable
EPA	Environmental Protection Agency
FEMA	Federal Emergency Management Agency
GAO	Government Accountability Office
HMGP	Hazard Mitigation Grant Program
HMP	Hazard Mitigation Plan
LISA	Local Moran's I cluster/outlier spatial statistic
MTP	Missouri Transect Project
NHS	National Household Survey
NIBS	National Institute of Building Sciences
NPG	National Preparedness Goal
NPR	National Preparedness Report
NRI	National Risk Index
NSF	National Science Foundation
RAPT	Resilience Analysis and Planning Tool

RUPRI	Rural Policy Research Institute
R/V	Resilience/Vulnerability
SHP	State Hazard Mitigation Plan
SLTT	state, local, tribal, and territorial governments
SPR	Stakeholder Preparedness Review
THIRA	Threat and Hazard Identification and Risk Assessment
US	United States

CHAPTER 1: Introduction

When natural disasters strike, governments are accountable for minimizing death, injury, and property damage and ensuring community functions' rapid restoration. Hazards such as earthquakes, droughts, floods, hurricanes, landslides, and volcanic eruptions are natural hazards that cannot be avoided. When they lead to deaths and damages in the community, they are termed a "disaster" due to human acts of omission and commission rather than the act of nature (Chmutina et al., 2019). When the definition of natural hazard and disaster differs, it becomes apparent why disasters are not an act of nature but an act of humans (Chimutina et al., 2019; Plastrik et al., 2020). Research indicates wealth inequality increases when communities experience loss of property and life due to disasters, despite significant taxpayer investments of relief funds (Howell and Elliot, 2019, p. 450). When rural, suburban, and urban communities understand why a resilient region inhibits disaster impacts and supports the restoration of local economic, social, and ecosystem services, there is greater participation in the preparedness process (FEMA, 2020b; Plastrik et al., 2020; Biggs et al., 2015).

Natural hazard resilience literature defines community as "a group of individuals and organizations bound together by geography and perceived self-interest to carry out common functions" (Meadows, 2008, p.188; Plodinec, 2012). The National Preparedness Goal (NPG)[1]

[1] Report presents the *National Preparedness Goal* (the Goal); it describes 32 activities, called "core capabilities," that address the nation's most significant risks. The Goal then organizes these core capabilities into five categories, called "mission areas." Three core capabilities—Planning, Operational Coordination, and Public

developed by Federal Emergency Management Agency (FEMA) affirms individual and community preparedness is fundamental to natural disaster resilience. FEMA (2004) defines a community as a geographically bound location that functions within a governance structure, for example, a town, city, or county. The tension between natural hazard versus disaster and community defined as shared self-interest versus a governance structure motivates my research about why strategic regional partnerships and community hazard planning matter.

Whether urban, suburban, or rural or from different United States (US) geographic regions, communities expect public officials to guide them to better prepare for and adapt to changing conditions and recurring natural hazard threats. Notwithstanding fiscal constraints and the competing challenge of meeting both regional and local interests. Community planners serving the public have the responsibility to partner with emergency management officials to jointly determine what shared values and potential solutions work best for preparing regions and communities for a natural hazard event occurrence (Schwab, 2010). State hazard mitigation plans (SHP) serve as the roadmap for regional and local natural hazard preparedness measures and identify vulnerable populations, communities, environmental ecosystems, and land use types.

States depend on local governments to dispense services through their budgets, specifically for public safety and infrastructure investments, and rightfully so because local governments know the most about their built environment and infrastructure capacity. Research

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Information and Warning—apply to all five mission areas. FEMA refers to these three core capabilities as "Cross-Cutting capabilities.

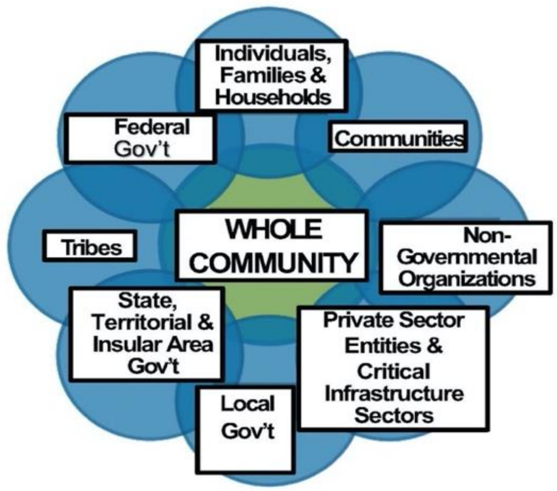
suggests "by establishing a healthy relationship; the state will be more likely to entrust local governments with greater authority to serve their respective jurisdictions" (Russell & Bostrom, ACCE, 2016, p.9). Local governments are in control of developing natural hazard plans. State governments are the coordinator for local government plans. FEMA serves as the federal support to states and local governments for natural hazard plan activities.

FEMA disaster response approaches continue to be tested across states and local governments as natural disasters increase in both frequency and extent. Since 1980, the US economy has sustained losses of more than $1.6 trillion of taxpayer dollars due to natural disasters (NOAA, 2019). It is essential to understand how a community's capital, defined as its social, financial, political, built, natural, economic, and cultural conditions, along with its geography, informs natural hazard preparedness conditions (Cutter et al., 2003; 2008; 2016, Dabson, 2011). The Government Accountability Office (GAO, 2021) indicates that 35% of the more than $19 billions of FEMA grant funds made available as of 2018 (Frank, 2021) have gone unspent due to local government and tribal area community's inability to match the funds, implement projects, and navigate the grant process. The ability to foster coordination and working relationships amongst communities, states, and regions keeps natural hazards from turning into disasters, reduces property loss and taxpayer costs, and saves lives (Cutter et al., 2016).

Resilience to natural hazards is the community's capacity to absorb severe shock and return to the desired state following a disaster. It is of growing interest academically, practically, and politically (Godschalk et al., 2009). Natural hazard resilience is more than building environmental protection measures; it is essential to the economic well-being and public health of communities and states (Plastrik et al., 2020). The vulnerability of communities to natural hazards incorporates such features as susceptibility, exposure, and coping capacities (Birkmann, 2005). Natural hazard preparedness conditions characterize the compilation of resilience and vulnerability conditions and incorporate prior response decisions into state and local natural hazard planning, policies, and practices. Effective resilience building requires state and local collaboration because they are interdependent. States cannot just make their assets resilient and ignore local needs; resilience relies on a regional perspective (Dabson, 2007; Dabson et al., 2012; Plastrik et al., 2020).

My research examines US natural hazard preparedness conditions across urban, suburban, and rural counties by evaluating social, economic, environmental, and infrastructure resilience and vulnerability conditions. US natural hazard policy oversight is via FEMA's ten (10) regional management areas that oversee its mission to support citizens and first responders in preparation for, protection against, response to, and recovery from natural disasters. The NPG, as a requirement of the Post-Katrina Emergency Management Reform Act of 2006 (PL 109-295), requires a 'whole community' approach for preparedness that includes real-world examples of community efforts to increase personal- and community-level preparedness (FEMA, 2020a; US Congress 2006). FEMA defines its 'whole community' focus as the ability to support the NPG by enabling a more comprehensive range of entities from the private and nonprofit sectors to foster greater participation, coordination, and working relationships (see Figure 1-1) (FEMA, 2020e). It is important to emphasize that individuals and communities are first responders when a natural disaster occurs, not FEMA.

Figure 1-1: FEMA Whole Community Entities



To understand how individual and whole community perception of natural hazard disaster preparedness and resilience has changed over time, since 2013, FEMA has conducted the annual National Household Survey[2] (NHS). The 2020 NHS results indicate hurricane-prone areas are more likely to have taken community-based action or have prepared a plan than other natural hazard areas or the Nation (FEMA, 2020b). In summary, the 2020 NHS (FEMA, 2020b) indicates that the approach to changing perceptions and understanding about natural hazard preparedness

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[2] National Household Survey (NHS). The NHS assesses six hazard regions related to tornado, flood, hurricane, wildfire, earthquake, urban event. The survey is collected using an English and Spanish telephone interview survey from individuals whose primary phone number is associated with a landline or cellular phone are randomly selected to take the survey. For the 2020 NHS all respondents (n=5,020) answered the same set of NHS core questions related to six basic preparedness actions: gather supplies to last three or more days; talk with others on getting prepared; attend a local meeting or training; seek information on preparedness; participate in an emergency drill; make an emergency plan.

requires knowledge about the readiness to act instead of any individual or community socio-demographic difference. The survey responses also indicate that preparedness actions tend to cluster together (FEMA, 2020b).

The 2019 Natural Hazard Mitigation Saves study conducted by the National Institute of Building Sciences (NIBS) (MHMC, 2019) indicates community natural hazard mitigation is a sound financial investment. The study examines five sets of mitigation strategies and determines a societal benefit-cost ratio (BCR) of $6 for every $1 spent through mitigation grants funded through select federal agencies (MHMC, 2019). To better address community and regional resilience, FEMA migrated with the DMA to a pro-active preventative policy approach to resilience. As part of the process, FEMA partnered with professional planners such as the American Planning Association (APA) to reverse and minimize the repetitive damage, community vulnerability, and the increasing and continual demands for federal natural disaster assistance. APA and FEMA worked together to figure out what would be needed to proactively empower communities to plan for protection against natural hazards comprehensively, build local self-sufficiency, and as a result, become more sustainable when faced with the next natural disaster event (Schwab, 2010). The ability to align land-use practices, zoning, building code regulations, and comprehensive plans with community development practices supports natural hazard resilience technical, organizational, social, and economic dimensions (Godschalk and Rouse, 2015). It is advanced not only by government regulations and policy actions but also by individuals, communities, organizations, and businesses.

An increasing array of measurement systems, processes, and tools are available to assist hazard planners, public officials, and communities identify priorities for improvement, assess progress, and compare the costs and benefits of investments to increase natural hazard resilience and reduce vulnerability (NASEM, 2019). The literature indicates that measurement systems help communities set priorities, establish community resilience baselines, and monitor change over time (NRC, 2012). Despite many different natural hazard measurement systems and community resilience tools, US natural hazard policy continues to evolve to address the needs of natural hazard plans that better reflect the community and regional resilience (Bakkensen et al., 2017; Cutter et al., 2010; 2016).

My dissertation evaluates a county-level natural hazard resilience measurement tool developed at the University of Missouri entitled the Missouri Transect Project (MTP) (Dabson et al., 2012; Dabson, 2015; Dabson et al., 2016). It reflects a gap in the peer-reviewed research as the MTP has yet to be field-tested as a measurement tool. The MTP benefits from National Science Foundation (NSF) funding and US Environmental Protection Agency (EPA) oversight. The MTP design purposively assists rural areas in better understanding their resilience and vulnerability to natural hazards. To date, FEMA does not specify or require the use of a natural hazard resilience measurement tool for the development of the SHP. Each state has the discretion to select from the many available natural hazard resilience measurement tools (NASEM, 2019). FEMA includes access to the Resilience Analysis and Planning Tool (RAPT) (FEMA, 2021) and the National Risk Index (NRI) (FEMA, 2017) on its website and contains links to other natural hazard mitigation tools developed by other federal agencies, universities, and public entities.

1.1 Dependent Variable - University of Missouri, Missouri Transect Project (MTP) Resilience Toolkit

The University of Missouri, Rural Policy Research Institute (RUPRI) developed the online interactive MTP resilience toolkit to offer no-cost readily available resilience and vulnerability (R/V) indexes for all contiguous US counties (Dabson, 2015; Miller et al., 2016a, 2016b). The project set out to create a series of comparative county-level indexes to measure resilience and vulnerability across the US. The purpose is to provide communities with the capacity and tools to prepare natural hazard plans to respond to multiple threats. The outputs are datasets of resilience and vulnerability index measures for each of the four MTP variables: social, economic, infrastructure, and environmental. The MTP website is hosted by the Engagement Network Building Regional Resilience website. Users can create custom maps and generate customized reports as contributions to local awareness-raising and resilience planning.

The purpose of the MTP is to increase resiliency at local and regional levels by empowering planners and community leaders, particularly those serving rural areas, with a sense of how their county's strengths or resilience and weaknesses or vulnerability compare across the variables and to others (Miller et al., 2017). Resilience is a set of positive attributes, characteristics, and capacities that describe a community's ability to withstand and recover from the impact of a natural disaster event. On the other hand, vulnerability is a set of community characteristics or qualities that may hinder, make a community more susceptible, or even prevent recovery after a natural disaster, hence reducing resilience.

The design of the MTP has three understandings (Miller et al., 2017). First, enhancing resilience cannot be confined to any single geography, population, governmental unit, or business but must be an expression of a collective whole resilient community. Second, communities are vulnerable to disaster events in different ways, and their speed of recovery is determined by the relationship between social, economic, physical, and institutional factors. Third, physical damages and costs are not the only measures of a disaster's impact; social and economic disruption and adaptation are vital considerations.

The MTP groups the range of data factors into four variables (Miller et al., 2017):

- Social: The degree to which a community has a robust set of social and human capital to rebound from a potential hazard (resilience) and the characteristics of the population that cause isolation or erosion of social capital (vulnerability).

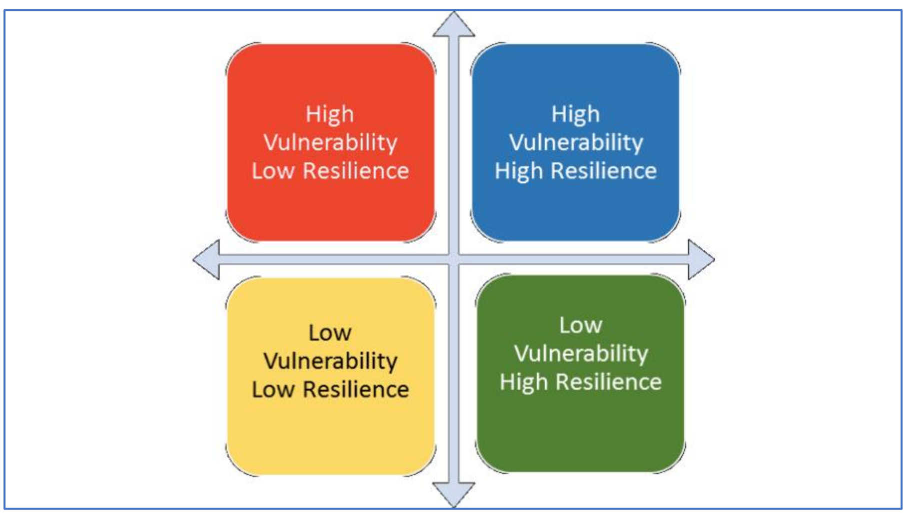
- Economic: The presence of factors that enhance a regional economy, such as economic diversity, entrepreneurship, growth in employment and businesses (resilience), and the indicators of underlying economic weakness, such as reliance on primary industries, unemployment, and shrinking business opportunities (vulnerability).

- Infrastructure: The capacity of a community to address potential disaster scenarios, including medical capacity, first response, and scale of preparedness investment (resilience), and the extent of at-risk housing, challenges for evacuation, and proximity to potentially hazardous facilities (vulnerability).

- <u>Environmental</u>: The inherent diversity of climate, landforms, and land cover that reduce the impact of and help recovery after disasters (resilience) and the range and severity of natural disaster risks that communities may face (vulnerability).

MTP assigns counties to one of four quadrants based on the average resilience (R/strength), and vulnerability (V/weakness) score relative to the median value for all US contiguous counties (see Figure 1-2). It identified counties above the median value as high resilience (HR) or high vulnerability (HV). In contrast, it identified counties below the median value as low resilience (LR) or low vulnerability (LV) (Dabson, 2015; Miller et al., 2016a, 2016b). The comparison of resilience and vulnerability values empowers planners and community leaders, particularly those serving rural areas, with a sense of how their county's resilience (strengths) and vulnerability (weaknesses) in four areas (economic, environment, infrastructure, and social) compare to others (Dabson, 2015; Miller et al., 2016a, 2016b).

Figure 1-2: MTP Resilience and Vulnerability Quadrants



Interactions and dependencies between these variables (Lavelle et al., 2015) are not explicitly addressed in the MTP other than allowing data and mapping to be organized at the county level in different dimensional combinations. Accordingly, for any county, economic factors can be presented alongside social and infrastructure factors to show and evaluate multiple resilience or vulnerability levels. Data is normalized using a maximum-minimum technique. All variables are rescaled to values between zero and one, where zero is assigned to the lowest value in the data set and one assigned to the greatest value (Miller et al., 2016a, 2016b).

The MTP data sources (see Table 1-1) are publicly available secondary data from a variety of agencies within the federal government (US Census Bureau, Internal Revenue Service, US Department of Health & Human Services, US Department of Transportation, US Army Corps of Engineers, US Environmental Protection Agency, US Department of Labor, US Department of Housing & Urban Development, US Geological Survey, US Department of Commerce). With support and funding, the MTP data sources may be readily updated. The one exception is environmental resilience, which is derived from the ESRI World Ecophysiographic Diversity 2015 database, making it somewhat less transparent than the other measures. The Engagement Network Building Regional Resilience team (accessed 4/30/2019), updated approximately half of the MTP infrastructure and more than two-thirds of the social and economic indicators in April 2017 with the 2013-2017 American Community Survey (ACS) from the US Census Bureau. All data, sources, and methods are presented for public use on the Engagement Network Building Regional Resilience web platform to allow discussion, adaptation, and replication.

Table 1-1: Description of the MTP Data Sources

MTP DATA CATEGORY	MTP DATA SOURCE
Social Resilience & Vulnerability Quadrants	Data Source: Missouri EPSCoR. 2017. Source geography: County
Economics Resilience & Vulnerability Quadrants	Data Source: Missouri EPSCoR. 2017. Source geography: County
Infrastructure Resilience & Vulnerability Quadrants	Data Source: Missouri EPSCoR. 2017. Source geography: County
Environment Resilience & Vulnerability Quadrants	Data Source: Missouri EPSCoR. 2017. Source geography: County
Infrastructure Vulnerability - Vehicle Access	Note: This indicator is compared to the national average. Data Source: US Census Bureau, American Community Survey. 2013-17. Source geography: Tract
Infrastructure Vulnerability - Drinking Water Violations	Note: This indicator is compared to the national average. Data Source: University of Wisconsin Population Health Institute, County Health Rankings. 2012-13. Source geography: County
Environmental Vulnerability - Drought	Note: This indicator is compared to the national average. Data Source: US Drought Monitor. 2012-14. Source geography: County
Social Vulnerability - Poverty Rate	Note: This indicator is compared to the national average. Data Source: US Census Bureau, American Community Survey. 2013-17. Source geography: Tract
Social Vulnerability - Violent Crime	Note: This indicator is compared to the national average. Data Source: Federal Bureau of Investigation, FBI Uniform Crime Reports. Additional analysis by the National Archive of Criminal Justice Data. Accessed via the Inter-university Consortium for Political and Social Research. 2019. Source geography: County
Social Vulnerability - Dependent Population (Disabled)	Note: This indicator is compared to the national average. Data Source: US Census Bureau, American Community Survey. 2013-17. Source geography: Tract
Social Resilience - Place Attachment	Data Source: US Census Bureau, American Community Survey. 2013-17. Source geography: Tract
Social Resilience - Voter Participation	Note: This indicator is compared to the national average. Data Source: Townhall.com Election Results. 2016. Source geography: County
Social Resilience - Educational Attainment	Note: This indicator is compared to the national average. Data Source: US Census Bureau, American Community Survey. 2013-17. Source geography: Tract

MTP DATA CATEGORY	MTP DATA SOURCE
Social Resilience - Home Ownership	Data Source: US Census Bureau, American Community Survey. 2013-17. Source geography: Tract
Social Vulnerability - Income Inequality	Note: This indicator is compared to the national average. Data Source: US Census Bureau, American Community Survey. 2013-17. Source geography: Tract
Social Vulnerability - Linguistic Isolation	Note: This indicator is compared to the national average. Data Source: US Census Bureau, American Community Survey. 2013-17. Source geography: Tract
Social Vulnerability - Dependent Population (Elderly)	Data Source: US Census Bureau, American Community Survey. 2013-17. Source geography: Tract
Social Vulnerability - Dependent Population (Children)	Data Source: US Census Bureau, American Community Survey. 2013-17. Source geography: Tract
Social Vulnerability - Uninsured Population	Note: This indicator is compared to the national average. Data Source: US Census Bureau, Small Area Health Insurance Estimates. 2017. Source geography: County
Economic Resilience - Proprietor Employment	Note: This indicator is compared to the national average. Data Source: US Department of Commerce, US Bureau of Economic Analysis. 2016. Source geography: County
Economic Resilience - Labor Force Participation	Note: This indicator is compared to the national average. Data Source: US Census Bureau, American Community Survey. 2013-17. Source geography: County
Economic Vulnerability - Business Vacancies	Note: This indicator is compared to the national average. Data Source: US Department of Housing and Urban Development. 2019-Q2. Source geography: County
Economic Vulnerability - Cost Burdened Housing	Note: This indicator is compared to the national average. Data Source: US Census Bureau, American Community Survey. 2013-17. Source geography: Tract
Economic Vulnerability - Unemployment	Note: This indicator is compared to the national average. Data Source: US Department of Labor, Bureau of Labor Statistics. 2019 - July. Source geography: County
Infrastructure Resilience - Grocery Store Access	Note: This indicator is compared to the national average. Data Source: US Department of Agriculture, Economic Research Service, USDA - Food Access Research Atlas. 2015. Source geography: Tract
Infrastructure Resilience - Medical Professionals	Note: This indicator is compared to the national average. Data Source: US Department of Health & Human Services, Health Resources and Services Administration, Area Health Resource File. 2014. Source geography: County
Infrastructure Vulnerability - Older Homes	Note: This indicator is compared to the national average. Data Source: US Census Bureau, American

MTP DATA CATEGORY	MTP DATA SOURCE
	Community Survey. 2013-17. Source geography: County
Infrastructure Vulnerability - Mobile Homes	Data Source: US Census Bureau, American Community Survey. 2013-17. Source geography: Tract

1.2 Problem Statement

My research examines the ability to predict the level of natural hazard preparedness due to the nature and extent of how and where state hazard mitigation policies, regulations, and building codes integrate into urban, suburban, and rural resilience and vulnerability policy and practices. It's theoretical approach and hypotheses are tied directly to crucial community planner's skills: such as "the ability to think comprehensively about the challenges facing a community, how to address them with the resources available, and how to steer the public and its decision-makers toward goals and objectives that are reasonably constructed to achieve the desired ends" (Schwab, 2010, p.4). My premise is natural disaster resilience increases when regional partnerships are better able to protect and restore community functions due to a highly resilient and low vulnerability of environmental, social, economic, and infrastructure conditions. My research provides context and insight about how regional natural hazard preparedness conditions may bolster community planning, social resilience, and capital across the urban-rural continuum. It suggests the importance of natural hazard plan partners both near and far and why partnering with planning professionals are essential to prevent natural hazards from becoming natural disasters.

1.3 Purpose of Research

This mixed-methods study examines the ability to use the MTP as a community planning tool to assist decision-makers and stakeholders with specific examples of how urban, suburban, and rural counties inform regional natural hazard preparedness conditions. My research aims not to compare counties to determine who is best or who is the worst. Nor is it intended to define equity as similar resilience and vulnerability conditions across urban and rural areas. Literature indicates that urban and rural natural hazard resilience does differ (Berke et al., 2012; 2014; Cutter, 2016; Dabson, 2007; 2011; Horney et al., 2012; Partridge et al., 2009). Additionally, the goal is not to argue that natural hazard policies should reallocate urban resilience resources to mitigate rural vulnerabilities. My goal is to tell the story of how natural hazard preparedness conditions compare across the differing geophysical provinces and population density areas of the US and FEMA regions. The objective is to help foster strategic regional resilience partnerships that reduce taxpayer costs and property loss, greater protection of lives, and inform local context about what regional resilience may mean for all citizens.

1.4 Research Questions

My research questions expand upon the study design of Cutter et al. (2016). I use the MTP as the dependent variable to examine the relationship between rurality and community resilience in the contiguous US. I examine the relationship between the MTP preparedness variables the 10 FEMA regions and rural areas as compared to suburban and urban areas. I question the value of the MTP as a visually appealing user-friendly tool to assist with telling the story about why preparedness matters to individuals and community stakeholders. Specifically, the MTP color code resilience and vulnerability quadrants coupled with county-level urban, suburban, and rural details as clusters of 'good' and 'bad' preparedness areas. My research questions are:

Question 1: How does the MTP natural hazard preparedness conditions compare amongst urban, suburban, and rural county population densities, and the 10 FEMA regions, based on the nature and extent of state natural hazard regulations, and building codes?

Question 2: How does the cluster/outlier high and low resilience/vulnerability spatial patterns of the MTP natural hazard preparedness conditions vary across neighboring urban, suburban, and rural counties within each state and across the 10 FEMA regions?

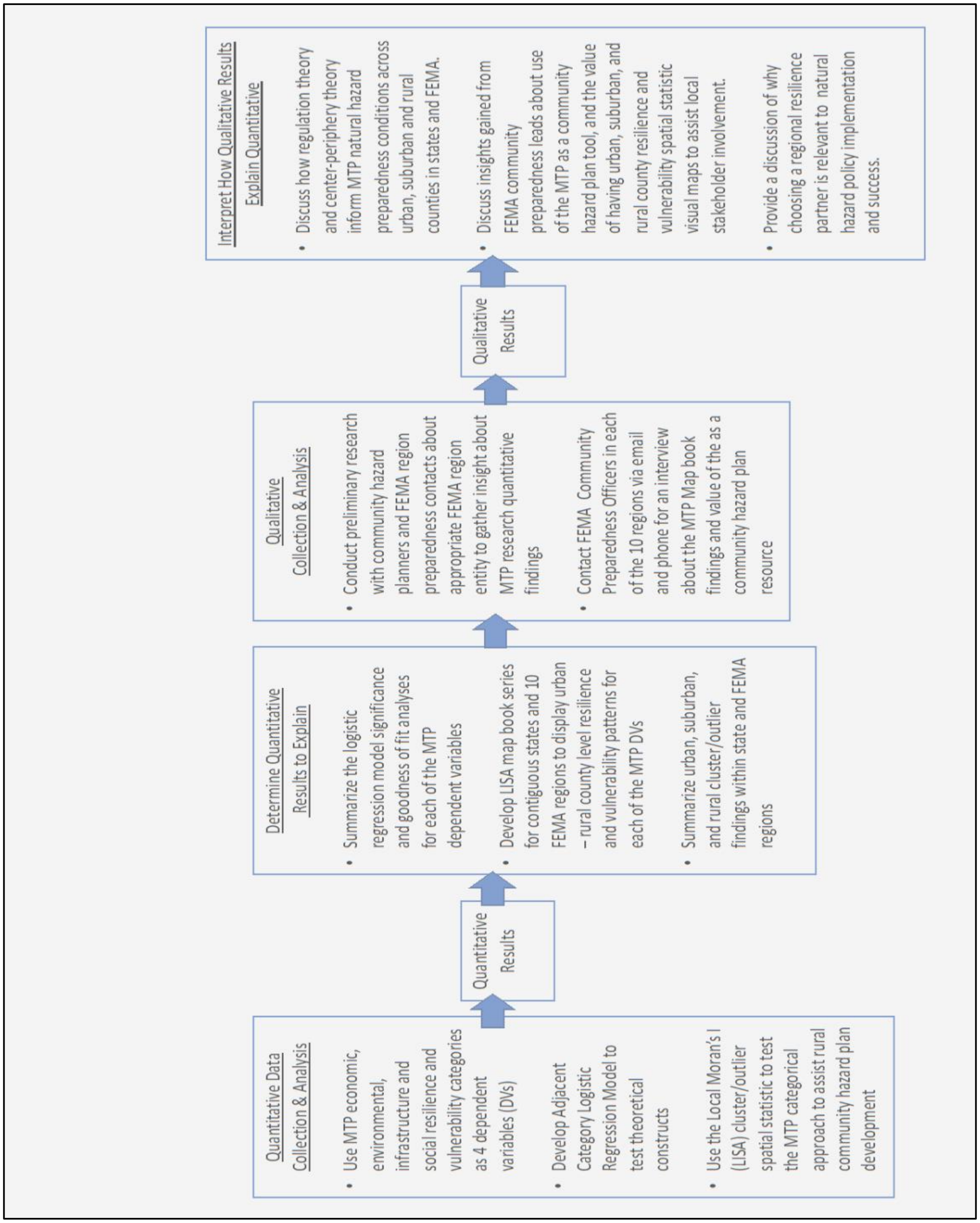
Question 3: How do FEMA community preparedness leads envision the MTP tool and cluster/outlier high and low resilience/vulnerability natural preparedness conditions county-level maps for each state and FEMA region to be of value for community hazard planners?

1.5 Overview of Methodology

I use a mixed-method approach with an explanatory sequential research design where my two quantitative analyses, a categorical regression, and a spatial cluster/outlier statistic, inform my qualitative interview questions see Figure 1- 2 (Baader et al., 2003; King et al., 1994; Creswell, 2015). My qualitative research does not require IRB approval (see Appendix A). I use a triangulation approach (Jink, 1979) to test the degree of external validity of the MTP community preparedness tool. The study includes 2,389 counties across the contiguous US that have received FEMA Hazard Mitigation Grant Program (HMGP) funds (1989 – 2017) and agreed to the local match component of those grant funds to improve the nature of their communities pre-and post- a natural disaster occurrence. Of the 2,389 counties I examine 1,189 or 50% are rural, 1,042 or 43% are suburban (886/37% mixed rural, 156/6% mixed urban), and 158 or 7% are urban (Isserman, 2005). The US may be predominately rural in population area density; however, it is not monolithic regarding its land use, community structures, and social and economic capacities (Dabson, 2011).

My research examines the ability to predict the nature of natural hazard preparedness across the urban-rural continuum. It explores FEMA regional natural hazard policy implementers' ability to ensure that vulnerable community’s partner with natural hazard plan partners that are more resilient than they are. It presents a regional approach that enables them to establish resilience partners near and far afield and support community hazard plan development (Bakkensen et al., 2017).

Figure 1- 2: Procedural Diagram for Mixed Methods Design



I conduct an adjacent categorical logistic regression model (Fagerland, 2014), with secondary data to evaluate the probability to predict natural hazard preparedness categories of least (LR/HV), somewhat, (LR/LV) moderately (HR/HV), and most prepared (HR/LV). My DV is the MTP high versus low categorical resilience and vulnerability measures (Dabson et al., 2012; Dabson, 2015; Miller et al., 2016a, 2016b). As shown in Table 1-1, the MTP includes county-level data from federal data sources for the years 2013-2019 for four variables, economic, environment, infrastructure, and social. The resilience compared to the vulnerability of a county for the four variables serves as a proxy in my research for establishing the adjacent ordinal categories for the level of county preparedness from least, somewhat, moderately, and most prepared in the event of a natural hazard occurrence.

I examine the ability to predict the level of natural hazard preparedness based on being in an urban, suburban (mixed urban, mixed rural), and rural areas (Isserman, 2005), the number of adopted state hazard regulations (APA 2019), the nature of the ATTOM (2016) building risk insurance code, prior FEMA, and local hazard mitigation investments (FEMA 2018a), the extent of previous disaster exposures (FEMA, 2018b) and 2016 presidential preferences (MIT, 2018). I select the MTP county-level resilience and vulnerability measures as my DV because the University of Missouri developed them to assist rural areas with understanding and access to readily available measures to inform natural hazard planning decisions.

For my second quantitative analysis, I evaluate the MTP resilience and vulnerability county-level values for potential nearest neighbor spatial patterns of high-high, high-low, and low-low relationships using a Local Moran's I (LISA) cluster/outlier spatial statistic (Anselin, 1995). The LISA analysis is not limited to the FEMA HMGP county local match criteria as in the regression model, so for this analysis, there are 3,107 county observations. I developed a map book of urban-rural county resilience and vulnerability cluster/outlier relationships for the 48 contiguous states and 10 FEMA regions (see Appendix B) to support the construct of urban-rural relationships and provide the community planning context for my qualitative questions.

For my qualitative analysis, I share the LISA spatial statistic quantitative findings map book with the 10 FEMA region community preparedness leads. I gather their insight and understanding about the patterns of natural hazard preparedness conditions in urban, suburban, and rural counties across the 48 contiguous states and 10 FEMA regions. I also inquire about the value they see for using the map book of state county-level resilience and vulnerability cluster/outlier analysis with urban-rural details as a community hazard planner tool. I use my qualitative data and analysis to bolster my multimethod results (Jick, 1979). To assist with developing the interview questions, I conduct preliminary research with local and FEMA community hazard planners. Based on their feedback, I determine that a visual data presentation such as the MTP map book approach is the best option to support my research questions about the perceived value of the MTP as a community hazard planning tool.

1.6 Rationale, Significance and Policy Implications

My research expands upon the current literature by assisting public officials, hazard planners, emergency management personnel, nonprofit and business owners, and local stakeholders with knowledge and examples of why regional resilience conditions matter, particularly for rural areas. The study findings benefit community, regional, and state natural hazard planners in addition to testing theories. The study contributes to the regulation theory (Aglietta, 1979; Painter 1977), posit that for FEMA to address an environmental crisis, such as the increased frequency of natural disaster events, the response needs to consider the economic and socially constructed nature of the issue (Lipietz, 2002; Belanger and Levesque, 1991; Boyer and Salliard, 2002). Therefore, the US natural hazard policy will need to consider the strained relationship of economics, social construct, and the environment to reflect a resilient outcome or more sustainable future for communities and regions.

It is important to recognize how cultural capital (Bourdieu, 1973) may inform a community's ability to prepare for an accelerating and changing world and adapt to a system thinking approach. Community capital includes cultural capital which is based on the skills, worldview, and experiences of a community. It is important because it informs how to best communicate context sensitive preparedness measures. Second, it uses center-periphery theory (Friedmann, 1966; 1972), concepts to evaluate the dynamics of the urban-rural continuum influence on natural hazard preparedness relationships. It examines how the relationship between urban economic growth and rural economic limitations has informed regional natural hazard preparedness conditions.

The theoretical test serves as an applied test of the MTP as a natural hazard measurement tool, which as stated previously, has yet to be field-tested and published in a peer-reviewed journal. It presents areas where counties in the state may be more vulnerable than resilient to a natural disaster. It may lead to a local resilience index used by community hazard planning entities and inform strategies for selecting appropriate near and far natural hazard resilience partners. With this information, community, state, and FEMA natural hazard planners can use urban-rural county-level economic, environment, infrastructure, and social resilience and vulnerability spatial patterns to prioritize preparedness measures and inform strategic regional hazard plan partnerships.

This dissertation summarizes the rapidly expanding academic, policy, and practice literature related to US natural hazard policy implementation, state hazard preparedness plans, community resilience measurement systems, regionalism, and rural population subtleties. It evaluates and builds upon the MTP to assist with understanding rural resilience and vulnerability conditions. It suggests ways to improve regional resilience effectiveness and attractiveness to community natural hazard planners. It applies inferential and spatial statistics to examine how regionalism informs community natural hazard preparedness. The research includes perspectives from the 10 FEMA region community preparedness leads.

My research aims to inform public policy decisions that address living with, preparing for, and responding to the impact of natural disaster events by comparing the statistical relationships and spatial patterns of resilience and vulnerability conditions in urban, suburban, and rural counties across the continental US. My comparative analysis of county-level natural hazard preparedness conditions and their relationship to adjacent urban, suburban, and rural areas uses a sorting technique. Specifically, I apply a basic structured analytic approach for grouping information to develop insight, identify patterns, uncover trends, and spot anomalies. My objective is to tell the story of how natural hazard preparedness conditions compare across the differing geophysical provinces and population density areas of the US and FEMA regions to foster strategic community conversations and resilience partnerships. The resilience literature indicates this results in reduced taxpayer costs and property loss, greater protection of lives, and informs community context about what sustainable natural hazard resilience may mean for all citizens (Cutter et al., 2003; 2008; 2016, Dabson, 2011).

FEMA hazard plan policy can foster the design and implementation of regional resilience with a boundary area not limited by political jurisdictions of states, counties, and municipalities. This flexible jurisdictional component of regional resilience is essential because governance boundaries do not reflect watershed boundaries or any natural resource boundaries that support ecosystem services (Biggs et al., 2015). Like natural resource boundaries, our supply-chains and commodity distribution economic boundaries defy state and local jurisdictional boundaries. They are increasingly dependent upon global supply-chains and commodity conditions in response to disaster events (Irwin, 2020).

When governance arrangements are not politically bounded and not seen as unidirectional, there is a need to stress the meaning of fostering collaboration between and engagement by different governance levels, as is appropriate for the policy process (Barca, 2009). Such multi-level governance or collaborative governance arrangements must be vertical and traverse the traditional boundary lines between local, regional, and state governments. Simultaneously, be horizontal, cross the boundary lines among multi-jurisdictional areas, and the public, private, and nonprofit sectors (Barca, 2009; Gollagher and Hartz-Karp, 2013; Hasselman, 2017). The literature suggests resilience to natural hazards will require FEMA support for natural hazard preparedness conditions that purposively blur jurisdictional boundaries of states and counties. This blurring is necessary to foster regional non-partisan multi-level governance and collaborative governance arrangements that include public, private, and nonprofit sectors (Barca, 2009).

On January 1, 2021, President Trump signed into law the Safeguarding Tomorrow through Ongoing Risk Mitigation (STORM) Act (Congress, 2021). The Act authorizes FEMA to grant $200 million to communities to create a resilience revolving loan fund for infrastructure mitigation projects. For the first time, FEMA revolving loan funds are available to allow different states to coordinate on large scale infrastructure projects to make them more resilient prior to a natural hazard. Prior to the STORM Act, a community in one state with shared infrastructure may have established a federal grant to mitigate and upgrade but a bordering state may have not. For example, the 2019 mid-west flood event in Minnesota affects Iowa and other states, the ability to coordinate funds to be more resilient is needed (Mannion, 2021). The STORM Act supports the recent FEMA paradigm shift to pre-disaster preparedness funds from post-disaster response funds.

1.7 Terminology

For my research, I define resilience as regions and local community functions' ability to adapt or bounce-back after natural disaster events (Auty, 2001; Biggs et al., 2015). Resilience is informed by the built environment and infrastructure, social capital, and economic and environmental conditions. Community resilience means "having the ability to live with change and develop with it while recognizing this persistence sometimes leads to path dependency and traps that are difficult to get out of" (Biggs et al., 2015, p. xx). Therefore, the ability to bounce back from natural disasters echoes the current social, economic, infrastructure, and environmental community conditions and its response to the loss of resources due to prior natural disaster experiences (Cutter et al., 2016). Resilience provides the framework for understanding the capacity to deal with unexpected shocks; it differs from sustainability, "defined as achieving human well-being in the present without compromising the social, economic or environment for future well-being" (Biggs et al., 2015, p. 23). Resilience is a component of sustainable practices between man and nature; however, it is not a given that all resilience practices are sustainable due to previous practice path dependency traps and the desire to restore community functions quickly (Biggs et al., 2015).

The vulnerability of communities to natural hazards shares the same multidimensionality as resilience yet incorporates such features as susceptibility, exposure, and coping capacities (Birkmann, 2005). Natural hazard preparedness conditions characterize the compilation of resilience and vulnerability conditions and incorporate prior response and mitigation choices and actions into natural hazard planning, policies, and practices. I define vulnerability as the conditions that inhibit a community's ability to adapt or bounce-back when faced with a natural disaster event (Birkmann, 2005). The concept of community resilience to natural hazards means strategically leveraging existing resources while systematically improving upon limited resources and vulnerabilities, thus erecting a stronger, more resilient community over time (Miller & Dabson, 2015). Resilience and vulnerability do not always reflect each other's inverse;

however, they are both relevant for understanding the natural hazard preparedness conditions of a region, county, or local government entity (Dabson, 2007; 2011).

The literature supports the development of better data for rural communities to overcome policy limitations that have "ill-equipped their ability to understand and compare their past, including the causes and consequences of failures in policy and practice, and to plan and implement their futures with the benefit of solid evidence" (Scally et al., 2020, p.37). I define rural communities based on the work of Andrew Isserman (2005). I choose the definitions developed by Isserman in support of center-periphery theoretical nuances beyond purely urban versus rural. It allows for a greater understanding of the adjacent spatial relationships conducted as part of the MTP map book visualization. Isserman (2005) defines urban (U) has a population density of at least 500 people-per-square-mile (ppsm), with at least 90 % of the population in urban areas and at least 50,000 people living in the urbanized areas. Rural (R) is a population density of less than 500 ppsm, with 90 % of their population living in rural areas, and with no urban area of 10,000 people. Mixed urban (MU) is a population density of at least 320 ppsm, and mixed rural (MR) is a population density of less than 320 ppsm. Suburban (S) in my research combines mixed urban and mixed rural population density areas; however, they are separate in my analysis.

The sociology literature differentiates disasters from hazards. According to Drabeck (2004), I define disaster based on the early research conducted by Fritz (1961) and Dynes et al. (1972). A disaster is "an event in which a community undergoes severe such losses to persons and/or property that the resources available within the community are severely taxed" (Drabek

2004, Student Handout 2-1, p. 1). For my research, I define a hazard as ". . . a condition with the potential for harm to the community or environment." (Drabek 2004, Student Handout 2-1, p. 1). Therefore, the term disasters refer to specific events like Superstorm Sandy in October 2012. In contrast, natural hazards define a class of threats like hurricanes, tornadoes, earthquakes, and floods. Accordingly, the literature refers to the hurricane hazard or the flood hazard that reflects the risk, vulnerability, or exposure confronting families, communities, or societies (Cutter et al., 2008; Longstaff et al., 2010; National Academies, 2012). I define emergency management "as the process by which the uncertainties that exist in potentially hazardous situations can be minimized and public safety maximized. The goal is to limit the costs of emergencies or disasters through the implementation of a series of strategies and tactics reflecting the full life cycle of disaster, i.e., preparedness, response, recovery, and mitigation." (Drabek 2004, Student Handout 1-3, p. 1).

Besides clarifying the definitions for disasters, natural hazards, and emergency management, I need to state what my research does not intend to address. It does not evaluate the US climate science policy or climate change relationship to natural disaster events. I focus on how natural hazard preparedness compares within states and the 10 FEMA regions across the urban-rural continuum. FEMA emphasizes community preparedness as intending to build "a secure and resilient nation with the capabilities required across the whole community to prevent, protect against, mitigate, respond to, and recover from the threats and hazards that pose the greatest risk" (DMA, 2000, Section 203(a)). Under this framework, preparedness (or resiliency building) is divided into five mission areas: prevention, protection, mitigation, response, and recovery. Community resilience focuses on a community's capacity to adapt to changing conditions, withstand disruption, and rapidly recover from emergencies (MitFLG, 2016). FEMA regulations specifically recognize the need to bolster rural populations with increased technical assistance and natural hazard planning capacity (DMA, 2000, Section 203(a)). FEMA does not require states to address climate change resiliency; instead, they require communities to better prepare for the next natural hazard event.

1.8 Research Hypotheses

I hypothesize that a regional approach that considers jurisdictional boundaries beyond city, town, and county boundaries within and between states is vital for robust natural hazard preparedness conditions. A strategy that incorporates the nature of urban-rural interdependence relationships and local community capital capabilities beyond the current FEMA regional partner criteria, which requires a regional partner for communities with less than 25,000 in population, is warranted (DMA, 2000, Section 203 (a)). The literature indicates a greater understanding of how regional resilience conditions may bolster rural natural hazard resilient measures is needed (Birkland & Waterman, 2008; Cutter et al., 2014; 2016, Dabson, 2011; 2015, Dabson et al., 2012).

The following hypotheses reflect my literature review, regulation theory (Aglietta, 1979; Painter 1977), which posits regulation expresses itself based on local social and economic constructs, and center-periphery theory (Friedmann, 1966; 1972), which posits urban human capital economic growth and rural physical capital economic limitations are the results of regional new economy conditions.

Hypothesis 1: Rural counties, compared to suburban and urban counties, are more likely to be less prepared for a natural hazard event despite enhanced government intervention.

Hypothesis 2: Due to the nature of federal hazard plan policy regulations, the 10 FEMA regions are more likely to reflect similar than unique patterns of urban, suburban, and rural county-level natural hazard preparedness conditions.

Hypothesis 3: Counties in states with more adopted state hazard plans and risk-reducing building code regulations are more likely to have increased natural hazard preparedness conditions than counties in states with fewer state-adopted hazard plans and building code regulations.

Hypothesis 4: Rural counties adjacent to only other rural counties are more likely to be less prepared for a natural hazard event than rural counties neighboring suburban or urban counties or neighboring suburban and urban counties.

Hypothesis 5: FEMA Community Preparedness Officers are likely to spend more time with rural counties and tribal areas than urban and suburban counties; thus, a user-friendly preparedness tool is more likely to be of value when compared to the technically advanced tools offered by FEMA and others.

1.9 Dissertation Structure

This dissertation has six chapters. This chapter serves as an introduction to the FEMA policy that informs my research, presents my dependent variable, describes my problem statement, purpose, research questions, provides an overview of my methodology, research rationale, selected terminology, and my hypotheses. Chapter 2 presents natural hazard policy and regional resilience literature perspectives. Chapter 3 links regulation theory and center-periphery theory to natural hazard preparedness conditions. It frames the approach to my research design and includes a discussion of my research questions' expected outcomes. Chapter 4 describes the process I used to operationalize my research design concepts. Chapter 5 presents the results and findings. It presents my research hypotheses with the logistic regression model outcomes, Local Moran's I outcomes, and interviews with FEMA community preparedness leads. Chapter 6 discusses research limitations and policy implications related to urban, suburban, and rural natural hazard preparedness conditions. Specifically pertaining to federal and state hazard regulations, land use and building code regulations, community hazard planning, and the importance of understanding why local social, economic, and cultural context matters for regional resilience, citizen preparedness, and property protection.

CHAPTER 2: Natural Hazard Policy and Regional Resilience Literature Perspectives

Based on the literature reviewed, the multi-jurisdictional state, county, and local approach embedded in US natural hazard policy have environmental, social, infrastructure, and economic benefits, particularly for regional natural hazard resilience measures (Bakkensen et al., 2017; Cutter et al., 2015; Dabson, 2011; White et al., 2015). A significant number of studies evaluate the relationship between community resilience and federal and state natural hazard policy. Precisely, the importance of ground-up or local community approach, to better understand the success, or lack of success, for natural hazard policy adoption and implementation at both the state and county level (Berke et al., 2012; 2014; Birkland and Waterman, 2008; Birkland, 2009; Cutter et al., 2003; 2014; 2016; Frazier et al., 2013; Homsy and Warner, 2013). The spatial aspect of this issue is prominent in the literature. It informs the county-level, social, environmental, economic, and infrastructure conditions that may make one place more or less resilient, or vulnerable, to a natural disaster event than another (Cutter et al., 2003; Cutter, 2016; Dabson, 2011, Dabson et al., 2012; Miller et al., 2015a; 2015b; 2016).

The literature recognizes the social capital of rural communities may be more vulnerable or less prepared for a natural disaster event, as compared to urban and suburban communities (Cox & Hamlen, 2015; Cutter et al., 2016; Pendall et al., 2010; White et al., 2015). Therefore, it is valuable to understand the setting of the relationships amongst rural, suburban, and urban areas within states and across the US to discern regional resilience patterns amongst differing community capital and social conditions. The ability to examine regional resilience patterns may provide insight into how political preferences and state hazard mitigation regulatory practices and policies reflect the nature and extent of rural community resilience compared to their suburban and urban counterparts. Patterns of regional resilience that rely on the relationship between the urban-rural continuum also serve as learning opportunities. The ability to see patterns of regional resilience and understand the context of why they exist in some regions and not others with comparable conditions is of value to federal and state hazard plan decisionmakers (Berke et al., 2012; Cutter et al., 2003; Cutter, 2016; Dabson, 2007; 2011).

2.1 US Natural Disaster Policy

To reduce increasing natural disaster losses, the US Congress passed the Disaster Mitigation Act (DMA) of 2000 to amend the Robert T. Stafford Disaster Relief and Emergency Assistance Act (Stafford Act) (42 USC 5131 et seq.). Section 322 of the DMA requires state and local governments to develop and routinely update a Hazard Mitigation Plan (SHP or HMP) to remain eligible for pre- and post-disaster mitigation funding. These funds include the Hazard Mitigation Grant Program (HMGP), Pre-Disaster Mitigation (PDM) program, and Flood Mitigation Assistance (FMA) program, all of which are administered by FEMA under the Department of Homeland Security as part of FEMA's Hazard Mitigation Assistance (HMA) program. USDA is responsible for rural disaster and infrastructure oversight and coordinates with FEMA when a disaster declaration has occurred. States and communities with an adopted and approved SHP or HMP are better pre-positioned and thus more apt to receive available mitigation funds before and after the next disaster strikes. The state SHP and community HMP are required to be updated every five years and are subject to FEMA approval (FEMA, 2018).

The literature indicates due to the 2017 dramatic increase in disaster-related damage losses; Congress passed the Disaster Relief Recovery Act (DRRA) in October 2018 (NPR, 2019). The DRRA is a response to the more than 260 billion dollars in recovery costs associated with the 2017 hurricane season, particularly Hurricane Maria in Puerto Rico (FEMA 2018, c). The DRRA (NPR, 2019 p.31) includes "more than 50 provisions that reduce complexities in mitigation and recovery processes, making it easier for communities to invest in mitigation-related activities moving forward." The DRRA gives communities flexibility in incorporating mitigation techniques and enables communities to build a culture of preparedness by allowing all government levels to invest in and manage long-term mitigation programs. The DRRA also significantly restructured federal grant funding to place greater emphasis on mitigation. The DRRA amended two sections of the Stafford Act. The amendments authorize FEMA to aid state, local, tribal, and territorial governments for building code and floodplain management ordinance administration and enforcement; and add post-disaster surge staffing assistance for code officials.

The literature about FEMA federal legislation such as the 2018 DRRA and the disaster relief bill, signed into law in June 2019, indicates increased national partisanship challenges than in the past (NOAA, 2019). Despite the initial partisan disagreement, Congress passed the 2019 disaster relief aid bill with bipartisan support and allocated 12.9 billion federal dollars to support disaster mitigation (NOAA, 2019). Current FEMA policies (DRRA, 2018; White House, 2016), research reporting sources (Addison, 2018; Knopman et al., 2017; MitFLG, 2016; NASEM, 2019; NMIS, 2019), and the literature reviewed (Cutter et al., 2016; Paveglio et al., 2017) suggest bipartisan support for disaster relief that includes building more resilient communities in response to natural disaster events will continue.

In 2017 Hurricanes Harvey, Irma, and Maria caused a collective $265 billion in damages compared to the 2005 $209.7 billion combined costs for Hurricanes Katrina, Rita and Wilma, and Superstorm Sandy in 2012 with a cost of $71 billion (FEMA 2018, c). Every year FEMA conducts many internal self-assessments and after-action debriefing reports. These reports inform policies and practices to establish a culture of preparedness within communities and government. FEMA understands laws and regulations bound its mission, but, for a disaster survivor, recovery is seen as a continuum relying on the community, state, local, tribal, and territorial partners and coordination at federal and state levels. The 2017 Hurricane Season FEMA After-Action Report clearly states, "As partners, we need to transform the way we facilitate recovery for the Nation's citizens in the face of increasing severe weather events" (2018c, p.50). As stated in the 2017 Hurricane Season FEMA After-Action Report (2018c, p.50), "The work of emergency management does not belong just to FEMA. It is the whole community's responsibility, federal, state, local, tribal, and territorial (SLTT), private sector partners and private citizens to build collective capacity and prepare for the disasters that we will inevitably face. Jointly, we must continue to move forward by leveraging innovative approaches, engaging with new technology, reducing complexity, and strengthening our partnerships to improve outcomes for the Nation's affected communities and provide support for survivors." It is within the spirit of FEMA to empower through partnerships a more resilient future for all citizens.

2.2 FEMA- State Hazard Plans (SHP)

To receive grant funds and support to expedite recovery or 'bounce back' of the community, FEMA requires states to ensure that communities have their disaster management plans in place prior to the disaster occurrence. Recognizing smaller communities' limited ability to bounce back from natural disasters, FEMA provides additional resources to states for communities with less than 25,000 in population and small, impoverished communities with less than 3,000 in the population (FEMA, 2004, DRRA, 2018). Although FEMA provides the funds for disaster preparedness, it is the responsibility of states to implement FEMA approved hazard mitigation plans for all residents to be eligible for these grant funds.

FEMA natural disaster regulations require residents' involvement in developing 5-year State Hazard Plans (SHP). These plans serve as the roadmap for regional and local natural hazard preparedness measures and identify vulnerable populations, communities, environmental ecosystems, and land use types. FEMA permits states to work with counties to seek enhanced funds to support rural areas in developing natural hazard plans. The additional support for rural areas is to ensure natural hazard preparedness measures reflect fair and equitable community resilience, across the US, urban, suburban, and rural regions (DMA, 2000, Section 203(a)).

FEMA (2013), per the Stafford Act (42 USC 5131 et seq.) and the Disaster Mitigation Act 2000 (DMA) (PL 106-390), (FEMA, 2004) requires states via the SHP and communities via the HMP to coordinate. The SHP and HMP are subject to FEMA regulations and approval to receive federal pre-and post-disaster assistance funding. FEMA is required to conduct an annual evaluation of the Nation's preparedness capabilities and highlight challenges, opportunities for improvement, and develop strategies for closing capability gaps. The National Preparedness Report (NPR) uses the Threat and Hazard Identification and Risk Assessment (THIRA) and Stakeholder Preparedness Review (SPR) (FEMA, 2019b) data to understand how prepared the Nation is in its ability to respond to and recover from threats and hazards. In 2019, for the first time, FEMA established national response and recovery capability targets as part of the $1.7 billion awarded in preparedness grants across the Nation (FEMA, 2020e). Previously state, local, tribal, and territorial (SLTT) governments used the THIRA and SPR to assess the threats of most significant concern to their communities and were permitted to establish response and recovery targets priorities independently.

Building Resilient Infrastructure and Communities (BRIC) authorized by DRRA Section 1234, in 2018, is designed to reduce costs and the loss of lives from natural hazards by building a national culture of preparedness, encouraging investments to protect communities and infrastructure, and building mitigation capabilities to foster resilience. The DRRA and BRIC were approved by Congress in 2018 in response to a 48% increase in Pre-Disaster Mitigation (PDM) grant appropriations from $56 M average/year between 2009-2016 to $200 M average/year from 2017-2019 (FEMA, 2019). The DRRA reflects recognition by FEMA and Congress that increased taxpayer-funded natural disaster event costs are unsustainable. The need to bolster pre-disaster mitigation planning and community preparedness needs was recognized in BRIC. Specifically, the need to promote partnerships, support community capacity building, and enable the implementation of large-scale innovative infrastructure projects. BRIC replaces the FEMA PDM grant program.

The 2020 BRIC funding allocation is $500M, twice the amount of the 2019 funding allocation ($250M) and twenty times more than the 2015 funding allocation ($25M) (FEMA, 2020d). The NMIS (2019, p.25) definition of 'whole community' builds on FEMA's DRRA and BRIC regulation approach for enhancing community preparedness. BRIC's focus is to improve participation in NEP national preparedness activities, including private and non-profit sectors, nongovernmental organizations, and the general public, in conjunction with all government levels. The goal is to foster better community coordination and working relationships to prevent natural hazards from becoming disasters.

As of December 30, 2020, all 50 states, the District of Columbia, and five territories have FEMA-approved state hazard plans (SHP). Fourteen (14) states have opted to receive FEMA enhanced approval for their SHP (FEMA, 2020c). These enhanced plan states are eligible to receive increased funds under the Hazard Mitigation Grant Program (HMGP) following a disaster declaration per the Stafford Act. For a state to receive FEMA approval of an enhanced plan, it must demonstrate that it has developed a comprehensive mitigation program and can manage increased funding to achieve its mitigation goals. Eighty-seven percent (87%) of the US population resides in communities with currently approved FEMA mitigation plans (FEMA, 2020c). Six (6) states have FEMA authority to approve local hazard plans, and approximately 25,100 local government HMPs have been approved or are pending approval (FEMA, 2020c). Per FEMA policy, these communities benefit from hazard mitigation planning by appreciating the risk of natural hazards for their community. In response, they have developed local mitigation strategies and are eligible for specific non-emergency FEMA planning assistance grants (FEMA, 2019).

FEMA HMGP grant obligations reflect up to 75 percent of the damage award funds. The local budget must agree to match the other 25 percent or reflect aid from other government agencies or private donors. The HMGP local match component burdens rural or suburban communities limited revenue capacity more so than their urban counterparts. FEMA HMGP funds focus on returning communities to the way they were before disaster struck, not necessarily ensuring that they create protective infrastructure or build resilience to future natural hazard events. Therefore, FEMA focuses on a 'bounce back' mindset for restoring community functions, not necessarily creating protective infrastructure, or building resilience to future natural hazard events. The BRIC program is FEMA's recognition that natural disasters' continued funding via the HMGP is unsustainable financially, socially, and environmentally.

2.3 State Hazard Policy Implementation

The literature is limited regarding connecting the local, specifically rural or underserved or small impoverished community needs, to SHP design and implementation (Berke et al., 2012; 2014). The SHP literature indicates the local authority responsible for those actions is readily identified, but the specifics about how they will be empowered to implement in rural versus urban communities, or as a regional approach is limited (Birkland and Waterman, 2008; Birkland, 2009; Dabson, 2007; 2011; Dabson et al., 2012). Clarifying the local empowerment component is vital, specifically for rural areas. Despite FEMA being responsible for state hazard plan policy, rural areas benefit from the US Department of Agriculture (USDA) funds and rural planning. USDA is responsible for oversight of rural infrastructure, broadband connections, and disaster recovery and management so that it can get confusing about the lead entity in charge (USDA, 2008; 2016). The literature concludes that the USDA influence on rural America is mainly a side-effect of sectoral agricultural support. Federal rural development programs are fractured, with approximately 88 different rural programs administered in 16 various agencies (Partridge et al., 2009; Kilkenny and Johnson, 2007). A better understanding of how the SHP is informing the regional approach to natural hazard preparedness for rural, suburban, and urban areas warrants further study based on the literature reviewed.

Berke et al. (2012) indicate a disconnect in the SHP about the role of the USDA, may undermine the purpose this federal agency partner serves for rural areas of the state, and reduce the effectiveness of federal, state, and local disaster coordination components. The literature about rural resilient communities and rural development policy practices indicates that the compartmentalization of rural policy undermines distressed areas' ability to benefit from place-based economics (Barca et al., 2012). This compartmentalization limits rural economies to a sectored agricultural lens versus a comprehensive urban-rural continuum regional approach (Partridge et al., 2009). The literature supporting equitable taxpayer resources recommends making resilience to natural hazards a condition for all relevant federal spending programs and reducing the regulatory review process among multiple federal agencies (Knopman et al., 2017).

The literature about community and regional resilience continues to expand. There is growing awareness by the public, philanthropic and non-profit entities, private sector, and academia about the importance of urban-rural interdependence and regionalism in the US natural hazard policy (Berke et al., 2012; Cox and Hamlen, 2015; Cutter et al., 2016). Problems in rural hazard plan preparedness and resilience may include limited funding for rural assistance agencies, such as an ambulance and fire staff, increased travel impedances, longer travel distances and response times for emergency management personnel, out-migration of young people, which affects workforce and staffing, and because public communication infrastructure is more expensive per capita, effective communication systems may be substandard or non-existent (RHIH, 2018). However, rural communities tend to have strong collective action traditions to accomplish public improvements and provide public safety, which helps build social capital, which is an asset for hazard preparedness activities (Dabson, 2007).

However, according to Partridge et al. (2009), rural development spending accounts for only 9% of USDA expenditures. Of this, 90% goes to infrastructure rather than economic development. If one were to include environmental expenditures as rural development, the share only rises to, on average, 41% of USDA non-nutritional expenditures (Partridge et al., 2009). Johnson (2006) indicates that the federal government spends two to five times more on a per-capita basis for community development in urban areas versus rural areas. The literature suggests that rural development and US disaster policy should stress the new economy and human capital thinking, connect infrastructure and access to urban areas, provide better access to rural financing, and both leverage and protect natural amenities (Dabson et al., 2012; Miller et al., 2015a; 2015b; 2016, Partridge et al., 2009).

Resilience practices and FEMA SHP regulations specifically recognize the need to bolster rural populations with increased technical assistance and planning capacity. The recognition of the need for both spatial and place-based approaches to natural hazard resilience has been suggested in the seminal National Research Council report findings (NRC, 2012; Cutter et al., 2016). The need to equip rural regions with the right resiliency tools is recognized in the literature (Dabson, 2007; Cutter et al., 2008; 2016); what is essential to understand is these communities' capacity to influence the effectiveness of natural hazard resiliency planning.

Urban communities reflect a different resiliency experience based on the literature reviewed. For example, urban areas benefit from the 100 Resilient Cities initiative created by the Rockefeller Foundation conducted from 2013 to 2019 (AURP & Rockefeller Foundation, accessed 9/24/2018). This private foundation helped cities worldwide learn through practice about how to deal with the physical, social, and economic challenges of daily stresses and shocks, such as natural hazards. The findings indicate increased resilience elevates the whole community's threshold if a natural hazard leads to a disaster. The 100 Resilient City participants joined a global network of member cities. As part of the partnership, the cities received technical guidance on how to establish a "Chief Resilience Officer" and support the development of vigorous resilience strategies. These cities were also connected to service providers, partners, and solutions for putting their resilience strategies to work. Although rural areas reflect 90% of the US land area and approximately 20% of the population, these vast areas based on the literature reviewed (Cox & Hamlen, 2015; Berke et al., 2014) are not benefitting from the same level of resilience planning interest as cities, nor do they have the resources to attract the kind of philanthropic investments in a cohesive, practical learning option like the 100 Resilient Cities initiative.

2.4 Community Resilience

FEMA has a wealth of information for individuals, families, communities, and training programs for emergency managers and responders. FEMA, the Environmental Protection Agency (EPA) and the National Science Foundation (NSF), as well as others in academia and the private sector, have supported the research and development of individual and community disaster resilience tools (FEMA, 2019). For example, the Ready.gov launched in 2003 is a public service campaign designed to educate and to promote preparedness through public involvement. These tools assist with educating the public about natural disaster preparedness and inform SHP and HMP strategies. They are designed to be a valuable free source of technical data to assist individuals and community stakeholders develop better hazard preparedness plans (NRC, 2012).

When a state natural disaster event occurs or is imminent, the Governor decides to make a disaster declaration per the Stafford Act, which alerts the President and Congress that the state is seeking federal FEMA support, technical assistance, and funding. As a result of the Governor's declaration FEMA[3] deploys within its ten regions, people, and resources to assist state, county, and local government response and recovery efforts. Once the response and recovery efforts have stabilized, FEMA supports community resilience efforts with grant funds and technical assistance

[3] On Oct. 5, 2018, President Trump signed the Disaster Recovery Reform Act of 2018 into law as part of the Federal Aviation Administration Reauthorization Act of 2018 (DRRA. 2018). The purpose of this reform is to acknowledge the shared responsibility for disaster response and recovery. It aims to reduce the complexity of FEMA and build the nation's capacity for the next catastrophic event. The law contains approximately 50 provisions that require FEMA policy or regulation changes for full implementation, as they amend the Robert T. Stafford Disaster Relief and Emergency Assistance Act (https://www.fema.gov/robert-t-staford-disaster-relief-and-emergency-assistance-act-public-law-93-288-amended).

(FEMA, 2004; DRRA, 2018). The local government and community are responsible for deciding the community's new development and progress in 'bouncing back' from the disaster. This local focus highlights the importance of equipping communities with the right tools to manage and bounce back from the impacts of a natural disaster. Therefore, the more knowledgeable and prepared a community is prior to a natural disaster event, the more resilient they maybe once disaster strikes (NOAA, 2019b).

Community resilience practices based on US natural hazard policy developed by FEMA[4] specifically recognize the need to bolster rural populations with increased technical assistance and SHP planning capacity (FEMA, 2004). Although efforts to equip rural regions with the right community resiliency tools have been underway, what is essential to understand is these communities' capacity to influence the effectiveness of natural hazard preparedness plans (Cox & Hamlen, 2015; Dabson, 2011). The additional support for rural areas is meant to ensure SHP preparedness measures reflect comparable community resilience conditions across the US, urban, suburban, and rural areas (FEMA, 2004).

The increased intensity, occurrence, and type of natural disaster events in the US have caused a spur in conversations regarding best practices and solutions for communities to employ

[4] The FEMA regulations and the State Hazard Plan (SHP) requirements include oversight for more than natural disasters; however, natural disasters are the focus of my research. The FEMA regulations are appropriate for evaluating state-level community resilience conditions because states are responsible for the implementation of FEMA regulations. The analysis of counties is appropriate as resilience measurement tools gather national available data sources for counties across the U.S. Sources such as the US Census, Department of Labor, Department of Energy, economic Development Agency, Department of Agriculture, etc. are readily available at the county level

as part of their hazard plan preparedness (DRRA, 2018; NOAA, 2019b; NAS, 2019; NMIS, 2019). In 2005, Hurricane Katrina became known as the guidepost for learning how to formulate policy better, plan for, and manage natural disasters (NAS, 2019). As a result, the term "community resilience" entered the vocabulary of disaster management policy and regulations (Cutter et al., 2016; Cutter & Emrich, 2006; Fothergill & Peek, 2015; Fussell et al., 2010; Laska & Morrow, 2006; Levine et al., 2007; Weber & Peek, 2012). However, there is no consensus on what community resilience is, although there is no shortage of definitions and interpretations coming from an array of disciplinary perspectives (Rose, 2007; Cutter et al., 2008; 2014; 2016; Norris et al., 2008; Wilbanks, 2008; Pike et al., 201; Pendall et al., 2010; Simmie & Martin, 2010; Linnenluecke & Griffiths, 2010; Longstaff et al., 2010; Martin, 2012; Alderson et al., 2015; White et al., 2010; Martin & Sunley, 2015). Nonetheless, the pressing need to operationalize resilience has led to an acceptance that community resilience is the capacity of a community to prepare for expected natural or man-made hazards, adapt to changing conditions, and withstand and recover rapidly from disruptions (NIST, 2016 a, 2016 b).

Resilience to natural disasters means intentionally guiding a system's adaptation process to reserve some qualities and allow others to diminish, all while retaining the identity of the system (Post Carbon Institute, 2017). Vulnerability is the characteristics of a person, group, or place in terms of the capacity to anticipate, cope with, resist, and recover from a natural hazard event (IFRC, 1999). As stated above, the concept of community resilience to natural hazards means strategically leveraging existing resources while working systematically to improve upon limited resources, thus erecting a stronger, more resilient community over time (Miller &

Dabson, 2015). Community natural hazard preparedness reflects both adaptation and guidance to support resilience and address vulnerability characteristics (Miller & Dabson, 2015).

Based on the literature, geography matters (Tobler, 2004) and a community's identity are essentially determined by what people value about where they live, so the people who inhabit a community should be part of the resilience-building process (Birkland & Waterman, 2008; Cox & Hamlen, 2015; Cutter et al., 2008; 2010; Dabson, 2011; White et al., 2015). The nature of the spatial economy, such as the growth of urban centers that may perpetuate a decline in rural periphery areas, makes them less resilient or more susceptable to natural disaster threats. As a result, rural communities may not have the agency to develop and implement natural hazard management policy as compared to their more empowered regional urban communities (Berke et al., 201; Cutter et al., 2003; Cutter et al., 2016; Dabson, 2007; Miller et al., 2015a; 2015b; 2016). Cutter et al. (2010) indicate communities are the ideal level of focus for building regional resilience because the powers held at the state and county government levels in the US regarding natural hazard policy make this kind of work possible.

Governments are accountable when natural disasters strike, not only to maximize safety and minimize damage but also to ensure community functions restoration in the weeks and months that follow. The taxpayer-funded SHP echoes government safety and community responsibility. Public officials and managers will be expected to know what resilience means beyond the superficial headlines and better prepare for and adapt to changing conditions and recurring threats despite fiscal constraint pressures and short-term expediency (Dabson, 2011). The ability to create and use measures, evaluate current capacities and vulnerabilities, compare alternative actions' effectiveness, and gauge preparedness progress will be essential to ensure that limited taxpayer resources are appropriately directed and leveraged (Bakkensen et al., 2017). The emergence of resilience measurement systems on the face of it should help justify expenditures and regulations. Still, public officials and managers must understand both how these measures are constructed and their limitations. Moreover, research suggests that certain conditions need to be in place before the availability and collection of performance data translates into day-to-day decision-making, and these too must be considered (Kroll, 2015; Kwon & Gonzalez-Gorman, 2014).

2.5 Definitions of Resilience and Vulnerability

The literature indicates there are variations in the definitions around the concepts of community resilience and vulnerability. This variation may be contributing to differences in SHP development and implementation. For example, definitions differ if they are based on socio-ecological systems (SES) frameworks influenced by global change or from the perspective of environmental hazards (Cutter et al., 2014). Renschler et al. (2010) define community natural hazard resilience as the ability to mitigate hazards, contain the effects of disasters, and carry out recovery in ways that minimize social disruption and mitigate the impact of future extreme weather events. The National Institute of Standards and Technology (Gilbert, 2010, NIST, 2016 a, b) definition provides context for cost and time "Disaster resilience is defined as the ability to minimize the costs of a disaster, return to the status quo, and to do so in the shortest feasible time." The literature indicates community vulnerability as the attributes of populations that inhibit their ability to prepare, respond, and recover from a natural disaster event (Cutter et al., 2014, p. 66). The literature supports my use of resilience and vulnerability to form a natural hazard preparedness perspective, they are seen as separate but linked concepts with some overlap (Cutter et al., 2014, p.66).

Definitions for resilience typically have several common components. First, the subject of resilience is not just one entity – no one geography, population, governmental unit, or business. Instead, it is the collective within a geographic area that creates a resilient whole, a regional approach, a recognition of fairness for all community types (Berke et al., 2012; Dabson, 2015). Second, the definitions acknowledge that resilience exists in several phases, from responding to a natural disaster to recovering from its losses (Cutter et al., 2014). It is important to appreciate that, just as a community is not impacted uniformly during a disaster, nor will it recover uniformly. Some areas within a community will rebound quickly, while others may struggle. Finally, physical damages and costs are not the only components of potential natural disasters, but social disruption and adaptation to a new status quo are also important to resiliency (Bakkensen et al., 2017). The literature defines a resilient region as one that can anticipate natural hazard threats to social and ecological systems (SES), reduce the impact of risks by taking pre-emptive action, and respond appropriately when threats materialize and recover afterward (Dabson et al., 2012).

The literature is robust about understanding urban vulnerability and resilience conditions (Godschalk 2003; Pelling 2003; Vale & Campanella 2004; Borden et al. 2007; Leichenko 2011). However, less is known about the characteristics that influence disaster resilience in rural communities (Cox & Hamlen, 2015; McManus et al. 2012; Boon, 2014). Rural disaster resilience is an important distinction because the challenges are different in rural communities. Rural communities often have limited government and business entities that may reduce their resilience as compared to urban and suburban areas. As a result, they may not have the capacity and resources needed during and after a natural disaster occurrence (Kapucu et al., 2013; Cox & Hamlen 2015). In contrast, the literature indicates the self-reliant nature of rural communities, along with their strong sense of community, reliance upon and connections to natural resources, along with strong cultural linkages can enhance resilience, as compared to urban communities (Cutter et al., 2014; 2016; Dabson, 2007; 2011; Homsey & Warner, 2013). Cutter et al. (2016, p. 4) state, "Social inequalities might be magnified in both rural and urban areas, leading to less disaster resilience, but at the same time, economic diversification in metropolitan areas helps to promote disaster resilience compared to the single-sector economic dependence often seen in rural areas. Understanding the fabric of rural places is important because the context and capabilities for hazards management are distinctly different. For example, there has been a steady population decrease in rural populations in the US, but that decline is not spatially consistent."

2.6 Principles of Community Resilience Measurement Tools

The research on community resilience related to natural disaster management has been growing. In 2019, the National Academy of Science, Engineering, and Mathematics (NASEM) committee studied 33 community resilience measurement approaches (NASEM, 2019). The NASEM evaluates the current state of resilience measurement science and practice and includes discussions with community stakeholders and experts from urban and rural regions across the US.

The findings indicate communities continue to grapple with measuring their resilience or vulnerability now and how to track progress toward future planned resilience goals. The report determined there is no single measurement of resilience for all communities (NASEM, 2019). The report indicates "several actions are needed to build and measure community resilience: utilize community participation and engagement at the outset of community resilience building and measurement efforts to engender buy-in around resilience priorities, goals, and leadership; design and measure resilience around multiple dimensions of a community, for example, the natural, built, financial, human, social, and political "capitals" of resilience; use measures to track progress and in decision making and ensure that the data collected, integrated, or synthesized are relatable and usable for decision making; and incentivize measuring resilience by expressing multiple benefits gained from single investments." (NASEM, 2019, p.3).

The MTP resilience tool was not one of the 33 resilience measures evaluated by the NASEM study. In fact, as the NASEM (2019) report findings indicate, there is no tool approved by FEMA or NASEM as being the best for measuring community resilience. The report found "despite the many resilience measurement approaches, there is a dearth of use of the tools, which suggests a gap between the research and the implementation of resilience measurement" (NASEM, 2019, p. 5). What matters is the ability to use a tool in an organized approach with an engaged community that understands why natural hazard preparedness results in increased community resilience. The NASEM findings support my use of the MTP with a LISA cluster/outlier map analysis for each state at the county- level.

The literature reviewed indicates community resilience measurement systems have yet to reach maturity (Cutter et al., 2014; 2016; NASEM, 2019). The research suggests uncertainty about whether this will progress via expanded community resilience planning or enhanced computational modeling (NASEM, 2019; NIST 2016 a; 2016 b). However, merely making resilience measurement systems readily available to the public does not necessarily mean that they will be used in the manner intended (Bakkensen et al., 2017; Cutter et al., 2014; 2016). Despite these obstacles, the MitFLG (2016), NRC (2012), and NASEM (2019) reports indicate community natural hazard resilience incentives and the application of performance measures in public organizations continue to emerge.

The empirically based literature about community-level natural hazard resilience indicators or composite measures is limited and thus confines the ability to compare different communities existing levels of resilience (Barnett et al., 2008; Burton 2015; Cutter 2015; Cutter et al., 2016; Horney et al., 2012; Renschler et al., 2010; NASEM, 2019). There is limited ability to understand if natural hazard community indexes are meaningful or relevant to resilience outcomes or processes. The Sherbinin et al. (2019) paper conducted a systematic review of 84 studies that incorporated a mapping of social vulnerability to natural hazard climate-related impacts. The 84 studies use vulnerability maps to highlight areas where natural disaster impacts are anticipated to be the greatest and thus require adaptation and interventions. Further, it identifies limitations such as a "lack of future climate and socio-economic projections in many studies, insufficient characterization of uncertainty, challenges in map validation, and insufficient engagement with policy audiences for those studies that purport to be policy-relevant." (Sherbinin et al., 2019 p. 1)

Therefore, as Cutter et al. (2016, p. 4) states, "We do not know whether the pattern of resilient places shapes or is shaped by the relative impact of disaster losses and social vulnerability, especially between and among rural places. Understanding and applying empirically based measures of what makes rural communities resilient illustrate the landscape of differences across the Nation. It guides structural, economic, or social actions that might lessen the impacts of disasters and accelerate recovery following them." The MTP appears to be supported by current research and augments the empirical-based literature about community-level natural hazard resilience index measures.

CHAPTER 3.0: Linking Regulation and Center-Periphery Theories to Natural Hazard Preparedness

The following discussion links the literature reviewed about the two distinct, but interconnected theories included in my regional natural hazard preparedness research. Regulation theory (Aglietta, 1979; Painter 1977), which posits regulation expresses itself locally, and center-periphery theory (Friedmann, 1966; 1972), which posits urban economic growth and rural economic limitations are the results of regional economic conditions.

3.1 Regulation Theory

In recent decades, ecological awareness questions our perspectives about economic actors being considered independent of ecological limits, an economy blind to the natural environment (Biggs et al., 2015). Regulationist maintain the economic system is embedded in a social dynamic which precedes it and determines its operating framework (Gendron, 2012). This regulationist thinking seems particularly relevant to natural disaster events given the fact economic theorizations of environmental issues do not consider the role of crisis in the contemporary capitalist system (Gendron, 2012, p.32). In capitalism, growth is the economic norm, and crisis is seen as the irregularity.

The regulation approach puts forth the idea "the growth period is an exceptional period in itself which contains the seeds of crisis which will follow, such that growth periods and crisis must be analyzed simultaneously as two sides of the same coin" (Gendron, 2012, p. 33). Regulationist posits that to address an environmental crisis, such as the increased frequency of natural disaster events, the response needs to consider the issue's socially constructed nature. The regulation theory literature indicates an environmentally sustainable solution to an economic crisis needs to account for environmental and social issues (Lipietz, 2002; Belanger & Levesque, 1991; Boyer & Salliard, 2002). Therefore, the US natural hazard policy will need to consider the tension of economics, society, and the environment to reflect a resilient outcome or a more sustainable future for communities and regions.

Regulation theory is a conceptual framework introduced in France in the 1970s (Aglietta, 1979; Painter 1977), which has subsequently influenced studies of the states and social and economic policy in both Europe and the US (Goodwin et al., 1995). Regulation theory is derived from the discipline of economics and regionalism; it underscores the social norms, regulatory mechanisms, and institutions which come together to serve as reliance and stability in capitalist growth processes (Aglietta, 1979; 1998; Boyer, 1990; Jessop, 1990; 1997; Lipietz, 1987; Peck & Tickell, 1992; 1995). According to Friedman (2000, p.61), "this establishes a distinctive theoretical starting point in which the economic development tends neither to an automatic equilibrium as in conventional economics nor to an inevitable breakdown as in Marxist theory."

Several researchers have utilized regulationist insights to position and inform their analyses of urban development politics (Goodwin et al., 1993), UK urban and regional development (Peck & Tickell, 1992; 1995), US urban policy (Florida & Jonas, 1991), and US housing policy (Florida & Feldman, 1988). According to the literature, regulationists have also expounded on the regulationist approach's several weaknesses, particularly denunciations of structuralism and economic determinism (Valler & Wood, 2010). The literature indicates researchers have stressed the importance of agency and practice (Goodwin, 2001; Jenson, 1989; 1990; 1993; Jessop; 1997; Painter, 1997; Painter & Goodwin, 1995) as well as accentuating political and institutional dynamics (Purcell, 2002). Goodwin and Painter (1996) argue regulation theory serves as a perspective and form of analysis in the literature. From the standpoint of a regulationist, "contemporary local and regional economic development activity is best viewed within the context of overall patterns of institutional change and policy experimentation directed towards the establishment of some form of post- Fordist (economic cycle of mass production and consumption) mode of regulation." (Goodwin, 2001, p. 74).

The regulation approach allows for considering a multitude of economic configurations and allows for a great deal of space for social innovation. In *Regulation Theory and Sustainable Development* (2012), Gendron establishes a connection between the regulation approach and political ecology, building a case for why environmental issues' socio-economic perspective is a critical lens for sustainable or resilient outcomes. This socio-economic perspective is prevalent in the literature about the policy and practices of US natural hazard preparedness (Berke et al., 2012; Biggs et al., 2015; Cutter, 2016; Cutter et al., 2003; Homsey & Warner, 2013; Pike et al., 2010; Redman, 2014). Becker and Raza (2000) posit it is essential to integrate the relationship between man and nature into regulation theory. The environment serves as both a source for materials and energy inputs and a sink for production externalities, thus reflecting the need to reformulate the capitalistic economic valuation process to describe the dynamics of societies' relationship with nature (Becker & Raza, 2000, p.58). Zuindeau (2007, p. 286-288) acknowledges that due to capitalism's diversity, there is not one single perfect public policy to manage the environmental problem. Therefore, environmental policy depends on the specific form of capitalism where it is implemented.

There are three levels of analysis attributed to regulation theory. The first is the *production mode* or the US capitalist production system. Second is the *regime of accumulation* or the set of economic and social coercive forces that guide economic agents. The third is *institutional forms* that channel agents' behavior based on the rule of law or regulation, resulting in negotiated compromise or common sense of values or representations (Boyer, 1986 pp. 55-56; Boyer & Salliard, 2002, p. 41). Regulation theory identifies five primary institutional forms "whose hierarchical order results in a mode of regulation that is a priori largely unintentional: the *monetary regime* establishes market relations, the *wage-labor nexus* is the main institutional form of capitalist societies, *forms of competition* describe the market structure, the *international regime* relates to the way nation-states integrate into the international space, and *forms of state intervention* characterize the link between the political sphere and economic dynamics" (Boyer 1986, pp. 48-53).

Regulation theory, in its institutional form, as related to natural disasters or an environmental crisis, describes why social and economic regularities need to recognize that sustainable solutions to a social or economic problem must take the environmental crisis into account (Lipietz, 1999; 2002). This contradicts the argument that all that is needed for community prosperity post a natural disaster event is to return to the past social and economic order. Regulation theory helps explain why federal and state institutions, local governments, and political leaders are most focused on returning to social and economic regularities following a natural disaster occurrence versus establishing a sustainable or longer-term solution. The desire to return to the norms of the past, as described by regulation theory, is because personal and community relations supersede market relations such that "the economy is still embedded in the social sphere" (Belanger & Levesque, 1991, p.22). It helps explain why in the US economy growth is seen as normality and crisis, or a natural disaster event is perceived as an aberration.

Natural hazard preparedness conditions reflect forms of state intervention. As a result, state natural hazard regulations are expressed as compromises that allow agents, such as FEMA, state hazard planners, and local governments, to relate to each other, particularly during crisis times, when tension and conflict between agents are the sources of tension elevated. A real-world example of this type of natural hazard regulation theory agent compromise is demonstrated by FEMA's implementation and oversight regarding its floodplain regulations. More than 22,000 communities participate in the FEMA National Flood Insurance Program (NFIP), supporting local communities to rebuild or elevate the first floor of structures above the expected peak on a major flood. In 2019 FEMA audited 610 of these communities to ensure they had used the benefits of the NFIP accordingly. In the five decades since the NFIP has been in existence, the FEMA audit found that 77 communities have been put on probation, and only 12 have been suspended for failing to enforce the rules (Flavelle & Schwartz, 2020). FEMA NFIP oversight leads indicate they are reluctant to enforce the NFIP rules because the property would become unsellable and flood insurance policy costs would increase, also; if they did act, it might prompt political concerns from Congress about the need to support these communities to recover from natural disasters (Flavelle & Schwartz, 2020).

In 2016, Livingston Parish near Baton Rouge, Louisiana, was severely damaged by flooding, and thousands of homes were recorded as damaged. According to local officials, they appreciate FEMA's concern about the nature of the rebuilding effort in Livingston Parish not meeting the NFIP regulations and their funding and technical support. However, they knowingly did not meet NFIP guidelines as part of the rebuilding effort because the priority is to get people back into their homes and the community back to normal as soon as possible. Local Officials indicate residents don't care what the FEMA regulations are at that point (Flavelle & Schwartz, 2020). Although just one example of how natural hazard preparedness conditions may inform local social and economic conditions, it demonstrates how FEMA and local official compromises are based on the desire to return to the past's norms instead of the longer-term resiliency embedded in the NFIP regulations.

Regulation theory does not attempt to explain why an environmental crisis or natural disaster event occurred; its origin is in response to the economic crisis of the 1970s (Gendron, 2012, p.49). Although it is grounded in economic theory of the Fordist wage-labor nexus and social movements, it has been evaluated to describe the transformation of values and reconfiguration of social relations between the regulationist corpus and 21st-century sustainable development with respect to the environmental crisis. In this capacity, I employ in my research the regulationist perspective for better understand the probability of predicting natural hazard preparedness conditions across US counties, based on their geographic relations, aberrations of state hazard regulations, and FEMA policy compromises. Regulation theory allows "nature to be understood as a social construct whose evolution responds to a dialectical relationship between man and nature" (Gendron, 2012, p.61). The content and development of the institutional form in the regulationist approach reflects a relationship between the economy and the environment; therefore, it offers the possibility to link the economic crisis analysis with the environmental problem and address resilience issues.

According to regulation theory (Painter, 1997), US natural hazard regulatory and funding allocation practices operating at various scales should find expression locally by increasing resilience in states and communities. Regulation theory is a theoretical framework to examine what might count as success or failure in the urban-rural landscape and inform what type of policy might be sustainable in the context of regional dynamics. As a result, it may inform what kind of natural hazard preparedness policy might be sustainable if expressed in a regional context. However, if the federal policy is to fund the management of natural disasters uniformly across the US, or if it is informed by political motivation (Reeves, 2011) versus local conditions and need (Ballew et al., 2019), and motivated by *ex-post* social and economic tensions and agent compromises to a natural disaster event, that too will be expressed locally.

The Quebec school of regulation describes three dimensions of analysis for the construct of social action; social relations, institutional, and organizational (Belenger & Levesque, 1991; 1994). The institutional dimension establishes the ground rules, the organizational dimension reflects the roles played by the actors imposing the regulations, and the social relations reflect the compromises that take shape as a result. The French sociologist, Alain Tourane's sociology of action or actionalist analytical framework, is in opposition to Marxist thought "yet brings the class conflict in Marxism up to date by placing social movements at the center of a functioning society through innovative linkages between social classes and collective action" (Gendron, 2012, p. 82). Touraine's actionalist analysis builds upon these three dimensions to inform the distinctions between economics and the social sphere suggested by regulation theory (Belanger & Levesque, 1994, pp. 28-29). In regulationist thinking, social structures, per Touraine *historicity*, defined as "the capacity of a society to act upon itself "(Touraine, 1978, p.159) may be thought of as "historical miracles that are unspecified and unpredictable and are the result of political and social struggles" (Gendron, 2012, p. 66). Chartres posits, "the regulation approach recognizes the need for the political sphere to intervene to get out of the crisis, the development model that will emerge from the struggles between social actors will nonetheless be unintentional" (Charttres, 1995, p.274).

Gendron (2012, p. 64) argues the emergence of new social relations induced by an environmental crisis will need to consider the type of institutional compromise that is likely to result. Suppose we are to establish a renewed degree of stability or sustainability. It will require the social actors to agree upon a new compromise model to redefine the role between man and nature. With this respect, regulation theory offers an approach based on the idea of an economic system shaped by major social relations and their resulting compromises (Gendron, 2012, p. 66). Per regulation theory, the intervention of the state institution and the political sphere when a natural disaster event occurs reflects an outcome based on the compromises of these agents who desire to mitigate this aberration and return to or bounce back to the normal pre-disaster socio-economic order. This compromise unintentionally establishes differing regional or local resilience or natural hazard preparedness conditions for all stakeholders.

Peck and Tickell (1992, p. 347) examined how the regulationist framework may be levied upon social regulation issues and uneven development. In capitalist development, forms of uneven development reflect the differences in the accumulation or economic system, and the mode of social regulation are implicit within each national regime (Peck & Tickell, 1992, p. 352). Per Touraine's *historicity*, each geography's empirical realization is conditioned by its pre-existing regional history of accumulation and social regulation. The resultant uneven development is concrete due to prior patterns of uneven development (Touraine, 1978). When these "geographies of accumulation and social regulation interact, they produce unique regional couplings, which intern are embedded within a national regime" (Peck & Tickell, 1992, p.352).

Regulation theory is rooted at the level of national social formation, so the ability to examine how the theory may be spatialized needs to be considered (Smith, 1989). The literature indicates that regulation theory is operationalized at the local level; it is necessary to integrate subnational uneven development to distinguish between durable and fragile forms of growth (Scott, 1988; Peck & Tickell, 1992). This theoretical lens allows for an understanding of how national hazard preparedness conditions may differ amongst urban, suburban, and rural economic and social conditions and vary across and within the 10 FEMA regions of the US.

Based on the literature, I hypothesize regulation theory in the context of a one size fits all federal natural hazard policy may present as federal policy design and implementation limitations when expressed at the state and county scale. Valler et al. (2000) and Valler and Wood (2010) posit that the regulationist approach has advanced the context of regional development policy by broadening the political, economic, and institutional arena and by providing critical connections that inform economic, social, political, cultural, and institutional practices. Based on my review of the existing literature, I argue these vital connections are essential to state hazard policy design, adoption, implementation measures, and the resulting local and regional natural hazard preparedness conditions.

3.2 Center -periphery theory

Theories of regional growth reflect little agreement on how regions are defined; they tend to assume the a priori existence of a geographic and economic entity (Dawkins, 2003, p. 133). Regions tend to reflect interdependencies between natural resource systems and human populations (Markusen, 1987). Historical patterns of regional formation correspond to some political or planning homogeneity boundaries such as the FEMA regions or the metropolitan statistical areas (MSA) identified by the US Census Bureau (Richardson, 1979). Regions tend to be a spatially contiguous population bound either by functional economic areas defined by necessity or by choice to a geographic location (Fox & Kumar, 1994). Neoclassical trade theory and growth theory postulate the theoretical basis for understanding whether regional economies will grow to be more similar (convergent) or more differentiated (divergent) over time (Dawkins, 2003, p. 134).

The economics of uneven development and regional growth are informed by central place theory (Christaller, 1933;1966; Losch, 1954). The theory defines order as determined by the diversity of goods and services offered within a mostly retail/service-oriented region, starting with lower-order cities, villages, and towns as importers of service and market needs and higher-order cities as exporters. Central places emerge where market areas for different products overlap. Central place theory serves as a conceptual foundation for regional economic development theory. It informs my examination of how US economic conditions and institutional planning practices have primed natural disaster resilience conditions across the urban-rural continuum and FEMA geographic regions.

Neoclassical economic theory convergence posits that poor economies will grow faster than rich economies, leading, in the long run, to a convergence of economic status, assuming a steady state of savings rates, technological progress, and population growth (Solow, 1956). The literature about regional economic convergence theories indicates regions with a large initial supply of inventors and entrepreneurship tend to attract innovation entities, attracting more inventors (Dawkins, 2003; Kwon & Gorman, 2014; North, 1955). North indicates over time, regions tend to "lose their identity as regions" (North 1955, p. 258). If regional economies are to converge, according to the demand side approach of export-based theory argued by Charles Tiebout (1956a; 1956b) and Douglass North (1956; 1955), their economy becomes more diversified, and over time they lose their identities as regions and tend toward interregional convergence. In neoclassical exogenous growth theory, convergence in a region's productive capacity may be assisted by supply-side investments such as infrastructure or capital; they are exogenous or outside the economic model. These central government policies may be politically biased or reflect a response to economic growth and create additional capital investments, leading to regional economic convergence.

The economic debate concerning regional economic convergence theory led to incorporating a prediction of regional economic growth theories via divergence. Gunner Myrdal's cumulative causation theory (1957) posits the process of growth tends to feed on itself through a process of cumulative causation. He argues underdeveloped regions may offer low-wage labor; however, these economic benefits tend to be offset by economies' agglomeration within industrialized regions. Underdeveloped regions may benefit from growth in developed regions through "spread" effects; however, these benefits will be offset by "backwash" effects resulting from the flow of capital and labor from the "lagging" region to the developed region (Myrdal, 1957). Growth pole theory Perroux's (1950) "space as a force" view of spatial interaction replaces Myrdal's theory by placing cumulative causation into a spatial context. Perroux (1950) defines "space as a type of network that is held together by centripetal forces as the basis for the growth pole concept" (Dawkins, 2003, p. 140). Hirshman (1958) argues that growth in a developed region produces favorable "trickling down" effects within a region as the lagging region's goods are purchased, and the developing region hires labor. These regional economic growth divergence theories, like all theory development, have evolved, been refined, or abandoned over time. They support an understanding of why counties may be uneven in their economic, infrastructure, and social capacity and, as a result, are less prepared or more vulnerable in response to a natural disaster event due to limitations within their region's economic growth history.

Central place theory and divergent regional economic growth are expanded upon with the center-periphery model (Friedmann, 1966). It is principally based on Myrdal's (1957) theory of unbalanced regional growth via cumulative causation, and the literature indicates it also incorporates elements of export base theory (Dawkins, 2003). Like export (or economic) base theory, Friedmann recognizes that growth may be externally induced. Export base theory was developed in the 1950s by Tiebout (1956 a; 1956 b) and North (1956; 1955), who argue that local political, economic, and social institutions' growth trajectory is mostly determined by the region's response to exogenous world demand. North (1955) argues that "regional development during the modern era has emerged primarily from the efforts of capitalists to exploit regional resources to meet demands on the world market and not from the gradual progression of an economy from subsistence to more advanced forms of exchange" (Dawkins, 2003, p. 155). Tiebout (1956 b) indicates the stages theory of economic growth that North (1955) criticizes is not necessarily wrong; however, it is only applicable to a limited number of cases. Friedmann (1966) departs from traditional export-based theory by recognizing that local political and economic entrepreneurship and leadership may affect export demand (Dawkins, 2003).

Friedmann (1966, 1972) posits large urban areas have the initial advantage in the competition for new growth because of the decreasing cost benefits of urbanization economies. The literature suggests these factors tend to work to the advantage of urban core areas within the region, which tend to be the inherent beneficiaries in the economic development process (Friedmann, 1979; Krugman, 1991; 1995; 1999; Porter, 1990). The regional economic geography literature indicates that outside of the core, regions are differentiated by their relative degree of regional economic autonomy. These 'resource frontiers' are undeveloped regions whose primary draw is the plentiful supply of untapped natural resources. As a result, "downward-transitional areas are rural areas trapped in a stage of structural poverty, primarily due to their structural dependence on adjacent core regions" (Dawkins, 2003 p. 140).

Friedmann (1979) applies the Marxist perspective in considering the relationship between urbanized areas and rural areas as a contradiction between opposing, but potentially complementary, social forces. Friedmann (1979) argues the contradictions between city and country are contradictions between well-designed (interest-based) forms of social amalgamation and territorial (geographic and historical) forms of social amalgamation. Concerning the center-periphery regional model, Friedmann states, "An advantaged central region invariably emerges and draws resources from the peripheral regions. Inter-regional equilibrium is seen as possible, but only if the government intervenes" (Knox & Agnew, 1994, p. 82). According to Friedmann (1972), integration in the core is more rapid than in the periphery. Thus, bringing all these regions into equilibrium is an ideal that will probably never be realized. The "core tends to maintain its status over time because it offers advantages in capital, labor, and markets" (Knox & Agnew, 1994, p. 83).

As crises emerge in the peripheral regions, there is greater economic power within core regions as the periphery becomes more dependent on the core for investment, credit, and economic leadership. Core regions will gain more importance at the expense of peripheral ones (Friedmann, 1979). Like the role of history recognized by Touraine (1978) in regulation theory, Friedmann (1966) indicates that local leadership's nature informs the region's development history. These economic base theories of regional economic convergence attempt to describe how regional economies develop and thus inform the region's economic and social capacity to address natural disaster resilience.

Krugman's "new economic geography" narrative framework argues the interaction of increasing consumer demand, increasing returns in manufacturing production, and transportation systems drive a cumulative process resulting in a core-periphery economy (Krugman, 1991). Krugman's core-periphery model is not confused with Friedmann's center-periphery model. Krugman's core-periphery pattern has all manufacturing located in the core and agricultural production in the periphery, allowing for economies of scale, transportation costs, and regional population in manufacturing employment (Krugman, 1991). Cronon (1991) considers geographic factors such as climate and topography in determining patterns of regional growth and decline. The approach of new economic geographers is to ask, "why regional economies experience such different patterns of economic growth when there are no apparent geographic differences between regions" (Dawkins, 2003, p. 148). Krugman (1999, p.159) “combines these two approaches to suggest an understanding of the large effects of seemingly random events—an idea central to the new economic geography—can also be used to understand why differences in natural geographic features across regions can have such large persistent effects over time."

The literature suggests the development of early US regional planning focused on a polarized development viewpoint on regional growth (Friedmann & Weaver, 1979). The literature about regional development theory appears to have developed from several different scholarly traditions. It suggests neoclassical trade theory and growth theory serve as the conceptual basis for understanding whether regional economies will become more similar or more differentiated over time (Dawkins, 2003). The "strategy for improving interregional efficiency and equity depends on the nature of the source of divergence and the benefits and costs of diverting the path of growth in the other direction" (Dawkins, 2003 p. 152).

Per Center-Periphery Theory (Friedmann, 1966; 1972), when focused on large urban centers, the spatial economy results in impoverished rural periphery areas that are not as resilient to disaster threats. The literature supports the decision by FEMA (DMA 2000, Section 203 (a)) to recognize the potential for uneven growth and the need to provide additional capacity to address the needs of "small, impoverished areas" of less than 3,000 people as in need of special regulatory consideration and local empowerment as part of FEMA SHP development.

Exogenous growth theory models acknowledge the influence of conditions outside the economic growth model parameters, appreciating a significant role for public policy in encouraging growth or reducing regional disparities compared to neoclassical models that predict a regional convergence towards steady-state growth. So, if federal and state natural hazard policies provide funding and technical resources within a region, these exogenous public policy interventions should reduce regional disparities to natural disaster events. However, Markusen (1987) argues the uneven spread of capitalism in the US has produced economic differentiation at the regional level, which has given rise to unique patterns of regional political conflict that have, in turn, been reinforced by the US federal system of government. This thinking informs my comparative evaluation of natural hazard preparedness conditions across the US regarding the geography and spatial adjacency relationships within states and across the 10 FEMA regions.

CHAPTER 4: Methodology

My research design builds upon the work of Cutter et al. (2016). Their study is an empirical analysis that uses the Building Resilient Infrastructure and Communities (BRIC) natural hazard resilience measures developed by FEMA as the DV with county-level urban-rural definitions based on the US Department of Agriculture (USDA) and metropolitan statistical area (MSA) boundaries. I expand upon the Cutter et al., 2016 approach with a mixed-methods explanatory sequential design (Creswell, 2015). I use triangulation to test the degree of external validity (Webb et al., 1966). According to Jick (1979, p. 607) "the triangulation approach assists for systematically ordering eclectic data in order to determine congruence or validity." I test for theoretical constructs related to how natural hazard regulation is expressed at the local level due to varying geographic, economic, social, and built environment conditions.

I include interviews with FEMA personnel, and comparative descriptive and spatial statistical analyses for understanding county-level urban-rural, based on the work of Isserman (2005), and FEMA regional natural hazard preparedness conditions. Instead of the BRIC, I use the MTP measures as my DVs. My model provides for the addition of predictor values or EVs for the number of adopted state hazard plan regulations, the ATTOM (2016) building infrastructure risk index value, and the 2016 presidential majority votes for rural, suburban, and urban counties and the 10 FEMA regions (see Figure 4-1). I like Cutter et al. (2016) control for the nature and extent of natural disaster exposures for each county and include county-level federal and local HMGP grant total award dollar values.

I use the Local Moran's I (LISA) spatial cluster/outlier spatial statistic to test for spatial autocorrelation in the MTP measures. Specifically, to test for spatial patterns in resiliency and vulnerability along the urban-rural spectrum. For my qualitative analysis component, I include outreach to FEMA community preparedness leaders, giving insight into the resilient measurement tools they see being implemented in their region by states. I ask their perceived value of the MTP map book approach I developed as a visual tool for assisting community hazard planners with describing urban-rural and regional resilience and vulnerability conditions. I also inquire about what they perceive, affecting the nature of urban-rural resilience and vulnerability conditions within their FEMA region.

Dr. Cutter's primary research interests are in disaster vulnerability/resilience science, specifically "what makes people and the places where they live vulnerable to extreme events, and how vulnerability and resilience are measured, monitored, and assessed" (NASEM, 2019, p. 98). The research questions for Cutter et al. (2016) build upon the extensive research Dr. Cutter has conducted (Cutter 2008; 2016, Cutter et al., 2003; 2010; 2016) regarding social vulnerability, community resilience, natural disasters, and how and why they differ for urban-rural communities across the US. Dr. Cutter served as part of the National Academies of Sciences, Engineering, and Medicine Studies (NASEM, 2019) team that evaluated 33 community resilience measures from across the nation to understand better how these measures and their variables compare to others and inform US regional resilience conditions.

Cutter et al. (2016) indicate natural disaster funding programs and resilience planning needs to be locally customized to recognize urban and rural community conditions to achieve regional resilience milestones. This finding supports the conclusions of the FEMA 2020 National Household Survey (NHS, 2020). Dr. Cutter indicates "the ability to highlight the strengths and weaknesses in resilience that could be addressed by government agencies, nongovernmental organizations, and the communities themselves is a critical first step, but the evidentiary basis for measuring natural disaster resilience must be credible and built on sound science and understanding" (Cutter et al., 2016 p.16). The mixed-methods comparative design for my research builds upon this recognition by Cutter and the literature specific to the importance of local context, customization, and community participation as critical components for enhancing regional resilience conditions (Berke & Lyles, 2012; Birkland, 2009; Cutter et al., 2016; Dabson, 2007; 2011; Homsey & Warner, 2013; Horney et al., 2012).

4.1 Quantitative Logistic Regression Methodology

In the spirit of the existing resilience literature, the research of Dr. Cutter, and the NASEM 2019 report findings, I selected the MTP as my DV because it reflects a gap in the research and assists rural areas in understanding and planning for natural hazard events. Secondary sources that can be updated inform the MTP social, economic, environmental, and infrastructure resilience and vulnerability index developed for all continental US counties. The MTP uses county-level reputable data sources for each dimension of resilience and vulnerability. (Miller et al., 2016). The variables that inform each dimension of the MTP are scaled using a minimum-maximum method rescaling ranging from 0 to 1, except for distance-based measures that use a US census area. The minimum and maximum values were capped versus using standardized scores to establish county-level high and low categories of resilience and vulnerability (Dabson 2015; Dabson et al., 2012; Miller et al., 2015a; 2015 b; 2016; Miller & Dabson, 2017).

The MTP development team indicates in their working papers (Miller et al., 2015a; 2015 b) that many of the existing community natural hazard indicators theoretically focus on resilience; however, they frequently evaluate vulnerability. The development team indicates resilience to natural hazards, or measures of strengths in a community may, at times, be the inverse of the community's vulnerability or weaknesses. Communities are likely to react to a natural disaster event differently due to their leadership capacity, access to resources, and social networks (Miller et al., 2015a; 2015b). Therefore, it is essential to discern and communicate the value of the relationship between resilience compared to vulnerability for the community. The MTP is a free, web-based technical data source with scalable reporting features to assist rural communities better understand how they compare to neighboring counties' resilience and vulnerability conditions and identify potential partnerships in the case of a natural disaster event.

The MTP team developed an index from multiple data sources at the county level using many different academic, scientific, and government sources (see Table 1-1) (Miller et al., 2015a; 2015b; 2016). The county value for each DV is assigned to one of four quadrants based on its combination of high/low resilience (strengths) and high/low vulnerability (weakness). For example, a county with high economic resilience (HR) and low economic vulnerability (LV) indicates it may be better prepared for a natural disaster event than a low economic resilience (LR) and high economic vulnerable (HV) county. Table 4-1 summarizes the MTP variable resilience (R)/vulnerability(V) measures for the 2,389 counties in my study. Tables 4-2 through 4-5 summarize each of the MTP variables for urban, mixed urban, mixed rural and rural population counties.

Table 4-1: MTP R/V Preparedness Measures

MTP Variable	Least Prepared (HV/LR)	Somewhat Prepared (HV/LV)	Moderately Prepared (HR/HV)	Most Prepared (HR/LV)
Economic R/V	671	485	525	708
Environment R/V	647	411	555	776
Infrastructure R/V	574	597	634	584
Social R/V	827	338	360	864
Total # of counties	2719	1831	2074	2932

Table 4-2: MTP Economic Preparedness Measures by Population Density Type

MTP Economic Preparedness Variable	Least Prepared (HV/LR)	Somewhat Prepared (HV/LV)	Moderately Prepared (HR/HV)	Most Prepared (HR/LV)
Urban	6	1	98	53
Mixed Urban	15	9	52	80
Mixed Rural	219	136	204	327
Rural	431	339	171	248
Total # of counties	671	485	525	708

Table 4-3: MTP Environment Preparedness Measures by Population Density Type

MTP Environmental Preparedness Variable	Least Prepared (HV/LR)	Somewhat Prepared (HV/LV)	Moderately Prepared (HR/HV)	Most Prepared (HR/LV)
Urban	31	15	71	41
Mixed Urban	24	10	53	69
Mixed Rural	244	110	248	284
Rural	348	276	183	382
Total # of counties	647	411	555	776

Table 4-4: MTP Infrastructure Preparedness Measures by Population Density Type

MTP Infrastructure Preparedness Variable	Least Prepared (HV/LR)	Somewhat Prepared (HV/LV)	Moderately Prepared (HR/HV)	Most Prepared (HR/LV)
Urban	0	1	96	61
Mixed Urban	3	9	68	76
Mixed Rural	165	143	305	273
Rural	406	444	165	174
Total # of counties	574	597	634	584

Table 4-5: MTP Social Preparedness Measures by Population Density Type

MTP Social Preparedness Variable	Least Prepared (HV/LR)	Somewhat Prepared (HV/LV)	Moderately Prepared (HR/HV)	Most Prepared (HR/LV)
Urban	43	2	70	43
Mixed Urban	38	18	35	65
Mixed Rural	348	172	101	265
Rural	398	146	154	491
Total # of counties	827	338	360	864

The MTP in my research serves as a measure for evaluating differences in county resiliency and vulnerability conditions it informs how prepared a community maybe when faced with a natural disaster occurrence. I examine if the probability of increased preparedness conditions can be predicted. My model is based on the nature of state-level hazard policies, land use regulations, and building codes; FEMA geographic locations; urban-rural population density; local political preferences; previous federal and local HMGP investments and differing natural disaster incident frequencies and types (e.g., earthquake, tornado, coastal storm, etc.). Efforts to control these variations are included as EVs with fixed effects using an adjacent categorical logistic regression model (Goodman, 1983). The adjacent category model approach compares the probability of being at a given point compared to the probability of being at the next highest point, for example, [probability (y = *m*)/probability (y = *m* + 1)] (Fullerton, 2009, p. 308). The adjacent approach is an extension of log-linear models that model the outcome categories as a series of "local odds ratios" (Agresi, 1984, p.19). It is a constrained form of the more familiar multinomial logit model (mlogit) (Fullerton, 2009).

Ordinal response regression models, such as the adjacent category, best describe the relationship between an ordered categorical response DV, such as the MTP, and one or more EVs. I use the logit link function to describe the functional relationship between the DV's and the EV's. The Stata 14.2 version command I used for the adjacent category logistic regression is 'adjcatlogit' (Fagerland, 2014), and the coefficients are interpreted as odds ratios (ORs) (Hosmer et al., 2013). The interpretation of ORs is based on the exponentiate of the coefficients. The exponentiated coefficients provide the ratio by which the DV changes for every unit change in the EV and is presented as a multiplicative scale. The adjacent category model compares each response category to the next larger response category. Such that least prepared (HV/LR) is compared to somewhat prepared (HV/HR), which is then compared to moderately prepared (HR/HV), and then compared to most prepared (HR/LV) for each of the MTP four (4) DVs.

The equation (Equation #1) for the adjacent category model is based on the work of Clogg and Shihadeh (1994), Goodman (1983), and Long and Cheng (2004, p. 275) it is defined as:

<u>Equation #1</u>

$$Log\left(\frac{\Pr(y = m|\mathbf{x})}{\Pr(y = m+1|\mathbf{x})}\right) = \tau_m - \mathbf{x}\boldsymbol{\beta} \qquad (1 \leq m < M),$$

where *m* is a category, **x** is a vector of EV's, t is the cut-point, and **ß** is a vector of logit coefficients. The probability equation (Equation #2) of the outcome category *(m*) based on Long and Chen (2004, p. 276) is expressed as,

<u>Equation #2</u>

$$\Pr(y = m|\mathbf{x}) = \begin{cases} \dfrac{\exp\left(\sum_{r=m}^{M-1}[\tau_r - \mathbf{x}\boldsymbol{\beta}]\right)}{1+\sum_{q=1}^{M-1}\left[\exp\left(\sum_{r=q}^{M-1}[\tau_r - \mathbf{x}\boldsymbol{\beta}]\right)\right]} & 1 \leq m \leq M-1, \\ 1 - \sum_{q=1}^{M-1}\Pr(y = q|\mathbf{x}) & m = M, \end{cases}$$

where t is the cut-point, *x* is a vector of EVs, **ß** is a vector of logit coefficients that do not vary across adjacent comparisons, and *m* is the category and its corresponding logit equation, with the assumption that $ß_M = 0$. My DV's have four categories each, so the model estimates three binary logit models simultaneously. The marginal probabilities (Equation #3) for the categories are defined as:

Equation #3

$P1 = U_{1|4} / (U_{1|4} + U_{2|4} + U_{3|4} + 1)$, $P2 = U_{2|4} / (U_{1|4} + U_{2|4} + U_{3|4} + 1)$, $P3 = U_{3|4} / (U_{1|4} + U_{2|4} + U_{3|4} + 1)$, and $P4 = 1/(U_{1|4} + U_{2|4} + U_{3|4} + 1)$, where $U\ m|n$ represents the odds of Category *m* versus *n.*

The 'adjcatlogic' model can be used as an alternative to the proportional odds model or 'ologit' when the proportional odds assumption does not hold. I use it to compare response categories of increased adjacent categories of county-level natural hazard preparedness conditions. I use the model based on the theoretical construct of regulation theory and support my hypothesis that the probability of increased natural hazard preparedness conditions may be predictable based on the implementation of state hazard plans, land use regulations, hazard risk building codes and previous HMGP investments. I include the urban-rural and FEMA region dynamics based on center-periphery theory's theoretical construct, which posits preparedness conditions are inhibited due to economic limitations in less dense suburban and rural areas as compared to urban and mixed urban areas. So, it was important that my model not compare all MTP DV's to the largest occurring category (most prepared category (HR/LV) counties), such as with a multinomial logistic regression model (mlogit). The multinomial model ignores the ordering of the outcome, resulting in a loss of information (Long, 1997, p. 149). The adjacent category model is considered a constrained form of the multinomial model, where the proportional odds assumption is held for every EV (Fullerton, 2009, p. 323).

The fit for the adjacent category model applies the constrained multinomial logistic regression methodology, where the lowest category or the least prepared is used as the reference category. Results are interpreted as the OR for comparing category 'a' with category 'b' for every one-unit increase in the EV. Significant model coefficients with an OR value greater than 1.0 indicate an increased probability of natural hazard preparedness conditions. OR values less than 1.0 indicate a decreased probability of natural hazard preparedness conditions. The 'adjcatlogit' fits the adjacent category logistic regression models of ordinal variables DV's on the EV's. According to Fagerland (2014, p. 951), "The actual values taken on by the DV are irrelevant, except that larger values are assumed to correspond to higher outcomes" or, in the case of my research, more prepared for a natural disaster event.

I initially tested my model with the proportional odds model approach (ologit), "which compares two sets of response categories: an equal or smaller response versus a larger response" (Fagerland, 2014, p. 948). The parallel lines/proportional odds assumption or Brant Test (Long and Freeze, 2014) did not hold for the response categories' 'ologit' comparison. Although, the literature indicates this is anticipated as the parallel lines/proportional odds function is rarely met because few models meet the criteria of having the EV's that affect the DV's from moving into any other group be the same (Fagerland 2014, Williams, 2016). When 'ologit' assumptions are violated, Long & Freese (2014) indicate that researchers are left with a decision to stay with a model that violates assumptions or switches to the multinomial logit model mlogit', which makes no sense to the ordering of categories. Another option to consider is the generalized ordered logit or 'gologit' (Fu, 1998; Williams, 2006), which selectively relaxes the assumptions of the 'ologit' approach. However, if several variables violate the proportional odds assumptions, then Williams (2016) indicates the 'gologit' offers little in the way of parsimony, and perhaps the 'mlogit' approach may be better.

The ologit model does not meet my model's theoretical construct of adjacent category comparisons. I also tested the model using the 'mlogit' approach against the most prevalent natural hazard preparedness condition, the most prepared (HR/LV) base. The model fit was limited; however, more importantly, the 'mlogit' model did not align with my theoretical construct and nature of the adjacent MTP categories. I tested the model with the 'gologit' approach, and too many of the assumptions were violated to make sense of the model's parsimony. It also does not support the theoretical construct of increasing preparedness conditions as the 'adjcatlogit' approach. I used the 'ologitgof' Stata 14.2 command developed by Fagerland and Hosmer (2017) to calculate four goodness of fit tests for assessing the model's overall accuracy. The goodness-of-fit test includes the ordinal version of the Hosmer-Lemeshow (HL) test, the Pulkstenis-Robinson (PR) chi-squared, and deviance test, and the Lipsitz likelihood-ratio test. I choose the 'ologitgof' approach because it supports the 'adjcatlogit' logistic model package written by Fagerland (2014) to evaluate different types of lack of fit (Fagerland & Hosmer, 2017).

4.2 Adjacent Category Logistic Regression Model Details

The descriptions, sources, and descriptive statistics for the model DVs have been described in Table 1-1. The model EVs and CVs are described and summarized in Table 4-6. As stated previously, all DV MTP model variables are derived from secondary data sources for all US counties within the 48 contiguous US.

Table 4-6: Logistic Model Variables

Explanatory Variables

Variable	Description	Data Source	Type
Urban, Suburban, Rural	Urban = population (pop.) density of at least 500 people-per-square-mile (ppsm), with at least 90 % of the pop. in urban areas, and at least 50,000 pop. living in the urbanized areas. Rural = pop. density <500 ppsm, 90 % of their pop. in rural areas, and no urban area of 10,000 people. Mixed Rural =counties with pop. density of <320 ppsm, and Mixed Urban = counties with pop. density of at least 320 ppsm	Isserman, 2005	Categorical, US Census-based county-level Urban, Suburban (Mixed urban, Mixed rural), Rural population typology Urban = 1 (N=158)) Mixed Urban = 2 (N = 156) Mixed Rural =3 (N=866) Rural = 4 (N=1189) N= 2,389 counties
FEMA Regions	10 FEMA regions	FEMA, 2004	Categorical, based on the state and counties located within the 10 FEMA regions for the contiguous US (see Figure 4-1).

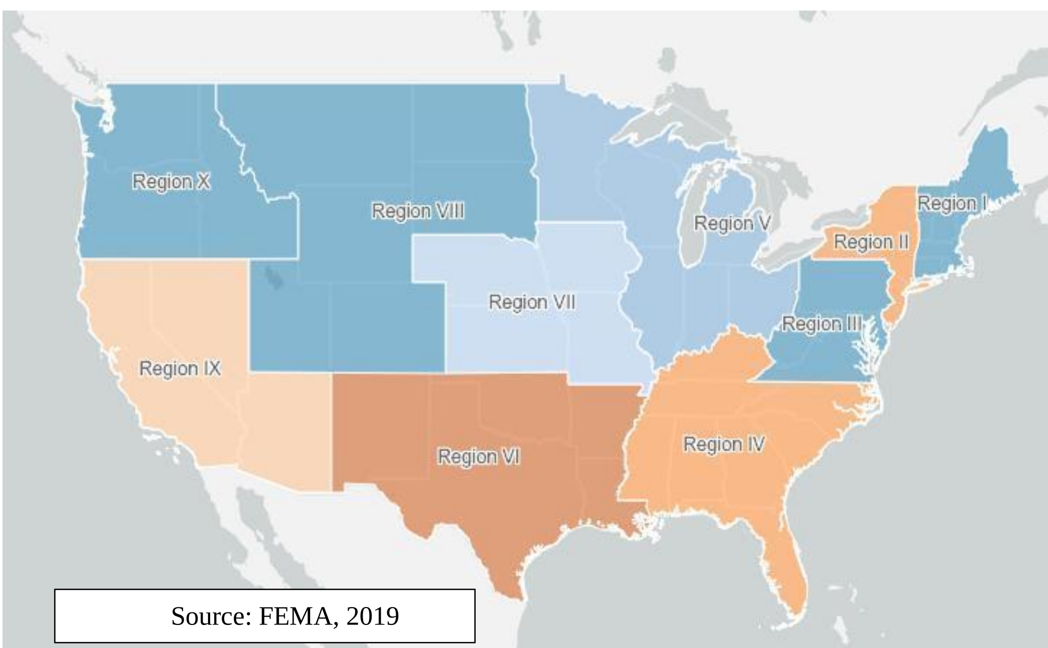
State Hazard Regulations	2002 - 2010 research survey of state land-use and natural hazard planning law examined the relationship between adopted state plans and ordinances in the context of state-level natural hazards planning	American Planning Association (APA, 2019)	Continuous, state-level ranges from 0 to 9 based on the # of state-adopted natural hazard plans and regulations. 0 = 696 1 = 677 2= 140 3 = 190 4 = 256 5 = 154 6 = 108 7 = 51 8 = 51 9 = 66
Natural Hazard Housing Risk Index	Based on the housing stock's insurance risk factors, if exposed to six natural hazards: earthquakes, floods, hail, hurricane storm surge, tornadoes, and wildfires.	ATTOM Data Solutions, 2016 [ATTOM Data Solutions]	Continuous, county-level Minimum = 0 Maximum = 102.91 Mean = 17.77 S.E.= 14.01

Control Variables

Political Preference	County 2016 Presidential Election majority vote (Democrat/Republican)	MIT, 2018	Dummy, county-level Republican = 1 (N=1988) Democrat = 0 (N=401)
Natural Hazard Incident Type & Frequency Factor	Controls for variation in the natural disaster incident type and the overall number of disaster exposures. Derived from the number of different natural hazard incident types reported (coastal storm, dam/levee break, earthquake, fire, flood, freezing, hurricane, mud/landslide, severe ice storm, severe storm(s), snow,	FEMA, 2019 [HMGP Grant Program (CDFA Number: 97.039) Data As Of: 1/5/18]	Continuous, county-level Minimum =1 Maximum = 1400 Mean = 20.68 S.E.= 54.30

	tornado, tsunami), multiplied the total frequency of all incident types.		
Total FEMA Hazard Mitigation Grant Program (HMGP) Funding	Total federal grant and local matching project dollars from six FEMA natural hazard grant programs (HMGP, PDM, LPDM, FMA, RFC, SRL). Data reflect only unique county approved or closed FEMA reported projects as of 1/5/2018, excluding all multi-county/state or statewide reported projects.	FEMA, 2019 [HMGP Grant Program (CDFA Number: 97.039) Data as of 1/5/18]	Continuous, county-level Reflects all HMGP Projects stored in the National Emergency Management Information System (NEMIS), note some are historical entries Minimum = 0 Maximum = $692 Million Mean = $5, 031,706 S.E.= 28.6 e+6

Figure 4-1: 10 FEMA Regions (contiguous states only)



I conducted the same four-category adjacent categorical logistic regression model (Equation #4) for each of the four DV's based on the nature of their preparedness measured by their MTP high or low resilience and vulnerability values. Using the Stata 14.2 'adjcatlogit' command, with ORs, predicted probabilities, and linear predictions. The model tests the probability of predicting preparedness using the MTP measures attributed to the economic, environmental, infrastructure, and social variables.

<u>Equation #4</u>

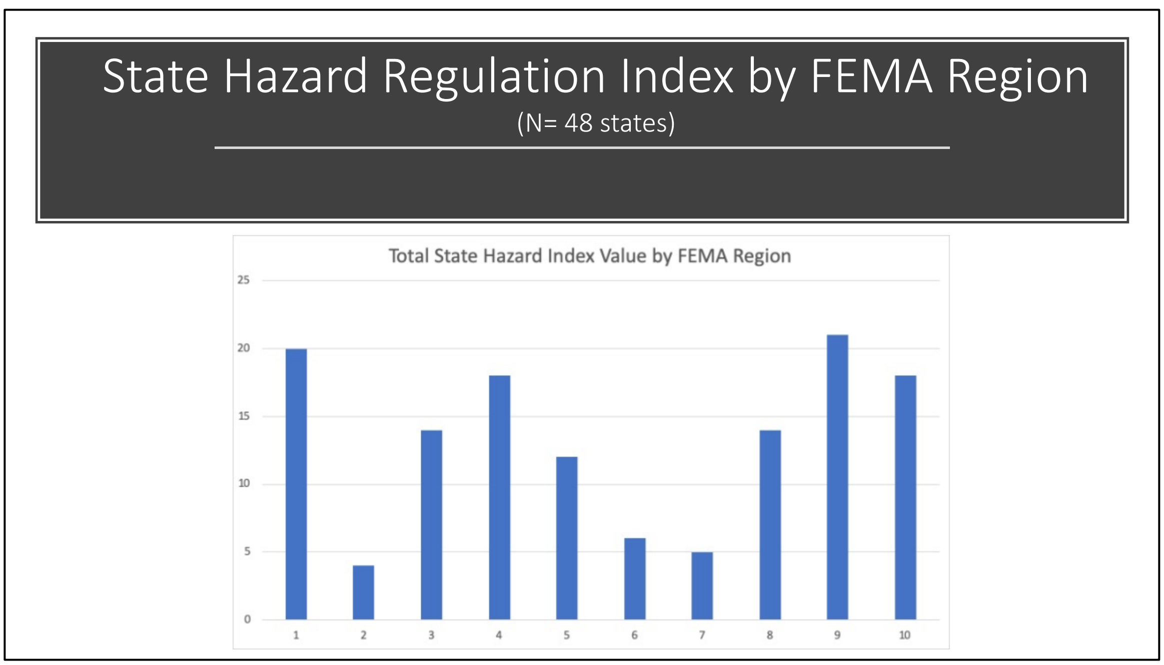
$$NHP_i = \beta' Rural_i + \beta'' FEMA_i + \beta_1 Reg_i + \beta_2 ATTOM_i + \beta_3 Rep_i + \beta_4 HMGP_i + \beta_5 Dis_i + \varepsilon$$

Where NHP_i is the MTP economic, environmental, infrastructure, and social R/V categories for county *i*, respectively. These are estimated separately but with the same EVs and controls which include: $Rural_i$ which is a vector variable of county-level urban, suburban (mixed urban and mixed rural), and rural population densities based on the research of Isserman (2005) which are operationalized with rural as the reference case; $FEMA_i$ is a vector variable indicating which of the 10 FEMA regions county *i* belongs to with FEMA region 4 as the reference case; Reg_i is the number of adopted state hazard regulations in the state which county i resides in; $ATTOM_i$ is the ATTOM building risk index factor for county *i*; Rep_i is a dummy variable indicating whether the 2016 presidential majority was republican in county i; $HMGP_i$ is the total HMGP federal and local match grant award value for county *i*; Dis_i is the total 1989-2018 disaster incident/frequency value for county *i*; finally, ε is the error term.

The county-level urban, suburban (mixed urban and mixed rural), and rural population densities (RU_Code) are based on the research of Isserman (2005). Andrew Isserman, from the University of Illinois, using US Census data, proposed a county-based typology that consists of four categories based on overall population density, the portion of the population living in urban areas, and the presence and size of those urban areas (Isserman, 1994; 2005). Isserman considers a county rural if it has a population density of less than 500 people-per-square-mile (ppsm), 90 percent of their population in rural areas, and no urban area of 10,000 people. A county is urban if it has a population density of at least 500 ppsm, at least 90 percent of the population in urban areas, and at least 50,000 people living in the urbanized areas. Counties that meet neither the urban nor rural county criteria are considered mixed and are subdivided based on a second population density threshold. Mixed rural counties have a population density of less than 320 ppsm, and mixed urban counties have a population density of at least 320 ppsm. I use the population density approach of Isserman (1994; 2005) based on the extensive literature about rural-urban interactions (Dabson, 2007; Irwin et al., 2010; Lichter & Brown, 2011; Kubisch et al., 2008) and due to his focus on finding better ways of differentiating between rural and urban beyond a simple dichotomy.

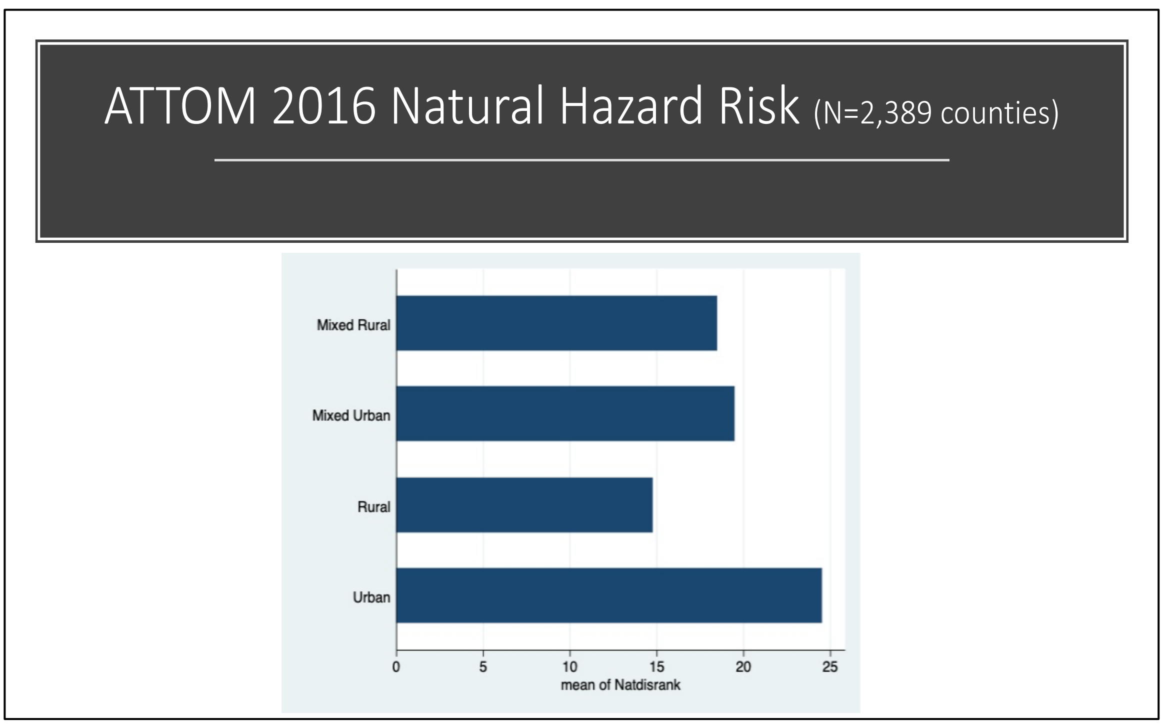
I use the 2002 to 2010 research survey conducted by the American Planning Association (APA, 2019) of state land-use and natural hazard planning law conducted with FEMA funding supporting the DRRA. The APA survey of 50 states examined the relationship between adopted state plans and ordinances in the context of state-level natural hazards planning. I created a 'State Hazard Legislation Index' based on whether or not a state had adopted regulations that required the following nine components into plans (index ranges from 0 to 9): adopted state hazard statute, mandatory hazards element in-state plan, required geographic coverage of state natural hazards, natural hazard specifications, the requirement that post-recovery be addressed in local comprehensive plans, other related comprehensive land-use plan requirements, require integration of hazards plans across state plans and if the resiliency of local communities was addressed in adopted statutes and plans. Figure 4-2 presents the state hazard legislation index by the 10 Fema regions. The 'State Hazard Legislation Index" (State_Haz) per regulation theory (Painter, 1972), posits states with adopted natural hazard regulations may be better able to express community natural hazard preparedness conditions across the urban-rural continuum as compared to states with limited natural hazard regulations in place.

Figure 4-2: State Hazard Legislation Index by FEMA Region



I include county-level natural hazard risk conditions (Natdisrank), based on the ATTOM Data Solutions (2016), RealtyTrac's parent company, the nation's leading source for comprehensive housing data US Natural Hazard Housing Risk Index. The index is based on the risk of the county housing stock exposure to six natural hazards: earthquakes, floods, hail, hurricane storm surge, tornadoes, and wildfires using data research data collected by ATTOM (2016). This index reflects building code regulations implemented within counties. Figure 4-3 presents the ATTOM 2016 natural hazard risk index by county population density type. It indicates the nature and extent of housing types built across the US and their risk to exposure from natural hazards based on the national insurance risk models developed by ATTOM.

Figure 4-3: ATTOM Natural Hazard Risk value by Population Density Type



To control for local cultural and political preferences, I use a partisan variable based on the presidential election results from 2016 (MIT, 2018). A dummy variable indicates if a county was majority Republican or Democrat based on the 2016 presidential candidate who received the majority vote for that county (2016Pres_pref). This partisan variable strongly correlates with the general ideological leaning of the county (MIT, 2018). This variable controls for community ideology across the US within urban, suburban, and rural areas. I selected this variable because the ability to design and develop a hazard mitigation response plan is not void of political or ideological influence (YPCC, 2019).

The perceived level of natural disaster threats is typically viewed with a partisan or ideological lens (YPCC, 2019). Therefore, political office holders may choose to design a natural hazard preparedness plan in a manner that constituents will be happy with, not the plan that may be warranted. As a result, the plan accepted by a community that believes in limited government interference in their affairs may be different from one where the community supports greater government involvement. Suppose a political leader's motives are incentivized by a guaranteed win in the next election. In that case, there will always be the danger of preparing for a natural hazard event that conforms to the community's political preferences rather than the actual degree of need (Ballew et al., 2019). Political preferences highlight challenges that may call for new solutions to natural hazard preparedness in urban, suburban, and rural settings. Therefore, considering this need, one purpose of this research is to assist policymakers with a greater understanding of why the reception of natural hazard resiliency tools from government entities may vary across urban, suburban, and rural regions.

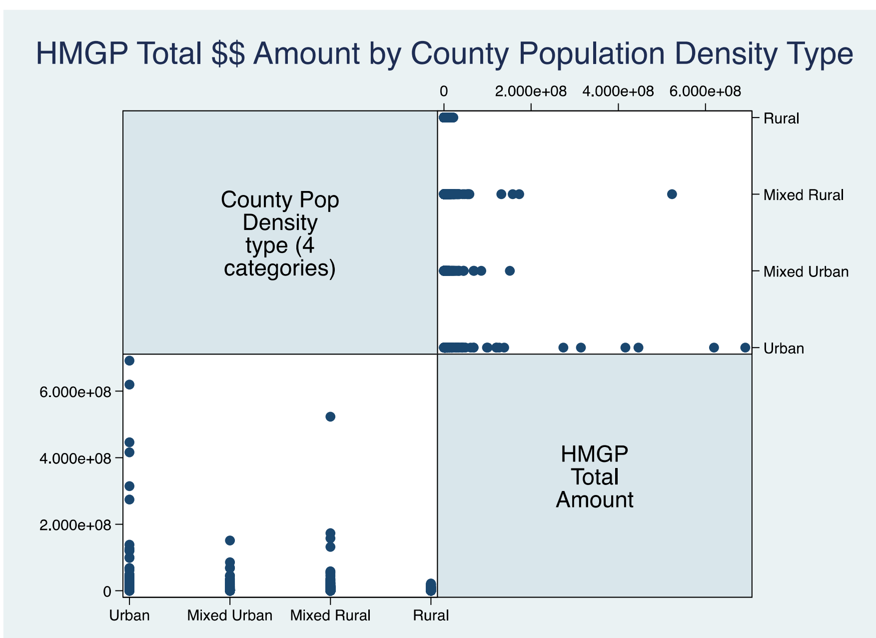
I control for the dollar amounts associated with the receipt of FEMA Hazard Mitigation Grant Program (HMGP) grants to states and local governments to implement long-term hazard mitigation measures after a major disaster declaration. I generated two different variables in my model to address the nature of natural disaster type and exposure frequency (Nat_Dis_exp) and federal and local investments to mitigate these disasters at the county level (HMGP_total). The variables are derived from FEMA reported data as of January 2018 for each official Presidential major disaster declaration in the areas of the state requested by the governor (FEMA, 2018).

The amount of HMGP funding available is based on the federal assistance to be provided by FEMA for disaster recovery under the Presidential major disaster declaration combined with the local match to the federal HMGP award reflecting the total project award amount. The federal component of the HMGP grant reflects only a portion of the total award, up to a 75% maximum. The remaining 25% portion comes from the state, local government, or private donors. So rural or suburban areas with a limited capacity tax base are often further burdened by the HMGP local match component. This variable controls for variation in states' access to and approval of federal HMGP grant dollars, which may be used by governments, businesses, and homeowners, and non-profit entities to address post-disaster property loss, mitigation needs, and natural hazard preparedness planning. This variable in the model is a function of how the FEMA regulations are expressed locally, not a function of preparedness. Per regulation theory, it controls for the local expression of the FEMA and state hazard plan regulations via their local commitment to the required 25% matching of funds for the HMGP.

The HMGP data are not reported at a FIPS or county-level. FEMA uses a disaster declaration identification number to report and track approved HMGP fund activities, not FIPS code county data. For example, the HMGP award total may have been approved for six counties; however, the FEMA reporting aggregates the obligated dollars for the six counties making it very difficult to discern the individual county level dollar values. An additional limitation is when the federal grant obligation to the state results in the benefit of multiple counties that may or may not have been directly associated with the natural disaster event. Therefore, I selected only the HMGP data (FEMA, 2018) for each unique county within 48 states. The use of the individual county local match fund allocation minimizes the error associated with assuming or guessing about how these federal matching dollars may have been allocated amongst the state and counties. This decision reduces the overall number of observations for my model from 3,110 to 2,389 counties. Figure 4-4 presents the HMGP total dollars by county population density type. The ability to discern federal and local matching interests specific to the county in my model is a conservative approach. The approach minimizes the uncertainty of each county within the statewide or multi-county HMGP funding allocation. It outweighs the value of the increased sample size in my model and any related HMGP award uncertainties.

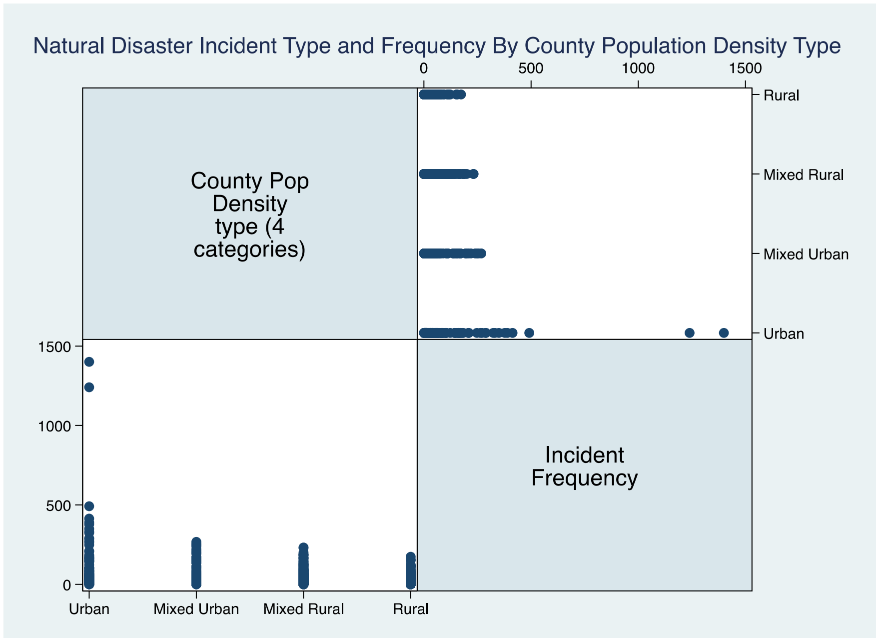
It is important to note that approved HMGP funds may not reflect all FEMA disaster declarations authorized by the US president per the 1988 Stafford Act for each county. Once FEMA has conducted the disaster assessment with state and local government input, it determines the nature and extent of the HMGP award. The interest, desire, and ability to participate in the HMGP may vary based on the disaster assessment findings. Recognizing that natural disaster declarations and natural hazard preparedness may reflect endogeneity in my model, I rely on Reeves (2011) work. Reeves (2011) posits disaster declarations may not represent potential endogeneity as a natural hazard preparedness control variable. They are politically motivated decisions that presidents use to gain electoral support, not natural disaster exposure conditions and mitigation measures. Specifically, Reeves (2011) evaluated presidential disaster declarations from 1981 to 2004 and found a state's electoral competitiveness influences whether they receive a disaster declaration from the president. Accordingly, a highly competitive state can expect to receive twice as many presidential disaster declarations as an uncompetitive state (Reeves, 2011). The work of Reeves (2011) is further nuanced in my model by selecting only counties that have agreed to the HMGP local match component. Therefore, this variable reflects the political motivation of a president and the nature of the state and local political will to match federal funds to participate in the FEMA mitigation program, not potential endogenic natural disaster exposure preparedness conditions.

Figure 4-4: HMGP Total Dollars by Population Density Type



I control for the frequency and variation in the type of natural disasters that may occur across the US (e.g., tornado, wildfire, coastal storm, etc.). To do this, I created a weighted variable that combines the total number of overall exposures or frequency of natural disaster events with the total number of types of natural hazards recorded for each county. The variable (Nat_Dis_exp) was derived from the 2,389 counties reported for the HMGP_total variable. This variable aims to control for variation of geographic incident types and the frequency of exposures for all counties across the contiguous US. Geography matters in my model therefore it is valuable to address the regions across the US that experience differing natural hazards types and frequencies. I created this county-level variable to account for regional geographic differences in natural hazard types and total number of disaster incidents. Not all natural disaster occurrences result in a FEMA Disaster Declaration per the Stafford Act and not all Stafford Act declarations result in federal FEMA HMGP funds. Figure 4-5 presents the natural disaster incident frequency and types by county population density type. The model variable does not attempt to link the importance of sustainability and resilience to climate change nor address the differences in their definitions and practices. There is significant literature about how sustainable communities, climate change, social vulnerability, and natural disaster events are interrelated and inform policy and process (Berke et al., 2012; Biggs et al., 2015; Cutter, 2016; Cutter et al., 2003; Homsey & Warner, 2013; Pike et al., 2010; Redman, 2014). However, that is not the policy lens that informs FEMA's natural hazard policy regulations.

Figure 4-5: Natural Disaster Frequency and Type by Population Density Type

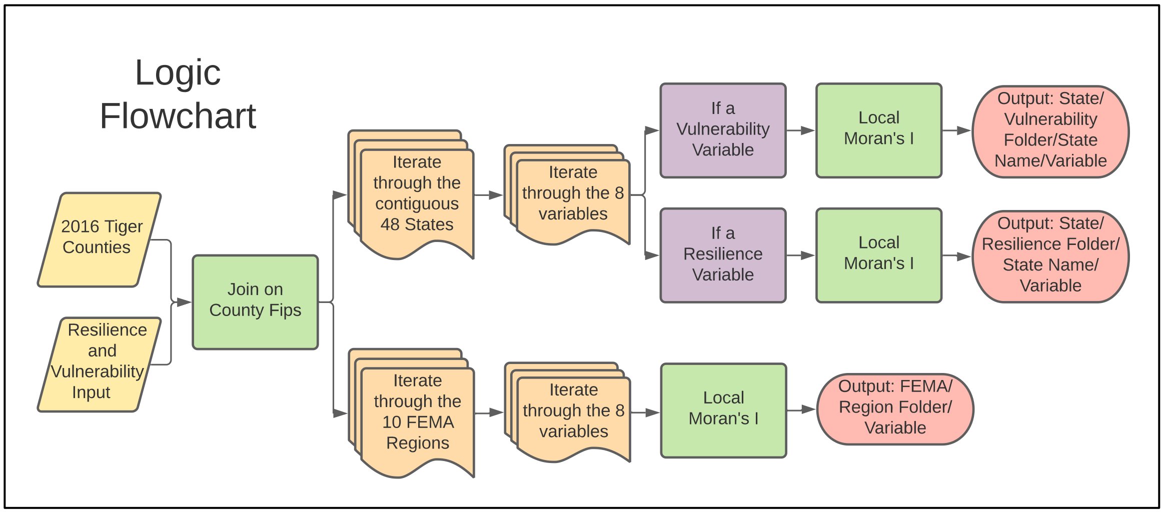


4.3 Local Moran's I (LISA) Spatial Statistic Details

I evaluate the four DV county-level resilience and vulnerability scores for spatial autocorrelation using LISA to examine if urban, mixed urban, mixed rural, and rural county-level spatial patterns or clusters are present within each state across the 10 FEMA regions. The number of observations for the spatial analysis includes 3,107 counties, as it is not limited by the 'adjcatlogit' regression model FEMA unique county HMGP award criteria. I apply a differential local Moran's I analysis implemented in ArcPro Esri software (Anselin, 1995) to identify the statistically significant clusters with hypothetically higher resilience conditions than hypothetically lower vulnerability conditions. The LISA analysis is commonly used to estimate the spatial autocorrelation between neighboring features. Spatial weight is defined using the *k*-nearest neighbors (KNN) algorithm with spatial neighbors. KNN is an asymmetrical spatial-weighting method (Getis & Aldstadt, 2010) and is particularly useful for spatial features with different sizes, such as counties (Chi & Ho, 2018; Tu et al., 2012). It ensures that the same number of nearby spatial features is used in all calculations, independent of the total number and size of spatial neighbors. For my analysis, I only compare county spatial patterns within states, not across states. The FEMA region LISA results presented in Appendix B display the individual county-level state results for that region.

LISA measures whether the local spatial association of the MTP resilience and vulnerability data for each county is similarly related to a neighboring county (Anselin, 1995). The Monte Carlo permutation approach is used to test for the significance of these neighboring county associations (Anselin, 1995). The neighbor association assumes "that the rate understudy is equally as likely to be observed at any location, so the observed values are randomly shuffled over the given spatial units, and the LISA is re-calculated for each permutation" (Tu et al., 2012, p. 198). For the LISA analysis, the significance is determined by generating a reference distribution using a sufficiently large number of the permutations. For this study, the value 499 was used as the reference distribution (Tu et al., 2012). Figure 4-6 presents the spatial analysis logic flowchart. Each state LISA analysis results in a series of cluster maps to illustrate the hypothetical local spatial patterns. Appendix B presents the results of the five categories of county-level spatial units defined as "high-high (HH)", "low-low (LL)", "high-low (HL)", "low-high (LH)", or "not significant (NS)" for each of the contiguous states and the 10 FEMA regions.

Figure 4-6: Spatial Analysis Logic Flowchart



It is important to note that for the LISA, I use the numerical value for each of the DV resilience and vulnerability conditions prior to them being rescaled and categorized into the MTP categories of HH, HL, LL, LH. These contiguous MTP data measures indicate the higher the resilience value; the hypothetically more prepared a county may be. The lower the vulnerability value, the hypothetically less vulnerable or more prepared a county may be. Therefore, high resilience adjacent relationships and low vulnerability adjacent relationships reflect more preparedness as compared to low resilience and high vulnerability clusters. Figure 4-7 through 4-10 present the MTP county resilience/vulnerability LISA results of the urban, mixed urban, mixed rural, and rural spatial patterns for the State of North Carolina (Appendix B includes each of the contiguous state and 10 FEMA region LISA map books).

Figure 4-7: North Carolina MTP Economic R/V LISA Results

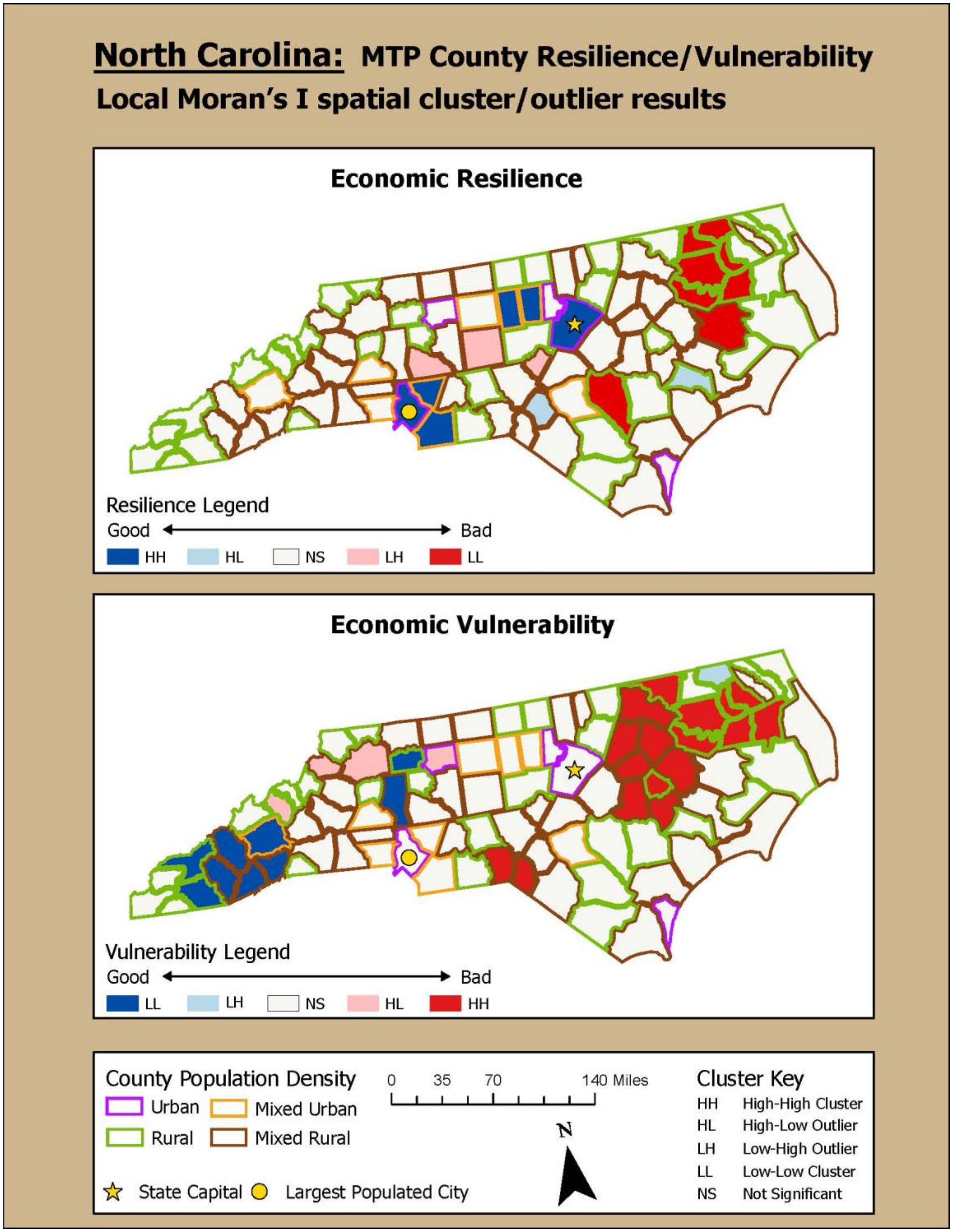


Figure 4-8: North Carolina MTP Environment R/V LISA Results

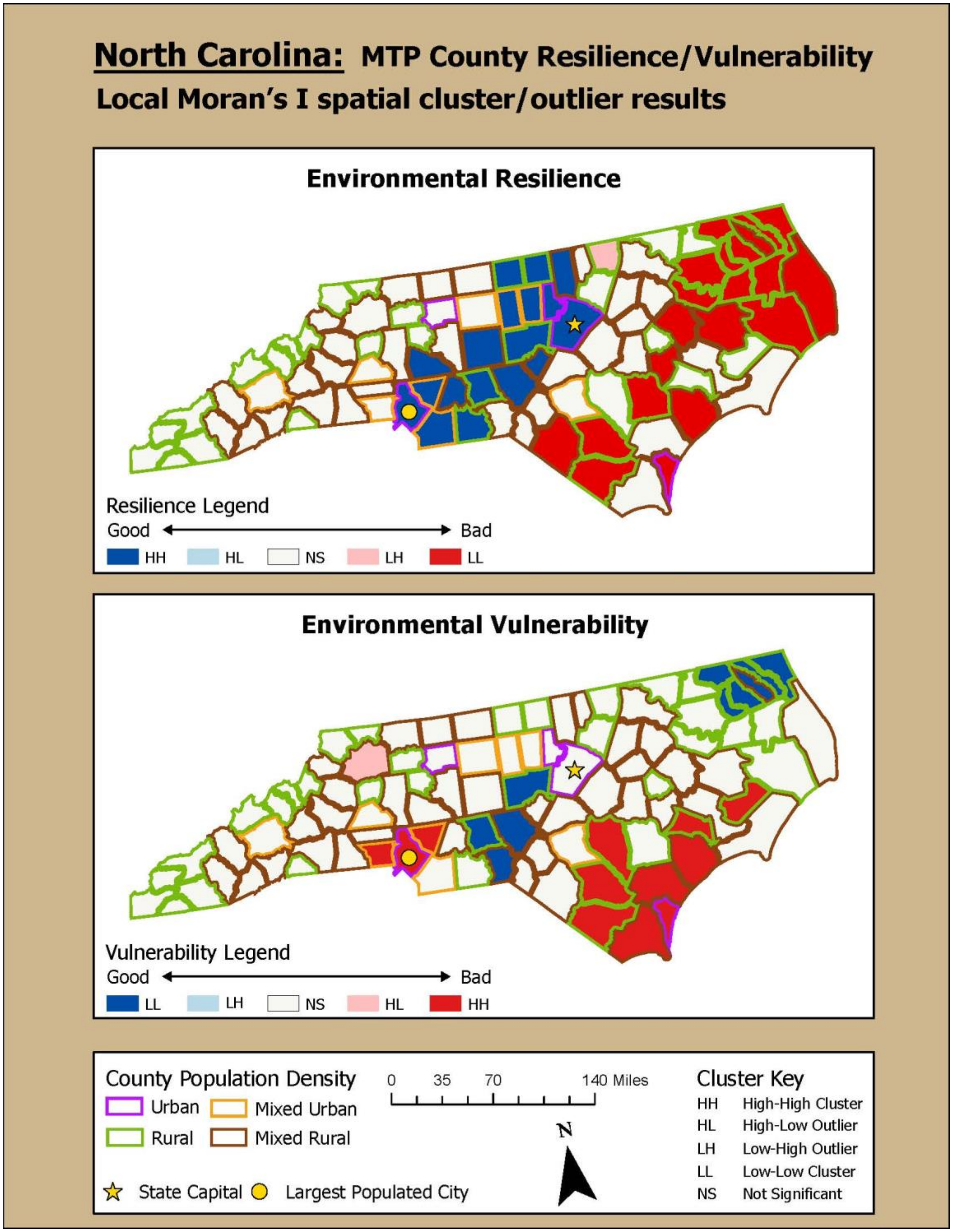


Figure 4-9: North Carolina MTP Infrastructure R/V LISA Results

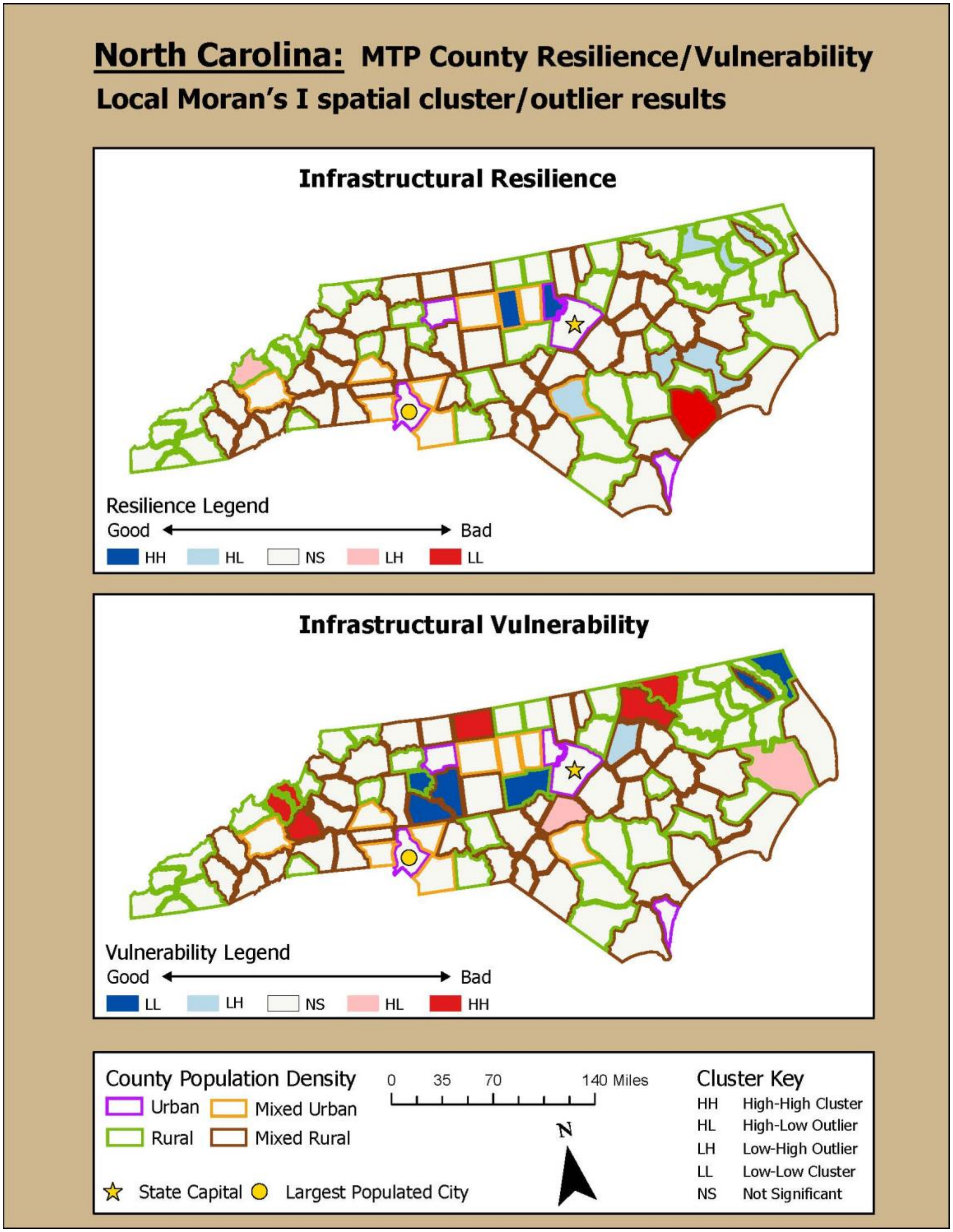
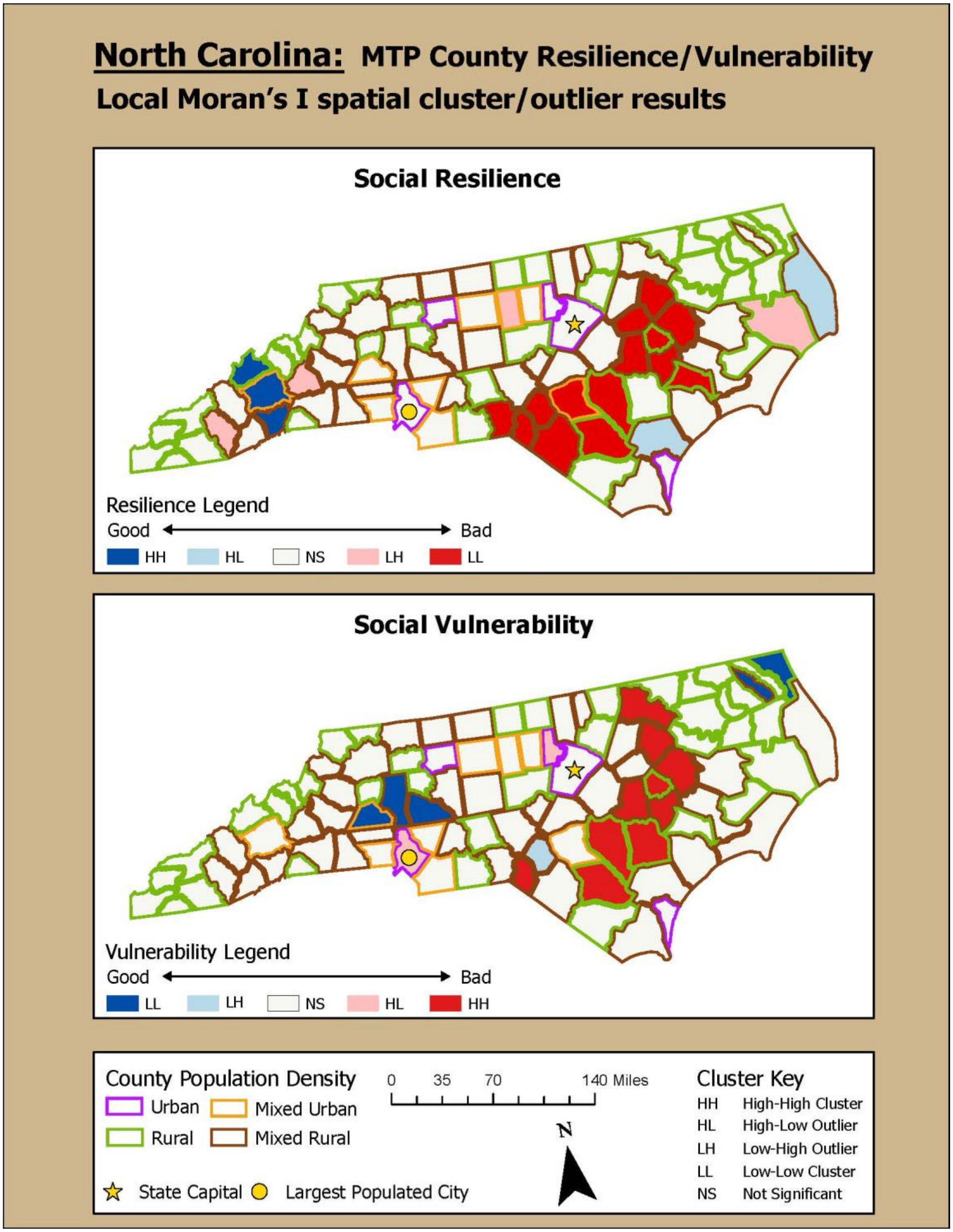


Figure 4-10: North Carolina MTP Social R/V LISA Results



I selected the LISA spatial statistic based on Tu et al., 2012, who used a county-level LISA analysis to examine the presence of low-birthweight clusters and race in the state of Georgia. My research design aligns with Chi and Ho (2018), who used a combination of spatial multicriteria analysis, zonal statistics, and spatiotemporal modeling to introduce the concept of "*population stress*," as areas with populations growing faster than the lands available for sustainable development. Their study used a LISA for contiguous US counties. It determined the county's population growth is associated with the decrease of land developability and the spatial influences of surrounding counties. Chi and Ho (2018) found the factors contributing to population stress may differ from place to place. The Chi and Ho (2018) findings indicate the "population stress" concept is useful and innovative for understanding growth pressures from adjacent counties due to land development practices and may serve to support sound, sustainable land-use policies.

In summary, the study concludes coordination among local governments and across different levels of governments is a must for effective land use planning (Chi & Ho, 2018). More broadly, the authors posit land developability linked to population change may support identifying hot spots of population-environment conflicts, including wildfire-urban interfaces, coastal and flooding areas, exurban areas, ecosystem areas around national parks, and declining urban areas. I selected Tu et al. (2012) and Chi and Ho (2018) approach because of shared research goals to provide insights and visual tools at the US county-level to assist with efficient and effective policies to tackle public complexity health-related population dynamics and population-environment conflicts.

It is important to recognize the literature indicates limitations with the use of a LISA statistic. Limitations include normality and randomization assumptions that do not reflect real-world phenomenon, theoretical matters associated with its analytic distributional properties, and multiple testing problems (Waller & Gotway, 2004). Additional limitations include outcome values sensitive to factors such as the choice of the null hypothesis, the definition of neighborhood, and the analytical scale. (Tu et al., 2012). However, the literature indicates these limitations should not discourage the application of LISA measures applied to public health and environmental policy studies (Tu et al., 2012; Chi & Ho, 2018).

4.4 Qualitative Methods

Based on the literature, urban, suburban, and rural counties differ in their resilience and vulnerability conditions, particularly in rural areas with socially vulnerable populations, such as the US's southeastern region (Berke et al., 2012; 2015; Cutter, 2016; Dabson, 2007; 2011; Horney et al., 2012; Partridge et al., 2009). In rural preparedness, problems include limited funding for ambulance and fire staff; travel impedances, such as mountains; longer response times for emergency personnel; out-migration of young people, which affects workforce and staffing. Also, because infrastructure is more expensive per capita, communication systems may be substandard or non-existent. On the other hand, compared to urban areas, rural areas tend to have strong collective action traditions to accomplish public improvements and provide for safety, which helps to build social capital, which is an asset for hazard preparedness activities. Suburban or mixed urban and mixed rural areas are also growing in their immigrant populations and based on the nature of their industrial base and geographic location, also reflect differing socio-economic dynamics based on their urban neighbors.

I use the 'adjcatlogit' and LISA analysis to tell the story of place and space. My quantitative comparative analysis results inform the interviews conducted with the 10 FEMA region Community Preparedness Officer (CPO). Based upon my research and conversations with former FEMA personnel and colleagues at the USEPA, I used a purposive approach (Creswell, 2015) to determine what division in FEMA would be best to speak with about my research. It was determined the most relevant and accessible are the 10 FEMA region CPO leads. The CPO for each region reflects the front-line FEMA community communicators that work with the state leads and local officials and stakeholders for FEMA national preparedness policy implementation.

Per the national strategy National Mitigation Investment Strategy ("NMIS" or Investment Strategy), the CPO is charged with coordinating with the states and local governments within their region to assist with hazard mitigation plan development and preparedness measures. The work of the CPO on the ground is coordinated within the NMIS to understand the needs of state and local governments so taxpayer natural hazard investments about when and where to make hazard investments are better informed and effective at the state, local or whole community level. The NMIS encourages the 'whole community' to invest in mitigation, pre-and post-disaster, FEMA goals. The CPOs focus on how the federal government and nonfederal partners can identify, support, influence, and align whole community natural hazard mitigation investments.

The CPO interview is subject to an exemption per the UNCC Institutional Review Board (IRB) due to being conducted under their professional capacity.

The CPO interview questions are as follows:

- What tools or methods are being used in your region to help states and counties develop their preparedness plans?
- Based on your professional experience, do you perceive value for using the MTP map as a visual tool to assist your team identify priority preparedness areas in your region that may be susceptible to a natural hazard event?
- Do you work differently with urban and rural communities within your FEMA region to meet community preparedness needs, if so, why?

My research is designed to assist public officials, hazard planners, emergency management personnel, non-profit and business owners, and local stakeholders in implementing federal natural hazard regulations informed by local resilience and vulnerability conditions. This context-sensitive understanding contrasts with what Cutter et al. (2016) refer to as a 'one-size-fits-all' federal mandated state-level policy implementation measures. The literature supports my research goal (Cutter et al., 2016; Tate, 2012; 2013) and recently revised FEMA protocols such as the National Mitigation Implementation Strategy (NMIS, 2019) and BRIC (DRRA Section 1234, 2018). The literature about the importance of understanding the social vulnerability conditions of communities is particularly relevant for rural areas who rely on regional resilience partners that are both near and far from their community (Berke & Lyles, 2012; Birkland, 2009; Cutter et al., 2016; Dabson, 2007; 2011; Homsey & Warner, 2013; Horney et al., 2012).

As clarified previously, my research interest is not to evaluate US climate science and climate change measures via the mitigation measures and adaptation approaches implemented via federal natural hazard policy. FEMA provides states with technical support and funding to develop their hazard plans to be eligible for federal disaster relief aid when a disaster is declared (DMA, 2000). FEMA is not a natural hazard prevention regulatory entity, despite its role in minimizing community disaster exposure risks.

My research design strives to use a comparative, readily understood resilience and vulnerability map image to drive SHP development towards a more equitable implementation while bolstering rural regions. The value of rural areas to the US and global economy includes but is not limited to air quality, food and water supply, ecosystem services such as natural amenities and tourism, and experiences that enhance citizens' quality of life. The 21st-century challenges for US rural communities include changing demographics, immigration resulting in increasing population diversity and spoken languages, closing of rural health care centers, and responding to a global agricultural, energy production, and manufacturing economy (Cutter et al., 2014; Partridge et al., 2009; USDA, 2016). I expect that my research will be a fulcrum for implementing effective regional US natural hazard policy that defies jurisdictional boundaries that, by design, may limit the ability to ensure equitable resilient measures and practices for communities.

CHAPTER 5: Research Results and Findings

In this chapter, I present the results of the hypothesis tests for the Missouri Transect Project (MTP) natural hazard preparedness variables. I discuss how my research serves as an opportunity to test the part of regulation theory that posits FEMA and state natural hazard policies and regulations are reflected locally. Thus, certain vulnerable populations and geographic regions may limit FEMA's ability to achieve its mission of equal protection of all US citizens regardless of where you live. It also presents an opportunity to examine how center-periphery theory implications for urban economic growth and rural economic limitations inform regional natural hazard preparedness conditions. I examine the question "Are urban areas more prepared for a natural disaster event than suburban and rural areas?" I test if the visualization of state and FEMA region MTP resilience and vulnerability conditions across the urban-rural continuum assist stakeholders to prioritize vulnerable populations and identify advantageous partnerships. Although there are many caveats associated with the ability to predict improved natural hazard preparedness, my findings indicate the MTP does support understanding about what it may mean to be ready for a natural hazard occurrence.

The MTP in my research serves as a measure for evaluating differences in county resiliency and vulnerability conditions; it informs how prepared a community may be when faced with a natural disaster occurrence. I examine if the probability of the MTP increased preparedness conditions can be predicted for urban, suburban, and rural areas and across the 10 FEMA regions. I also examine the existence of adjacent spatial county-level cluster/outlier relationships and gain insight from FEMA community preparedness professionals about the value of the MTP resilience and vulnerability spatial relationships as a community natural hazard preparedness tool.

The theoretical construct for my hypotheses is based on regulation theory (Aglietta, 1979; Painter 1977) which posits regulation expresses itself locally based on the nature of community capital. I examine how center-periphery theory (Friedmann, 1966; 1972) which posits regional economies reflect urban prosperity via human capital while rural prosperity due to its reliance on physical capital is limited. Thus, regional resilience conditions are informed by the increase of urban prosperity and resources and more vulnerable in rural areas due to shrinking capital and social investments. The theoretical construct of regulation theory supports my hypothesis that the probability of increased natural hazard preparedness conditions may be predictable across the urban-rural continuum based on the implementation of state hazard plans, land use regulations, hazard risk building codes and previous HMGP investments. I include the urban-rural and FEMA region dynamics based on center-periphery theory's theoretical construct, which posits preparedness conditions may be inhibited due to economic limitations in less dense suburban and rural areas as compared to urban and mixed urban areas.

5.1 Logistic Regression Results

I conducted the same four-category adjacent categorical logistic regression model for each of the four DV's based on the nature of their preparedness measured by their MTP high or low resilience and vulnerability values (N=2,389). Tables 5-1 through 5-4 present the MTP logistic regression model OR values, and results for the significant variables ($p = 0.05$). Figures 5-1 through 5-4 present the MTP model prediction graphs (95% confidence intervals). The results for hypotheses 1, 2, and 3 are summarized below.

Hypothesis 1: Rural counties, compared to suburban and urban counties, are more likely to be less prepared for a natural hazard event despite enhanced government intervention.

- The MTP economic variable model indicates no significance for urban, suburban, or rural counties, rejects hypothesis 1.
- The MTP environment variable indicates mixed rural counties have decreased odds (OR = 0.56) when compared to rural counties to be in the next more prepared for a natural hazard event category, rejects hypothesis 1.
- The MTP infrastructure variable indicates mixed urban counties have increased odds (OR = 4.59) when compared to rural counties to be in the next more prepared for a natural hazard event category, supports hypothesis 1.
- The MTP social variable indicates mixed rural counties have increased odds (OR = 1.51) when compared to rural counties to be in the next more prepared for a natural hazard event category, supports hypothesis 1.

Hypothesis 2: Due to the nature of federal hazard plan policy regulations, the 10 FEMA regions are more likely to reflect similar than unique patterns of urban, suburban, and rural county-level natural hazard preparedness conditions.

- The MTP economic variable indicates FEMA Region 3 (OR = 8.00), Region 5 (OR = 4.38), Region 6 (OR = 2.67), Region 7 (OR = 7.03), and Region 8 (OR = 6.69) have increased odds when compared to the Region 4 counties to be in the next more prepared for a natural hazard event category, rejects hypothesis 2.
- The MTP environment variable indicates FEMA Region 6 (OR = 0.036), Region 7 (OR = 0.099), and Region 10 (OR = 0.04) have decreased odds when compared to the Region 4 counties to be in the next most prepared for a natural hazard event category, rejects hypothesis 2.
- The MTP infrastructure variable indicates FEMA Region 1 (OR = 0.27), and Region 6 (OR = 0.65) have decreased odds when compared to the Region 4 counties to be in the next most prepared for a natural hazard event category. FEMA Region 5 (OR = 3.25), Region 7 (OR = 1.96), and Region 8 (OR = 4.75) have increased odds when compared to the Region 4 counties to be in the next more prepared for a natural hazard event category, rejects hypothesis 2.
- The MTP social variable indicates FEMA Region 1 (OR = 14.52), Region 2 (OR = 5.44), Region 3 (OR = 2.94), Region 5 (OR = 3.13), and Region 8 (OR = 2.07) have increased odds when compared to the Region 4 counties to be in the next more prepared for a natural hazard event category. FEMA Region 6 (OR =0.361) have decreased odds when compared to the Region 4 counties to be in the next most prepared for a natural hazard event category, rejects hypothesis 2.

Hypothesis 3: Counties in states with more adopted state hazard plans and risk-reducing building code regulations are more likely to have increased natural hazard preparedness conditions than counties in states with fewer state-adopted hazard plans and building code regulations.

- The MTP economic variable indicates counties with an increase in ATTOM (2016) building insurance risk values (OR = 1.01) have increased odds of lower building risk value counties to be in the next more prepared for a natural hazard event category, supports hypothesis 3.
- The MTP environment, infrastructure and social variables indicate no significant relationships for state hazard regulations, and county building risk codes and county-level natural hazard preparedness conditions, rejects hypothesis 3.

Additional model results indicate the following:

- The MTP environment variable indicates counties with increased natural disaster incidents and frequencies (OR = 0.989) have slightly decreased odds of counties with less natural disaster incidents and frequencies to be in the next more prepared for a natural hazard event category.
- The MTP social variable indicates counties with increased natural disaster incidents and frequencies (OR = 0.990) have slightly decreased odds of counties with less natural disaster incidents and frequencies to be in the next more prepared for a natural hazard event category.
- The MTP economic (OR = 3.14), environment (OR = 2.14), infrastructure (OR = 3.64), and social (OR = 4.1) variables indicate counties with a majority republican

vote for president in the 2016 election have increased odds of majority democratic counties to be in the next more prepared for a natural hazard event category. This model result is influenced by the nature of 1,988 counties identified as republican in the model as compared to 401 identified as democratic counties. However, this variable may serve as an interesting model predictor when tracked over time.

- All model pseudo R2 model values for all DV's are limited in their ability to predict natural hazard preparedness for counties. The model pseudo R2 values decrease in order from environment (0.2771), social (0.2006), infrastructure (0.1780), and economic (0.1521) MTP variables.
- The model prediction graphs at the 95% confidence interval indicate increased prediction associated with the most prepared DV counties, the most frequently reported DV value for the MTP variables. The infrastructure, social and economic MTP variables appear to be potentially a better overall predictor than the environment variable.

The model goodness of fit tests was conducted using the 'ogologit' command (Fagerland & Hosmer, 2017). The four tests included in the 'ologitgof' are designed to be tools to detect lack of fit, they are not intended to provide proof a model is well fit to the data. The ordinal HL and Lipsitz tests work best with continuous covariates and the two PR tests (chi2 and deviance) work best with categorical covariates (Fagerland & Hosmer, 2017, p. 684). Fagerland and Hosmer (2013, 2016) indicate the four tests have good power with moderate to large sample sizes, ideally tests for goodness of fit should be accompanied by case wise diagnostic tools, however these options are not widely available for ordinal models.

None of the 4 DV's were determined to indicate goodness of fit for the adjacent category regression model. All DV models were found to be significant for the ordinal HL test, the Lipsitz test and the two PR tests (chi2 and deviance). As suggested by Fagerland and Homer (2017) I tested the model using an unconstrained continuation-ratio model, (ucrlogit) the results are similar. Currently, no goodness of fit test exists for the unconstrained continuation-ratio model (Fagerland & Hosmer, 2017, p. 685). The results align with a memorable quote provided by my statistics and economics professors during my academic career, the statement by George Box in 1976 "all models are wrong, some models are useful" (Box, 2013, p. xii). The University of Wisconsin statistician was making a point that it is important to focus more on whether something can be applied to the real word condition in a useful manner rather than focusing on a debate about whether an answer is correct in all cases.

Table 5-1: MTP Economic Logistic Regression Model Results (p = 0.05)

Economic Preparedness	Odds Ratio	P>|z|	95% Confidence Interval
FEMA Region vs. Region 4			
3	8.00	0.000	4.55 - 14.06
5	4.38	0.000	2.94 - 6.53
6	2.67	0.000	1.75 - 4.08
7	7.03	0.000	4.59 - 10.78
8	6.69	0.000	4.14 - 18.82
Presidential 2016 Majority Vote			
Rebublican vs. Democrat	3.14	0.000	1.86 - 5.28
Natural Risk Building Code Rank	1.010	0.043	1.00 - 1.02
Psuedo R2 = 0.1521			

Figure 5-1: MTP Economic Model Prediction Graphs (95% Confidence Interval)

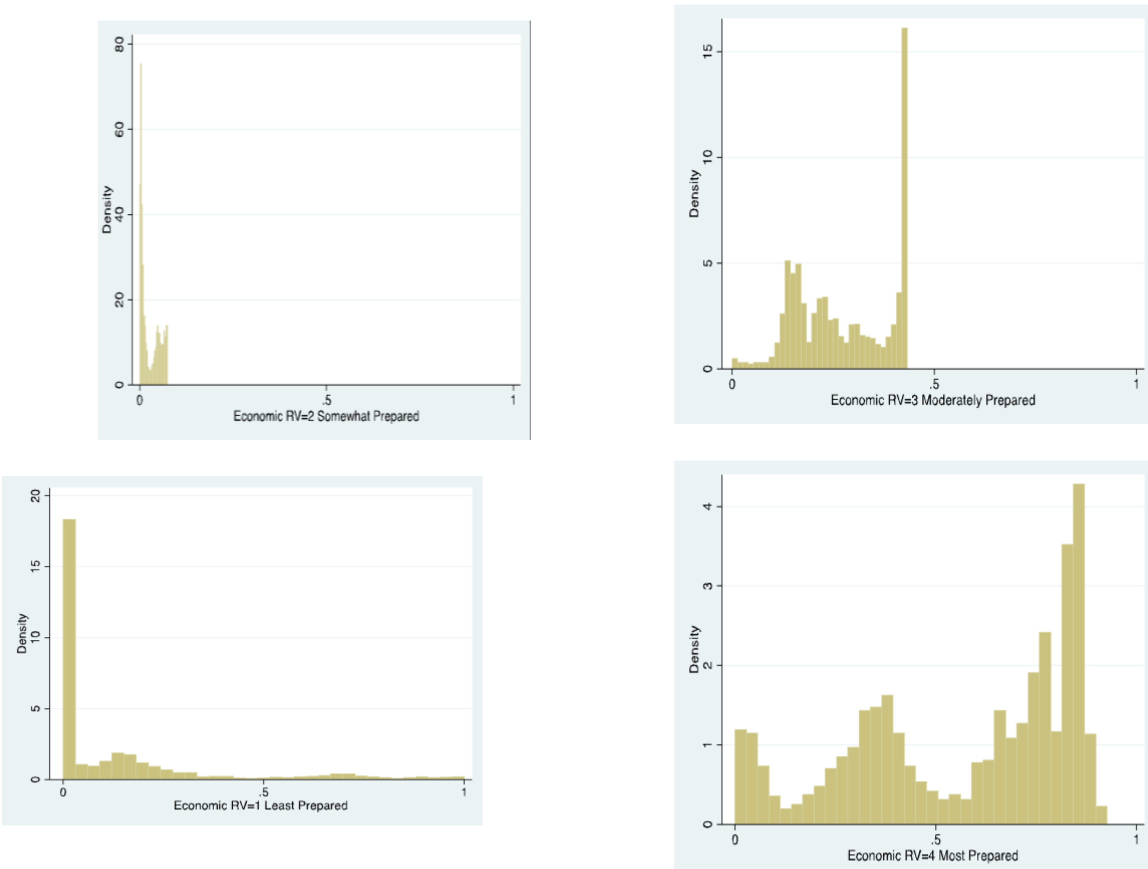


Table 5-2: MTP Environment Logistic Regression Model Results (p = 0.05)

Environment Preparedness	**Odds Ratio**	**P>|z|**	**95% Confidence Interval**
Mixed Rural vs. Rural	0.560	0.001	0.402 - 0.782
FEMA Region vs. Region 4			
6	0.036	0.000	0.019 - 0.069
7	0.099	0.000	0.062 - 0.159
10	0.050	0.000	0.011 - 0.248
Presidential 2016 Majority Vote			
Rebublican vs. Democrat	2.14	0.005	1.26 - 3.62
Natural Disaster Incident Frequency	0.989	0.005	0.981 - 0.997
Psuedo R2 = 0.2771			

Figure 5-2: MTP Environment Model Prediction Graphs (95% Confidence Interval)

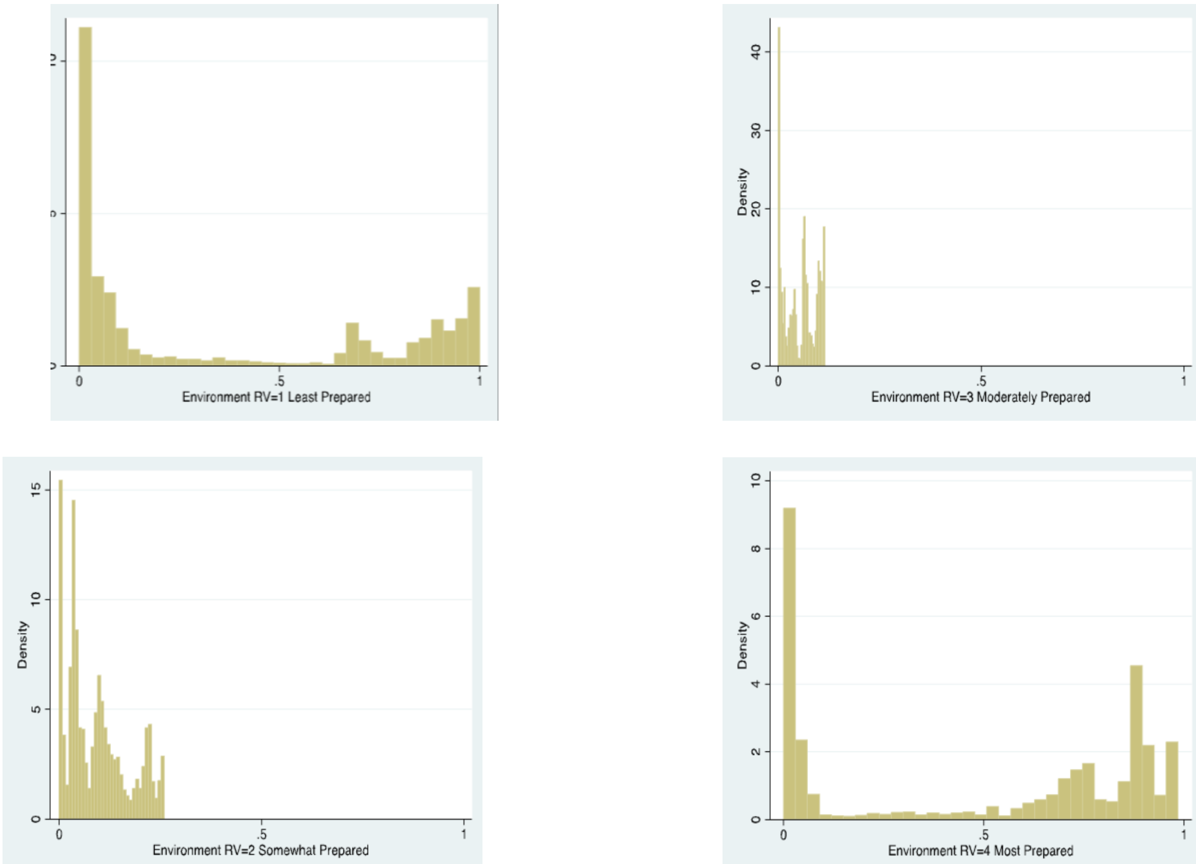


Table 5-3: MTP Infrastructure Logistic Regression Model Results (p = 0.05)

Infrastructure Preparedness	Odds Ratio	P>|z|	95% Confidence Interval
Mixed Urban vs. Rural	4.59	0.025	1.21 - 17.45
FEMA Region vs. Region 4			
1	0.27	0.047	0.074 - 0.982
5	3.25	0.000	2.17 - 4.86
6	0.65	0.037	0.433 - 0.975
7	1.96	0.000	1.35 - 2.84
8	4.76	0.000	2.67 -8.48
Presidential 2016 Majority Vote			
Rebublican vs. Democrat	3.64	0.000	2.04 - 6.50
Psuedo R2 = 0.1780			

Figure 5-3: MTP Infrastructure Model Prediction Graphs (95% Confidence Interval)

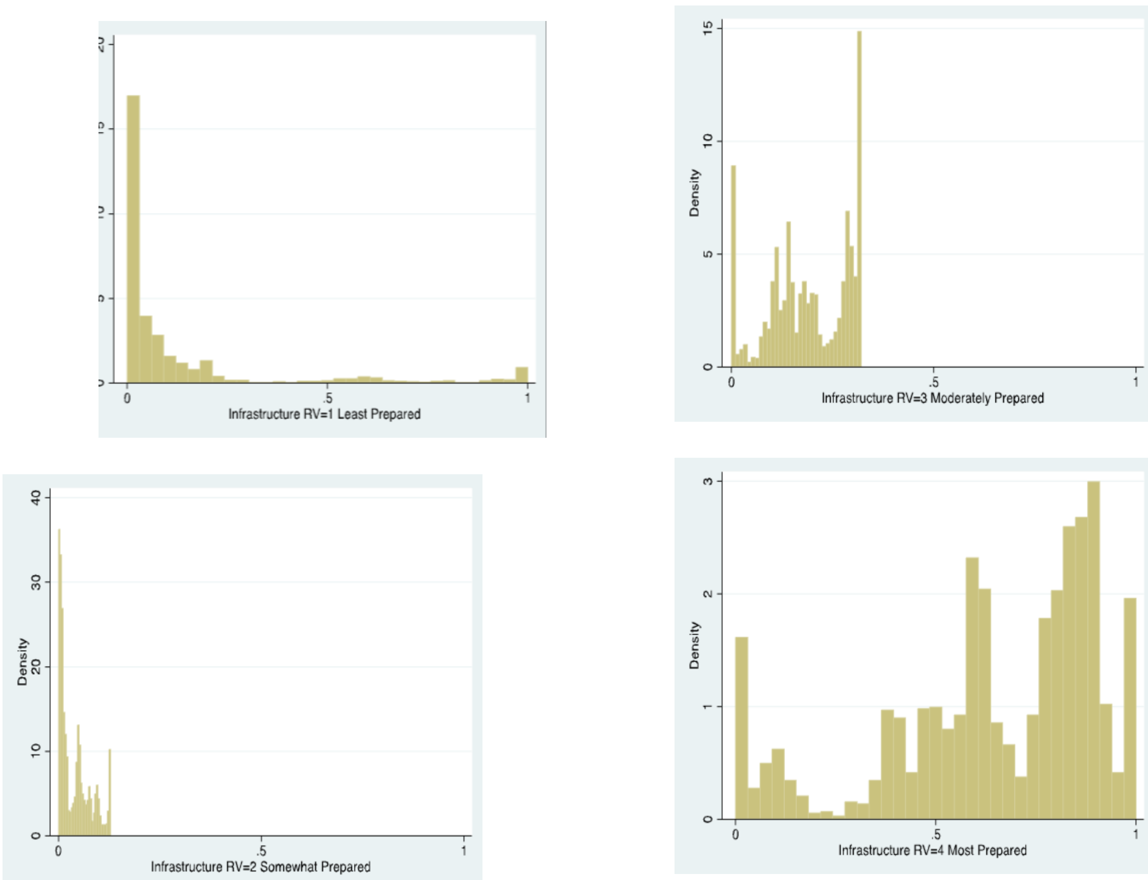
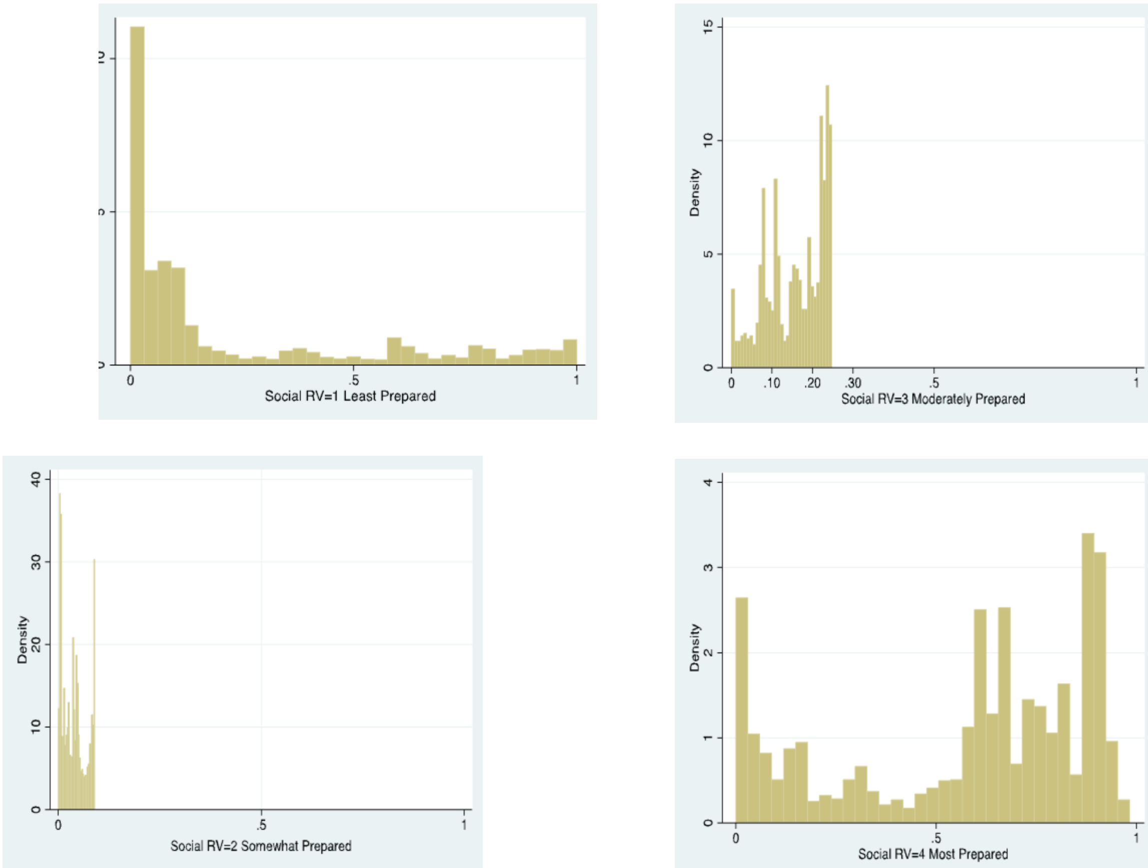


Table 5-4: MTP Social Logistic Regression Model Results (p = 0.05)

Social Preparedness	**Odds Ratio**	**P>|z|**	**95% Confidence Interval**
Mixed Rural vs. Rural	1.51	0.005	1.13 - 2.02
FEMA Region vs. Region 4			
1	14.52	0.005	2.22 - 94.84
2	5.44	0.000	2.30 - 12.87
3	2.94	0.000	1.71 - 5.06
5	3.13	0.000	1.93 - 5.10
6	0.361	0.000	0.23 - 0.56
8	2.07	0.024	1.10 - 3.90
Presidential 2016 Majority Vote			
Rebublican vs. Democrat	4.1	0.000	2.40 - 7.03
Natural Disaster Incident Frequency	0.990	0.002	0.983 - 0.996
Psuedo R2 = 0.2006			

Figure 5-4: MTP Social Model Prediction Graphs (95% Confidence Interval)



5.2 Logistic Regression Model Findings

The model findings for the MTP infrastructure and social variable indicate support for hypothesis 1 that rural counties are less prepared than more densely populated counties despite enhanced government interventions. The model findings reject hypothesis 2 for all four MTP variables. The patterns of preparedness conditions across the 10 FEMA regions are not similar. The model findings indicate limited support of hypothesis 3 that the probability of increased natural hazard preparedness conditions may be predictable based on the implementation of state hazard plan regulations and hazard risk building codes. The findings do not support per regulation theory that states with more adopted natural hazard regulations may reflect enhanced preparedness conditions across the urban-rural continuum as compared those with limited natural hazard regulations in place. The findings per regulation theory, also indicate the local expression of the FEMA and state hazard plan regulations via their local commitment to the required 25% matching of funds for the HMGP does not inform increased natural hazard preparedness.

The findings indicate the nature of the landforms associated with the MTP environment variable may decrease the odds of mixed rural counties as compared to rural counties to be in the next more prepared category. In addition to theoretical tests, my research does indicate the ability to assist hazard planning stakeholders with a greater understanding of about how preparedness conditions vary across urban, suburban, and rural regions. The MTP analyses findings serve as an opportunity to inform future MTP research to better understand what county-level data may serve to promote preparedness among individuals and communities across the US. The findings support FEMA, state, and local hazard plan stakeholder's ability to prioritize technical resources and regional resilience partnerships both near and far.

For example, understanding what MTP social variable data are influencing mixed rural counties as compared to rural counties and five of the ten FEMA regions to be in the next more prepared category when compared to Region's 4 and understanding why Region 6 is more probable to be less prepared than Region 4 is warranted. The MTP social variable findings suggest that counties with increased natural disaster events and frequencies (OR = 0.990) have slightly decreased odds of counties with less natural disaster incidents and frequencies to be in the next more prepared for a natural hazard event category. This supports the posit of regulation theory that the nature and extent of social capital and economics are embedded in the response and recovery to a natural disaster occurrence.

The findings suggest some support for FEMA region dynamics based on the center-periphery theory posit that preparedness conditions are inhibited due to economic limitations in less dense suburban and rural areas as compared to urban and mixed urban areas. However, the findings do not support the MTP economic variable as an overall predictor of preparedness for urban, suburban, or rural population density type counties. Understanding what MTP economic variables are influencing five of the ten FEMA regions increased probability to be in the next preparedness category as compared to Region 4 is warranted. Greater understanding is also warranted about how the MTP economic variable informs counties with an increase in ATTOM (2016) building insurance risk values (OR = 1.01) to have slightly increased odds than lower building risk value counties to be in the next more prepared for a natural hazard event category.

The findings indicate the MTP infrastructure variable informs mixed urban counties as compared to rural counties and FEMA Regions 5, 7 and 8 as compared to Region 4 to have an increase in their probability to be in the next prepared category. The MTP infrastructure variable results suggest decreased probability to be in the next prepared category for FEMA Regions 1 and 6 as compared to Region 4. Greater understanding about why the MTP infrastructure variable indicates no significant relationships for counties in states with enhanced hazard regulations, and county ATTOM (2016) building risk codes regarding natural hazard preparedness conditions is warranted. Particularly in support of the *Building Codes Save: A Nationwide Study* (FEMA, 2020g) finding which indicates by 2040, losses avoided from implementing more resilient building codes across the Nation will save around $3.2 billion annually in property loss. Being able to communicate the importance of enhanced building codes is relevant as FEMA plans to launch a multi-year communication and outreach strategy about the value of adopting resilient building codes to better prepare small communities for the next disaster.

The ability to predict natural hazard preparedness is complicated by many factors. The literature indicates some factors provide useful approximations for understanding the real world however most are not known or well understood (Bakkensen et al., 2017; Cutter et al., 2010; 2016; Dabson, 2015; Miller et al., 2016; NASEM, 2019). The predictability of the MTP variables is on par with the limited real-world implications of many of the natural hazard assessment tools evaluated by NASEM (2019). When compared to the similar study findings of Cutter et al. (2016), which was not grounded in a theoretical test just prudence based on the national scope of the study and previous research, the MTP serves as an additional community hazard planning tool for understanding local and regional resilience and vulnerability conditions.

The literature suggests any resilience planning tool is subject to continued funding and data management to support readily available updates, local customization, and user technical support. The MTP regression findings suggest further exploration of how the data that comprise each of the four MTP index variables (environment, infrastructure, economic, and social) inform county-level urban-rural, and FEMA regional results is warranted.

5.3 Local Moran's I (LISA) Spatial Statistic Results

I evaluate the four DV county-level resilience and vulnerability scores for spatial autocorrelation using LISA to examine if urban, mixed urban, mixed rural, and rural county-level spatial cluster/outlier patterns are present within each state across the 10 FEMA regions (N=3,107).

LISA analysis is commonly used to estimate the spatial autocorrelation between neighboring features. Spatial weight is defined using the k-nearest neighbors (KNN) algorithm with spatial neighbors. KNN is an asymmetrical spatial-weighting method (Getis & Aldstadt, 2010) and is particularly useful for spatial features with different sizes, such as counties (Chi & Ho, 2018; Tu et al., 2012). It ensures that the same number of nearby spatial features is used in all calculations, independent of the total number and size of spatial neighbors. For my analysis, I only compare county spatial patterns within states, not across states. Limitations include normality and randomization assumptions that do not reflect real-world phenomenon, theoretical matters associated with its analytic distributional properties, and multiple testing problems (Waller & Gotway, 2004). Additional limitations include outcome values sensitive to factors such as the choice of the null hypothesis, the definition of neighborhood, and the analytical scale. (Tu et al., 2012).

Table 5-5 presents a summary of the county population density types by FEMA regions. Rural (N = 1,662) and mixed rural (N = 1,062) population density types dominate the contiguous US. Mixed urban (N = 197) and urban (N = 178) population density types are limited throughout the US. Tables 5-6 through 5-13 present a summary of the MTP LISA cluster/outlier results for each DV by FEMA region and county population type. These tables also include the result as the percentage of county population types.

Figures 5-5 through 5-12 present the MTP LISA cluster/outlier results for FEMA region 4 (N = 736, the largest FEMA region). The ability to examine DV LISA patterns by each FEMA region provides context for identifying resilience and vulnerability relationships within states across the region. The state DV LISA patterns are unique for each state. The FEMA region maps are a compilation of states within the region. Appendix B presents the MTP LISA cluster/outlier results for each contiguous state and the 10 FEMA regions.

The LISA analysis supports hypothesis 4 by examining the relationship of adjacent urban, mixed urban, mixed rural and rural counties MTP resilience and vulnerability preparedness values. The cluster/outlier of HH for resilience indicates more potential natural hazard preparedness than LL values. The cluster/outlier of LL for vulnerability indicates more natural hazard preparedness potential than highly vulnerable counties. These are both indicated as blue or ‘good’ on the MTP LISA maps. The opposite condition LL resilience and HH vulnerability indicates reduced natural hazard preparedness potential and is indicated as red or ‘bad’ on the MTP LISA maps. The HL and LH resilience and vulnerability cluster/outlier relationship is shown as either light blue or light red on the LISA output maps. The results of hypothesis 4 are discussed below.

Hypothesis 4: Rural counties adjacent to only other rural counties are more likely to be less prepared for a natural hazard event than rural counties neighboring suburban or urban counties or neighboring suburban and urban counties.

- Rural economic resilience LISA results indicate more LL (21%) results than HH, (8%) indicating the probability of rural population types to be less prepared for a natural hazard than mixed rural (LL=7%/HH=15%), mixed urban (LL=0%/HH=8%), and urban (LL=0%/HH=15%) counties, supports hypothesis 4.
- Economic vulnerability LISA results indicate all county population density types have more or equal LL vulnerability than HH vulnerability patterns, rejects hypothesis 4.
- Rural environment resilience LISA results indicate similar HH (26%) and LL (27%) LISA results. This is true for mixed urban (HH=3%/LL2%) and urban (HH=2%/LL=3%) county population density types. Mixed rural counties have more LL (16%) than HH (13%) environment resilience results indicating a slight probability of mixed rural counties to be less prepared for a natural hazard, rejects hypothesis 4.
- Rural environment vulnerability LISA results indicate more LL (30%) than HH, (18%) indicating the probability of rural population types to be more prepared for a natural hazard than mixed rural (LL=15%/HH=16%), mixed urban (LL=2%/HH=3%), and urban (LL=2%/HH=4%) counties, rejects hypothesis 4.
- Rural infrastructure resilience LISA results indicate more LL (23%) than HH, (8%) indicating the probability of rural population types to be less prepared for a natural hazard than mixed rural (LL=7%/HH=9%), mixed urban (LL=0%/HH=7%), and urban (LL=0%/HH=14%) counties, supports hypothesis 4.

- Rural infrastructure vulnerability LISA results indicate more HH (21%) than LL, (17%) indicating the probability of rural population types to be less prepared for a natural hazard than mixed rural (HH=8%/LL=15%), mixed urban (HH=1%/LL=3%), and urban (HH=2%/LL=3%) counties, supports hypothesis 4.
- Mixed rural social resilience LISA results indicate more LL (15%) than HH (8%) indicating the probability of mixed rural population types to be less prepared for a natural hazard than urban (LL=1%/HH=4%). Mixed urban (LL=2%/HH=3%) and rural county results are comparable for LL (25%) and HH (24%), rejects hypothesis 4.
- Rural social vulnerability LISA results indicate more HH (23%) than LL, (18%) indicating the probability of rural population types to be less prepared for a natural hazard than mixed rural (HH=8%/LL=18%) counties. Mixed urban (HH=2%/LL=3%) and urban (HH=3%/LL=2%) counties are comparable in their HH and LL LISA patterns, supports hypothesis 4.

Table 5-5: Summary of Population Density Types by FEMA Region

FEMA Region	Population Density Type				Total Counties
	Mixed Rural	Mixed Urban	Rural	Urban	
1	21	11	22	13	67
2	36	8	12	27	83
3	87	54	112	29	282
4	265	48	388	35	736
5	214	40	242	28	524
6	190	11	285	17	503
7	89	6	307	10	412
8	62	4	219	6	291
9	49	7	24	10	90
10	57	8	51	3	119
	1,070	197	1,662	178	3,107

Figure 5-5: MTP Economic Resilience LISA cluster/outlier map

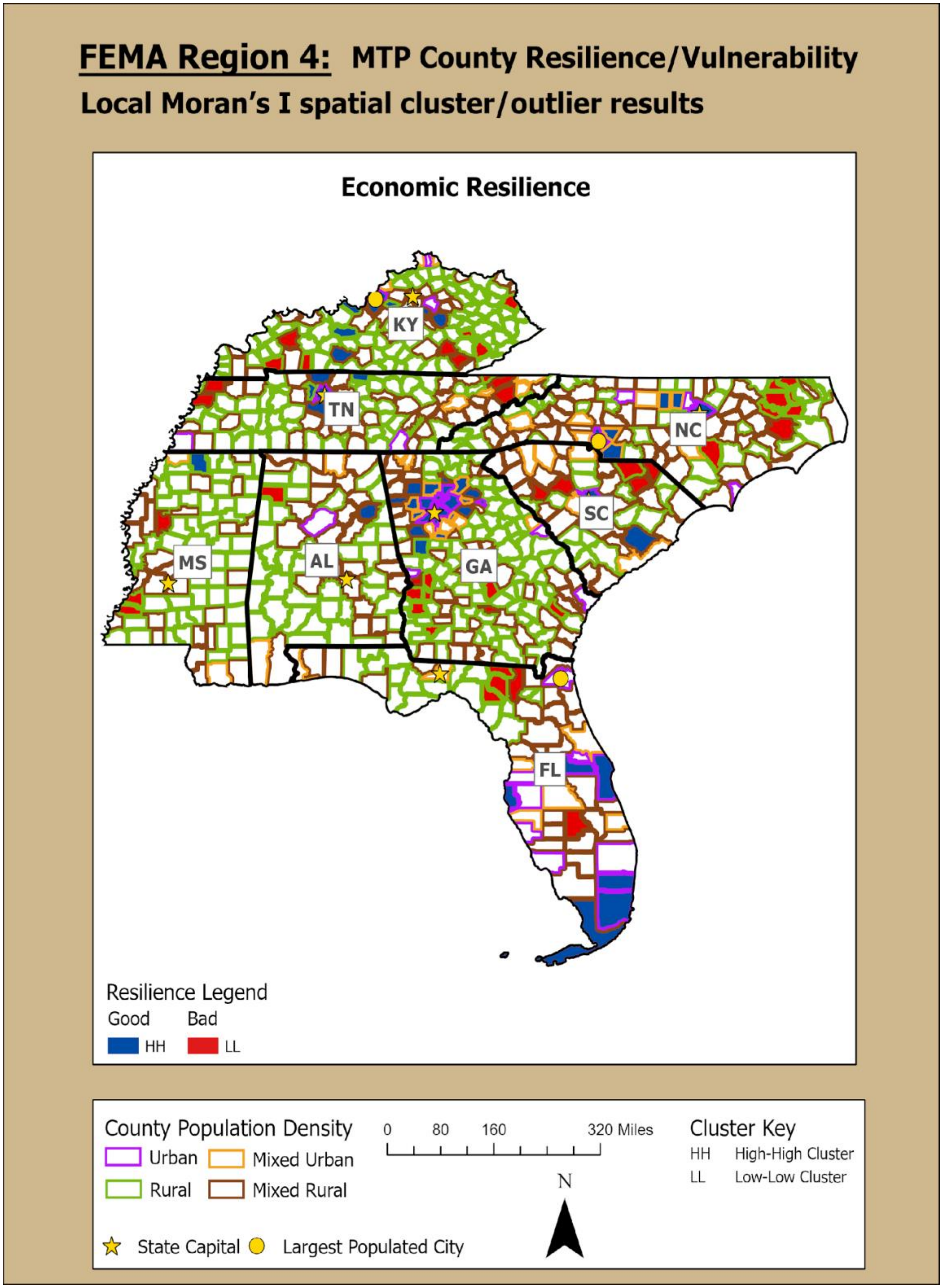


Figure 5-6: MTP Economic Vulnerability LISA cluster/outlier map

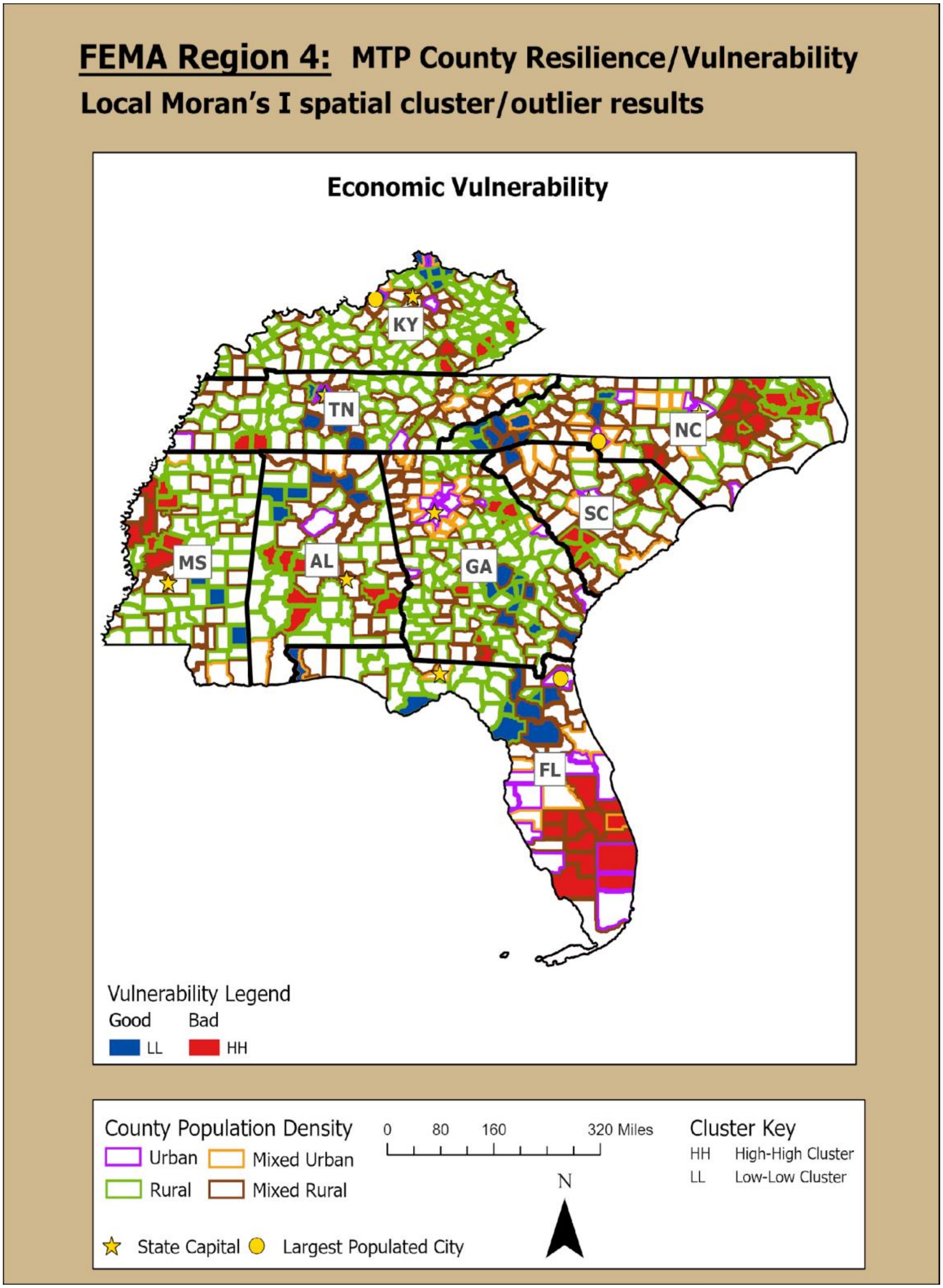


Figure 5-7: MTP Environment Resilience LISA cluster/outlier map

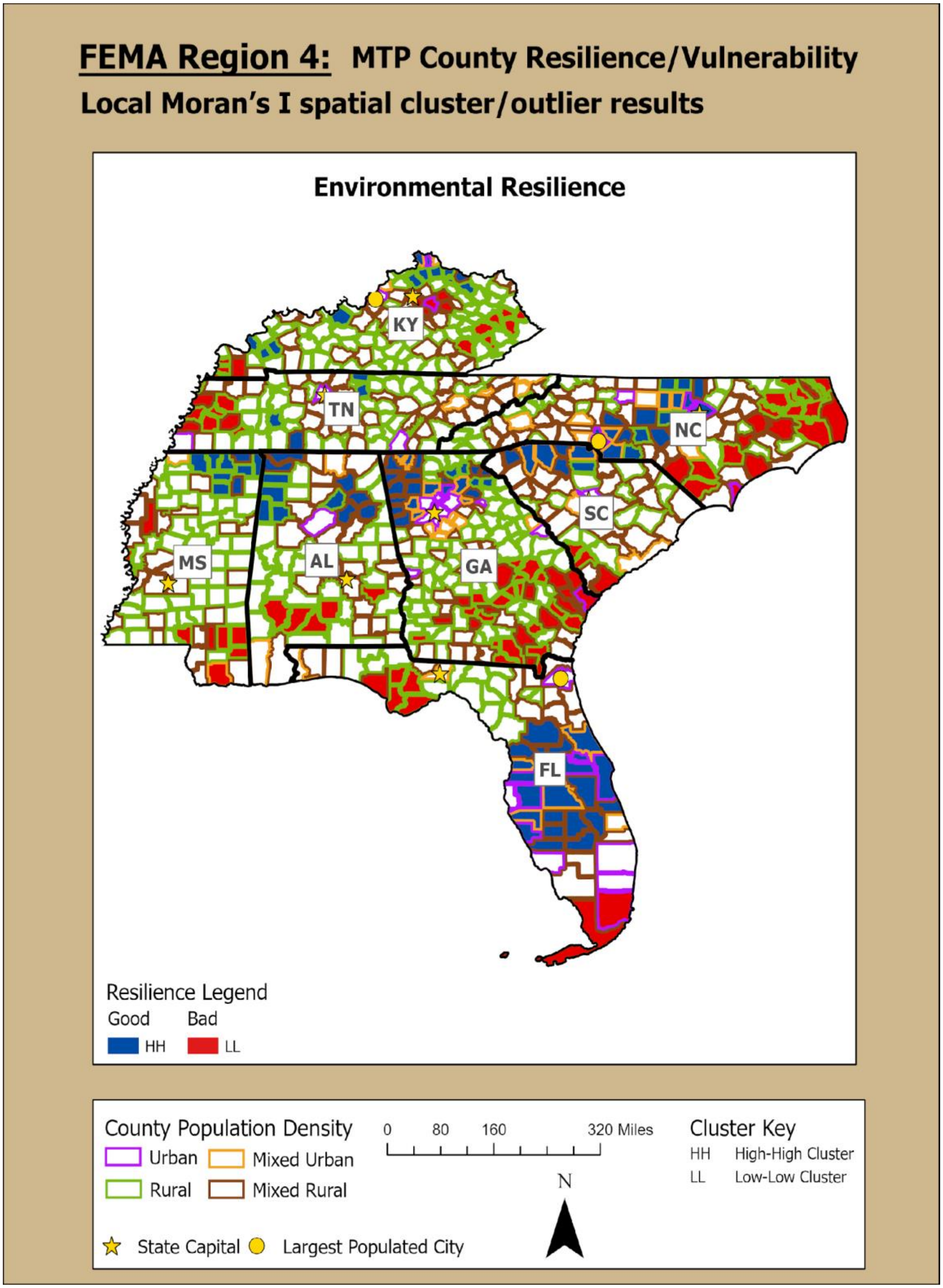


Figure 5-8: MTP Environment Vulnerability LISA cluster/outlier map

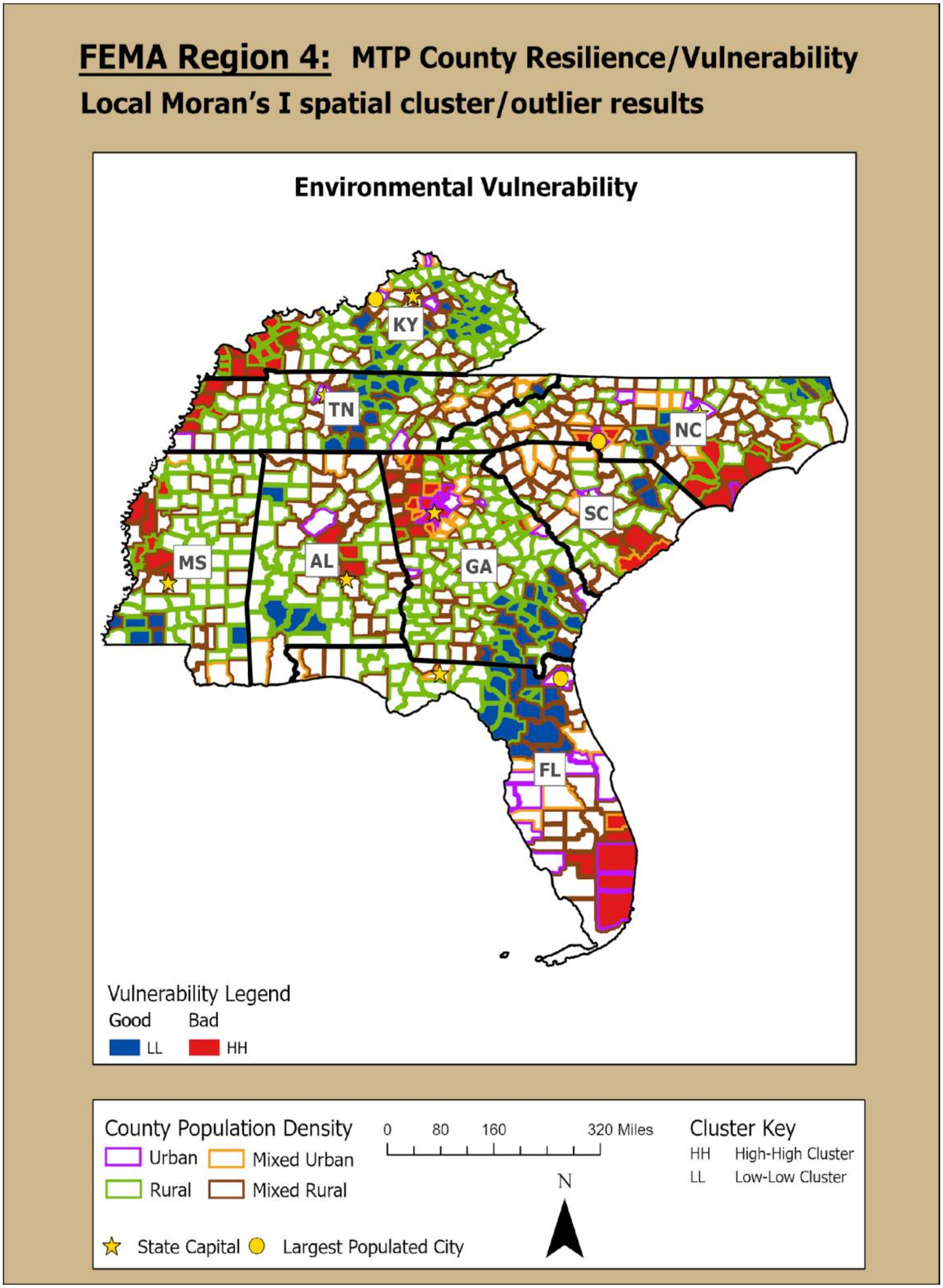


Figure 5-9: MTP Infrastructure Resilience LISA cluster/outlier map

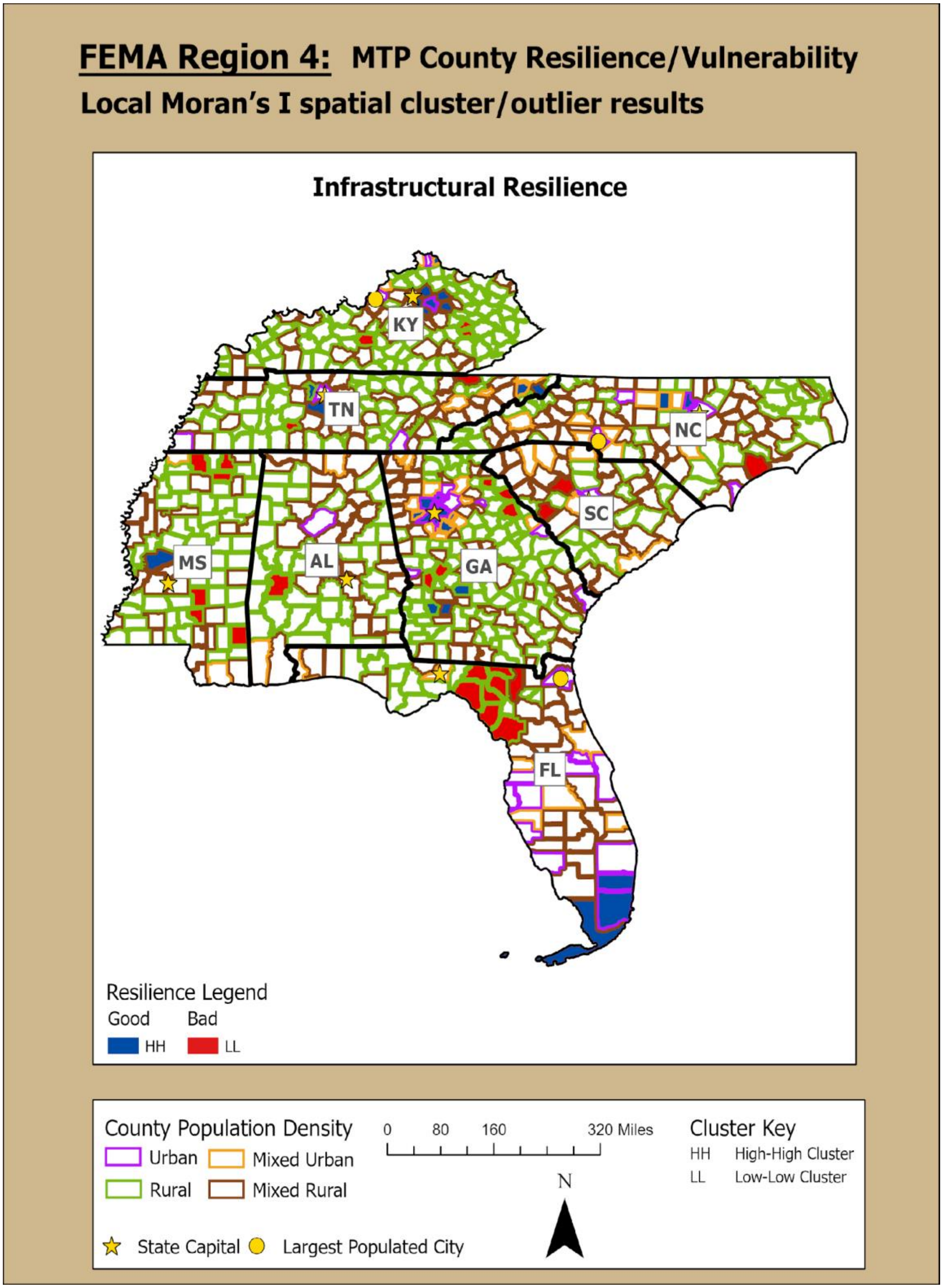


Figure 5-10: MTP Infrastructure Vulnerability LISA cluster/outlier map

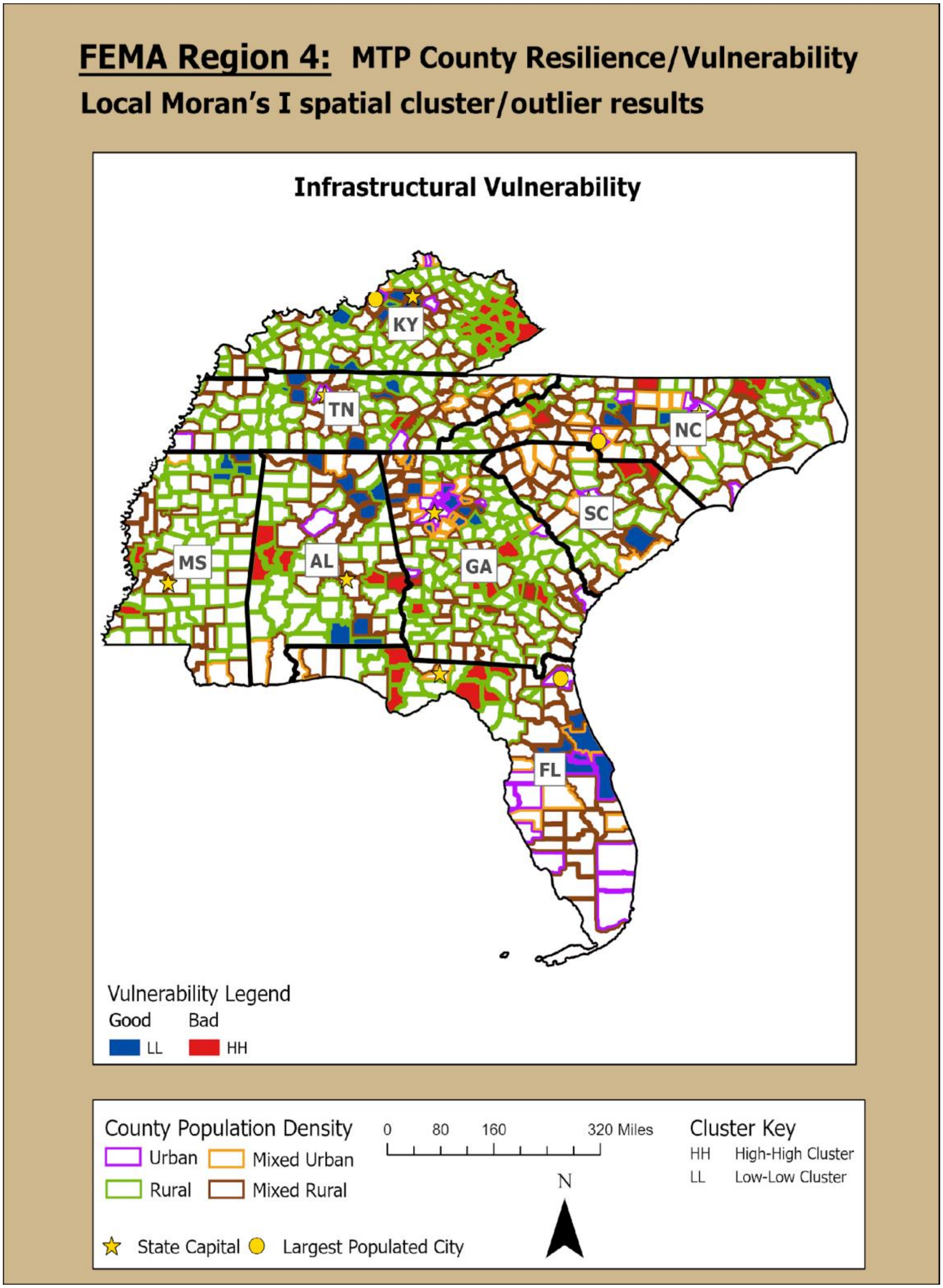


Figure 5-11: MTP Social Resilience LISA cluster/outlier map

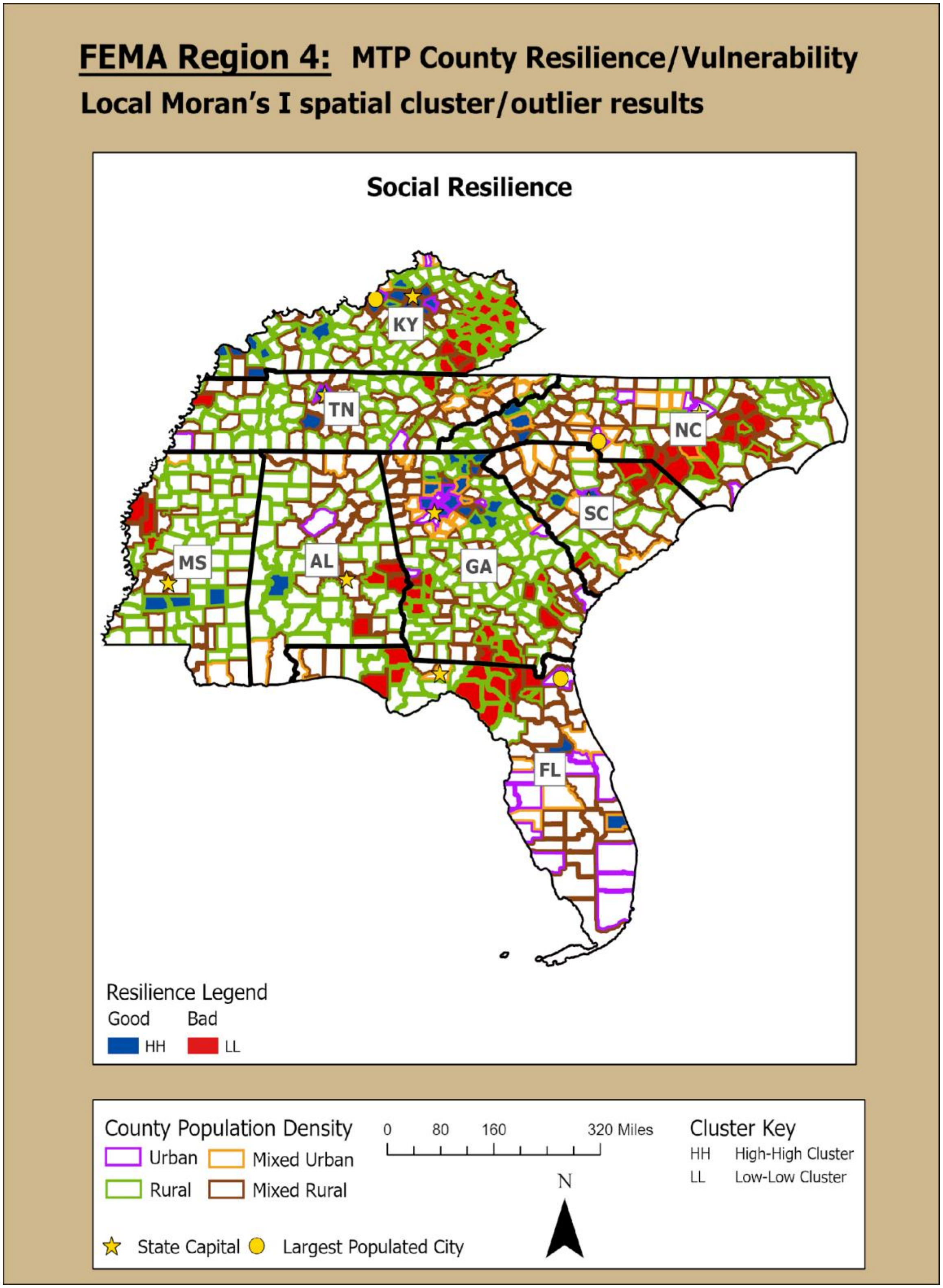


Figure 5-12: MTP Social Vulnerability LISA cluster/outlier map

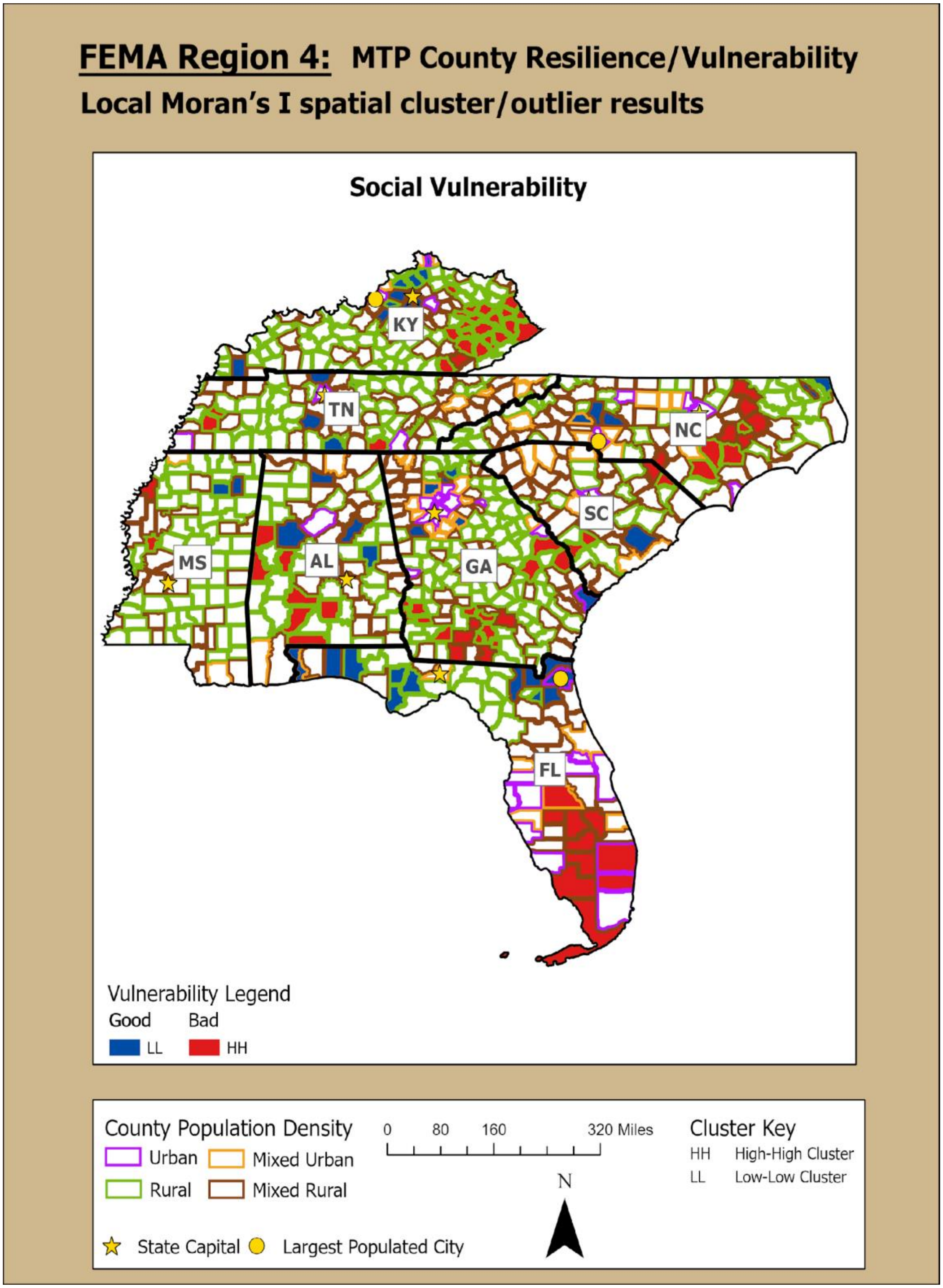


Table 5-6: Economic Resilience LISA results

FEMA Region	MTP Economic Resilience LISA cluster/outlier Results				Total Counties
	HH	HL	LH	LL	
1	0	3	1	1	5
2	18	0	3	6	27
3	30	8	6	24	68
4	49	15	12	45	121
5	51	20	8	30	109
6	66	14	14	36	130
7	16	12	9	14	51
8	31	7	7	12	57
9	12	4	1	7	24
10	12	4	1	4	21
	285	87	62	179	613

Population Density Type	MTP Economic Resilience LISA cluster/outlier Results				Total Counties
	HH	HL	LH	LL	
Mixed Rural	94	31	20	45	190
Mixed Urban	48	6	4	2	60
Rural	51	48	36	131	266
Urban	92	2	2	1	97
	285	87	62	179	613

Population Density Type	MTP Economic Resilience LISA %				Total Counties
	HH	HL	LH	LL	
Mixed Rural	15	5	3	7	31
Mixed Urban	8	1	1	0	10
Rural	8	8	6	21	43
Urban	15	0	0	0	16
	46	14	10	29	100

Table 5-7: Economic Vulnerability LISA results

FEMA Region	MTP Economic Vulnerability LISA cluster/outlier Results				Total Counties
	HH	HL	LH	LL	
1	2	3	0	8	13
2	8	1	2	15	26
3	18	8	10	17	53
4	64	17	17	54	152
5	26	17	16	34	93
6	30	6	15	52	103
7	16	10	7	25	58
8	15	10	6	28	59
9	6	3	4	4	17
10	3	3	1	7	14
	188	78	78	244	588

Population Density Type	MTP Economic Vulnerability LISA cluster/outlier Results				Total Counties
	HH	HL	LH	LL	
Mixed Rural	65	27	28	97	217
Mixed Urban	6	7	6	16	35
Rural	99	34	42	113	288
Urban	18	10	2	18	48
	188	78	78	244	588

Population Density Type	MTP Economic Vulnerability LISA %				Total Counties
	HH	HL	LH	LL	
Mixed Rural	11	5	5	16	37
Mixed Urban	1	1	1	3	6
Rural	17	6	7	19	49
Urban	3	2	0	3	8
	32	13	13	41	100

Table 5-8: Environment Resilience LISA results

FEMA Region	MTP Environment Resilience LISA cluster/outlier Results				Total Counties
	HH	HL	LH	LL	
1	8	1	0	8	17
2	6	0	2	16	24
3	33	3	2	43	81
4	92	6	4	118	220
5	81	4	8	63	156
6	67	4	7	81	159
7	61	2	9	53	125
8	38	1	3	40	82
9	13	0	3	10	26
10	20	0	4	22	46
	419	21	42	454	936

Population Density Type	MTP Environment Resilience LISA cluster/outlier Results				Total Counties
	HH	HL	LH	LL	
Mixed Rural	118	3	13	152	286
Mixed Urban	32	0	4	23	59
Rural	248	15	23	251	537
Urban	21	3	2	28	54
	419	21	42	454	936

Population Density Type	MTP Environment Resilience LISA %				Total Counties
	HH	HL	LH	LL	
Mixed Rural	13	0.3	1.4	16	31
Mixed Urban	3	0.0	0.4	2	6
Rural	26	1.6	2.5	27	57
Urban	2	0.3	0.2	3	6
	45	2.2	4.5	49	100

Table 5-9: Environment Vulnerability LISA results

FEMA Region	MTP Environment Vulnerability LISA cluster/outlier Results				Total Counties
	HH	HL	LH	LL	
1	8	0	0	3	11
2	5	1	0	12	18
3	19	9	4	25	57
4	73	8	4	100	185
5	77	4	5	69	155
6	74	4	5	69	152
7	25	8	12	33	78
8	26	3	8	43	80
9	11	2	3	14	30
10	11	3	2	10	26
	329	42	43	378	792
Population Density Type	MTP Environment Vulnerability LISA cluster/outlier Results				Total Counties
	HH	HL	LH	LL	
Mixed Rural	128	20	14	116	278
Mixed Urban	27	2	4	13	46
Rural	141	14	23	237	415
Urban	33	6	2	12	53
	329	42	43	378	792
Population Density Type	MTP Environment Vulnerability LISA %				Total Counties
	HH	HL	LH	LL	
Mixed Rural	16	3	2	15	35
Mixed Urban	3	0.3	1	2	6
Rural	18	2	3	30	52
Urban	4	1	0.3	2	7
	42	6.3	6.3	48	100

Table 5-10: Infrastructure Resilience LISA results

FEMA Region	MTP Infrastructure Resilience LISA cluster/outlier Results				Total Counties
	HH	HL	LH	LL	
1	2	1	2	0	5
2	17	4	0	7	28
3	29	4	3	18	54
4	26	28	8	28	90
5	37	23	8	33	101
6	16	18	6	19	59
7	18	17	4	9	48
8	9	10	2	4	25
9	10	3	2	10	25
10	9	2	3	8	22
	173	110	38	136	457
Population Density Type	MTP Infrastructure Resilience LISA cluster/outlier Results				Total Counties
	HH	HL	LH	LL	
Mixed Rural	41	60	13	30	144
Mixed Urban	30	6	4	0	40
Rural	37	40	20	106	203
Urban	65	4	1	0	70
	173	110	38	136	457
Population Density Type	MTP Infrastructure Resilience LISA %				Total Counties
	HH	HL	LH	LL	
Mixed Rural	9	13	3	7	32
Mixed Urban	7	1	1	0	9
Rural	8	9	4	23	44
Urban	14	1	0.2	0	15
	38	24	8.2	30	100

Table 5-11: Infrastructure Vulnerability LISA results

FEMA Region	MTP Infrastructure Vulnerability LISA cluster/outlier Results				Total Counties
	HH	HL	LH	LL	
1	1	2	1	0	4
2	7	2	4	3	16
3	11	11	10	19	51
4	54	20	22	55	151
5	27	12	6	35	80
6	44	9	16	40	109
7	17	12	7	21	57
8	8	10	4	13	35
9	2	4	4	10	20
10	2	2	4	9	17
	173	84	78	205	540

Population Density Type	MTP Infrastructure Vulnerability LISA cluster/outlier Results				Total Counties
	HH	HL	LH	LL	
Mixed Rural	43	38	23	83	187
Mixed Urban	5	5	5	14	29
Rural	115	29	43	90	277
Urban	10	12	7	18	47
	173	84	78	205	540

Population Density Type	MTP Infrastructure Vulnerability LISA %				Total Counties
	HH	HL	LH	LL	
Mixed Rural	8	7	4	15	35
Mixed Urban	1	1	1	3	5
Rural	21	5	8	17	51
Urban	2	2	1	3	9
	32	16	14	38	100

Table 5-12: Social Resilience LISA results

FEMA Region	MTP Social Resilience LISA cluster/outlier Results				Total Counties
	HH	HL	LH	LL	
1	3	1	3	4	11
2	6	1	2	2	11
3	28	5	4	27	64
4	52	11	8	83	154
5	23	12	9	41	85
6	55	16	11	49	131
7	33	9	8	25	75
8	17	6	9	8	40
9	6	0	2	6	14
10	5	3	0	0	8
	228	64	56	245	593

Population Density Type	MTP Social Resilience LISA cluster/outlier Results				Total Counties
	HH	HL	LH	LL	
Mixed Rural	50	15	21	86	172
Mixed Urban	17	3	7	9	36
Rural	140	44	18	147	349
Urban	21	2	10	3	36
	228	64	56	245	593

Population Density Type	MTP Social Resilience LISA %				Total Counties
	HH	HL	LH	LL	
Mixed Rural	8	3	4	15	29
Mixed Urban	3	1	1	2	6
Rural	24	7	3	25	59
Urban	4	0	2	1	6
	38	11	9	41	100

Table 5-13: Social Vulnerability LISA results

FEMA Region	MTP Social Vulnerability LISA cluster/outlier Results				Total Counties
	HH	HL	LH	LL	
1	1	3	0	12	16
2	13	3	1	8	25
3	20	6	6	23	55
4	74	19	12	47	152
5	18	18	4	33	73
6	48	18	7	55	128
7	24	12	6	32	74
8	18	12	3	28	61
9	2	3	4	10	19
10	9	5	4	9	27
	227	99	47	257	630

Population Density Type	MTP Social Vulnerability LISA cluster/outlier Results				Total Counties
	HH	HL	LH	LL	
Mixed Rural	52	31	14	114	211
Mixed Urban	11	14	4	18	47
Rural	146	29	27	115	317
Urban	18	25	2	10	55
	227	99	47	257	630

Population Density Type	MTP Social Vulnerability LISA %				Total Counties
	HH	HL	LH	LL	
Mixed Rural	8	5	2	18	33
Mixed Urban	2	2	1	3	7
Rural	23	5	4	18	50
Urban	3	4	0.3	2	9
	36	16	7.3	41	100

5.4 Local Moran's I (LISA) Spatial Statistic Findings

The findings indicate support for hypothesis 4 for all MTP variables, adjacent rural counties are less prepared than adjacent suburban and urban counties. The LISA findings like the regression results do not support hypothesis 2, the FEMA regions are not similar in their patterns of preparedness conditions. However, the overall LISA findings indicate high-high resilience and low-low vulnerability cluster/outlier patterns are more consistent than high-low resilience and low-high vulnerability cluster/outlier patterns for all DVs. These findings align with the 2020 NHS responses which indicate the nature of community preparedness actions tend to cluster together (FEMA, 2020b).

The MTP environmental vulnerability LISA cluster/outlier for rural areas found 18% high-high clustered counties as compared to 16% for mixed rural, 3% for mixed urban and 4% for urban counties, this mirrors the MTP environmental resilience high-high LISA patterns. Indicating a balanced pattern of urban-rural counties environmental R/V across the US. However, the FEMA region patterns of the MTP environment low-low resilience conditions indicate Region 4 on the southeastern coast has the most counties (118) with outlier/cluster patterns, followed by Region 6 on the gulf coast (81), and Region 5 on the Great Lakes in the mid-west (63). The MTP environmental high-high vulnerability conditions follow a similar pattern with Region 5 having the most counties (77), followed by Region 6 (74), and Region 4 (73). The MTP environment variable LISA cluster/outlier results indicate natural hazard events such as hurricanes, flooding, and snow and ice events due to coastal and lake features limit preparedness in these regions. Greater understanding about why the MTP environment variable LISA cluster/outlier results do not bring into line the 2020 NHS findings which indicate hurricane-prone areas are more likely to have taken community-based action or have prepared a plan than other natural hazard areas or the Nation is warranted (FEMA, 2020b).

The MTP economic resilience LISA cluster/outlier for rural areas found 21% of low-low clustered counties as compared to 7% of mixed rural counties and 0% for both urban and mixed urban counties. Rural counties also have the greatest percentage of high-high economic vulnerability patterns (17%) as compared to mixed rural (11%), mixed urban (1%), and urban (3%) counties. The results indicate the MTP economic variable supports the literature findings for rural areas being not as economically prepared for a natural hazard event as their more densely populated regional counterparts.

The MTP social vulnerability LISA cluster/outlier for rural areas found 23% high-high clustered counties as compared to 8% for mixed rural, 2% for mixed urban and 3% for urban counties, this mirrors the MTP social resilience high-high LISA patterns. Indicating a balanced pattern of urban-rural counties social R/V across the US. The findings support the literature which suggests rural areas tend to have more cohesive social capital resources than their urban counterparts.

The MTP infrastructure resilience LISA cluster/outlier found rural areas to have 23% of low-low clustered county patterns compared to 7% for mixed rural counties and 0% for both urban and mixed urban counties. Rural counties also have the greatest percentage of high-high infrastructure vulnerability patterns (21%) as compared to urban (2%), mixed urban (1%), and mixed rural (8%) counties. The findings indicate the MTP infrastructure variable supports the literature reporting limited rural area infrastructure investments make them less prepared for a natural hazard event than their more urban regional counterparts. This finding supports the recent cross-state community FEMA infrastructure risk mitigation revolving funds made available via the STORM Act (US Congress, 2021).

The literature indicates social and economic inequality have left more people in harm's way with fewer resources available to prepare for, respond to, and recover from disaster (Verchick, 2010). "Hazards-related damages and biased disaster policies may further widen wealth inequalities – especially along lines of race, education, and homeownership – rendering already marginalized population groups more vulnerable to future crises" (Peek et al. 2020, p. 2). My research serves as a "useful heuristic" to assist understanding about how county preparedness awareness "is likely to involve the twin realization that natural hazards do not just bring damages", they also represent a pre-disaster FEMA planning resource opportunity; and the ability to examine post-disaster FEMA aid which is "systemically designed to restore property rather than communities" (Howell and Elliot, 2019, p.465). Thus, limiting the promotion and implementation of sustainable development practices and enhancing community capital goals (Biggs et al., 2015).

5.5 FEMA Regional Community Preparedness Interview Results

My research is designed to assist public officials, hazard planners, emergency management personnel, non-profit and business owners, and local stakeholders implement natural hazard regulations informed by local resilience and vulnerability conditions. I use the

LISA analysis to tell the story of place and space. My quantitative LISA map book results inform the questions for my interviews conducted with the 10 FEMA region Community Preparedness Officers (CPO). The CPOs are within the FEMA Preparedness Division. They serve as FEMA's front-line communicator charged with ensuring the state leads, local and tribal officials and community stakeholders are empowered to meet the Nation's NPG.

I conducted a preliminary test of my interview questions and format with FEMA community hazard planner colleagues and the additional referrals they provided me. My conversations indicate due to COVID-19 pandemic needs, California wildfires, and hurricane season, it may be difficult to get the FEMA CPO personnel to respond for a lengthy interview with many questions. It was suggested to be prudent I should provide up to three questions, book it for 30 minutes of interview time, and include the MTP map series for their region to pique their interest and engage them in the process. The FEMA CPO interviews were conducted via recorded Zoom sessions from December 4 - 18, 2020. The Zoom CPO interview audio recordings were transcribed by *GoTranscript* services.

The interview details and questions are as follows. A series of maps have been prepared for your region based on my dissertation methodology. The maps present county level details for each state in your FEMA region. The counties have been identified as rural, mixed rural, mixed urban, and urban with a color-coded legend. The potential for more preparedness is shown as blue (good) on the maps and reduced preparedness as red (bad). Although there is a great deal of detail that supports the maps, the purpose is to gain your preparedness insight about them as a community planning tool. The aim of my research is to assist vulnerable communities that may not be as prepared thus more susceptible to a natural hazard event better understand how to prioritize their preparedness actions, and how their preparedness is reflected in their state and FEMA region.

The following reflects the questions that will be discussed during the interview session.

- What tools or methods are being used in your region to help states and counties develop their preparedness plans?
- Based on your professional experience, do you perceive value for using the MTP map as a visual tool to assist your team identify priority preparedness areas in your region that may be susceptible to a natural hazard event?
- Do you work differently with urban and rural communities within your FEMA region to meet community preparedness needs, if so, why?

5.6 FEMA Regional Community Preparedness Interview Findings

The findings related to hypothesis 5 and each interview question are discussed below. Appendix A presents the IRB determination for the Community Preparedness officer (CPO) interviews. The study is identified as IRB 19-0513 dated 12/12/2019 it is not subject to IRB approval.

Hypothesis 5: FEMA Community Preparedness Officers are likely to spend more time with rural counties and tribal areas than urban and suburban counties; thus, a user-friendly preparedness tool is more likely to be of value when compared to the technically advanced tools offered by FEMA and others.

The findings support hypothesis 5 and interview question 3 - Do you work differently with urban and rural communities within your FEMA region to meet community preparedness needs, if so, why? All CPOs indicate they serve as a broker, more often for rural and tribal areas, due to their limited technical resources as compared to well-resourced urban areas. They are often charged with identifying contacts and technical resources to assist states, tribes, and communities within their region. The CPOs recognize they are there to serve and assist all communities in their region, however they have limited staff within each FEMA region and are often responding to disaster requests that are varied and complicated.

Their shared mindset indicates failure would be FEMA showing up and telling people we know best about how to address your community preparedness needs. All interviewees indicate they use context specific measures and approaches for working with urban, suburban, rural, and tribal communities in their regions to meet the FEMA ‘whole community’ requirement. They rely on state and local contacts to serve as the lead for what is needed within their communities to address FEMA mandated natural hazard preparedness requirements and non-mandated resource and technical support needs.

The local knowledge particularly for rural and tribal areas is a critical component for understanding community needs, identifying local dialects and most important identifying a local champion that can speak for their community. All recognize the value of addressing preparedness by aligning community planning skills and outreach approaches with emergency management policy and procedures. They all strive to streamline the myriad of FEMA resources and technical documents that are available and try to understand what assets and gaps exist across the urban-rural continuum within their region. Across the regions the CPOs use several FEMA community preparedness programs such as the Youth Preparedness Councils, Community Emergency Response Team (CERT), Citizen Corps, the National Exercise program, and FEMA Hazard Planners to meet the mission of a more secure and resilient nation. The strengths of these FEMA programs vary across the 10 regions and like the community outreach approach of the CPOs, is context sensitive based on who is in charge and that region's priorities.

The following summarizes the response to interview question 1 - What tools or methods are being used in your region to help states and counties develop their preparedness plans? All regions work within the FEMA headquarters policies and regulations. They first recommend the tools and guidance provided by FEMA via the Department of Homeland Security because of training and familiarity, not because they are required to do so. These findings support hypothesis 2, the similarity of approach amongst the 10 FEMA region CPO leaders. How headquarters, the 'Federal Family', those federal agencies and entities that assist with implementation measures, and the 10 regional offices coordinate to meet the NPG and implement the National Preparedness System varies across and within regions. Each region indicates the need to work within the confines of their region and context of their states and communities to implement the recent policy changes designed to close the preparedness gaps identified by the 2020 NHS.

This includes BRIC, the first program to make mitigation funds available prior to a disaster versus relying on post-disaster funds for community disaster prevention and mitigation measures (FEMA, 2020d). The ability to use Community Development Block Grant (CDBG) Housing and Urban Development (HUD) supplemental grant funds to serve as local FEMA HMGP matching funds is seen as new funding and planning connections to address local housing, social and economic displacement needs. The interviewees indicate the document Increasing Resilience Using THIRA/SPR and Mitigation Planning (FEMA 2020f) is seen as valuable, yet to be tested, first time FEMA alignment of the requirements of the Preparedness Division with the Mitigation Division. This means that the annual SPR update, 5-year SHP update and the THIRA 3 -year mission area targets and 6-year mitigation targets document preparation and document submittal timing may combine.

Most indicate communities may now be able to streamline their efforts to reduce vulnerability, increase resilience and avoid a duplication of efforts, which may benefit rural and tribal communities that often lack the technical resources needed to complete these FEMA requirements. The ability to address differing urban-rural preparedness needs may also benefit from the recent FEMA standardization of how states are to address mitigation measures for their SHP mitigation targets. It is no longer accepted that a compilation of 50 differing approaches to specifying mitigation targets and criteria are appropriate to meet the NPG. These recent policy alignments are especially valuable to rural and tribal areas who are required to meet the same THIRA/SPR, and SHP criteria as their more resourced urban counterparts. These revisions are informed by the FEMA decision to partner with the APA (APA, 2019) as a peer technical partner to address the learning from Hurricane Katrina (Congress, 2006) and the need to improve the lack of individual and community preparedness measures identified by the NHS (FEMA, 2020b).

The findings support hypothesis 5 and interview question 2 - Based on your professional experience, do you perceive value for using the MTP map as a visual tool to assist your team identify priority preparedness areas in your region that may be susceptible to a natural hazard event? The MTP LISA map book was seen by all CPOs as a valuable, concise visual tool to foster local conversation about resilience and vulnerability for community hazard planners and stakeholders. It is seen as a practical, user-friendly map image to identify potential FEMA region priority support areas and build trust to address urban-rural community natural hazard preparedness. However, as is true for any online resilience tool, it's unfunded status and lack of data management and updates is of concern.

Despite the robust FEMA community hazard planning tools such as RAPT, NRI, and the Community Resilience Indicator Analysis (CRIA), along with the preparedness requirements of THIRA/SPR and the mitigation targets of BRIC, SHP and the Community Recovery Management Toolkit, all region CPO leads found value for use of the MTP LISA cluster/outlier maps. The ability to have an image that uses color and spatial clusters to highlight urban-rural resilience and vulnerability concisely is seen as a great conversation starter. The MTP four component and color-coded high-low quadrant approach is seen as a user-friendly and simple way to explain preparedness conditions. In general, it met the desire to serve as a visual community planning tool to start a conversation about how and what to think about when you are prioritizing community preparedness resources and needs within the states of their region.

Most indicated it would be valuable at the regional and local level to inform a big picture combination of resilience and vulnerability that may lead to the use of the RAPT, NRI or other similar tools to drill down on the specific needs at a census block level or to understand links to local and regional evacuation assets and/or emergency management infrastructure. The region leaders I spoke with also offered suggestions for improvement such as a color gradient or heat map GIS approach versus county boundaries, they also expressed concerns about the limited MTP funding and data management that are needed for any planning tool, and recognize the MTP, like all tools, requires a level of technical savviness that is not uniform across urban-rural and tribal communities.

CHAPTER 6: Research Limitations and Implications

My mixed-methods research examines the probability of the Missouri Transect Project (MTP) as a predictive and visual measurement tool for examining county and regional resilience and vulnerability across the urban-rural continuum within states and across FEMA regions. It uses triangulation to test the degree of external validity (Webb et al., 1966). It tests theoretical constructs related to how natural hazard regulation is expressed at the local level due to varying geographic, economic, social, and built environment conditions. It examines if urban center economic growth and rural periphery economic constraints inform county and regional preparedness similarly within states and across FEMA regions. It tests the value of the MTP as a visual tool with FEMA community preparedness leads in the context of current practices and regional resilience measures within their respective regions. It also documents various factors that may support the challenge of improving individual and community natural hazard preparedness despite significant taxpayer investments, technological support, and context-specific tools and programs.

I use triangulation (Jick, 1979) via a mixed-methods approach with the MTP to gain insights about how FEMA regulations may be expressed locally in the context of urban, suburban, and rural preparedness conditions. Triangulation assures the validity of my research and captures three different dimensions of the MTP as a community resilience tool. My findings indicate convergent and discriminant validation (Campbell and Fiske, 1959) of the MTP as a community natural hazard preparedness tool to promote urban-rural patterns of resilience and vulnerability. The value of the MTP is unique from FEMA's RAPT (FEMA, 2021) and NRI

(FEMA, 2017) resilience measurement tool approaches. My MTP research complements the findings of NASEM (2019) and the literature about the many natural hazard measurement tools available to assist states and counties. The literature suggests community measurement tools are useful for understanding individual and community preparedness needs. They provide insight and a springboard to inform a robust conversation about where priorities may be and where there is an opportunity to learn from those doing well.

The relationship between states and FEMA community preparedness leads serves as the front line for informing and monitoring our nation's individual and community preparedness status. The literature and FEMA indicate that natural disasters are local events, yet preparedness plans require local-regional partnerships (NHS, 2020; Plastrik et al., 2019; Biggs et al., 2015). Citizens need to understand they are the ones responsible for being prepared. FEMA serves as the state and local natural hazard preparedness partner, not the first responder or preparedness planner. They are the belay that provides funding, technical assistance, programmatic tools, and research to support individuals and communities preparing for the next natural hazard event. The challenge is about assisting states and communities in understanding what preparedness means for them and their community.

Most importantly, individuals and communities need to take ownership of the tools, plans, and procedures for preparedness. All FEMA region community preparedness leads indicate context matters. They do not prescribe or mandate what measurement tools or protocols a state or county uses to develop their THIRA, SRP, and SHP requirements for HMGP funding. The CPOs help disseminate FEMA preparedness information to their state and community partners. So, it is important to understand how the nature and extent of urban, suburban, rural, and tribal community capital informs what type of assistance they choose to ask for or if they even decide to ask FEMA for help.

In the following, I highlight some of the implications for future policy, practice, and research endeavors.

6.1 Policy

In a research letter published in Nature, related to climate resilience Burke, et al. (2018, p.549) “estimate that 71% of countries— representing 90% of the global population—have a more than 75% chance of experiencing reduced economic damages at 1.5°C, with poorer countries benefiting most.” My research supports the climate change socio-economic implications described by the Burke et al. (2018). It also supports the economic impact study of flood-related damages conducted by Davenport et al. (2021) who evaluate the community impact via a benefit-cost analysis of repetitive flood events. It posits the need for more actions and understanding about urban-rural resilience-building practices. These recent and relevant natural hazard empirical studies suggest that achieving more stringent global warming mitigation targets will probably generate a net global benefit, with substantial benefits for the most impoverished populations, including those in rural areas of the US. Davenport et al. (2021) conclude understanding the economic losses due to changing natural hazards provides critical information to inform policy and decision making. Natural hazard resilience-building barriers include silos due to geographic and political boundaries, electoral limitations, and governance and budget practices (Plastrick et al.,2020). These limit the ability to implement regional resilience across the urban-rural continuum.

My research provides support and context for establishing policies and procedures within FEMA, states, and counties to bolster regional and community resilience. Specifically, by reducing regional vulnerabilities through enhanced coordination of state and local hazard mitigation planning mechanisms. Context-sensitive policy approaches that better incorporate a visual story about why it matters for people and their community to coordinate and prioritize natural hazard preparedness measures are needed. Enhanced policy measures across the urban-rural continuum are required to lift-up the individual and community voices typically not at the hazard preparedness planning table, such as youth, those who are socio-economically disadvantaged, and the elderly and disabled populations. By incorporating planning professionals as peer partners for SHP and local HMP, in addition to emergency management professionals, the education and outreach process for local and regional hazard planning may evolve to a greater understanding of why preparedness matters.

6.2 Practice

Because natural disasters occur at the interface of built, natural, social, and economic environments the hazard risks and disaster field encourage cross disciplinary research that transcends organizational boundaries. The literature suggests the hazards and disaster field does recognize the value of cross-disciplinary teams collaborating in support of convergent science and policy outcomes (NSF, 2019, 2020; Peek et al. 2020). However, the professional planners and geographer's development contributions, the engineer's infrastructure and building designs, the risk communication messages crafted by sociologists, the regulations adopted by public officials, and the research of policy experts is deemed to be more "convergent-like" than a model of "true convergence" (Peek et al. 2020, p. 6).

One recent noteworthy example is the NSF CONVERGE Leadership Corps. It is an integrative framework that purposely brings together interdisciplinary teams to convergence organizational structure and governance systems (NSF, 2019). In 2018, the NSF implemented the first CONVERGENCE social science-led component of the Natural Hazards Engineering Research Infrastructure (NHERI) to study hazards and disaster research (Peek et al. 2020). The team at the University of Colorado, Boulder and its partners serves as a hazard and disaster field research effort to develop processes and training approaches that foster interdisciplinary teamwork. Their efforts are designed to ready researchers to both assess and address the many pressing social, economic, environmental, and technical challenges of the disaster research lifecycle to minimize disaster losses (NSF, 2020). My research findings support the concepts of the CONVERGENCE framework. I suggest the inclusion of more community planning professionals in research networks will assist with communication about why preparedness matters individually, locally, and regionally and improve the alignment of land development regulations with SHP mitigation targets.

The FEMA and APA technical partnership recognizes the value of including planning professionals to support the NPG. The current FEMA preparedness approach reflects a policy shift from relying on post-disaster resilience planning to the rise of pre-disaster and mitigation funds and practices (FEMA, 2020e). I suggest FEMA require a certified planning professional sign off for every SHP and local HMP to ensure regional and local comprehensive plans, land use and development regulations, and infrastructure investments align to support SHP mitigation targets. The literature indicates when building codes and land use development regulations don't support purported mitigation measures, resilience to natural hazards is inadequate (NIBS, 2019).

Although limited, my MTP economic variable logistic regression model findings indicate counties with an increase in ATTOM (2016) building insurance risk values (OR = 1.01) have slightly increased natural hazard preparedness odds than lower building risk counties. The MTP economic resilience LISA cluster/outlier for rural areas found 21% of low-low clustered counties as compared to 7% of mixed rural counties and 0% for both urban and mixed urban counties. Similarly, the MTP infrastructure resilience LISA cluster/outlier found rural areas to have 23% of low-low clustered county patterns compared to 7% for mixed rural counties and 0% for both urban and mixed urban counties. The ability to align land-use practices, zoning, building code regulations, and community development practices support natural hazard resilience. It is most advanced when it includes the actions of individuals, communities, organizations, and businesses.

One of the interesting approaches mentioned by the FEMA CPO representatives I spoke with was how FEMA's National Youth Preparedness Council (YPC)[5] is being implemented at

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[5] The Youth Preparedness Council (YPC) was created in 2012 to bring together youth leaders from students in grades eight through 11 from each of the 10 FEMA regions, usually one or two students representing each region who are interested in supporting disaster preparedness and making a difference in their communities are encouraged to apply. This is a competitive annual application process where students meet with FEMA staff throughout the year to complete disaster preparedness projects nationally and locally and participate in a national summit. The YPC

the regional level mostly within rural and tribal areas of states within their respective regions. FEMA regions that have significant rural and tribal areas and local champions for the YPC within their region are more apt to have an ongoing YPC regional program. All the CPO representatives were aware of the national YPC and had experience with a regional YPC, in general it was found to be of greater value in the predominately non-urbanized regions of the US.

Suggestions for making it more successful both nationally and regionally include the ability to outsource the regional YPC oversight as FEMA regions have limited staff available. Additional suggestions include the development of a comprehensive curriculum that includes financial preparedness and supports a customized and rich community preparedness experience for more YPC and middle and high school students across the US. For the YPC to be successful it will require greater funding and support from headquarters for regional YPC initiatives to be implemented at the state and tribal level, and greater awareness of the awesomeness that these youth bring back into the nation, their communities and as individual who serve as local messengers of preparedness.

6.3 Research

Despite many different natural hazard measurement systems and community resilience tools, US natural hazard policy continues to evolve to address the needs of natural hazard plans that better reflect the community and regional resilience conditions and requirements (Bakkensen

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supports FEMA's commitment to involve America's youth in preparedness-related activities. It also provides young people an opportunity to present their perspectives, feedback, and opinions to FEMA staff.

et al., 2017; Cutter et al., 2010; 2016). The MTP regression findings suggest further exploration of how the data that comprise each of the four MTP index variables (environment, infrastructure, economic, and social) inform county-level urban-rural, and FEMA regional results is warranted.

The literature and my study suggest more research about how to empower communities to understand why their relationship to regional resilience matters for individual and local preparedness is needed. Understanding what the FEMA jargon means alone is very complicated. The FEMA Acronyms, Abbreviations & Terms (FAAT) book is 78 pages long (FEMA, 2009). It is confusing and overwhelming for individuals and communities to understand how the FEMA technical assistance and grant program process works. The CPO interviews and the NHS (FEMA, 2020b) findings indicate the need to bolster the use of FEMA preparedness documents, support greater use of mobile applications, virtual disaster preparedness video and disaster simulation board games, and enhance social media outreach measures. Despite the abundance of FEMA, academia, non-profit, and state preparedness resources their application is limited. Particularly for those individuals and communities that have never experienced a natural disaster occurrence and even more challenging for those that have.

My research findings, coupled with the NHS (FEMA, 2020b), indicates changing perceptions and understanding about natural hazard preparedness requires knowledge about the readiness to act instead of any individual or community socio-demographic difference. The 2020 NHS survey responses also indicate that preparedness actions tend to cluster together (FEMA, 2020b). My MTP spatial cluster outlier research serves as a visual tool to foster a community conversation across the urban-rural continuum about near and far patterns of resilience and vulnerability. The community preparedness professionals I interviewed found the color patterns of good and bad economic, environmental, infrastructure, and social preparedness to be user-friendly and a simplified way to explain preparedness conditions. The ability to have an image that uses color and spatial clusters to highlight urban-rural resilience and vulnerability concisely is seen as a great conversation starter. The findings support the research question about the MTP's ability to serve as a visual community planning tool. Most importantly it is seen by FEMA CPOs as a conversation starter about how and what to think about when you are prioritizing community preparedness resources and needs within the states of their region.

The CPOs also indicate the MTP mapping approach is not grounded in personal or family socio-economic limitations if disaster strikes, compared to some of the FEMA RAPT (FEMA, 2021) and NRI (FEMA, 2017) mapping tool measures. Instead, it serves as a data story that may pique more interest in what may be causing some areas to be more prepared than others. It incorporates more of a social resilience focus on the region than local social vulnerability limitations. My research serves as a useful heuristic to understand why natural hazards do not just bring damages but provide pre-disaster planning insight and the ability to examine post-disaster aid as a community-building versus property re-building opportunity. I suggest by incorporating more planning professionals into the SHP process to evaluate how regional perspectives and social resilience strengthen community and individual preparedness, will result in better use of taxpayer funds, reduce the loss of lives and property, improve regional preparedness conditions, and result in a more resilient and sustainable Nation.

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APPENDIX A - IRB Determination Document

Christina Danis <cdanis1@uncc.edu>

IRB Notice - 19-0513

1 message

IRB <uncc-irb@uncc.edu> Thu, Dec 12, 2019 at 8:12 AM
To: cdanis1@uncc.edu, smleland@uncc.edu
Cc: uncc-irbis@uncc.edu

To: Christina Danis
Public Policy

From: Office of Research Compliance

Date: 12/12/2019
RE: Determination that Research or Research-Like Activity does not require IRB Approval
Study #: 19-0513

Study Title: U.S. natural hazard policy implementation: A comparative study of urban, suburban, and rural natural hazard preparedness conditions.

This submission was reviewed by the Office of Research Compliance, which has determined that this submission does not constitute human subjects research as defined under federal regulations [45 CFR 46.102 (e or l) and 21 CFR 56.102(c)(e)(l)] and does not require IRB approval.

Study Description:

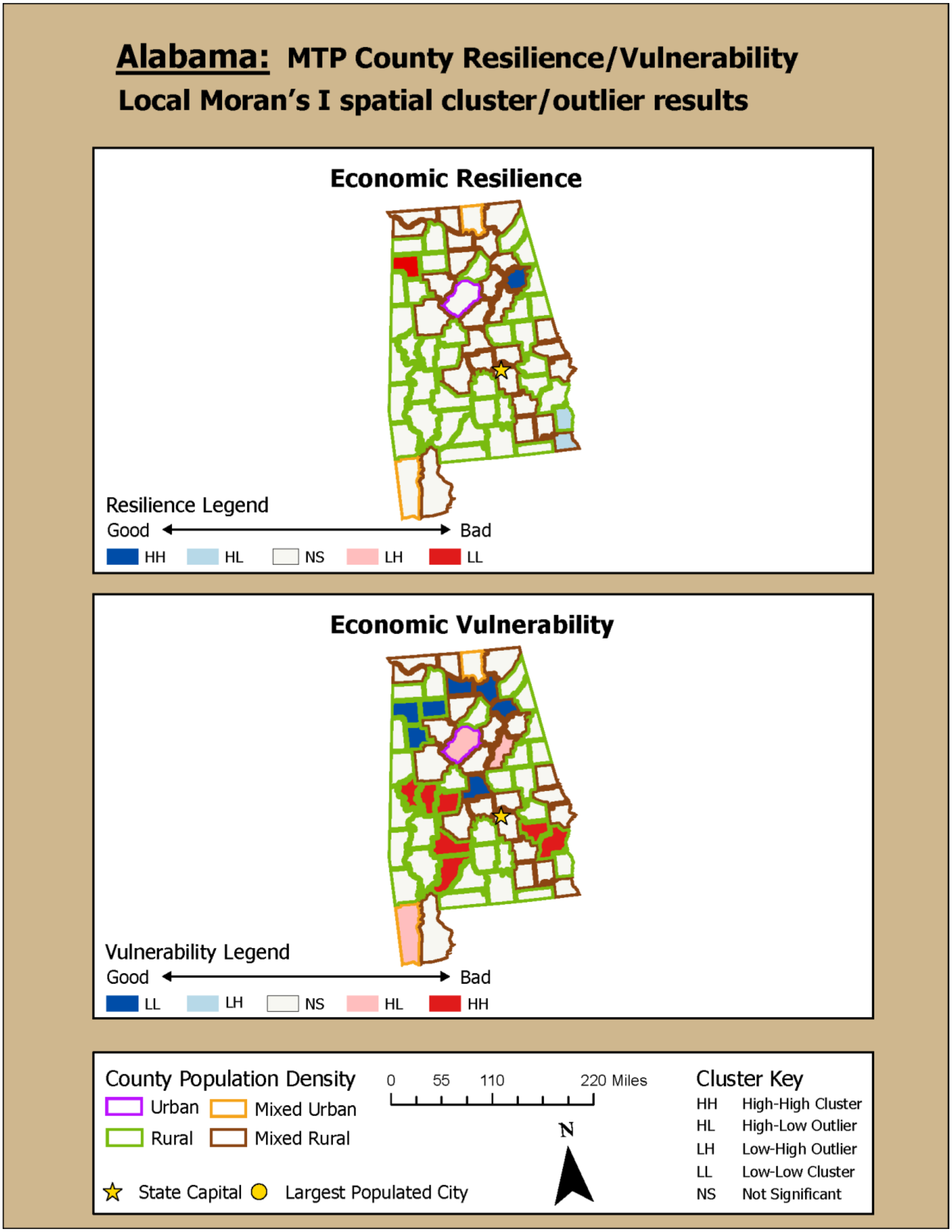
My dissertation proposes to use county-level cross-sectional data with a natural hazard resilience and vulnerability measurement tool, developed by the University of Missouri, to evaluate and compare urban, suburban, and rural natural disaster preparedness conditions. I propose via a mixed methods approach to examine if state implementation of federal U.S. natural hazard policy reflects differing natural disaster preparedness in urban, suburban, and rural counties and across states within the 10 Federal Emergency Management Agency (FEMA) regions. My methods include a multilevel regression model, spatial cluster pattern analysis, and interviews with the FEMA National Exercise Program (NEP) leaders.

The IRB approval is being requested for the qualitative portion of my dissertation.

Please be aware that approval may still be required from other relevant authorities or "gatekeepers" (e.g., school principals, facility directors, custodians of records), even though IRB approval is not required.

If your study protocol changes in such a way that this determination will no longer apply, you should contact the above IRB before making the changes.

APPENDIX B - Spatial Model Local Moran's I State and FEMA Region Map Books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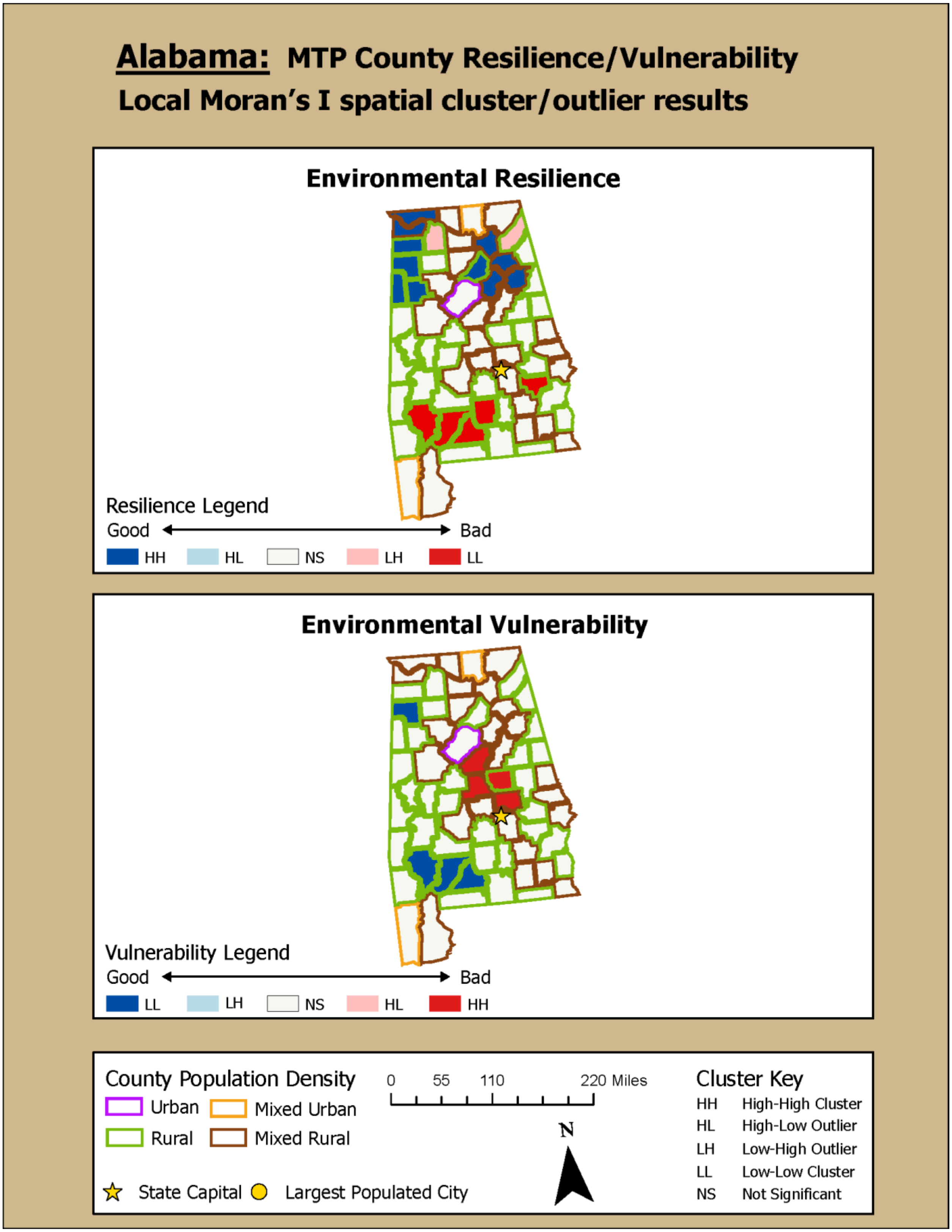
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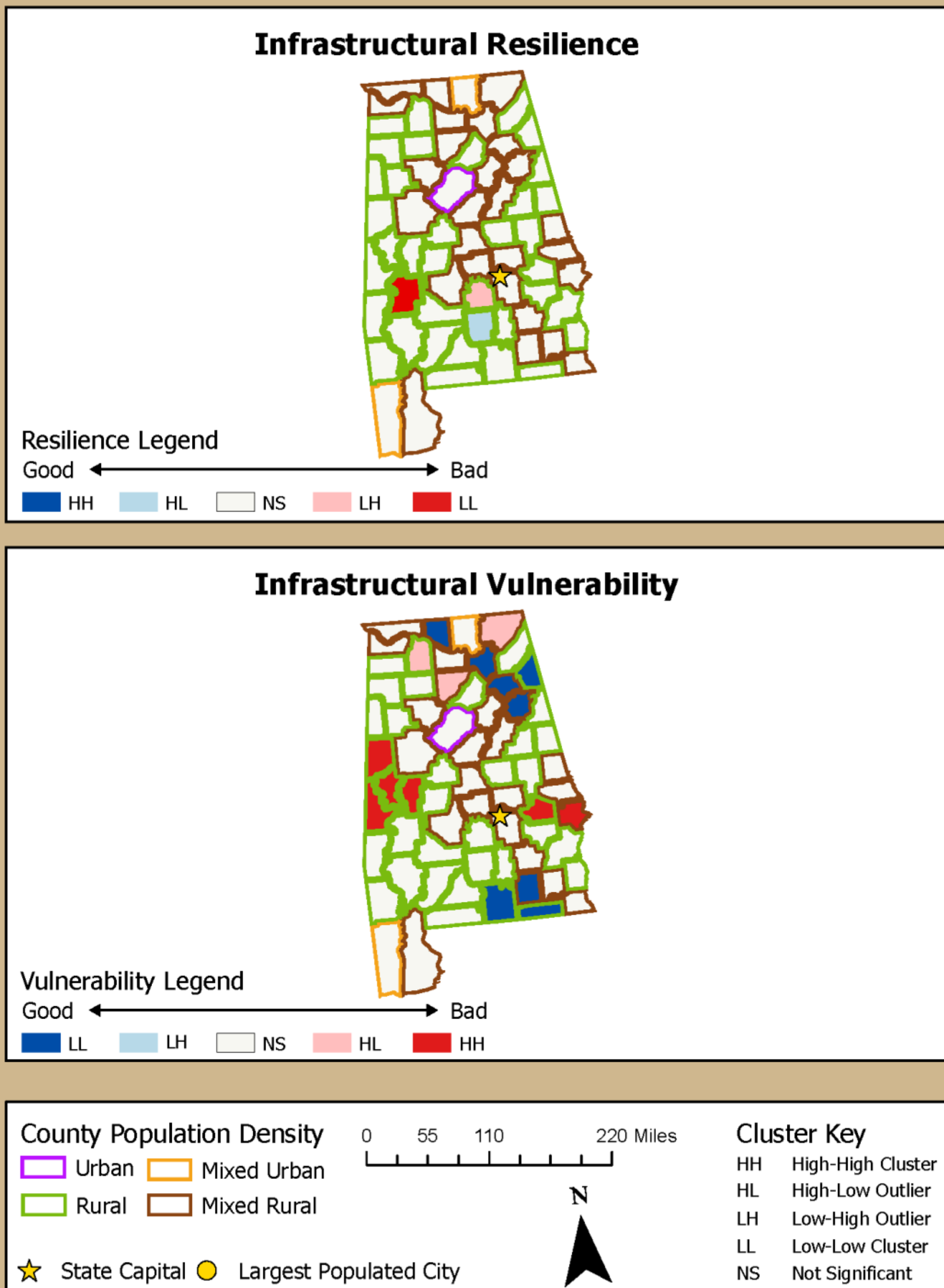

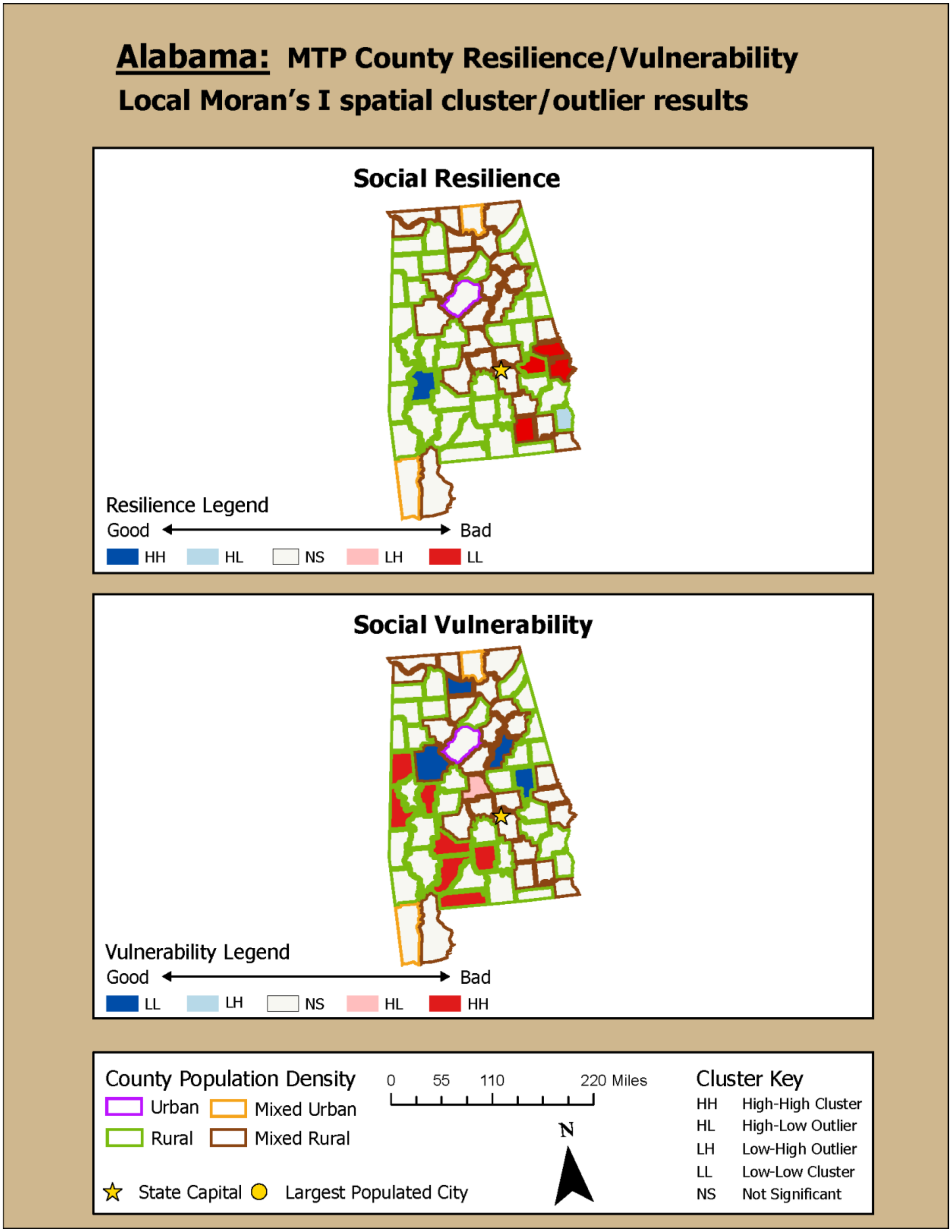
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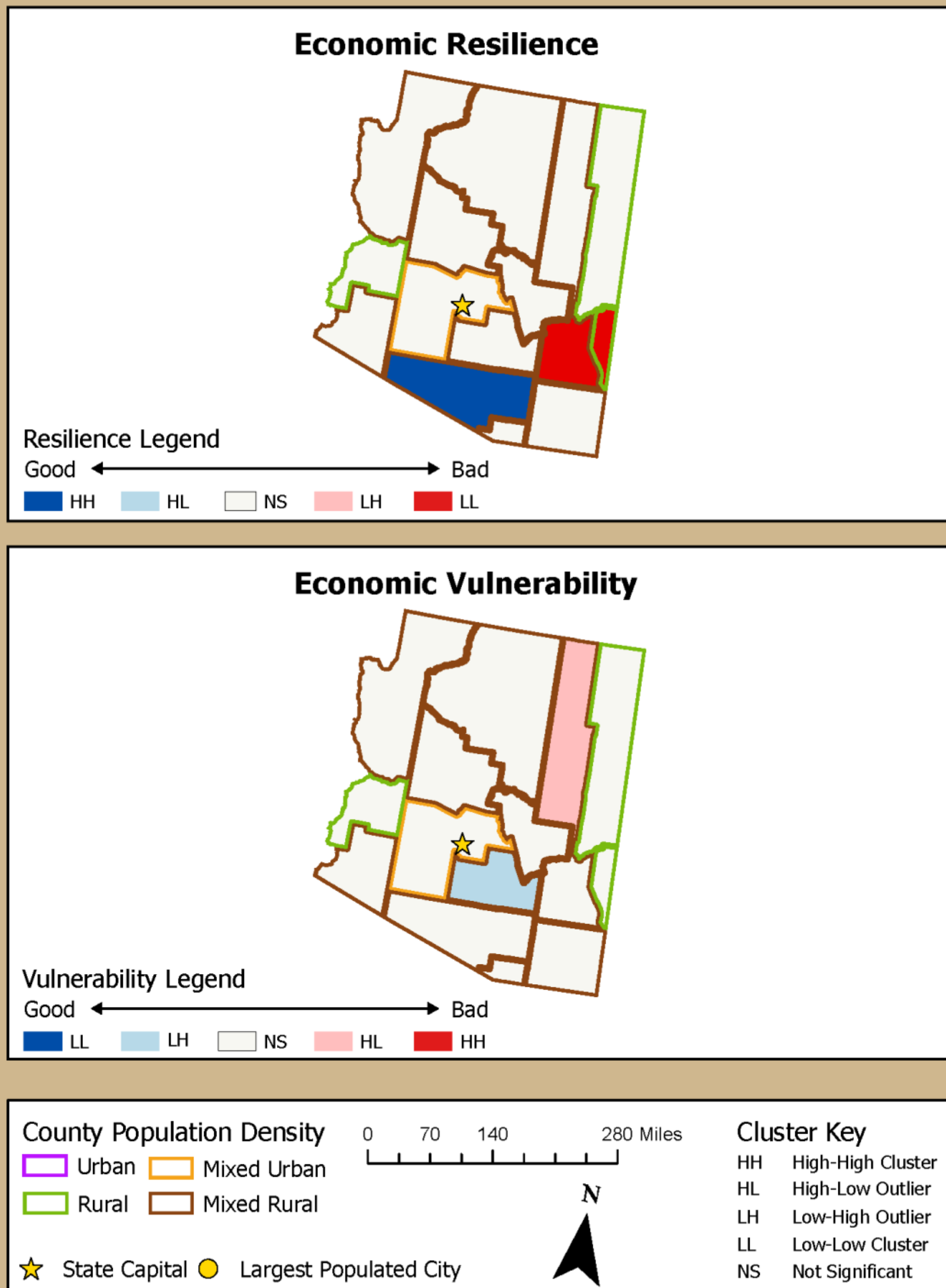

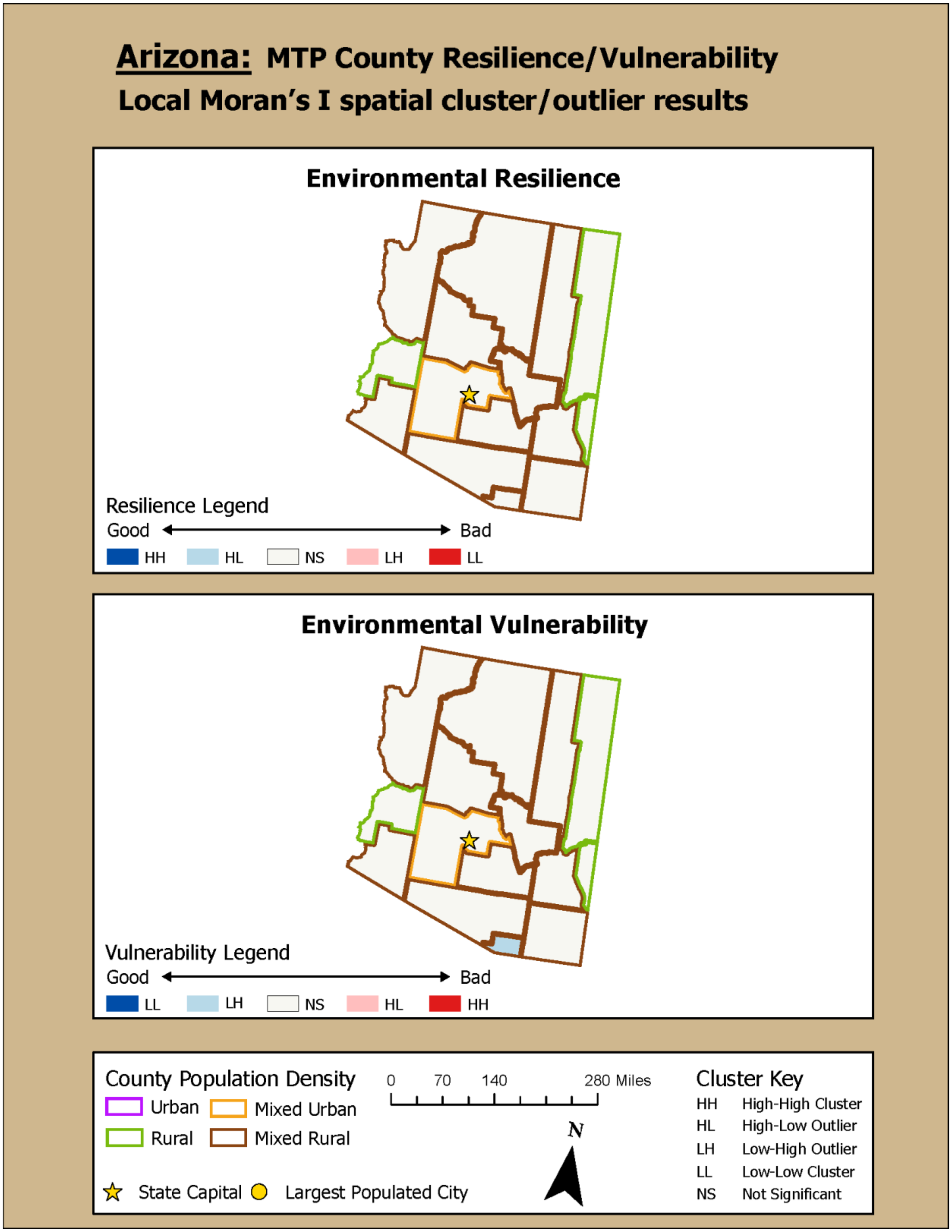
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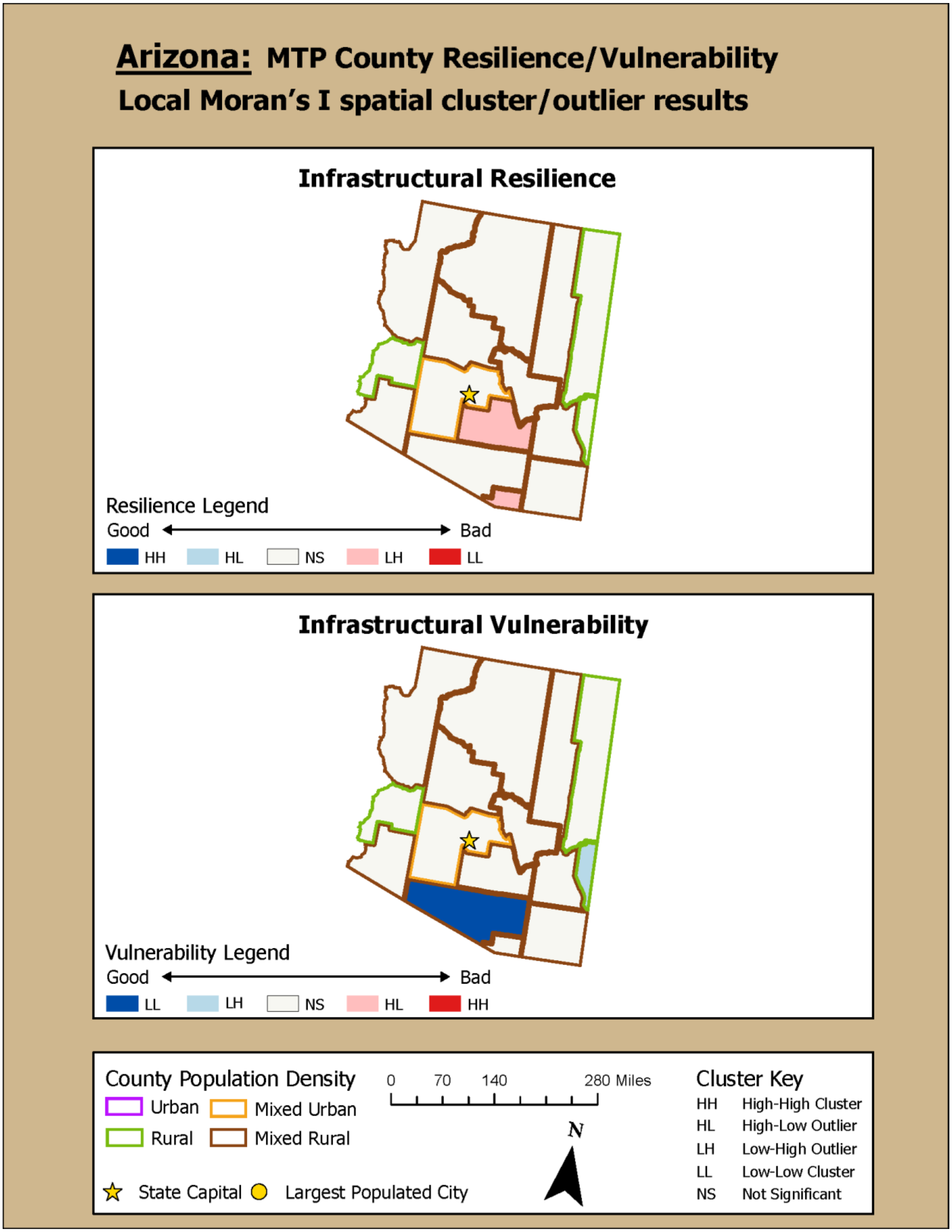
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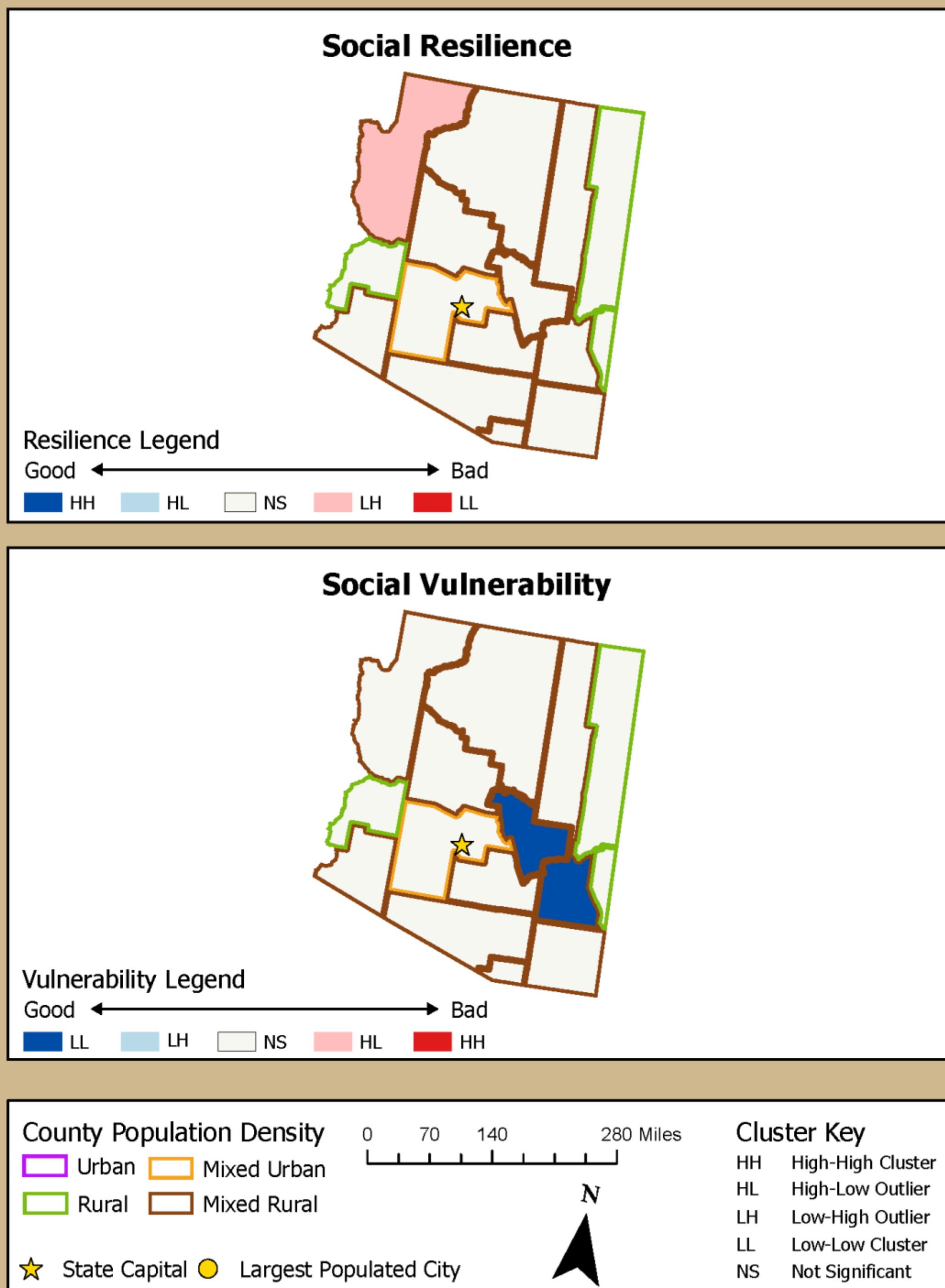

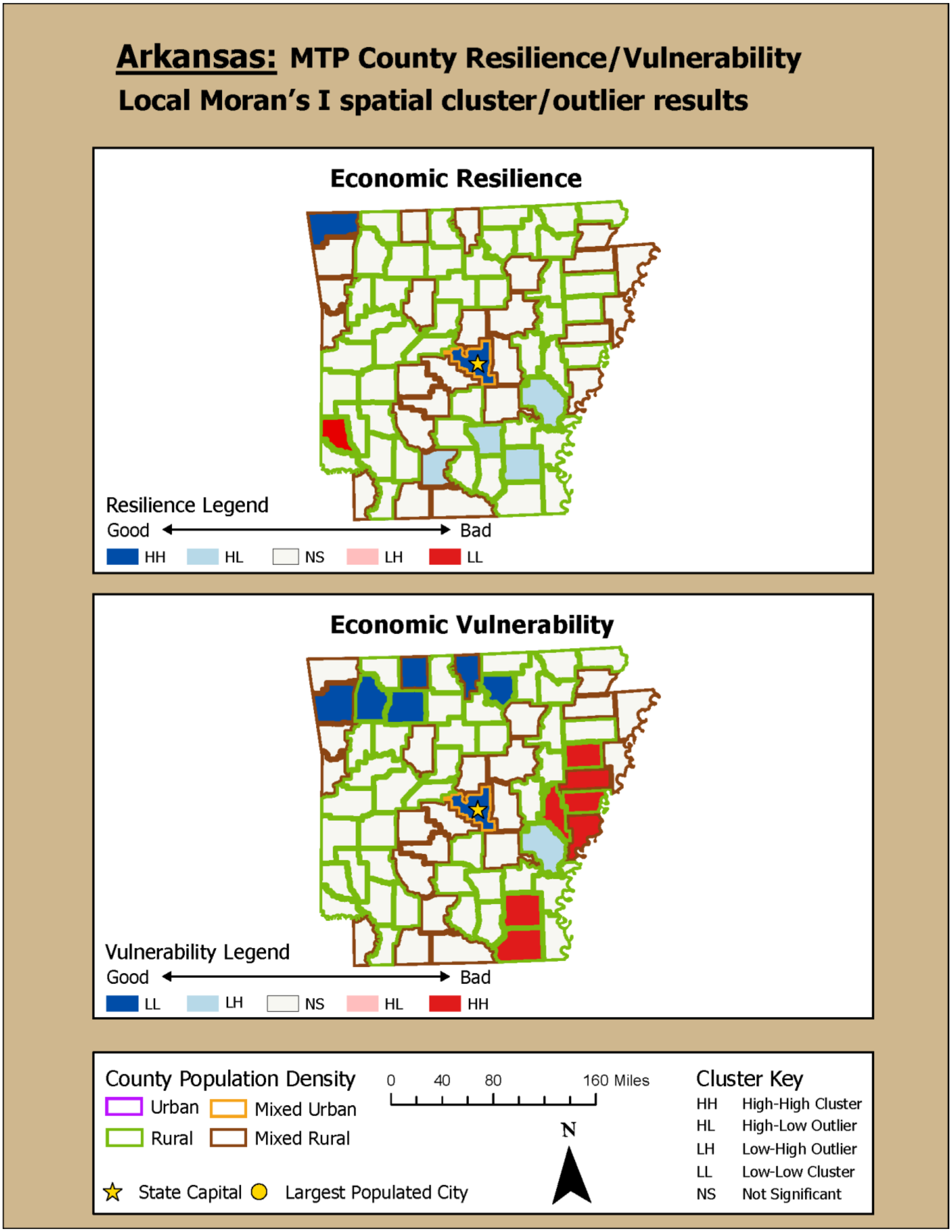
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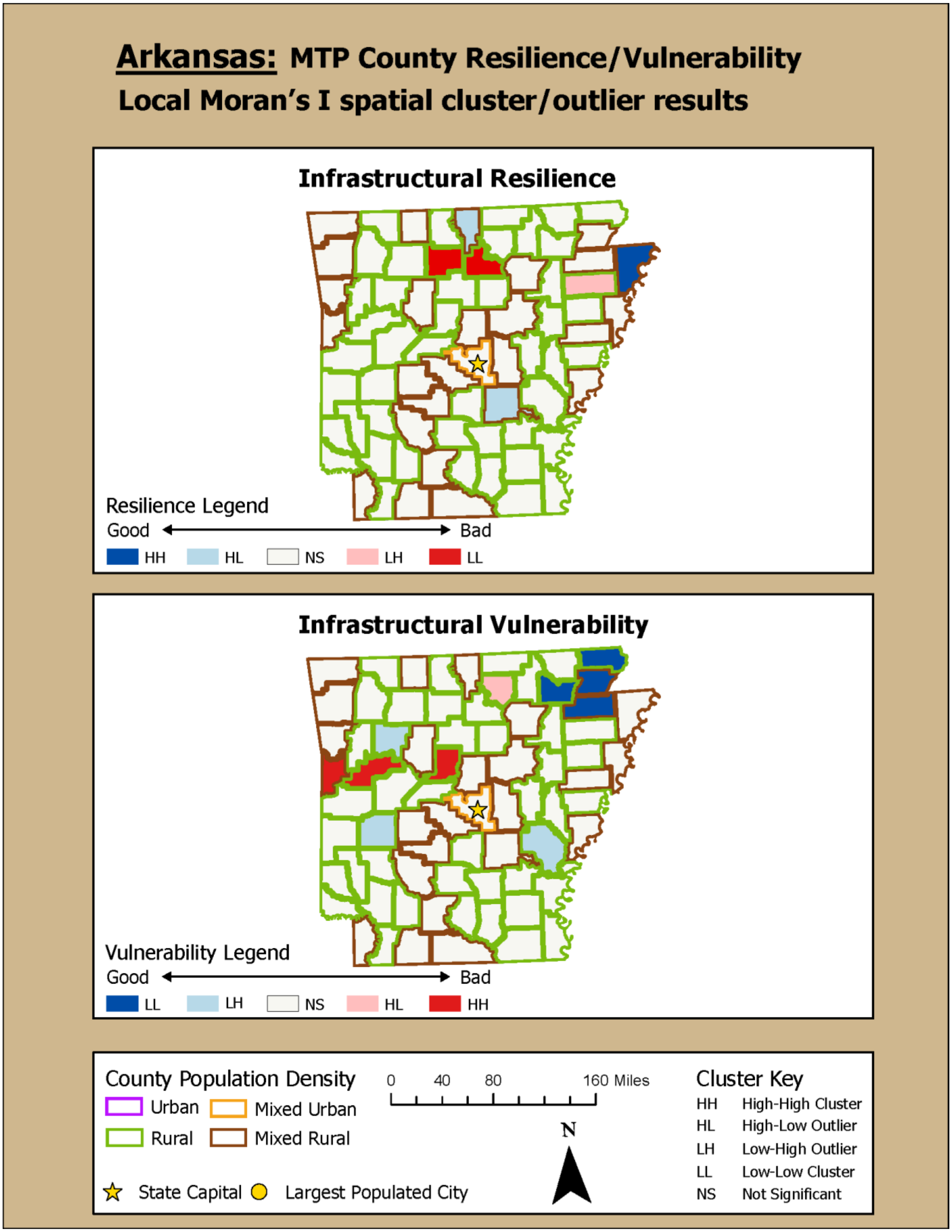
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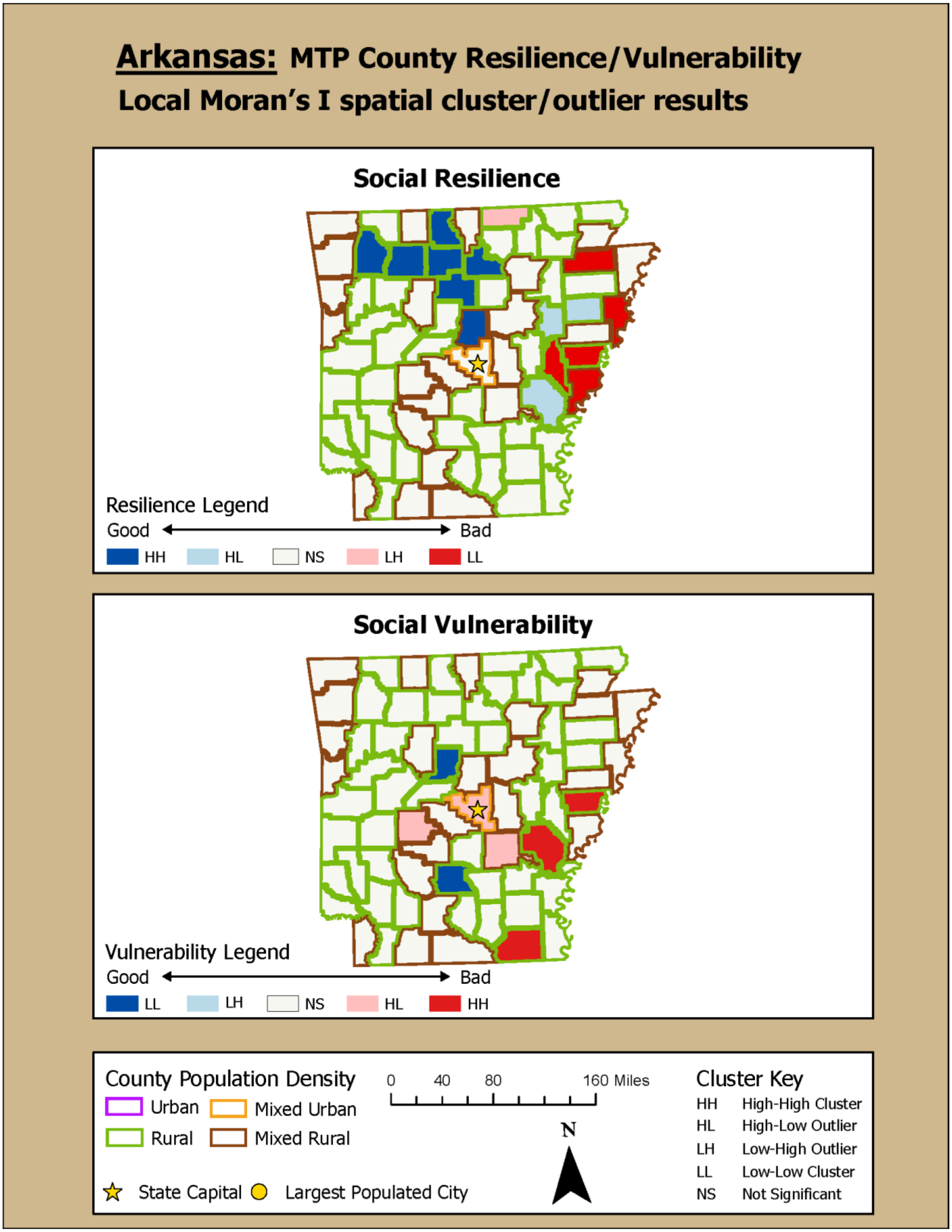
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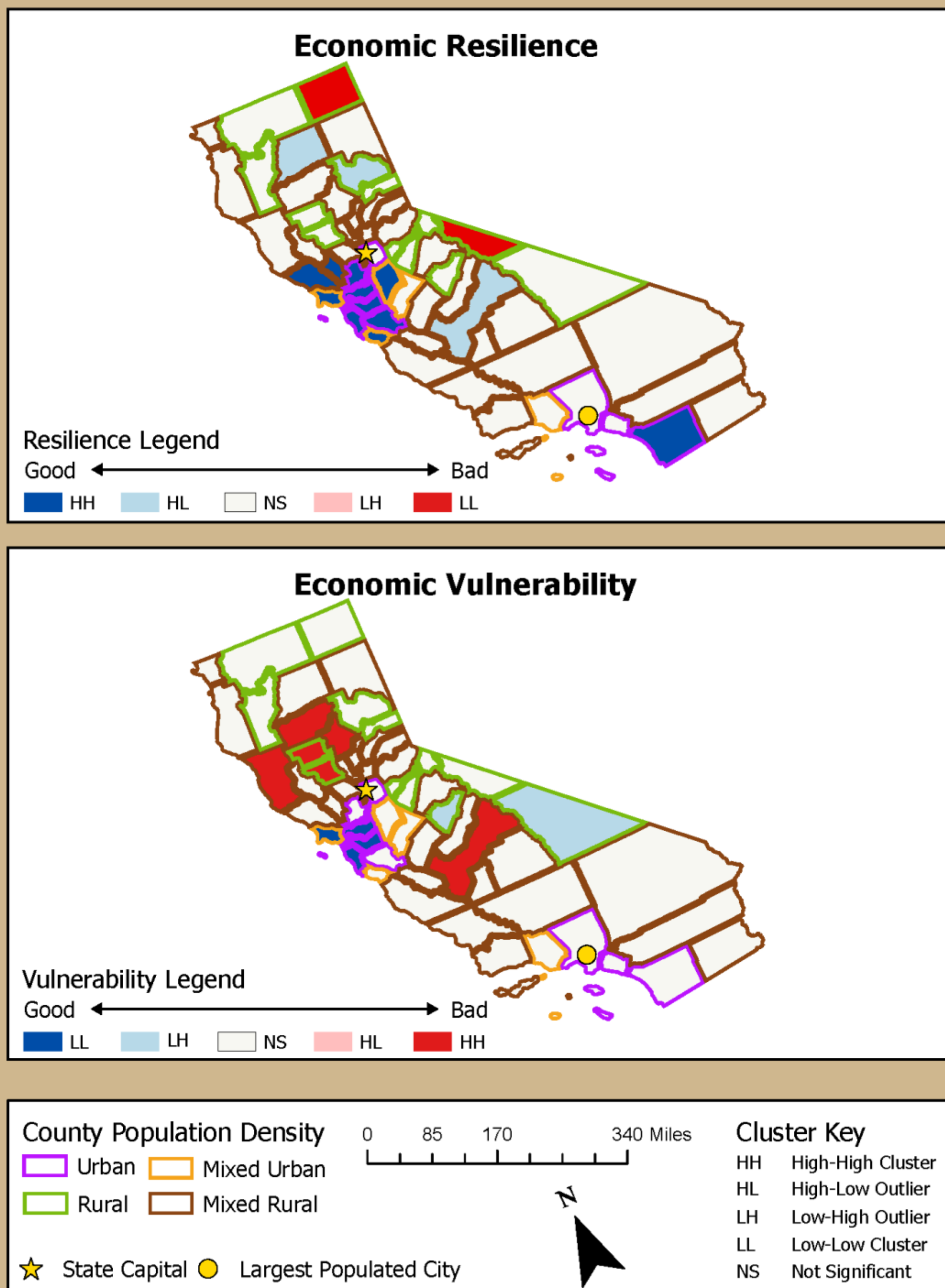

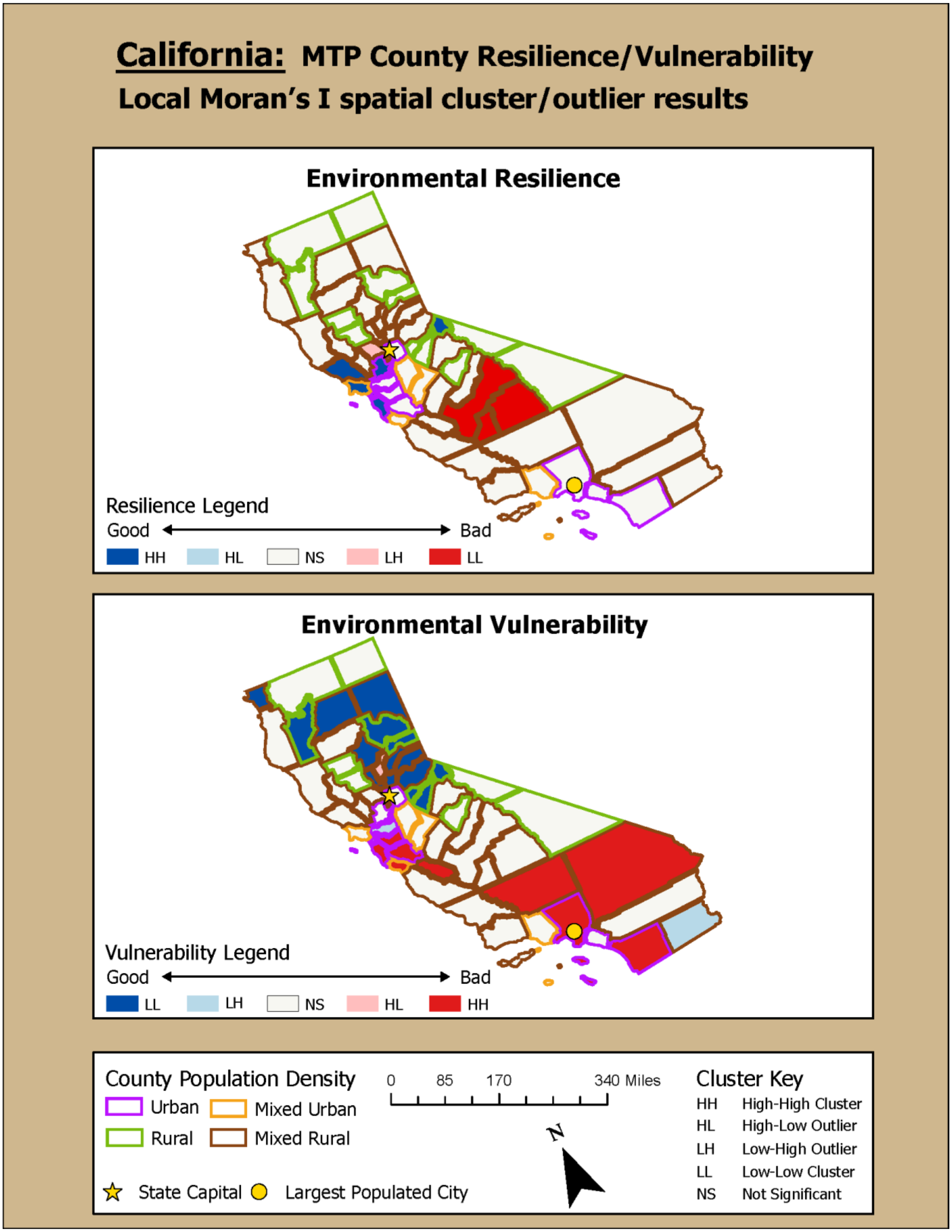
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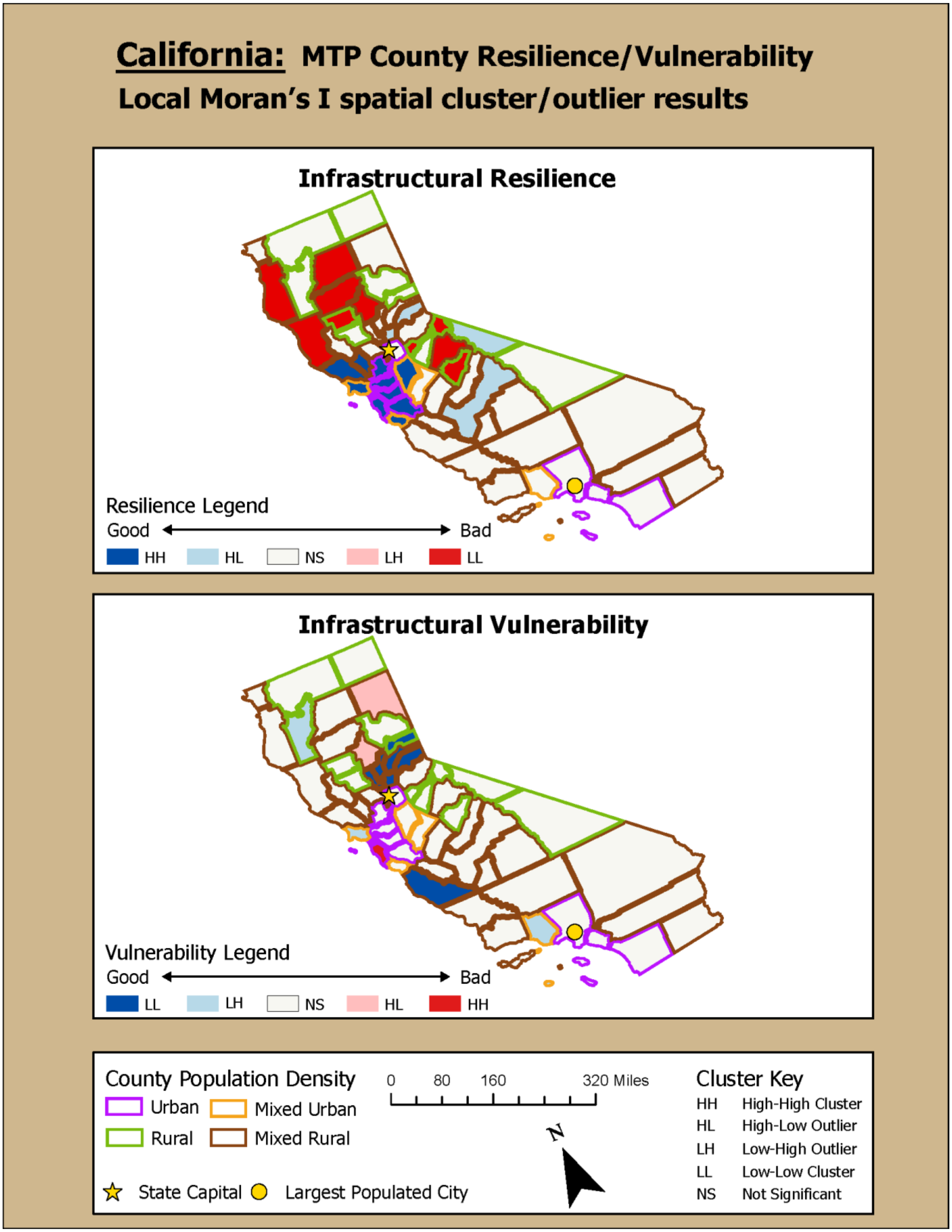
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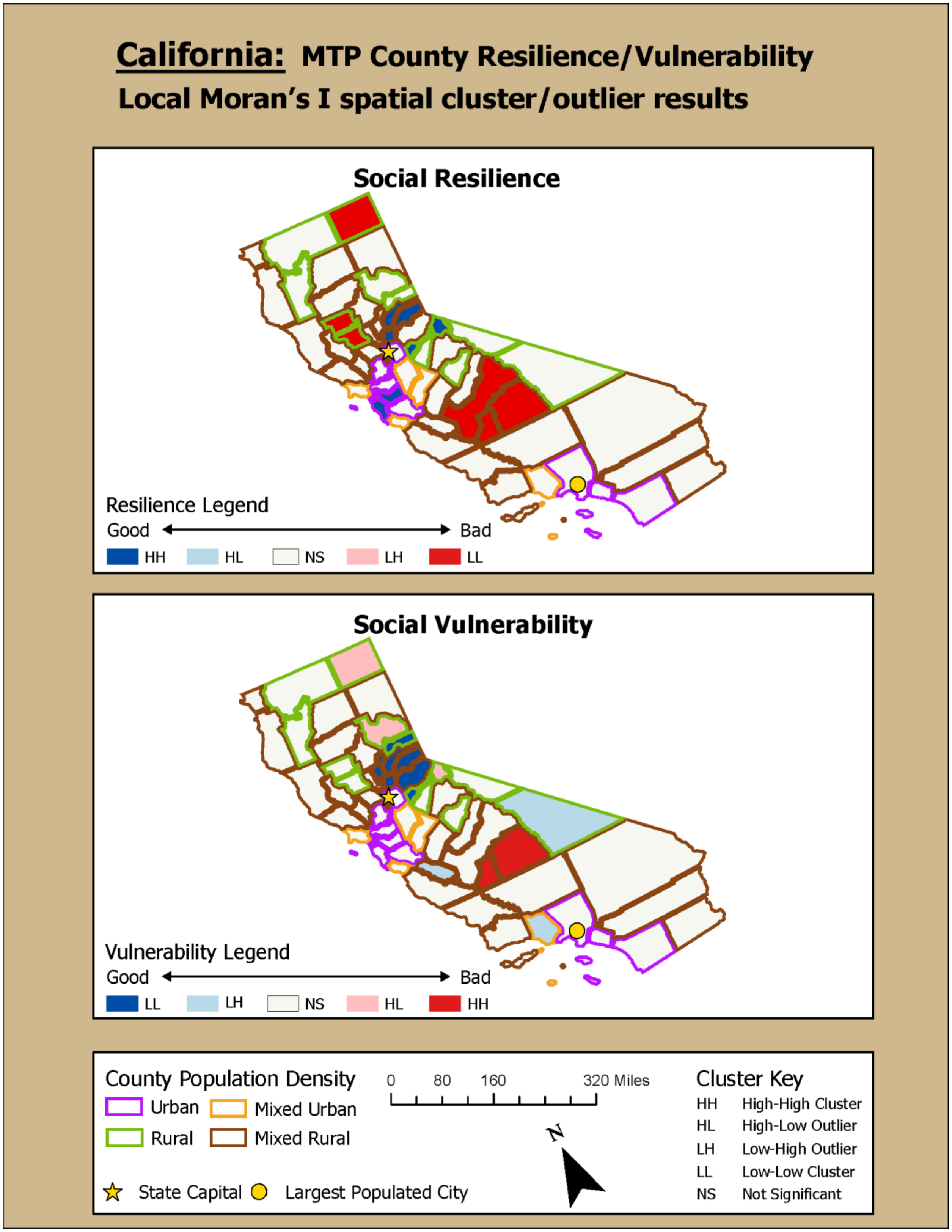
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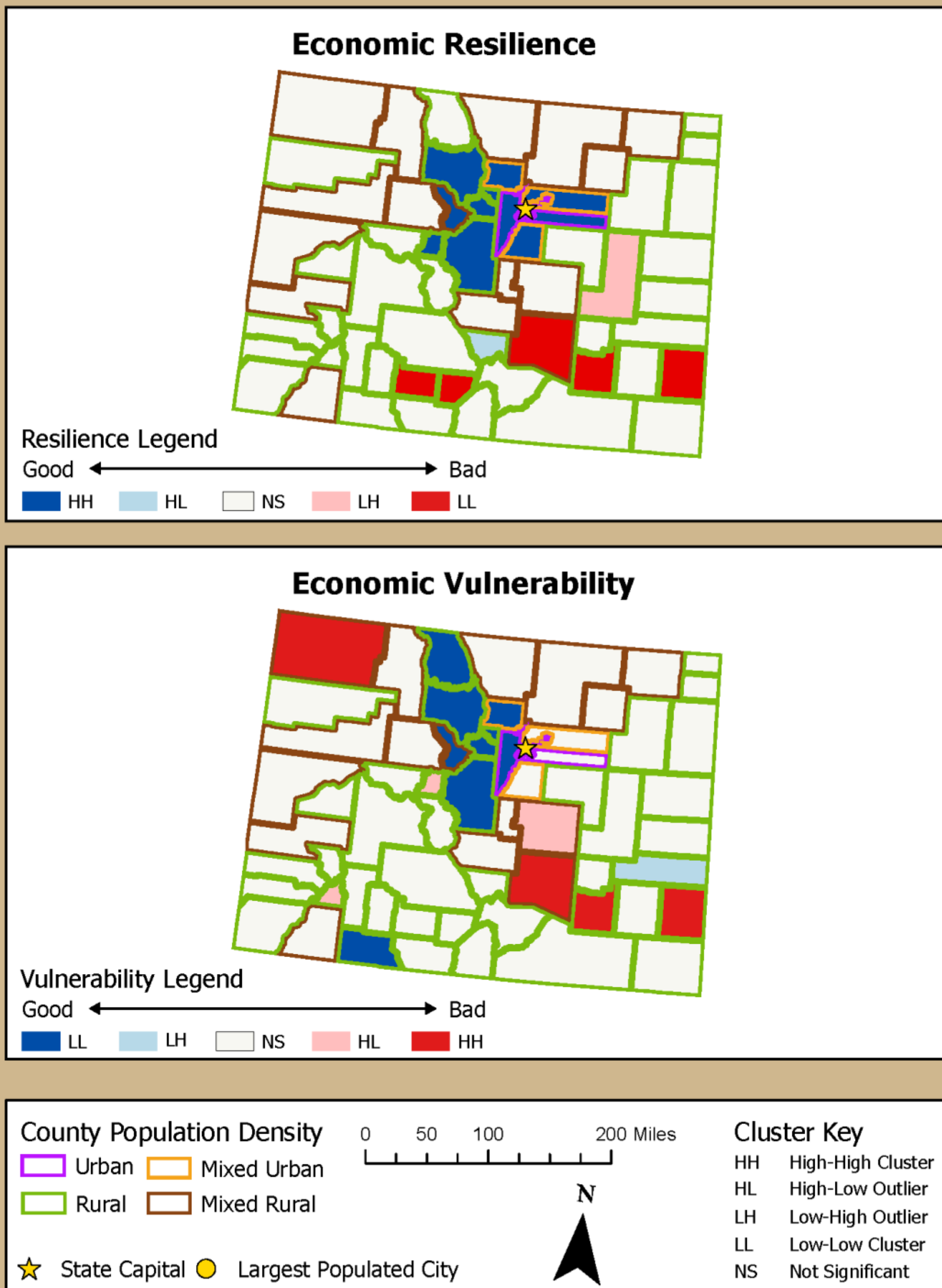

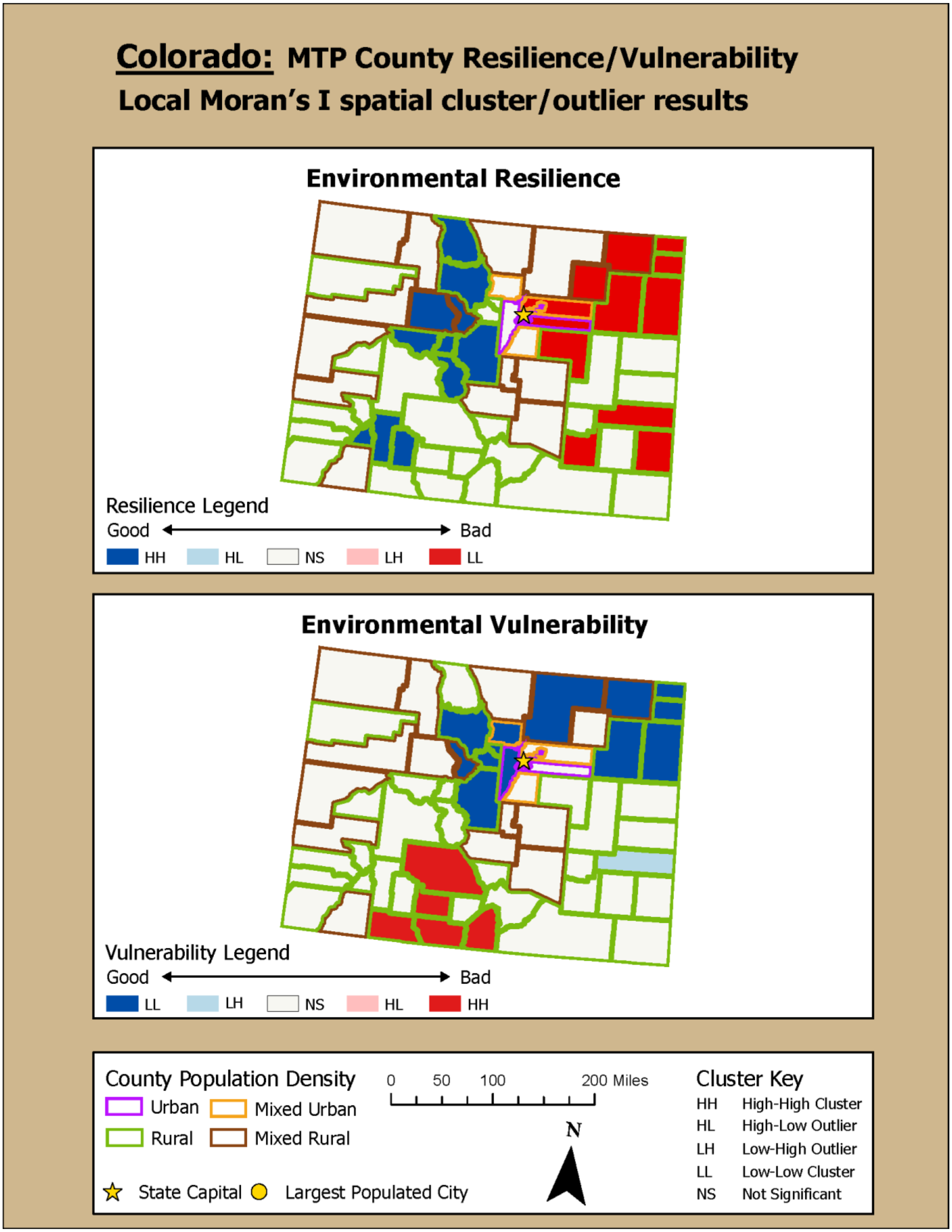
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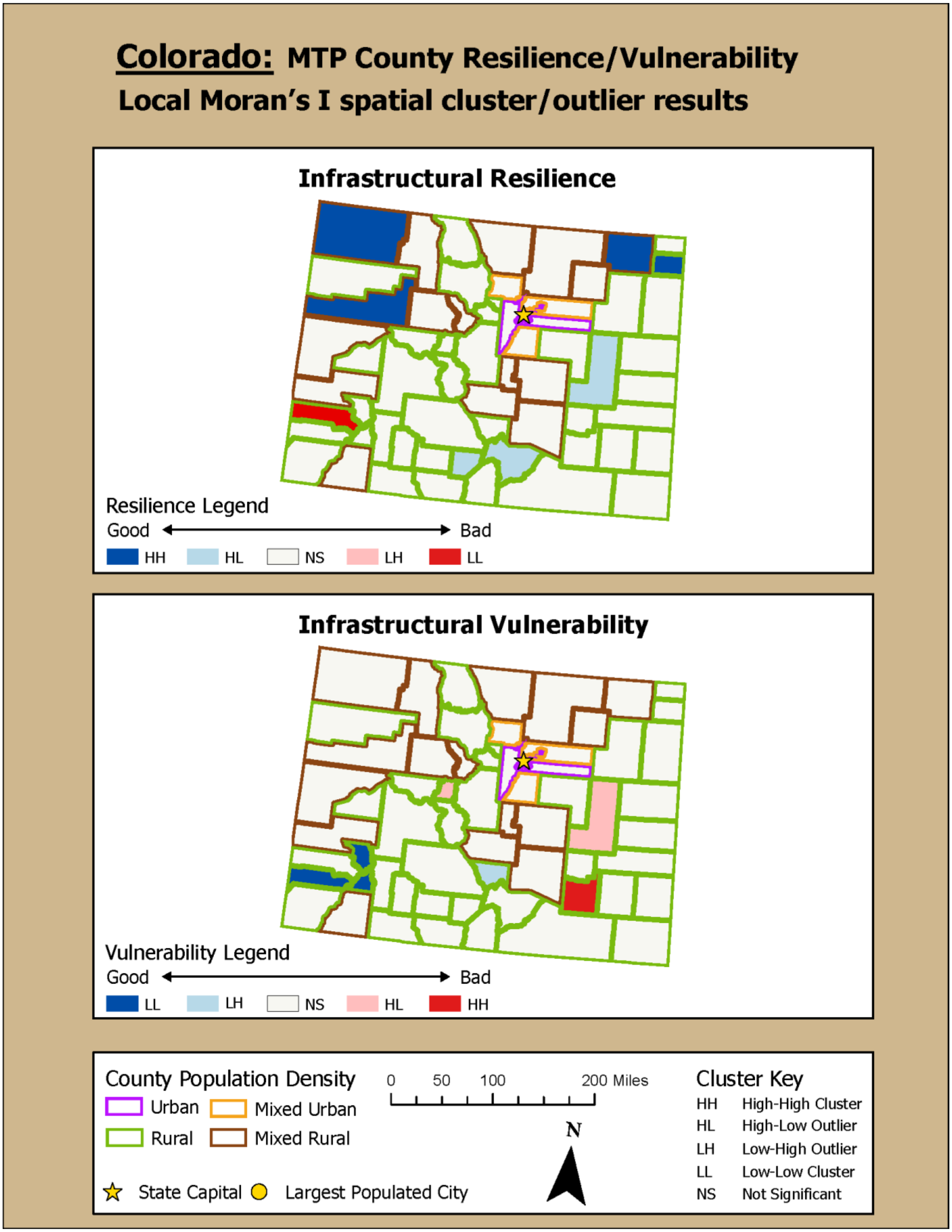
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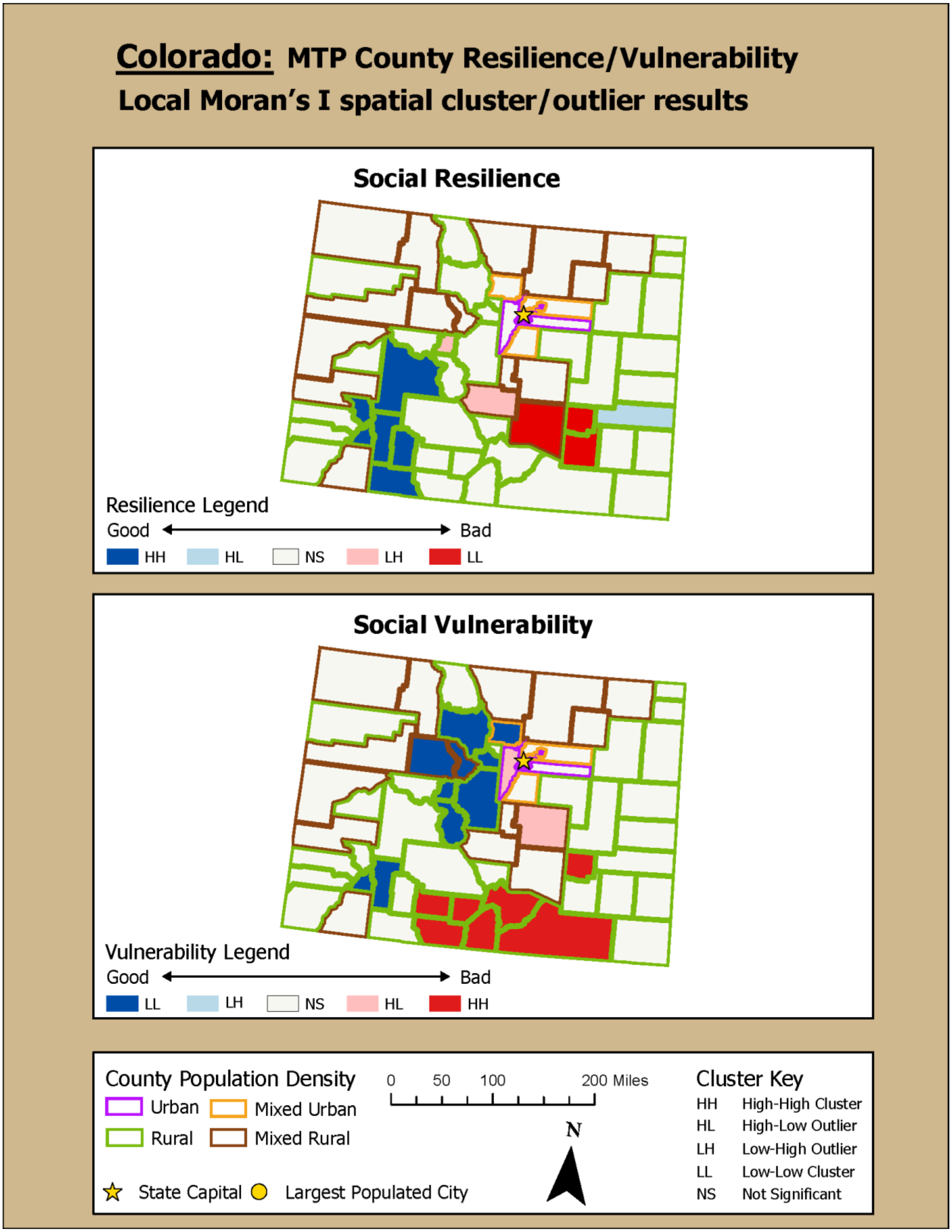
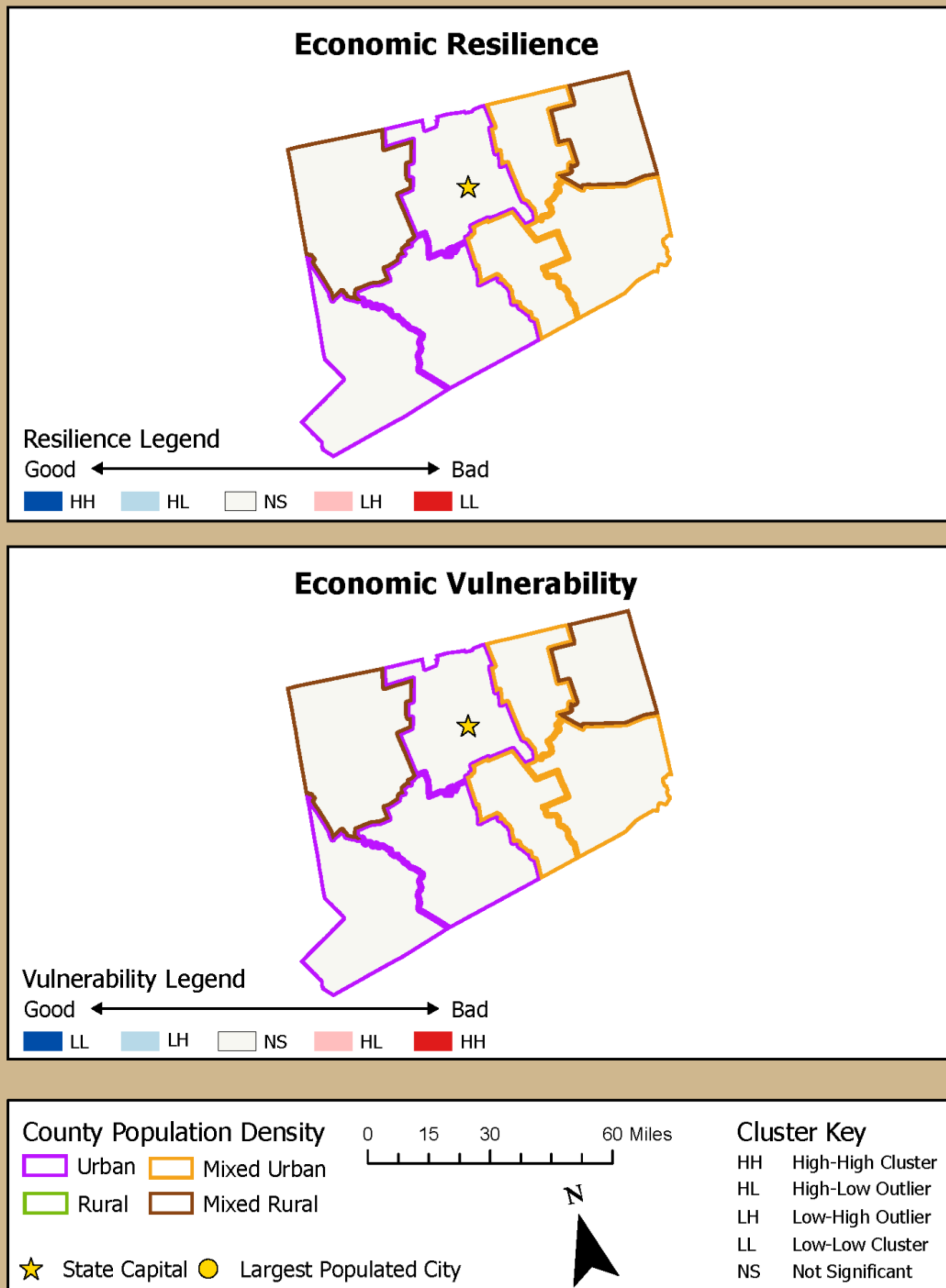
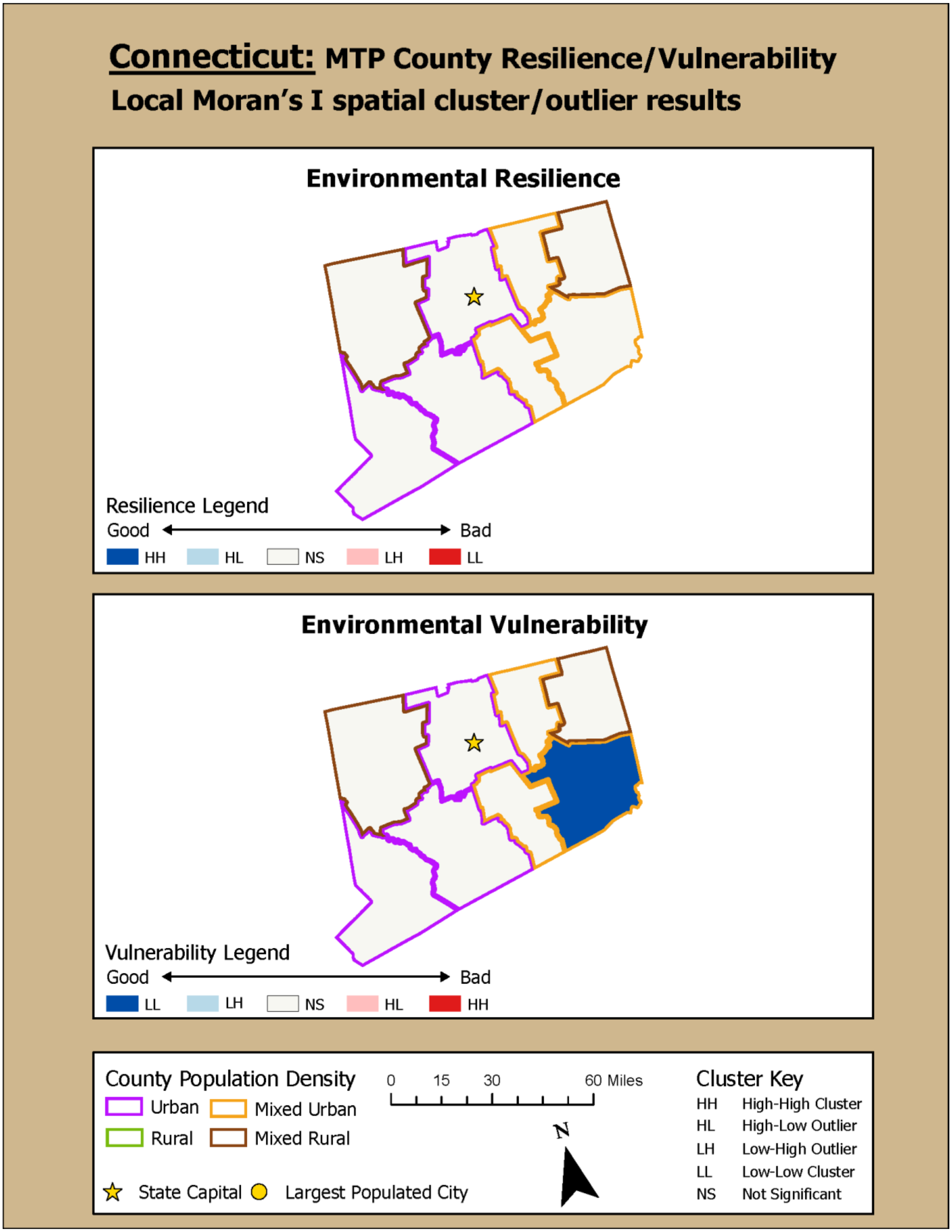
LL Low-Low Cluster
NS Not Significant

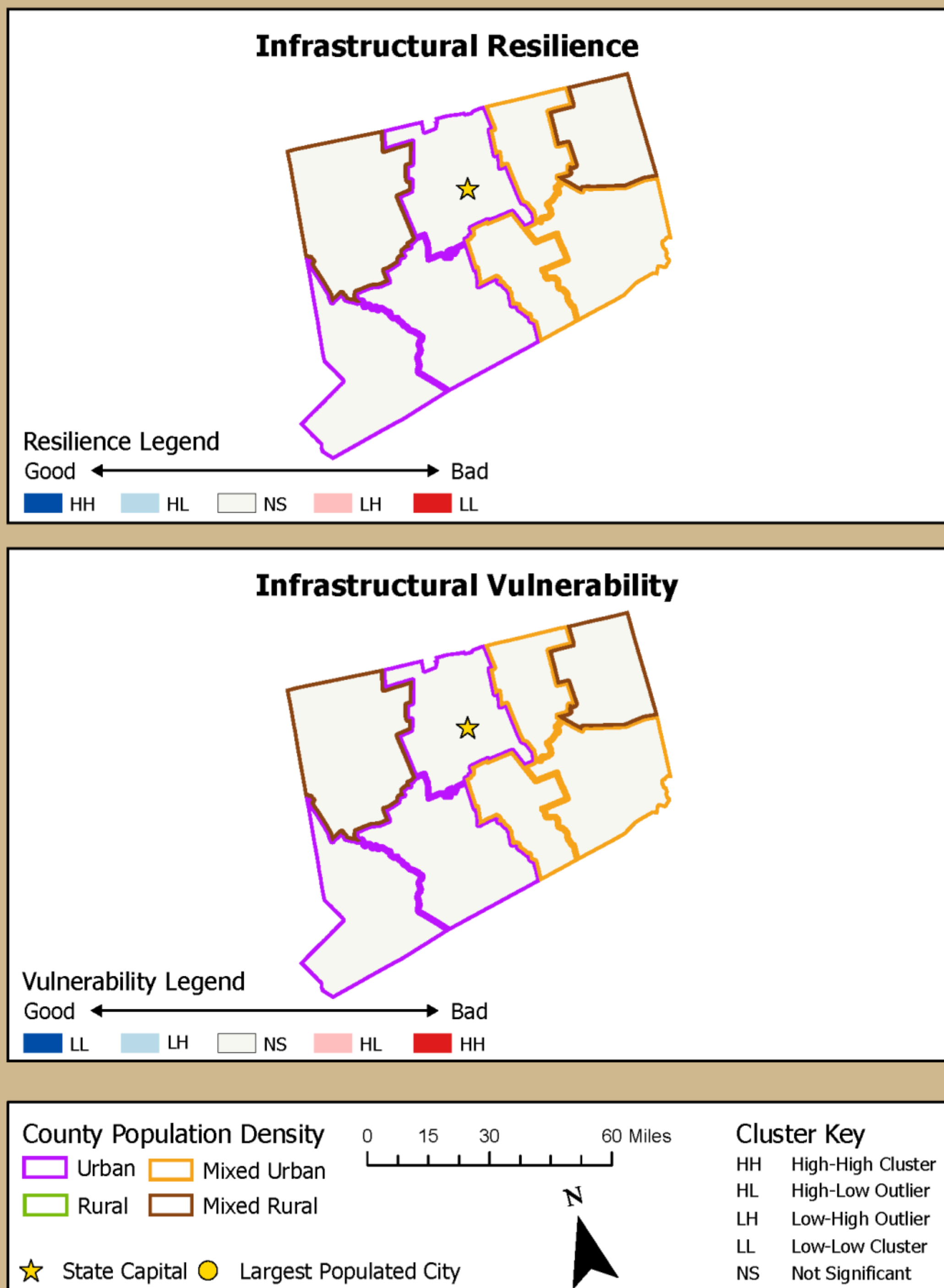

Colorado: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results
Social Resilience
Resilience Legend
Good
Bad
HH
HL
NS
LH
LL
Social Vulnerability
Vulnerability Legend
Good
Bad
LL
LH
NS
HL
HH
County Population Density
Urban
Mixed Urban
Rural
Mixed Rural
State Capital
Largest Populated City
0
50
100
200 Miles
N
Cluster Key
HH High-High Cluster
HL High-Low Outlier
LH Low-High Outlier
LL Low-Low Cluster
NS Not Significant

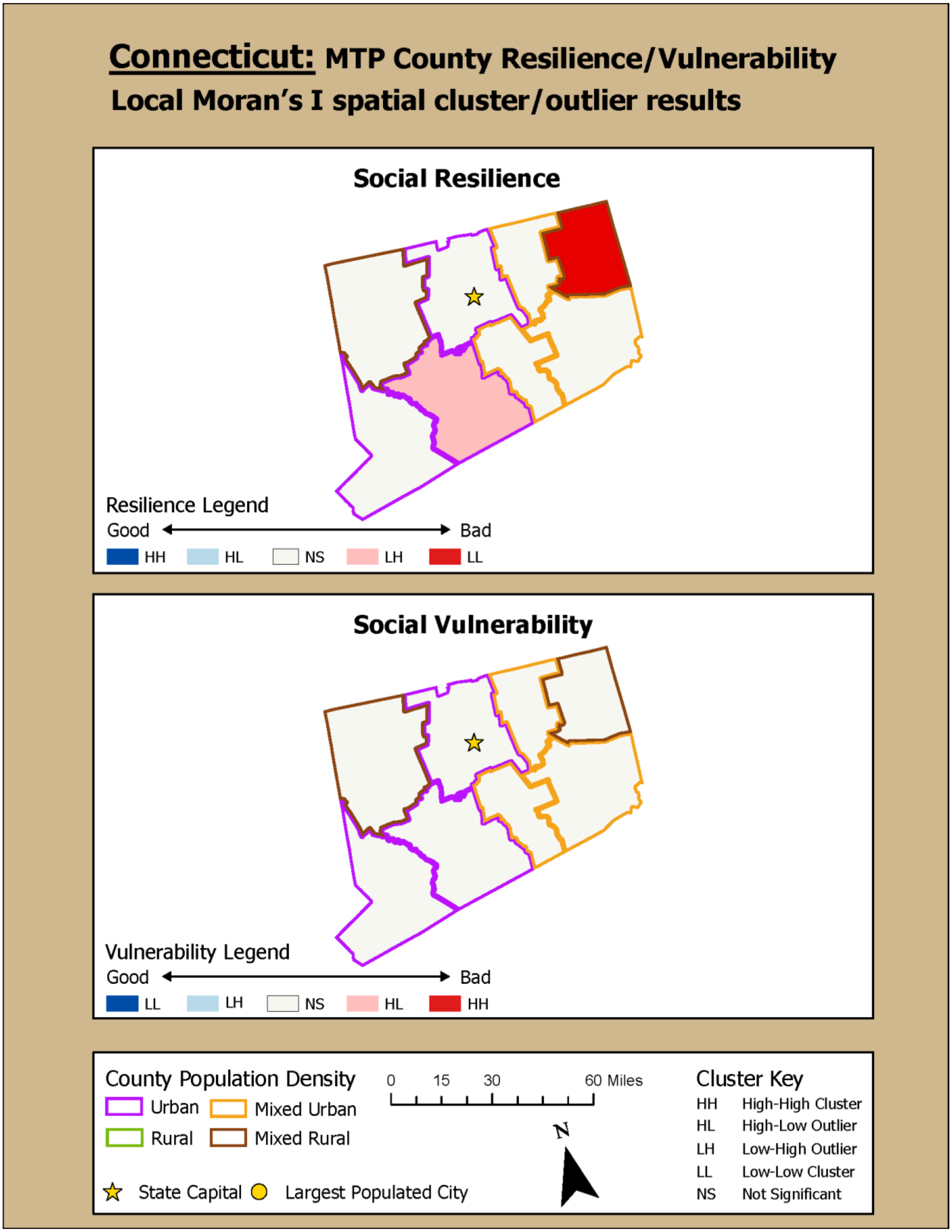
Connecticut: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results

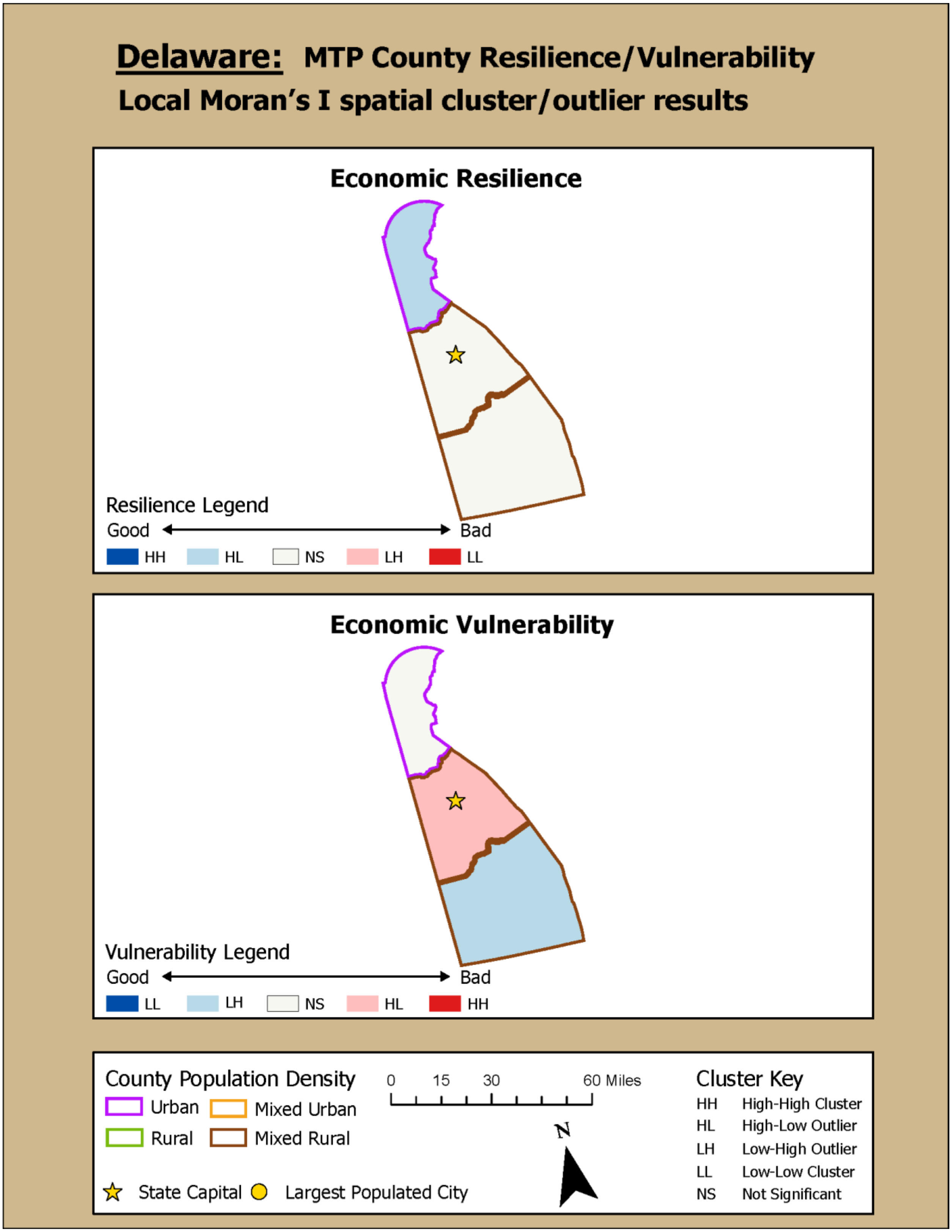



Connecticut: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results
Environmental Resilience
Resilience Legend
Good
Bad
HH
HL
NS
LH
LL
Environmental Vulnerability
Vulnerability Legend
Good
Bad
LL
LH
NS
HL
HH
County Population Density
Urban
Mixed Urban
Rural
Mixed Rural
State Capital
Largest Populated City
0
15
30
60 Miles
N
Cluster Key
HH High-High Cluster
HL High-Low Outlier
LH Low-High Outlier
LL Low-Low Cluster
NS Not Significant

Connecticut: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results




Connecticut: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results
Social Resilience
Resilience Legend
Good
Bad
HH
HL
NS
LH
LL
Social Vulnerability
Vulnerability Legend
Good
Bad
LL
LH
NS
HL
HH
County Population Density
Urban
Mixed Urban
Rural
Mixed Rural
State Capital
Largest Populated City
0
15
30
60 Miles
N
Cluster Key
HH High-High Cluster
HL High-Low Outlier
LH Low-High Outlier
LL Low-Low Cluster
NS Not Significant


Delaware: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results
Economic Resilience
Resilience Legend
Good
Bad
HH
HL
NS
LH
LL
Economic Vulnerability
Vulnerability Legend
Good
Bad
LL
LH
NS
HL
HH
County Population Density
Urban
Mixed Urban
Rural
Mixed Rural
State Capital
Largest Populated City
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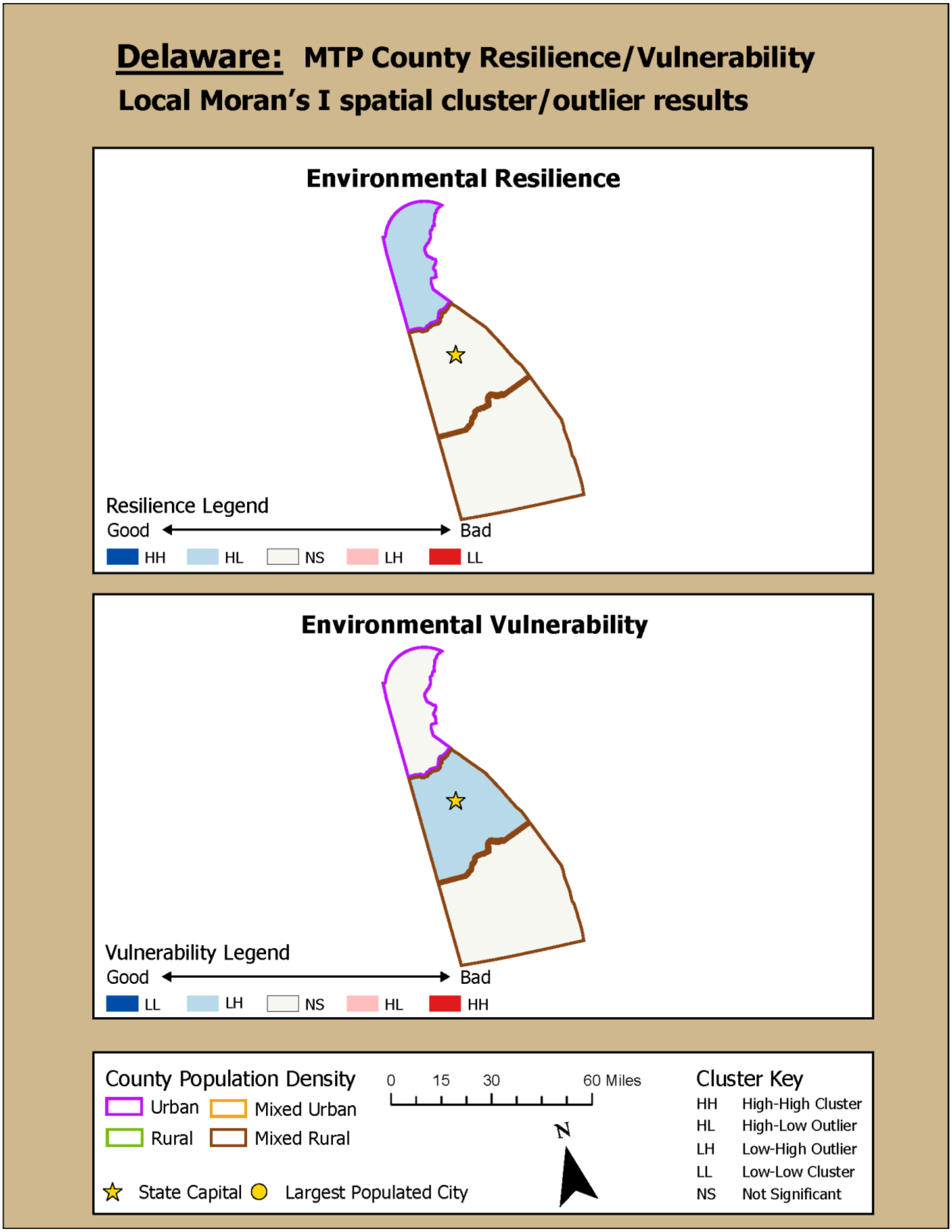
15
30
60 Miles
N
Cluster Key
HH High-High Cluster
HL High-Low Outlier
LH Low-High Outlier
LL Low-Low Cluster
NS Not Significant


Delaware: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results
Environmental Resilience
Resilience Legend
Good
Bad
HH
HL
NS
LH
LL
Environmental Vulnerability
Vulnerability Legend
Good
Bad
LL
LH
NS
HL
HH
County Population Density
Urban
Mixed Urban
Rural
Mixed Rural
State Capital
Largest Populated City
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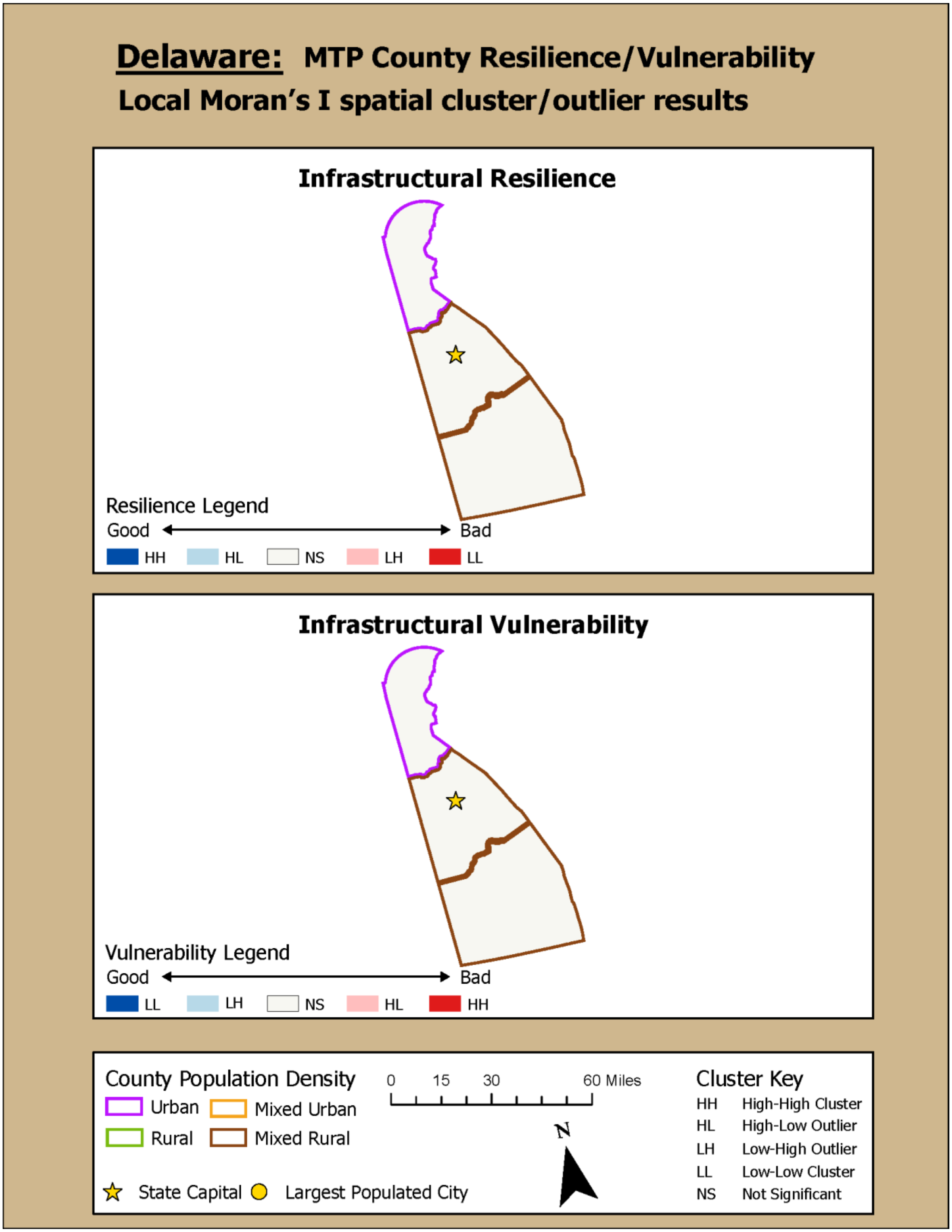
15
30
60 Miles
N
Cluster Key
HH High-High Cluster
HL High-Low Outlier
LH Low-High Outlier
LL Low-Low Cluster
NS Not Significant


Delaware: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results
Infrastructural Resilience
Resilience Legend
Good
Bad
HH
HL
NS
LH
LL
Infrastructural Vulnerability
Vulnerability Legend
Good
Bad
LL
LH
NS
HL
HH
County Population Density
Urban
Mixed Urban
Rural
Mixed Rural
State Capital
Largest Populated City
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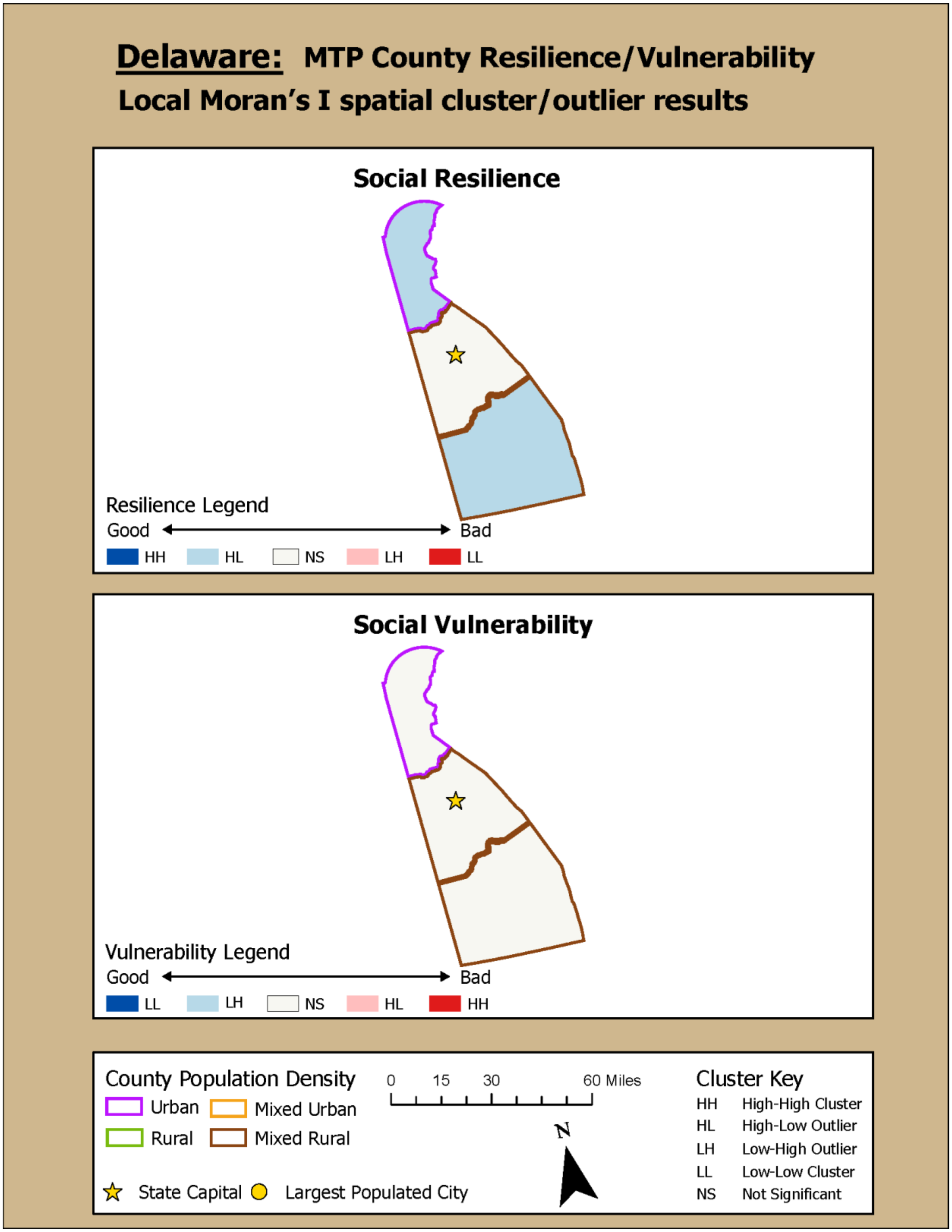
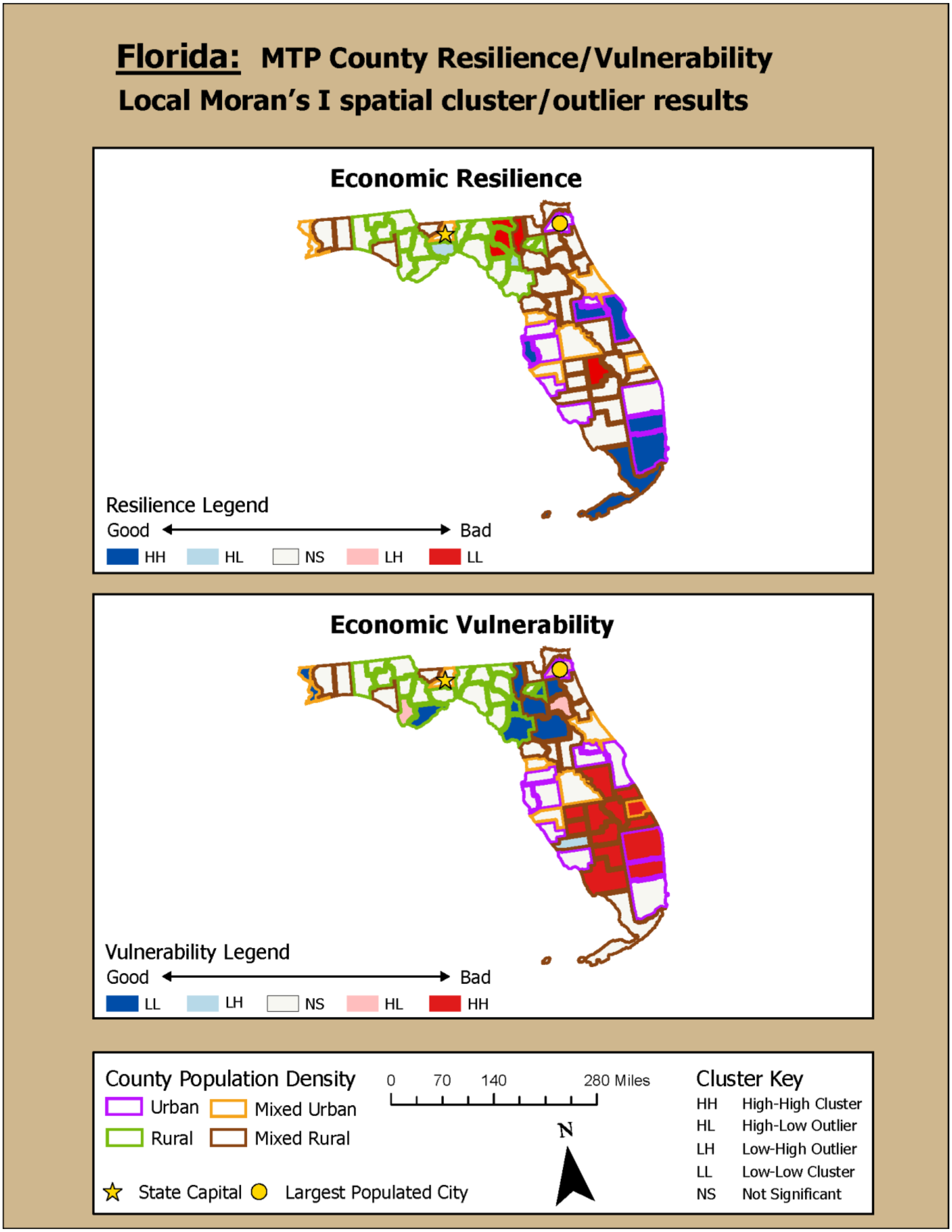
N
Cluster Key
HH High-High Cluster
HL High-Low Outlier
LH Low-High Outlier
LL Low-Low Cluster
NS Not Significant


Delaware: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results
Social Resilience
Resilience Legend
Good
Bad
HH
HL
NS
LH
LL
Social Vulnerability
Vulnerability Legend
Good
Bad
LL
LH
NS
HL
HH
County Population Density
Urban
Mixed Urban
Rural
Mixed Rural
State Capital
Largest Populated City
0
15
30
60 Miles
N
Cluster Key
HH High-High Cluster
HL High-Low Outlier
LH Low-High Outlier
LL Low-Low Cluster
NS Not Significant


Florida: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results
Economic Resilience
Resilience Legend
Good
Bad
HH
HL
NS
LH
LL
Economic Vulnerability
Vulnerability Legend
Good
Bad
LL
LH
NS
HL
HH
County Population Density
Urban
Mixed Urban
Rural
Mixed Rural
State Capital
Largest Populated City
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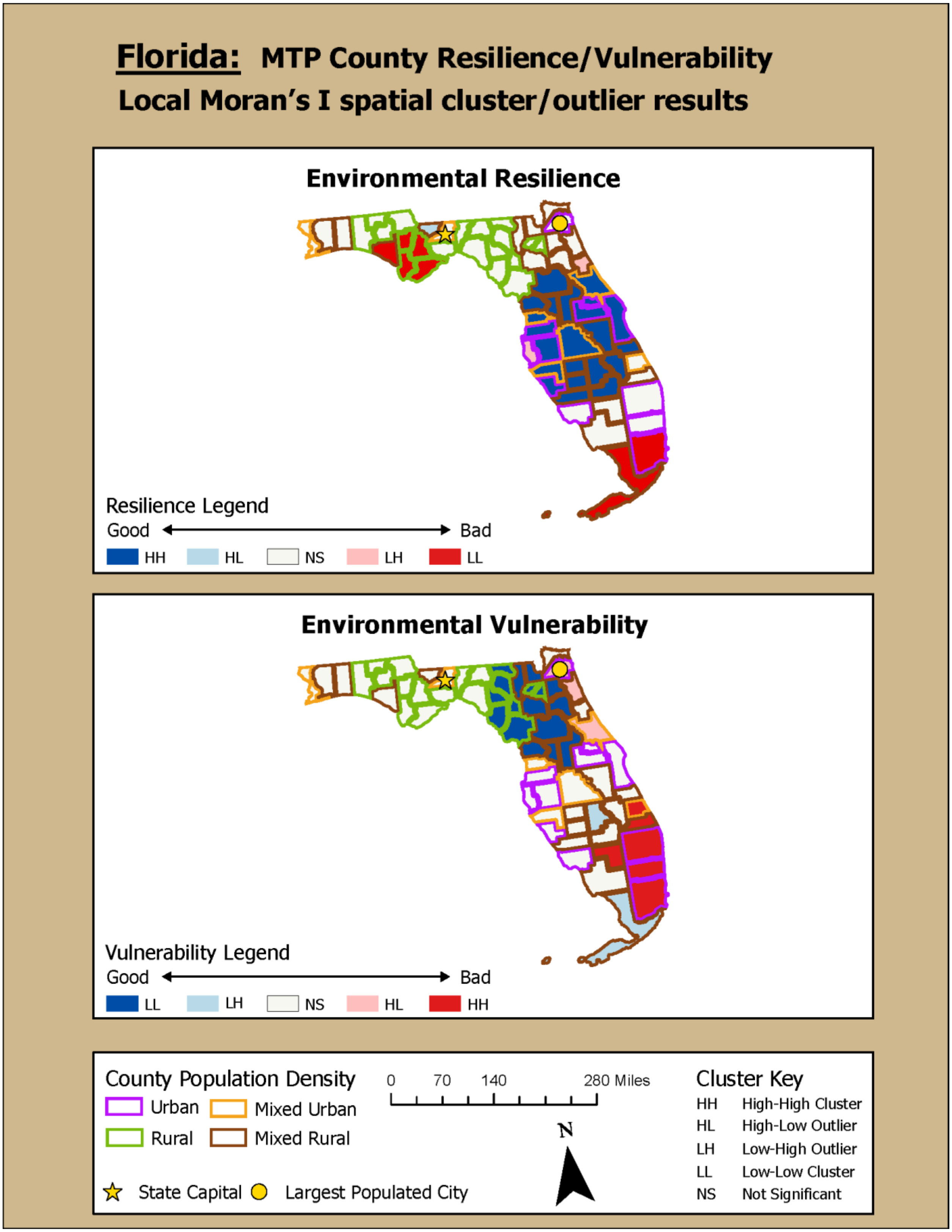
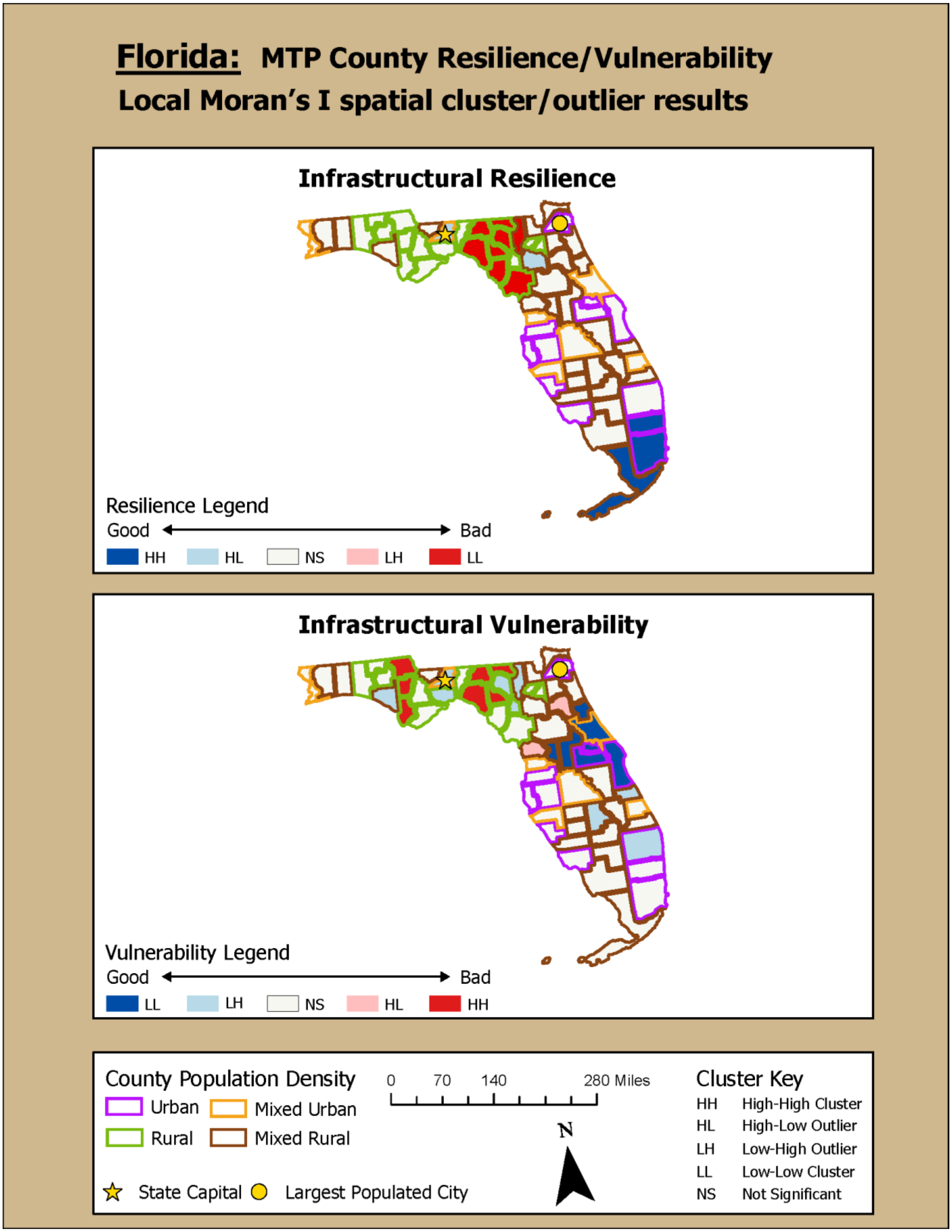
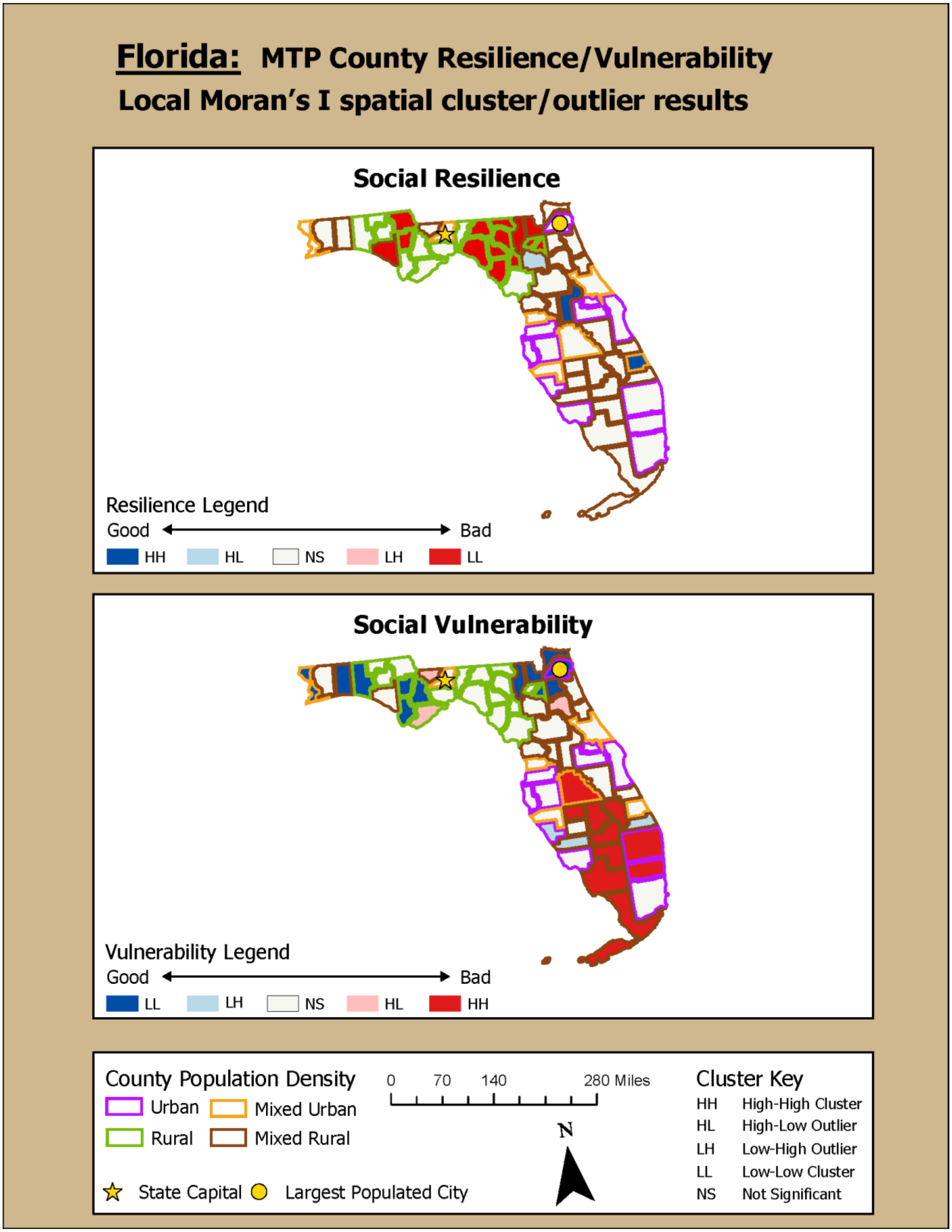
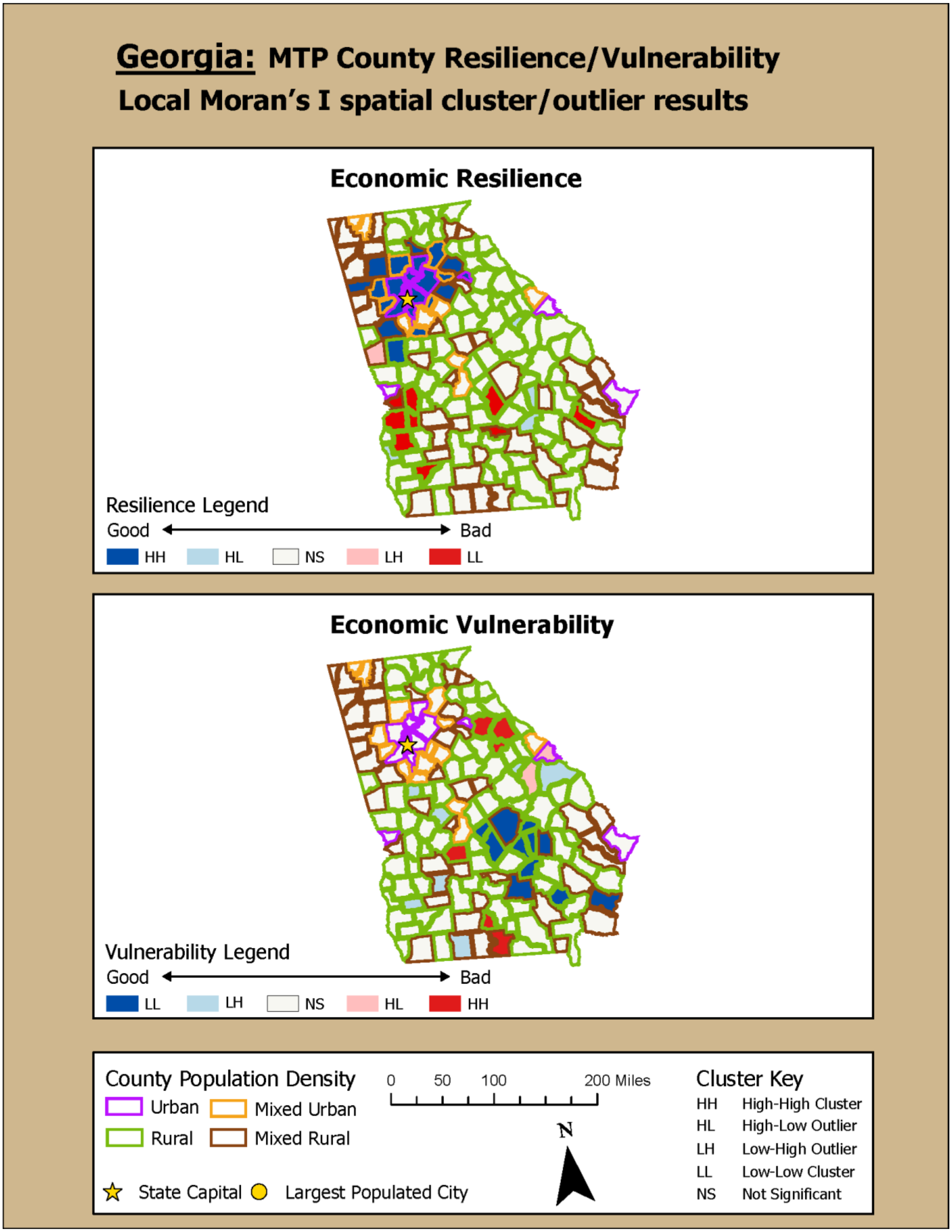
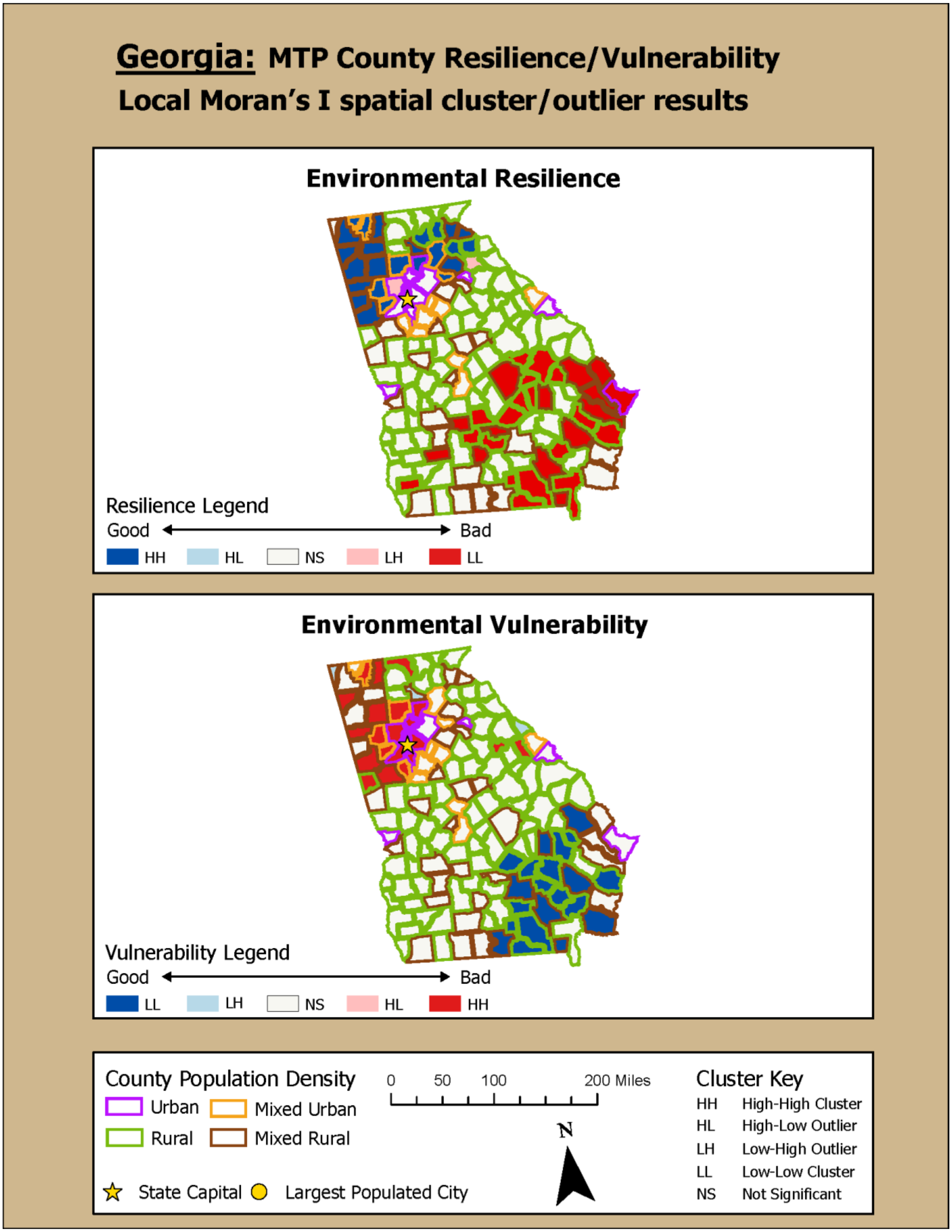
70
140
280 Miles
N
Cluster Key
HH High-High Cluster
HL High-Low Outlier
LH Low-High Outlier
LL Low-Low Cluster
NS Not Significant


Florida: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results
Environmental Resilience
Resilience Legend
Good
Bad
HH
HL
NS
LH
LL
Environmental Vulnerability
Vulnerability Legend
Good
Bad
LL
LH
NS
HL
HH
County Population Density
Urban
Mixed Urban
Rural
Mixed Rural
State Capital
Largest Populated City
0
70
140
280 Miles
N
Cluster Key
HH High-High Cluster
HL High-Low Outlier
LH Low-High Outlier
LL Low-Low Cluster
NS Not Significant


Florida: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results
Infrastructural Resilience
Resilience Legend
Good
Bad
HH
HL
NS
LH
LL
Infrastructural Vulnerability
Vulnerability Legend
Good
Bad
LL
LH
NS
HL
HH
County Population Density
Urban
Mixed Urban
Rural
Mixed Rural
State Capital
Largest Populated City
0
70
140
280 Miles
N
Cluster Key
HH High-High Cluster
HL High-Low Outlier
LH Low-High Outlier
LL Low-Low Cluster
NS Not Significant


Florida: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results
Social Resilience
Resilience Legend
Good
Bad
HH
HL
NS
LH
LL
Social Vulnerability
Vulnerability Legend
Good
Bad
LL
LH
NS
HL
HH
County Population Density
Urban
Mixed Urban
Rural
Mixed Rural
State Capital
Largest Populated City
0
70
140
280 Miles
N
Cluster Key
HH High-High Cluster
HL High-Low Outlier
LH Low-High Outlier
LL Low-Low Cluster
NS Not Significant


Georgia: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results
Economic Resilience
Resilience Legend
Good
Bad
HH
HL
NS
LH
LL
Economic Vulnerability
Vulnerability Legend
Good
Bad
LL
LH
NS
HL
HH
County Population Density
Urban
Mixed Urban
Rural
Mixed Rural
State Capital
Largest Populated City
0
50
100
200 Miles
N
Cluster Key
HH High-High Cluster
HL High-Low Outlier
LH Low-High Outlier
LL Low-Low Cluster
NS Not Significant


Georgia: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results
Environmental Resilience
Resilience Legend
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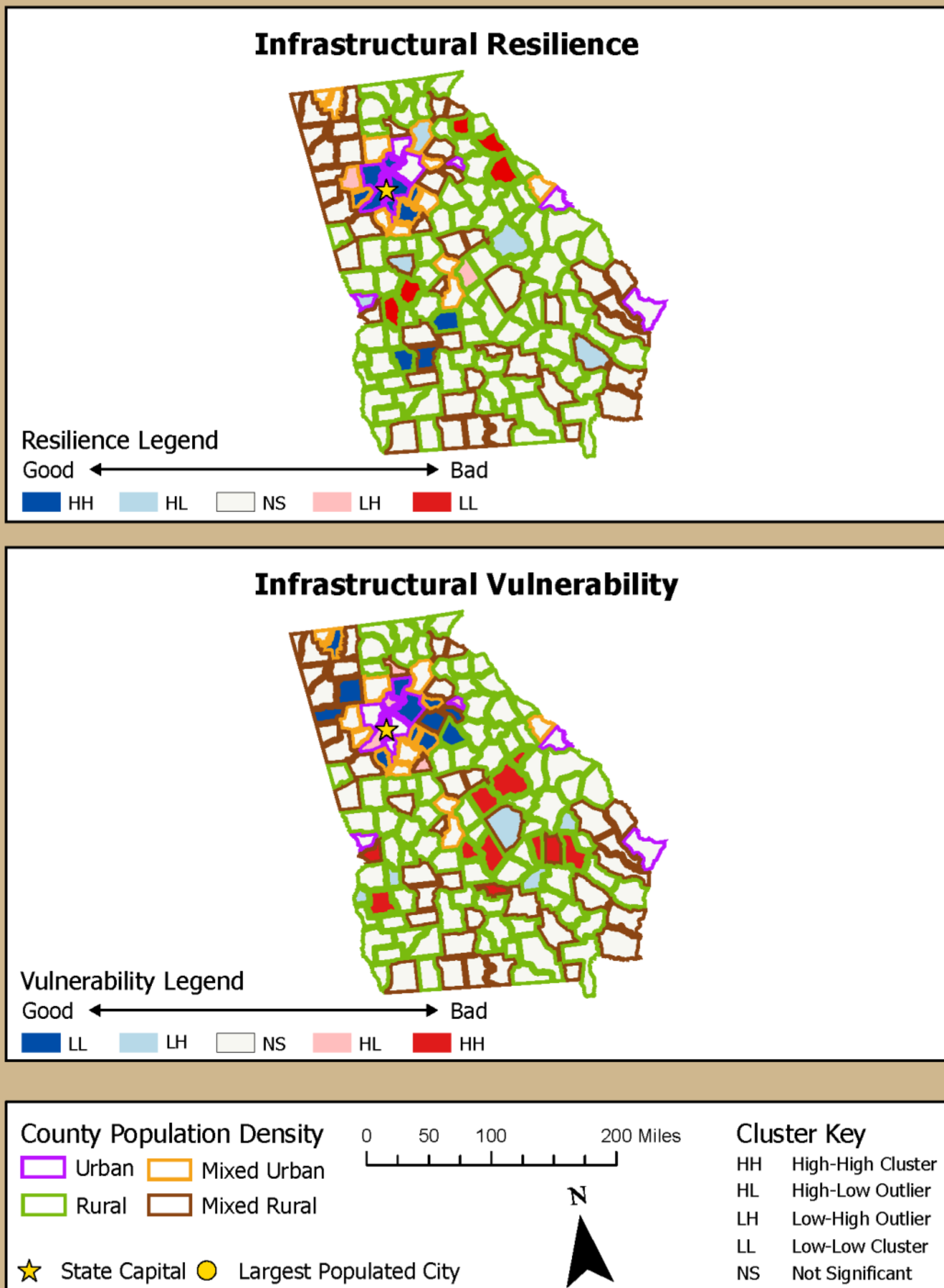
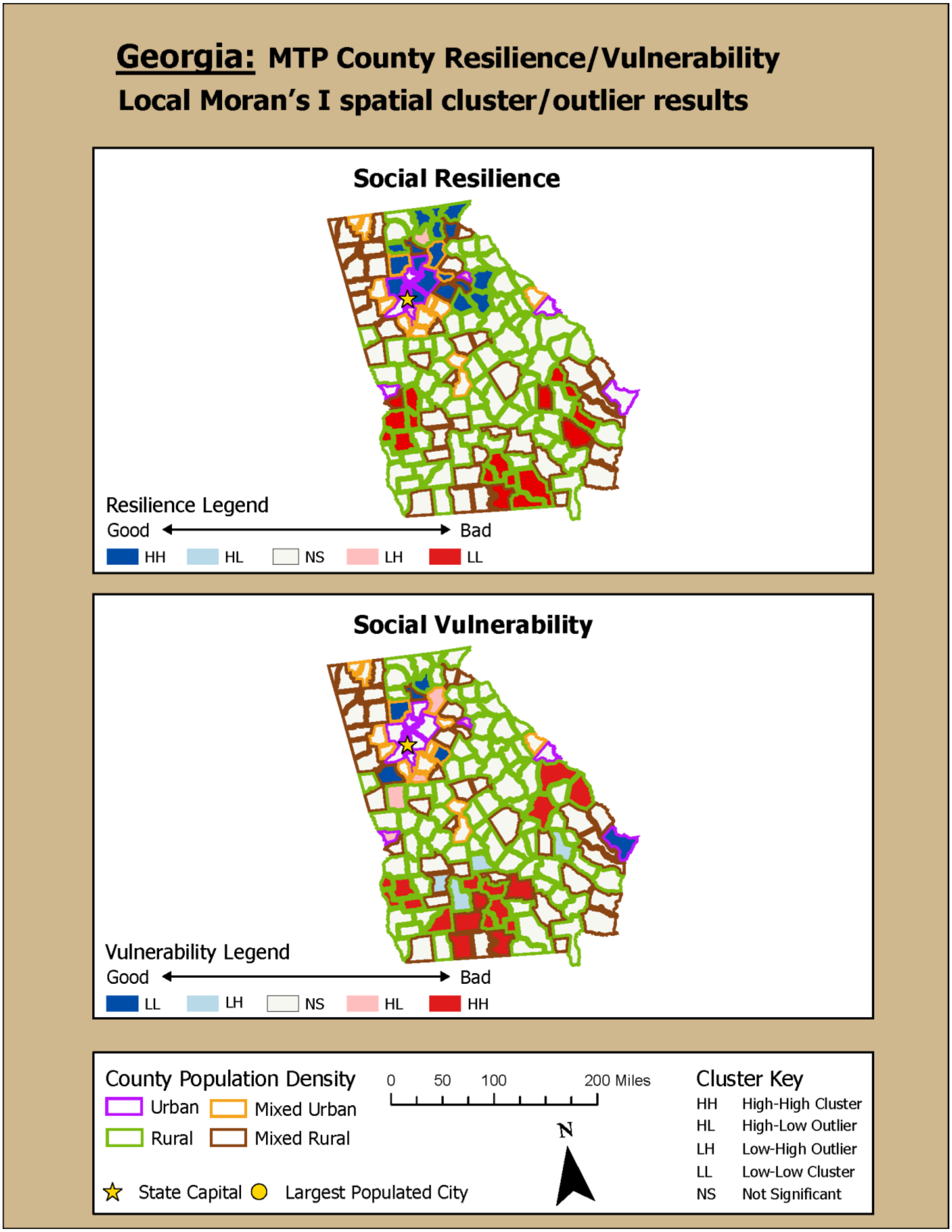
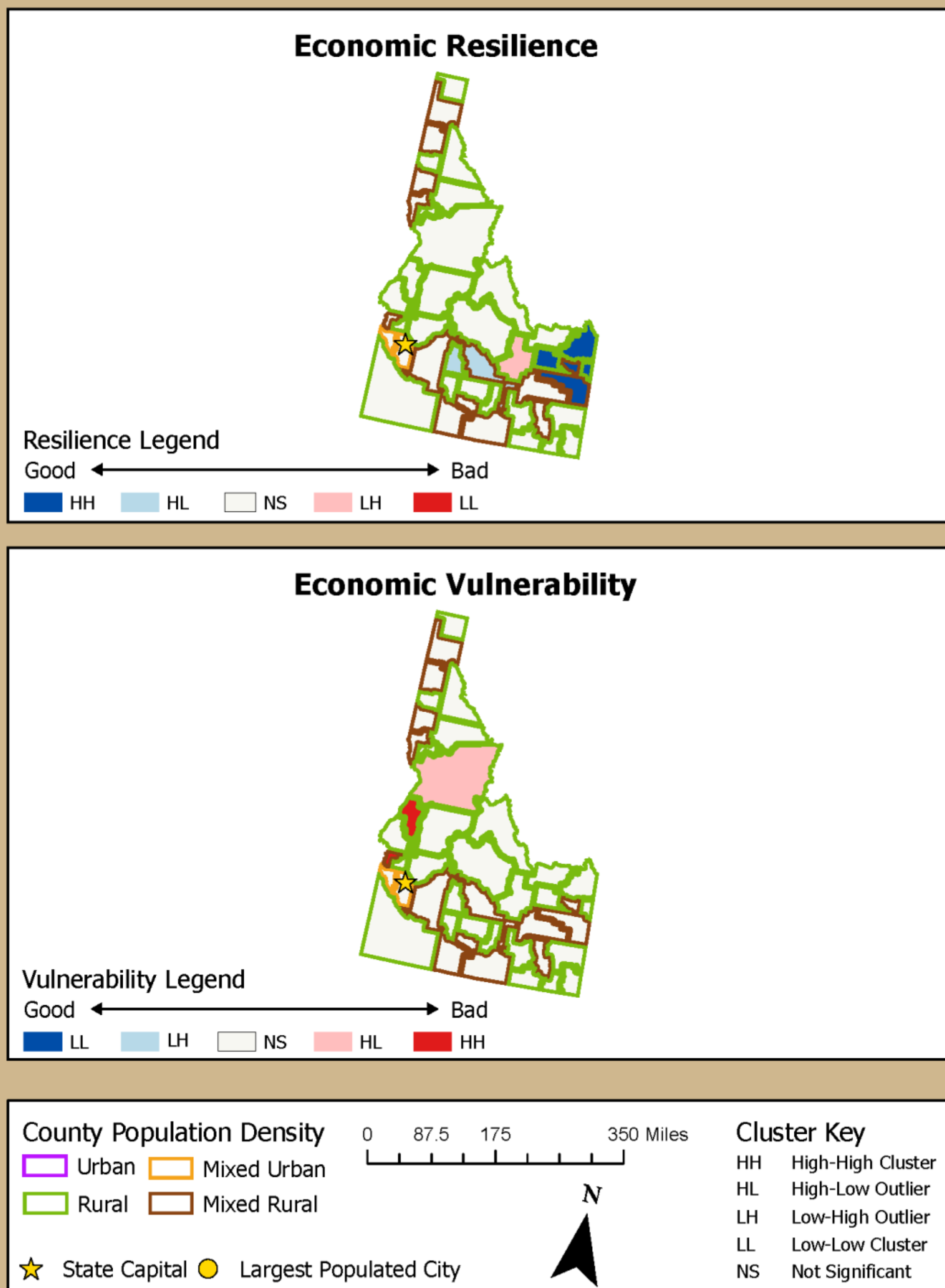
Bad
HH
HL
NS
LH
LL
Environmental Vulnerability
Vulnerability Legend
Good
Bad
LL
LH
NS
HL
HH
County Population Density
Urban
Mixed Urban
Rural
Mixed Rural
State Capital
Largest Populated City
0
50
100
200 Miles
N
Cluster Key
HH High-High Cluster
HL High-Low Outlier
LH Low-High Outlier
LL Low-Low Cluster
NS Not Significant

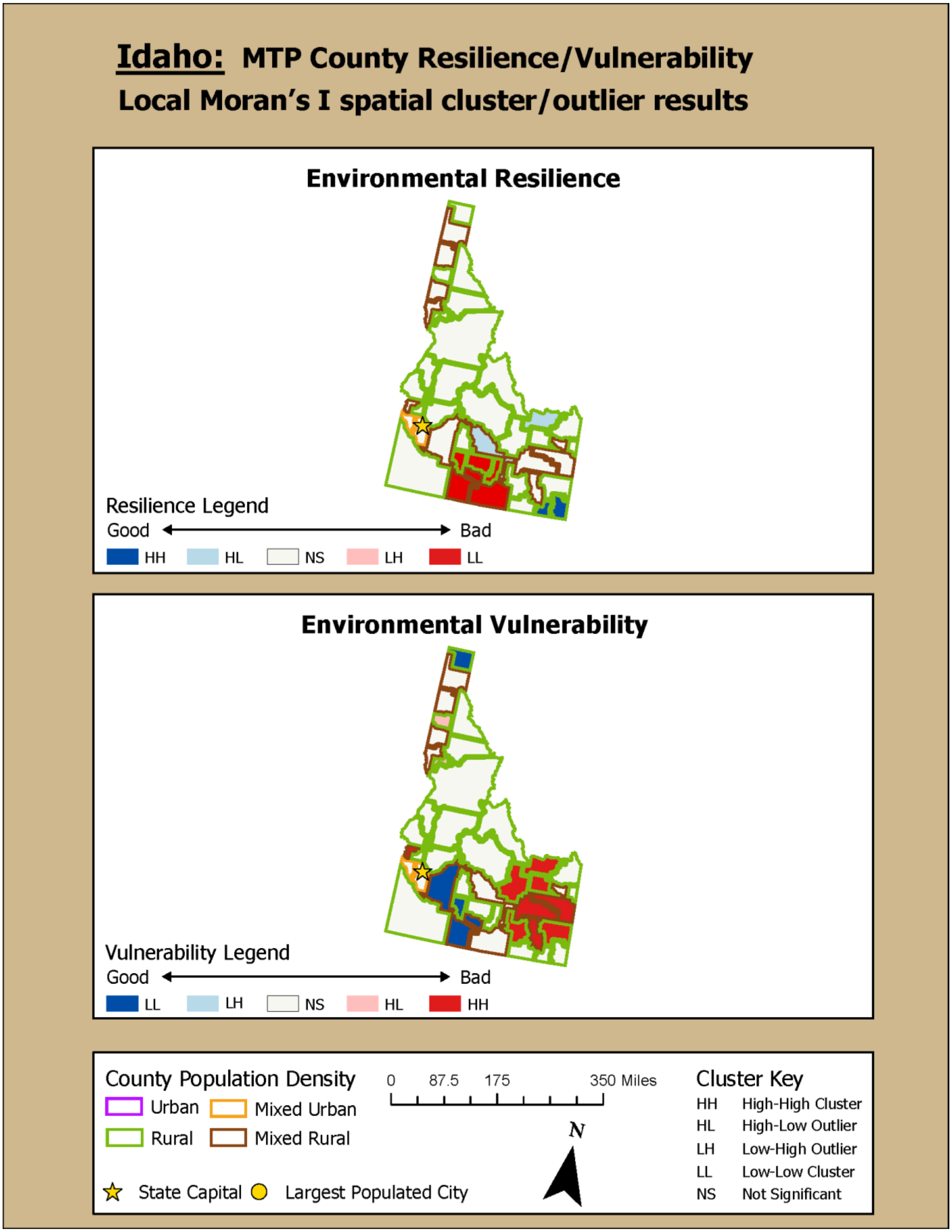
Georgia: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results

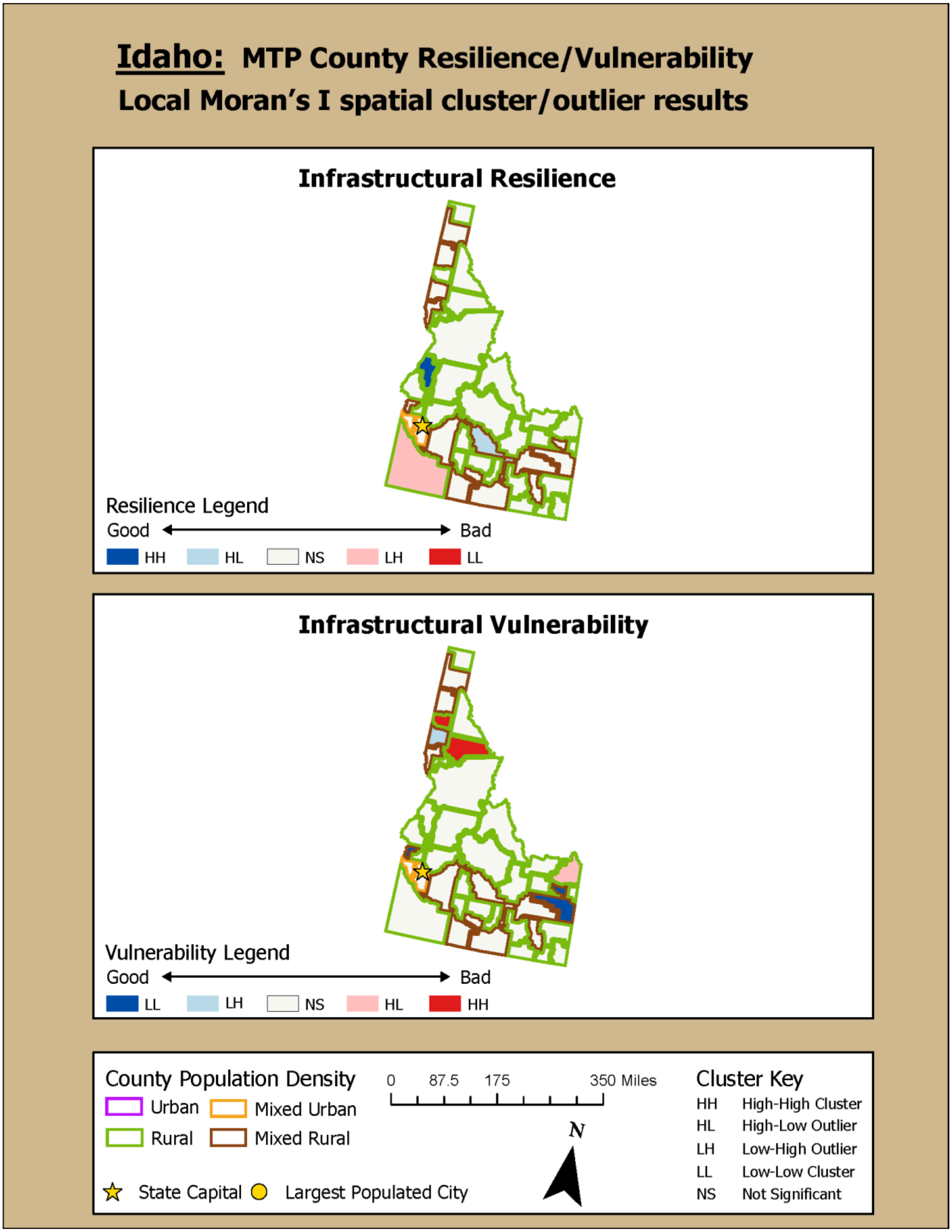


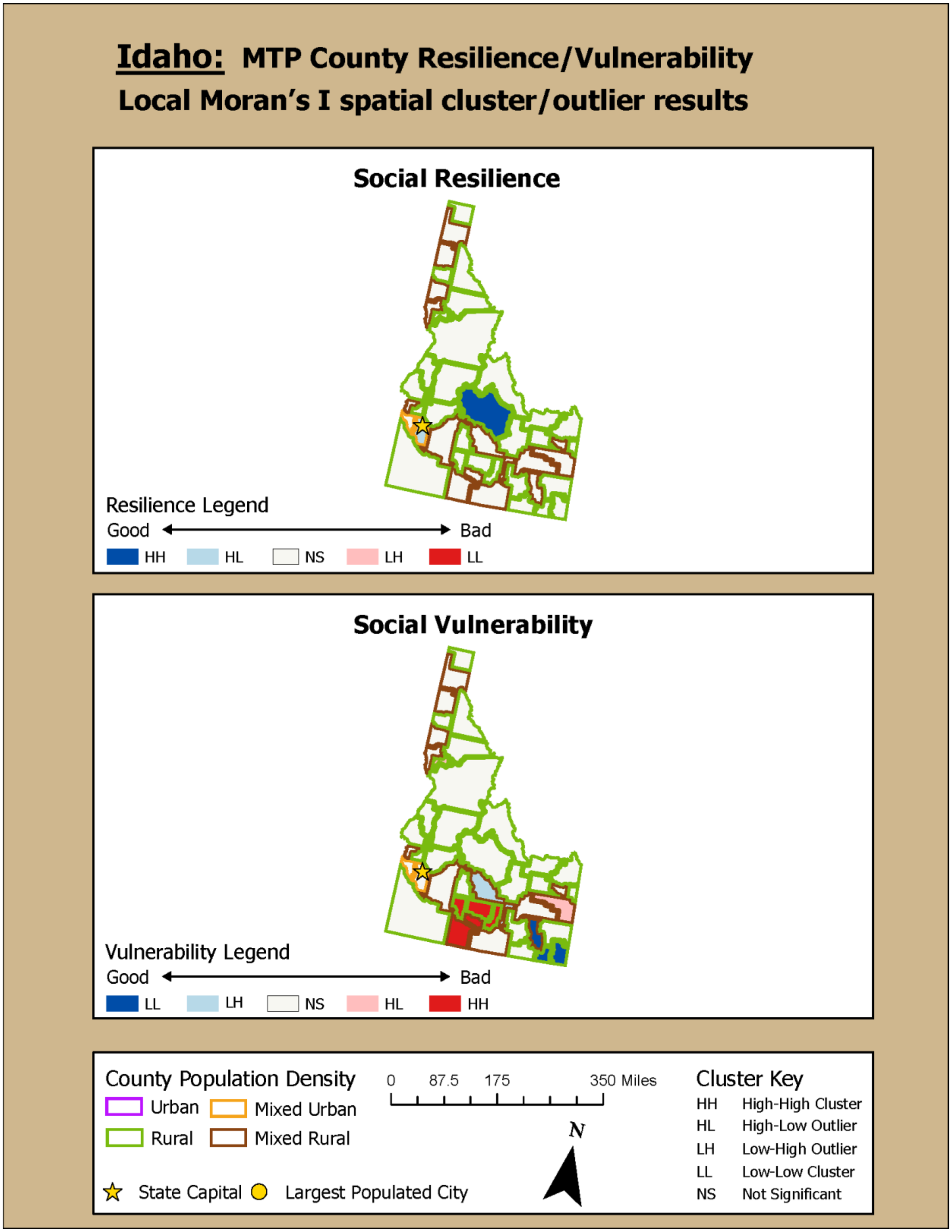

Georgia: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results
Social Resilience
Resilience Legend
Good
Bad
HH
HL
NS
LH
LL
Social Vulnerability
Vulnerability Legend
Good
Bad
LL
LH
NS
HL
HH
County Population Density
Urban
Mixed Urban
Rural
Mixed Rural
State Capital
Largest Populated City
0
50
100
200 Miles
N
Cluster Key
HH High-High Cluster
HL High-Low Outlier
LH Low-High Outlier
LL Low-Low Cluster
NS Not Significant

Idaho: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results

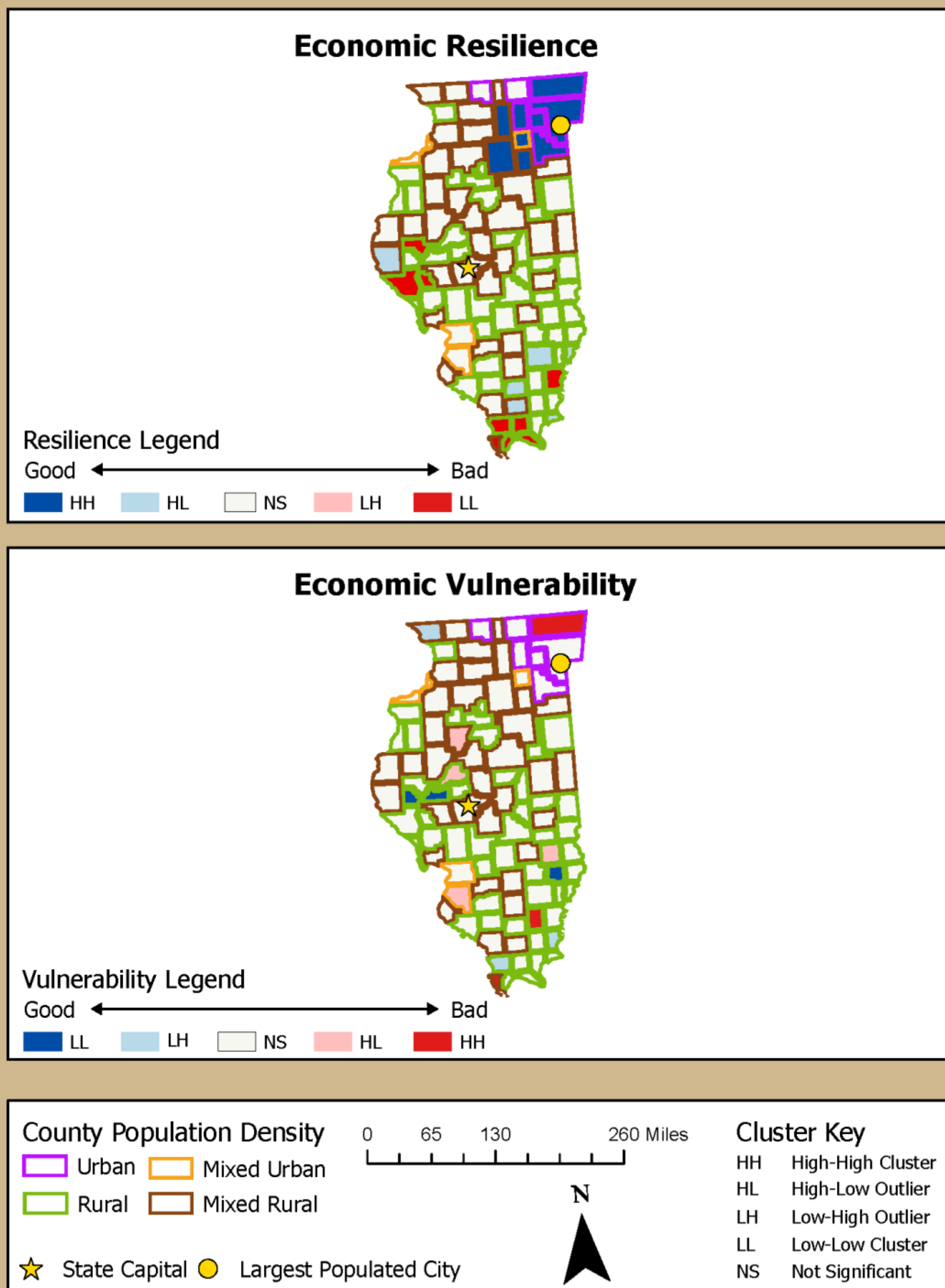



Idaho: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results
Environmental Resilience
Resilience Legend
Good
Bad
HH
HL
NS
LH
LL
Environmental Vulnerability
Vulnerability Legend
Good
Bad
LL
LH
NS
HL
HH
County Population Density
Urban
Mixed Urban
Rural
Mixed Rural
State Capital
Largest Populated City
0
87.5
175
350 Miles
N
Cluster Key
HH High-High Cluster
HL High-Low Outlier
LH Low-High Outlier
LL Low-Low Cluster
NS Not Significant

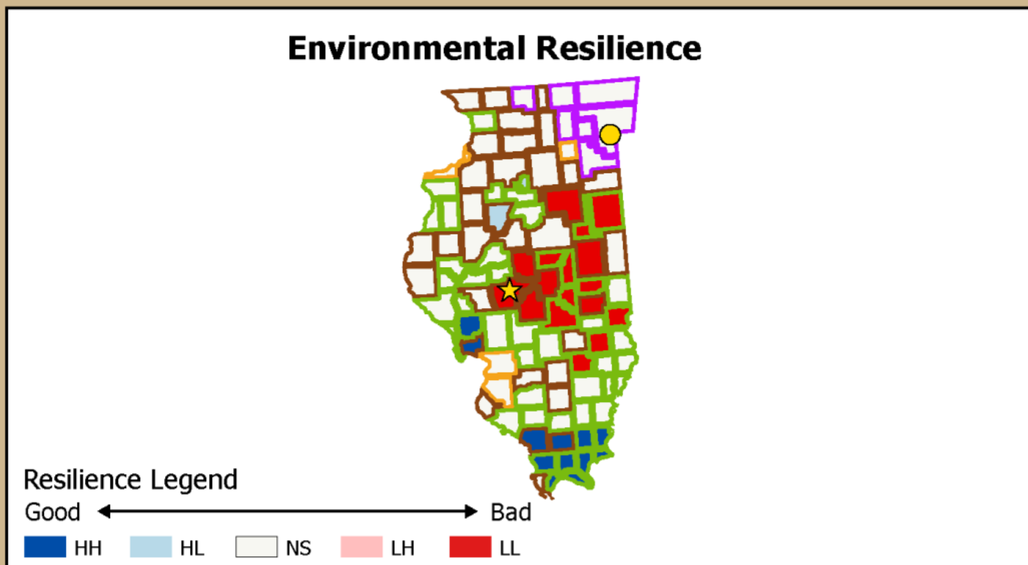

Idaho: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results
Infrastructural Resilience
Resilience Legend
Good
Bad
HH
HL
NS
LH
LL
Infrastructural Vulnerability
Vulnerability Legend
Good
Bad
LL
LH
NS
HL
HH
County Population Density
Urban
Mixed Urban
Rural
Mixed Rural
State Capital
Largest Populated City
0
87.5
175
350 Miles
N
Cluster Key
HH High-High Cluster
HL High-Low Outlier
LH Low-High Outlier
LL Low-Low Cluster
NS Not Significant

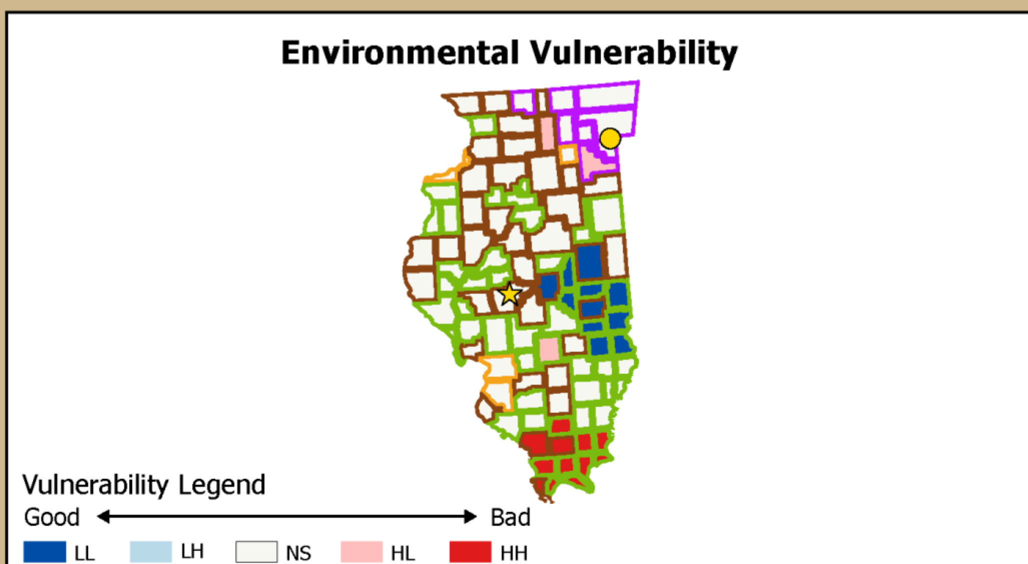

Idaho: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results
Social Resilience
Resilience Legend
Good
Bad
HH
HL
NS
LH
LL
Social Vulnerability
Vulnerability Legend
Good
Bad
LL
LH
NS
HL
HH
County Population Density
Urban
Mixed Urban
Rural
Mixed Rural
State Capital
Largest Populated City
0
87.5
175
350 Miles
N
Cluster Key
HH High-High Cluster
HL High-Low Outlier
LH Low-High Outlier
LL Low-Low Cluster
NS Not Significant

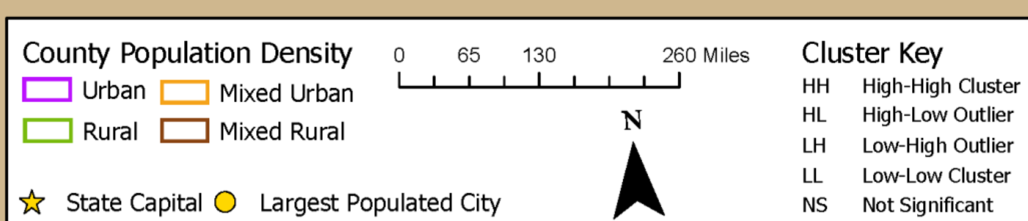
Illinois: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results

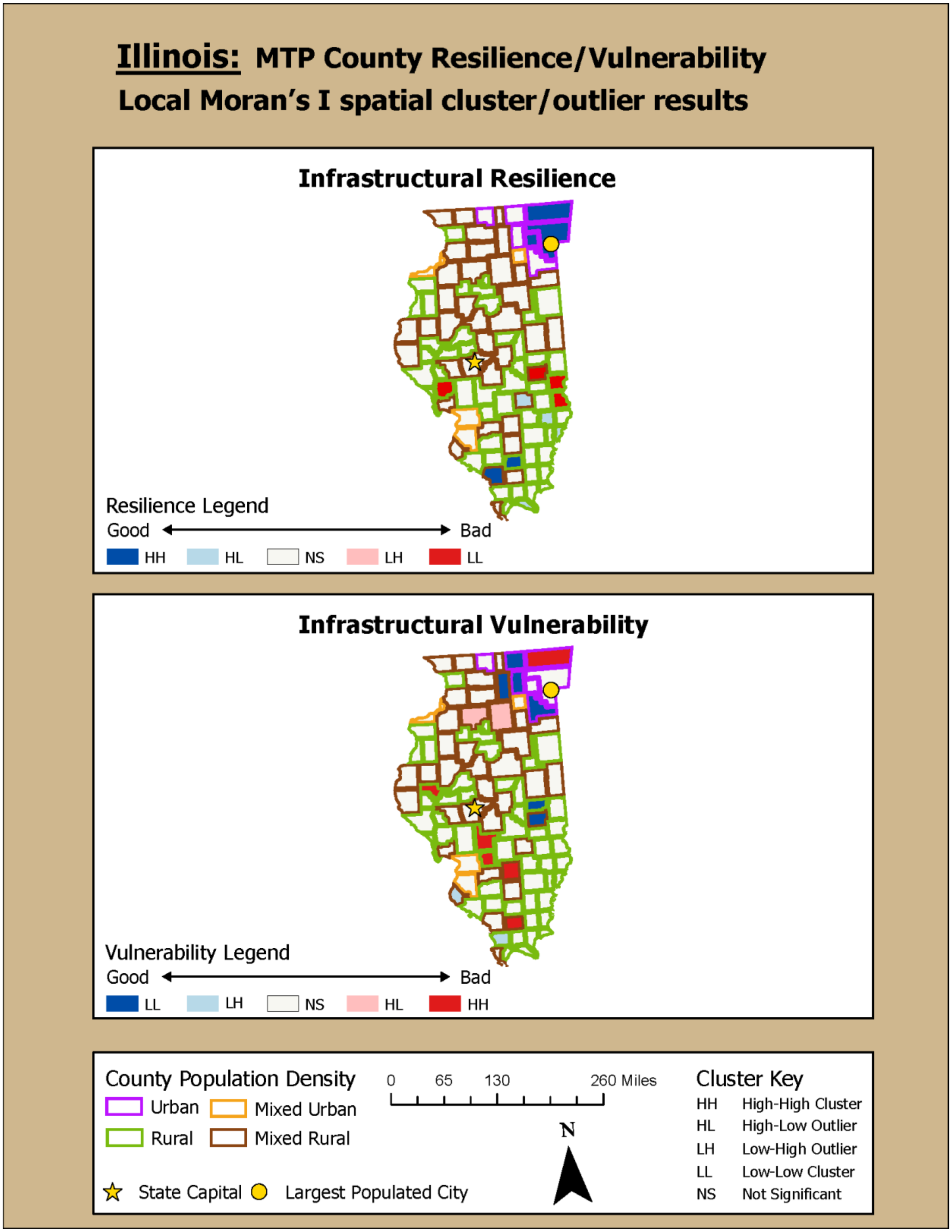


Illinois: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results



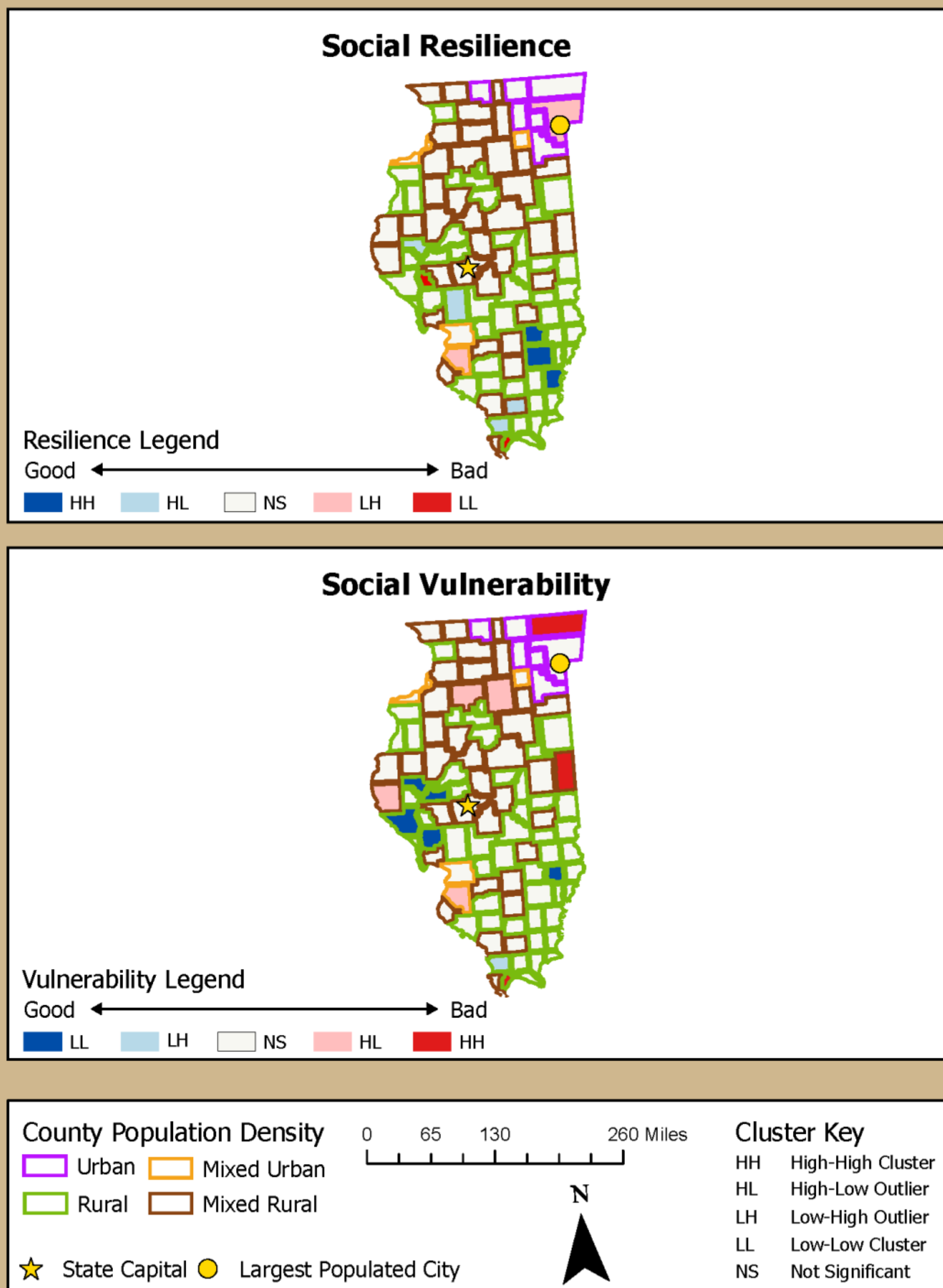


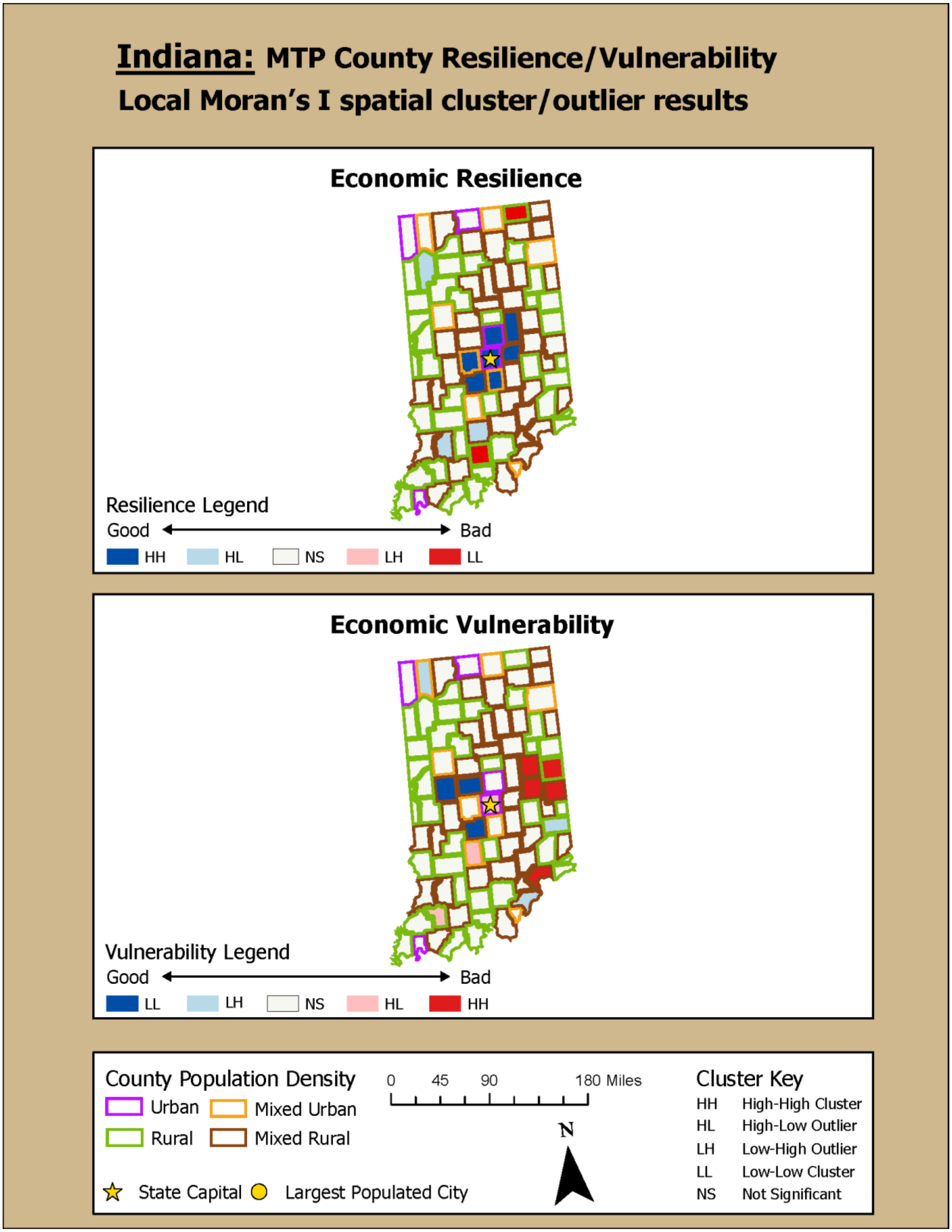


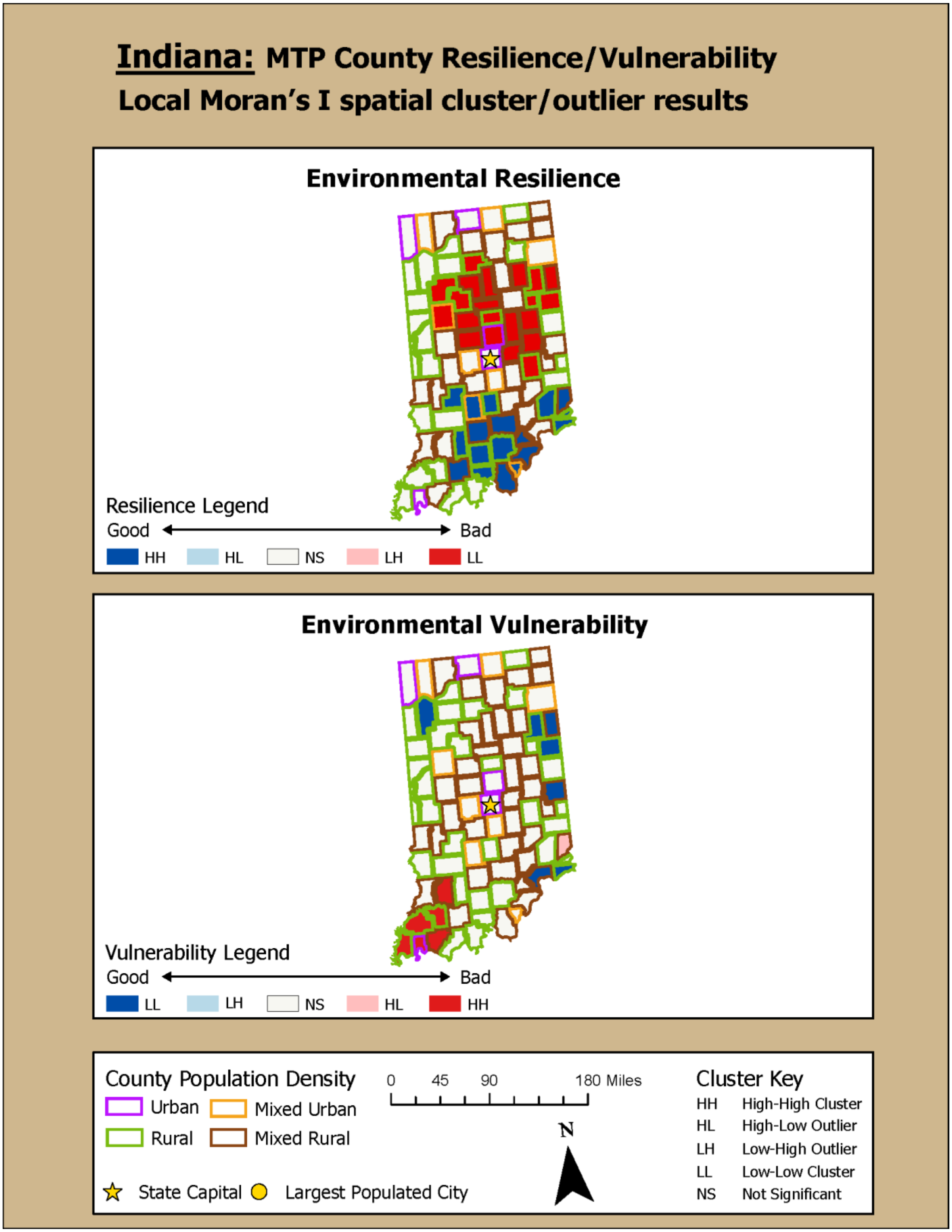


Illinois: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results
Infrastructural Resilience
Resilience Legend
Good
Bad
HH
HL
NS
LH
LL
Infrastructural Vulnerability
Vulnerability Legend
Good
Bad
LL
LH
NS
HL
HH
County Population Density
Urban
Mixed Urban
Rural
Mixed Rural
State Capital
Largest Populated City
0
65
130
260 Miles
N
Cluster Key
HH High-High Cluster
HL High-Low Outlier
LH Low-High Outlier
LL Low-Low Cluster
NS Not Significant

Illinois: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results




Indiana: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results
Economic Resilience
Resilience Legend
Good
Bad
HH
HL
NS
LH
LL
Economic Vulnerability
Vulnerability Legend
Good
Bad
LL
LH
NS
HL
HH
County Population Density
Urban
Mixed Urban
Rural
Mixed Rural
State Capital
Largest Populated City
0
45
90
180 Miles
N
Cluster Key
HH High-High Cluster
HL High-Low Outlier
LH Low-High Outlier
LL Low-Low Cluster
NS Not Significant


Indiana: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results
Environmental Resilience
Resilience Legend
Good
Bad
HH
HL
NS
LH
LL
Environmental Vulnerability
Vulnerability Legend
Good
Bad
LL
LH
NS
HL
HH
County Population Density
Urban
Mixed Urban
Rural
Mixed Rural
State Capital
Largest Populated City
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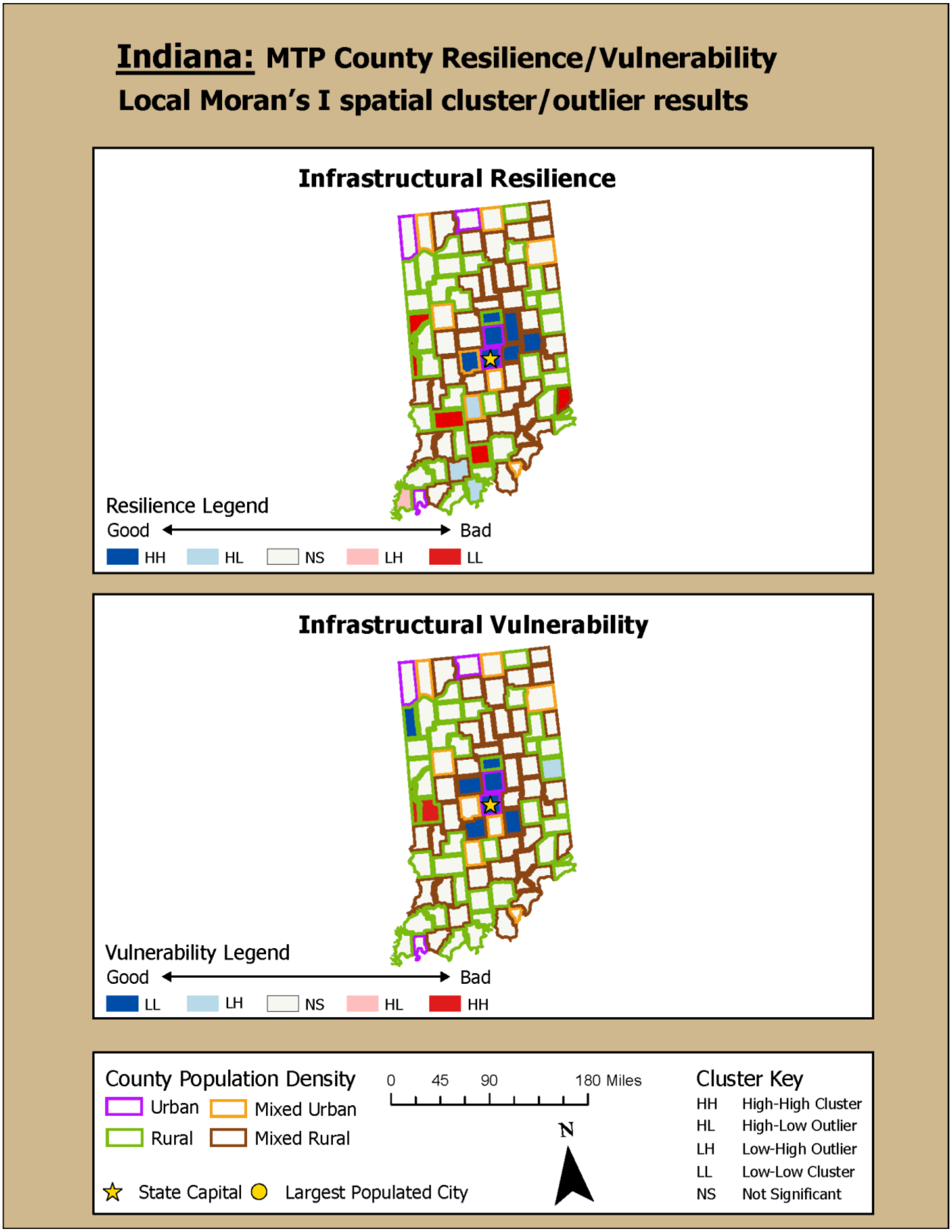
45
90
180 Miles
N
Cluster Key
HH High-High Cluster
HL High-Low Outlier
LH Low-High Outlier
LL Low-Low Cluster
NS Not Significant


Indiana: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results
Infrastructural Resilience
Resilience Legend
Good
Bad
HH
HL
NS
LH
LL
Infrastructural Vulnerability
Vulnerability Legend
Good
Bad
LL
LH
NS
HL
HH
County Population Density
Urban
Mixed Urban
Rural
Mixed Rural
State Capital
Largest Populated City
0
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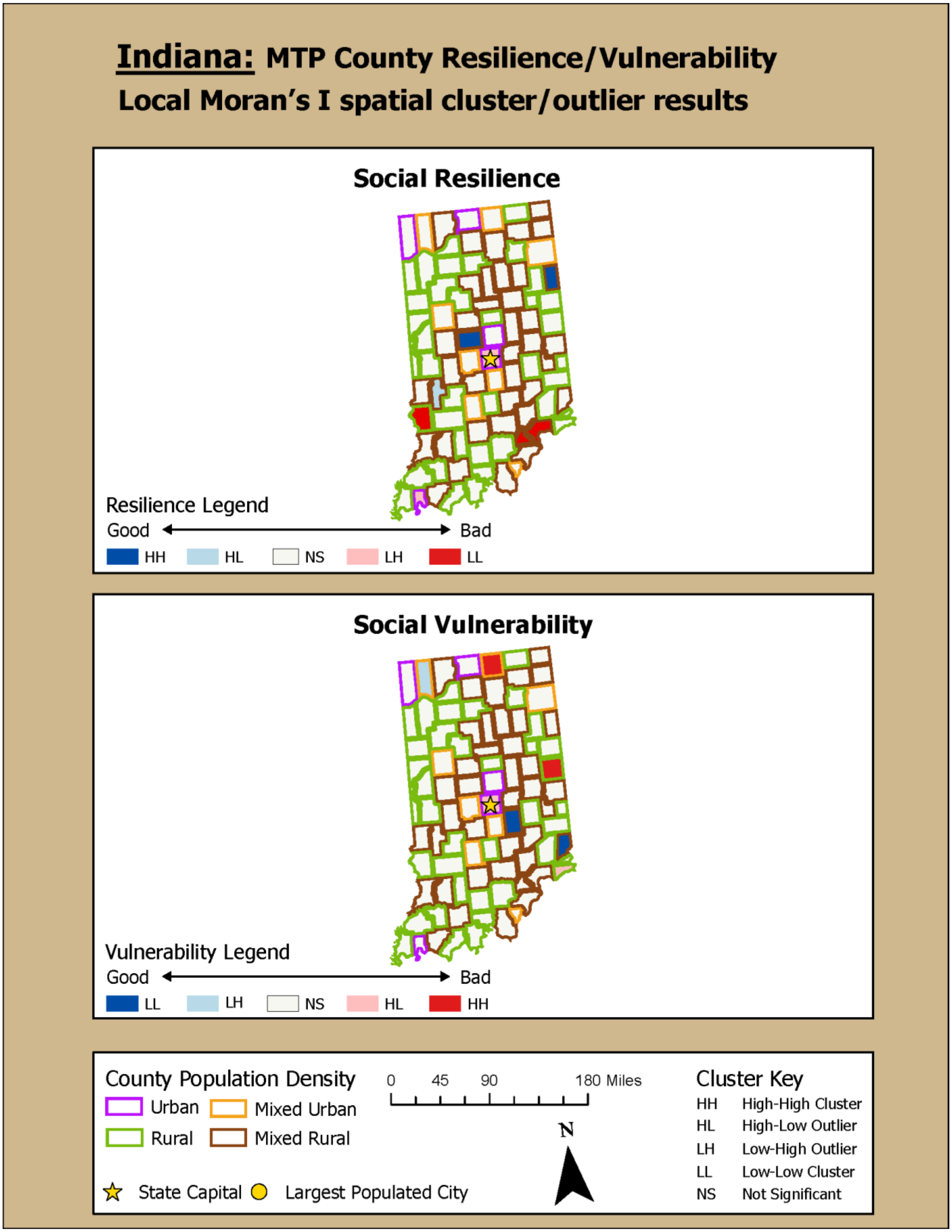
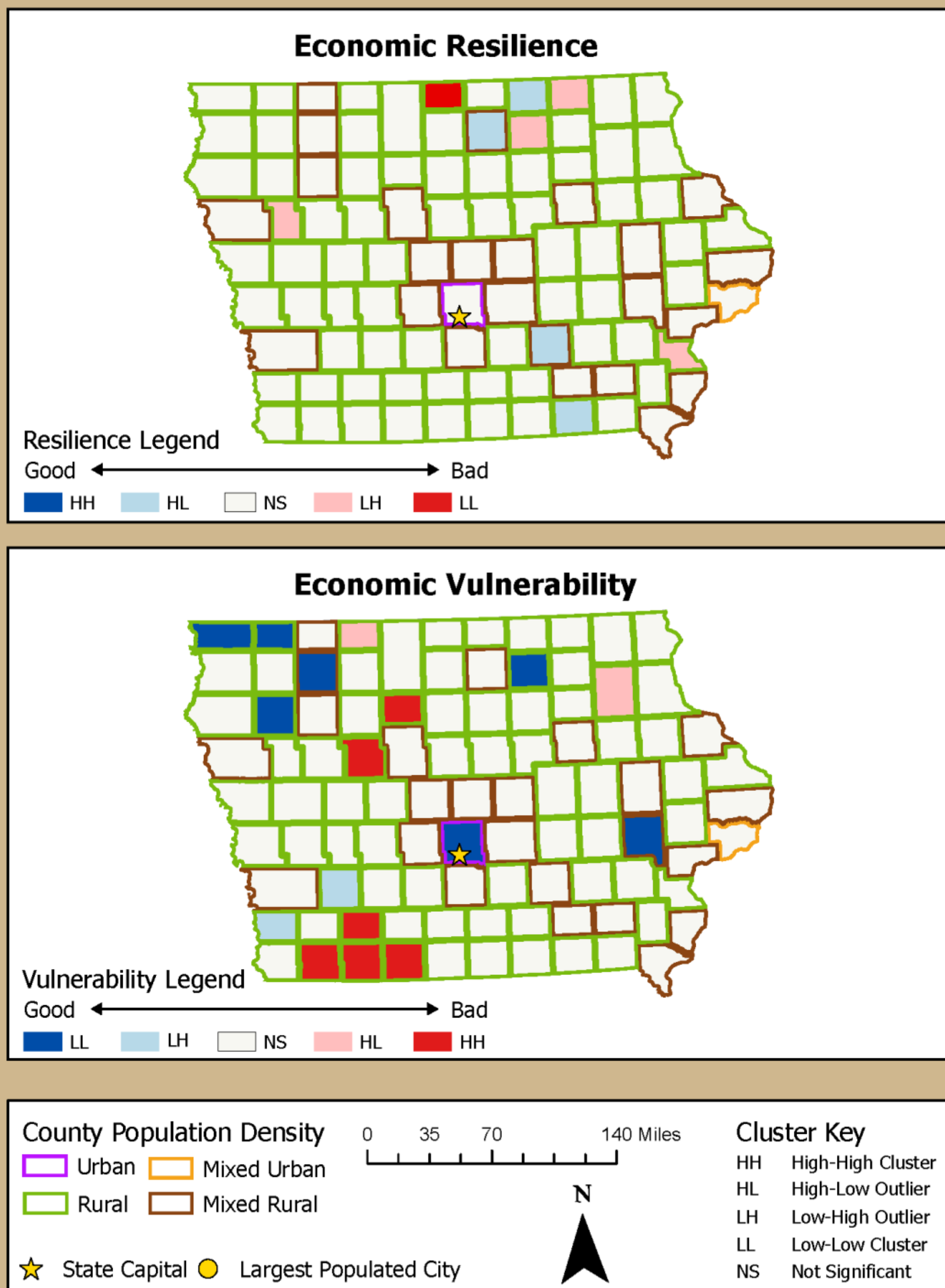
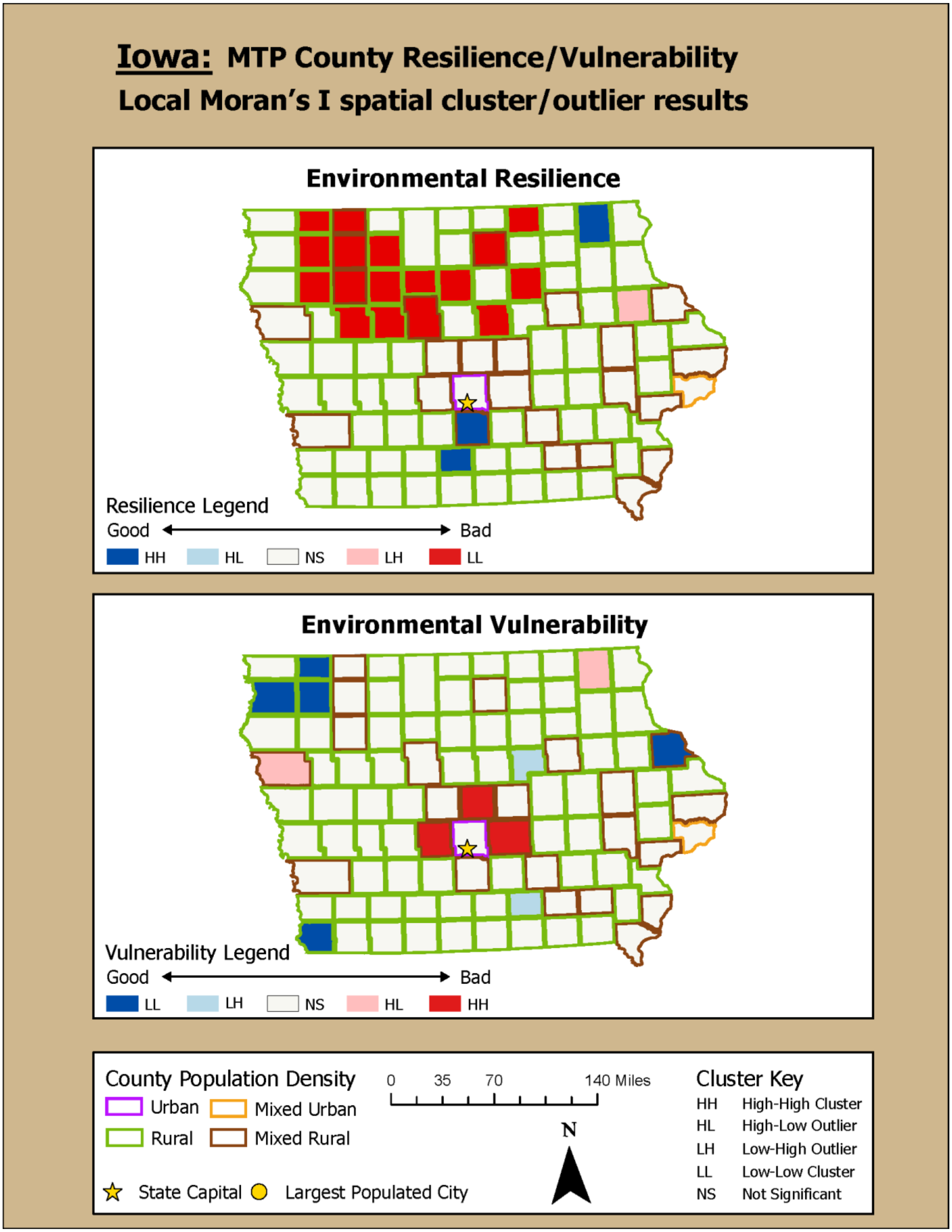
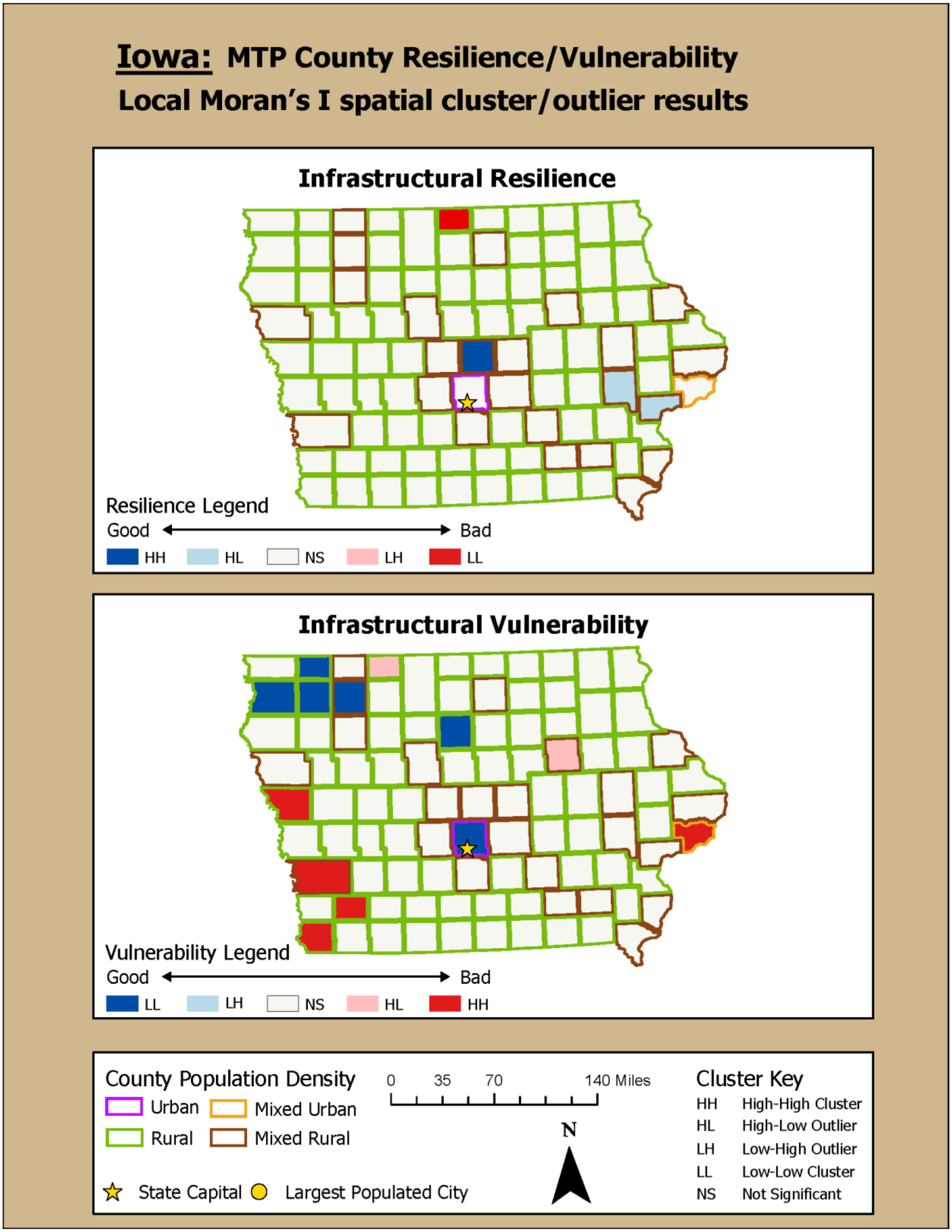
90
180 Miles
N
Cluster Key
HH High-High Cluster
HL High-Low Outlier
LH Low-High Outlier
LL Low-Low Cluster
NS Not Significant


Indiana: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results
Social Resilience
Resilience Legend
Good
Bad
HH
HL
NS
LH
LL
Social Vulnerability
Vulnerability Legend
Good
Bad
LL
LH
NS
HL
HH
County Population Density
Urban
Mixed Urban
Rural
Mixed Rural
State Capital
Largest Populated City
0
45
90
180 Miles
N
Cluster Key
HH High-High Cluster
HL High-Low Outlier
LH Low-High Outlier
LL Low-Low Cluster
NS Not Significant

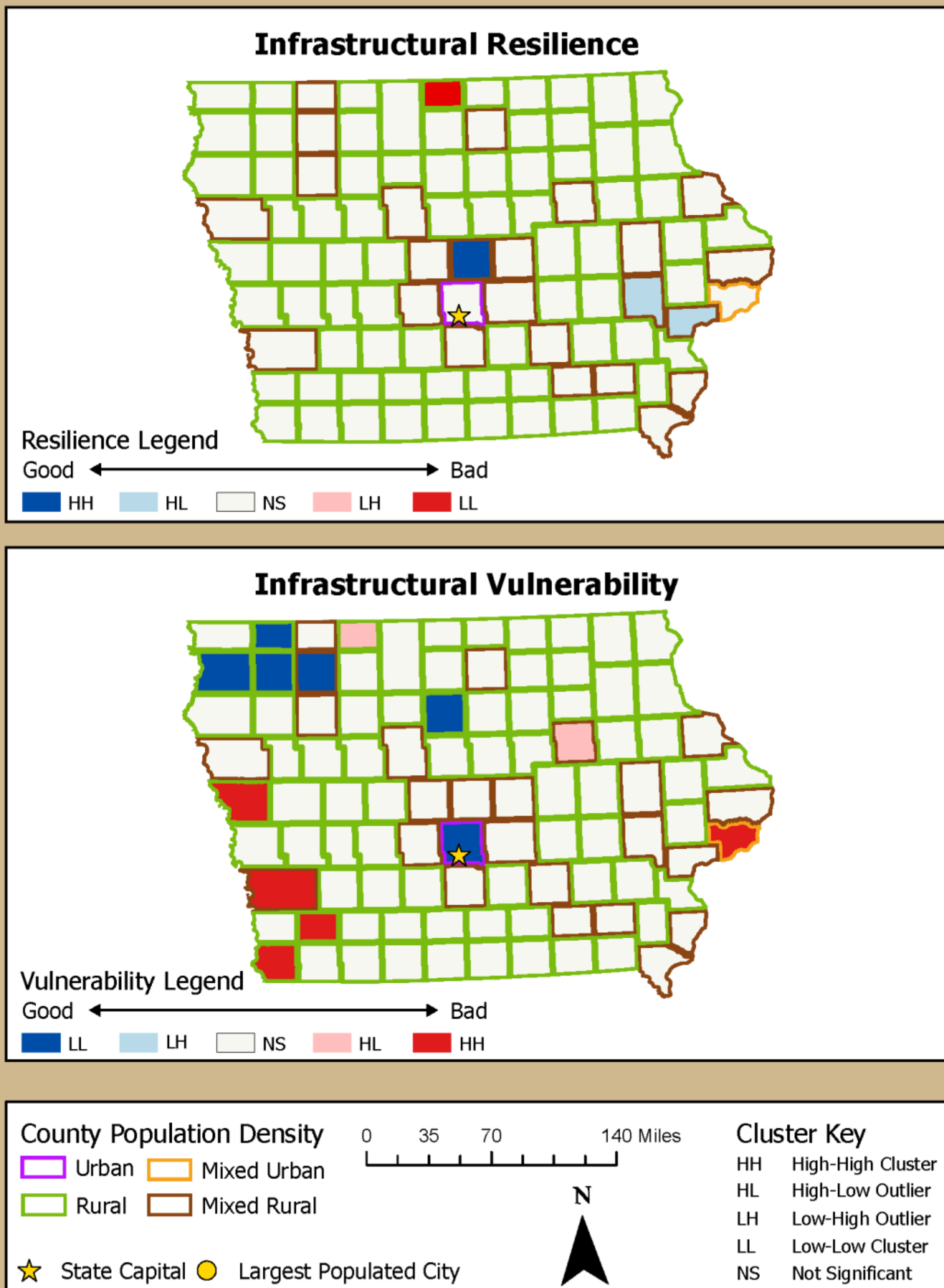
Iowa: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results

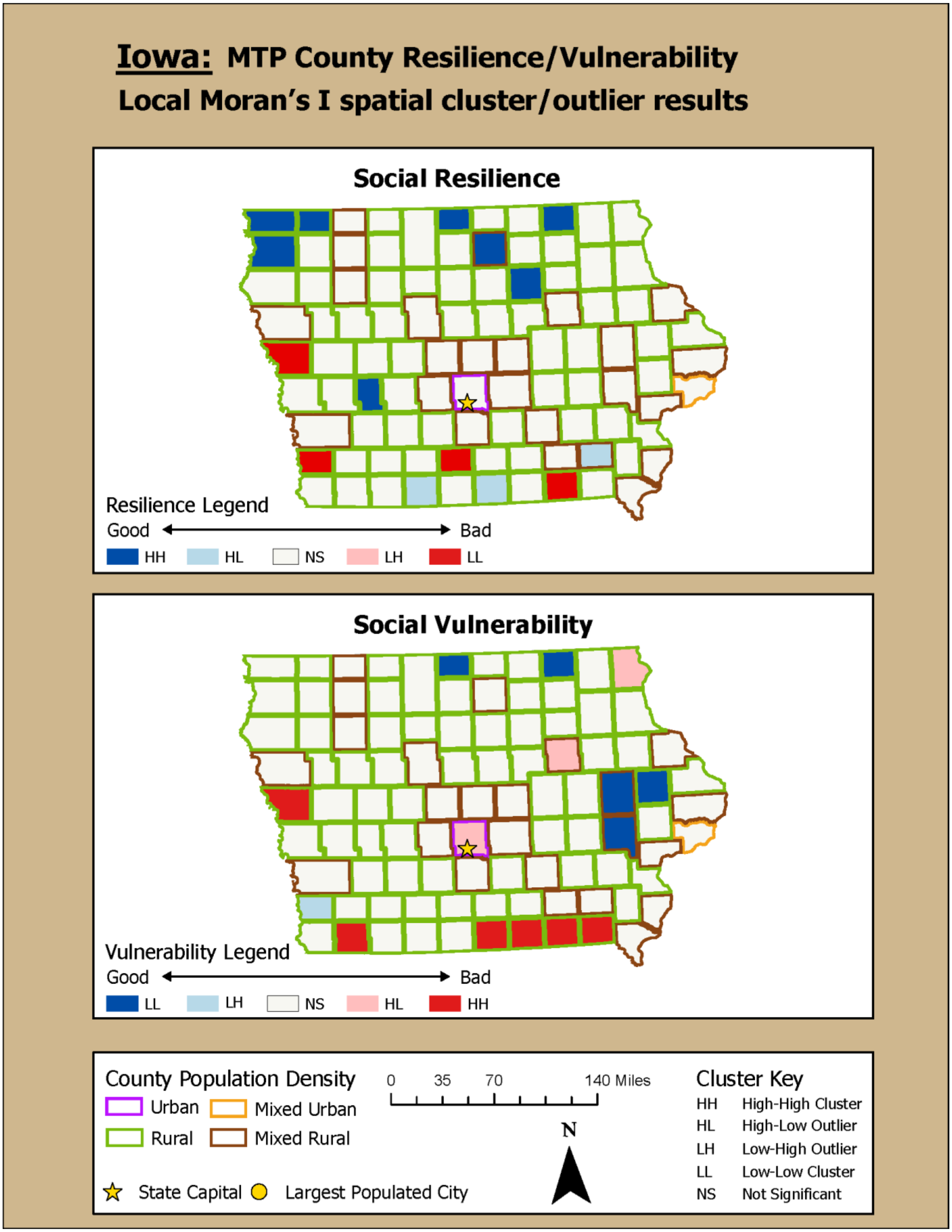


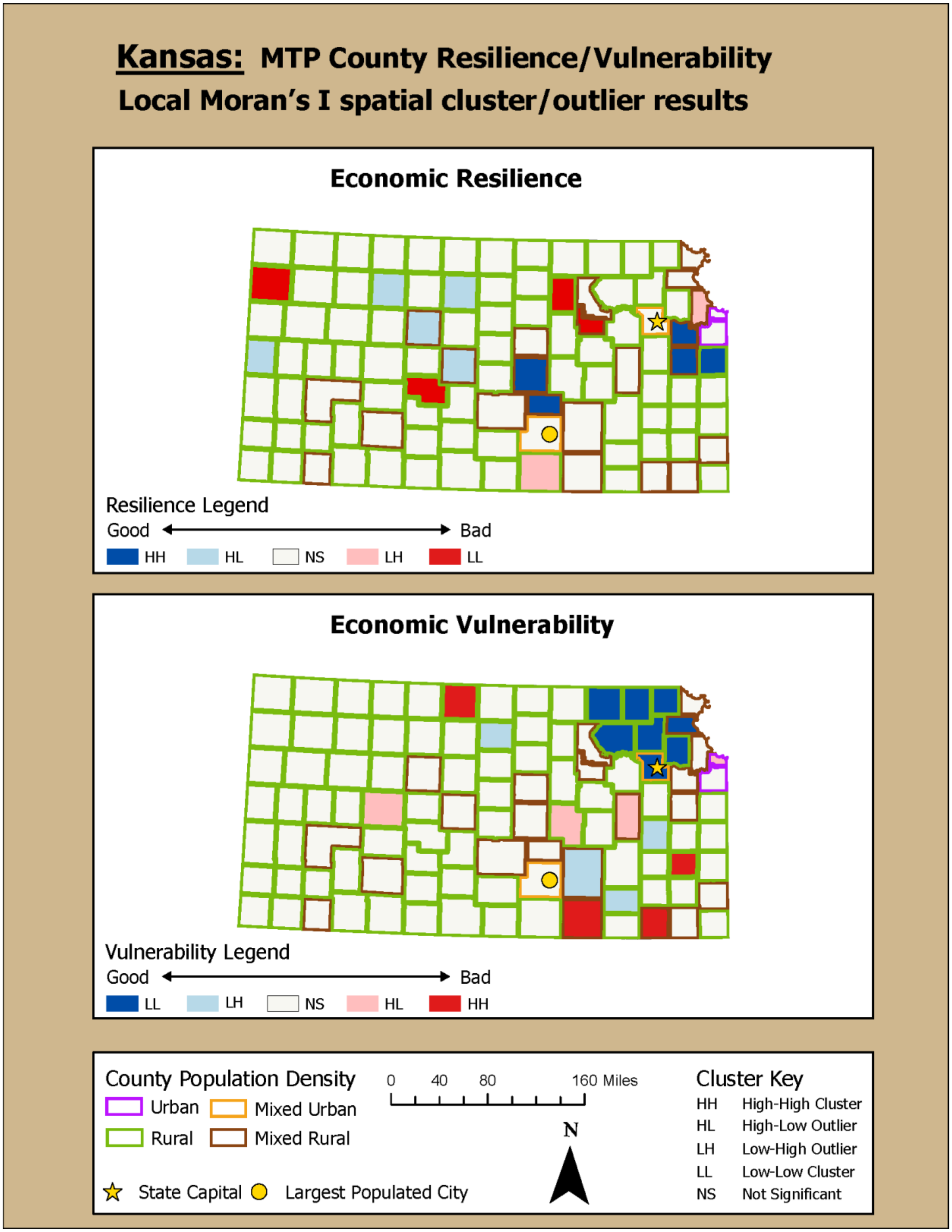

Iowa: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results
Environmental Resilience
Resilience Legend
Good
Bad
HH
HL
NS
LH
LL
Environmental Vulnerability
Vulnerability Legend
Good
Bad
LL
LH
NS
HL
HH
County Population Density
Urban
Mixed Urban
Rural
Mixed Rural
State Capital
Largest Populated City
0
35
70
140 Miles
N
Cluster Key
HH High-High Cluster
HL High-Low Outlier
LH Low-High Outlier
LL Low-Low Cluster
NS Not Significant


Iowa: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results
Infrastructural Resilience
Resilience Legend
Good
Bad
HH
HL
NS
LH
LL
Infrastructural Vulnerability
Vulnerability Legend
Good
Bad
LL
LH
NS
HL
HH
County Population Density
Urban
Mixed Urban
Rural
Mixed Rural
State Capital
Largest Populated City
0
35
70
140 Miles
N
Cluster Key
HH High-High Cluster
HL High-Low Outlier
LH Low-High Outlier
LL Low-Low Cluster
NS Not Significant

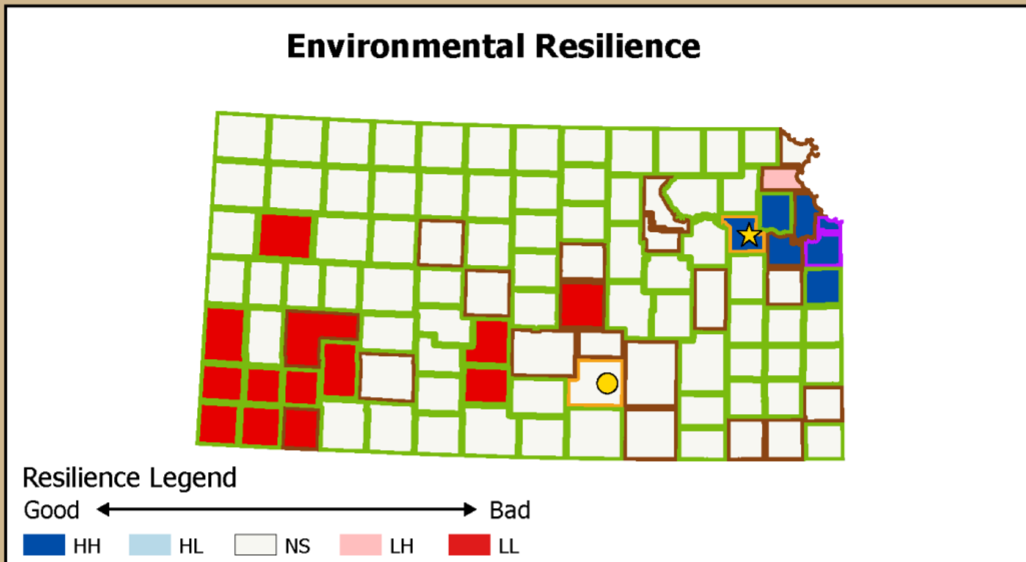
Iowa: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results

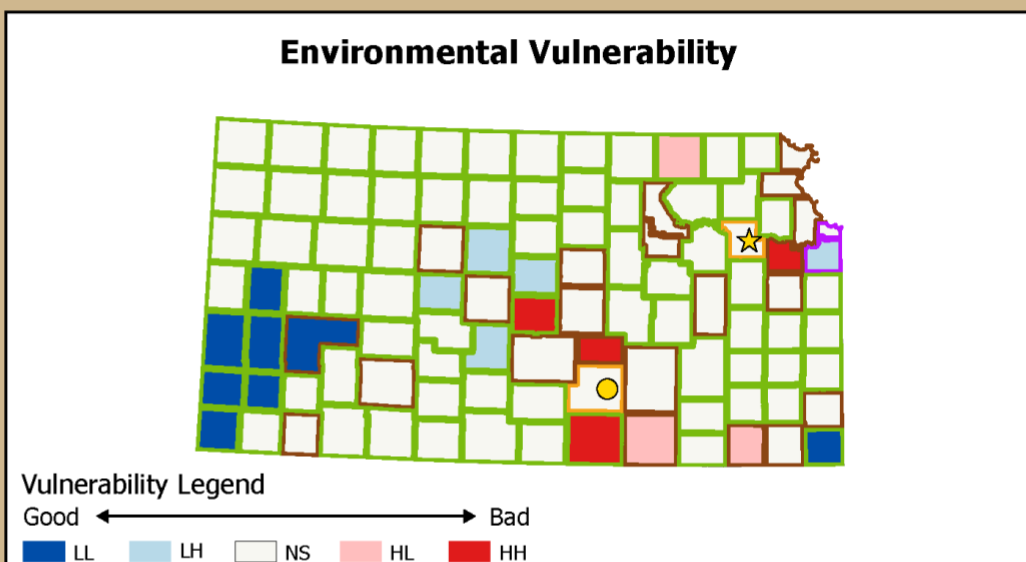


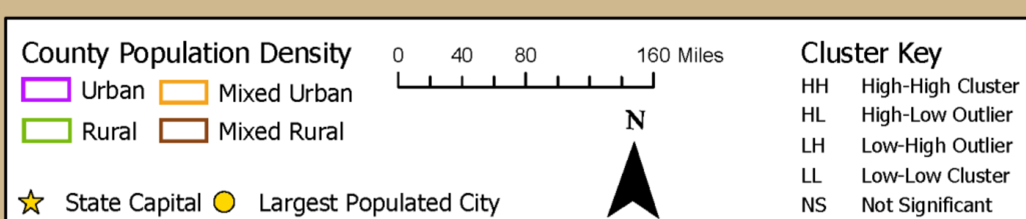

Iowa: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results
Social Resilience
Resilience Legend
Good
Bad
HH
HL
NS
LH
LL
Social Vulnerability
Vulnerability Legend
Good
Bad
LL
LH
NS
HL
HH
County Population Density
Urban
Mixed Urban
Rural
Mixed Rural
State Capital
Largest Populated City
0
35
70
140 Miles
N
Cluster Key
HH High-High Cluster
HL High-Low Outlier
LH Low-High Outlier
LL Low-Low Cluster
NS Not Significant


Kansas: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results
Economic Resilience
Resilience Legend
Good
Bad
HH
HL
NS
LH
LL
Economic Vulnerability
Vulnerability Legend
Good
Bad
LL
LH
NS
HL
HH
County Population Density
Urban
Mixed Urban
Rural
Mixed Rural
0
40
80
160 Miles
N
State Capital
Largest Populated City
Cluster Key
HH High-High Cluster
HL High-Low Outlier
LH Low-High Outlier
LL Low-Low Cluster
NS Not Significant

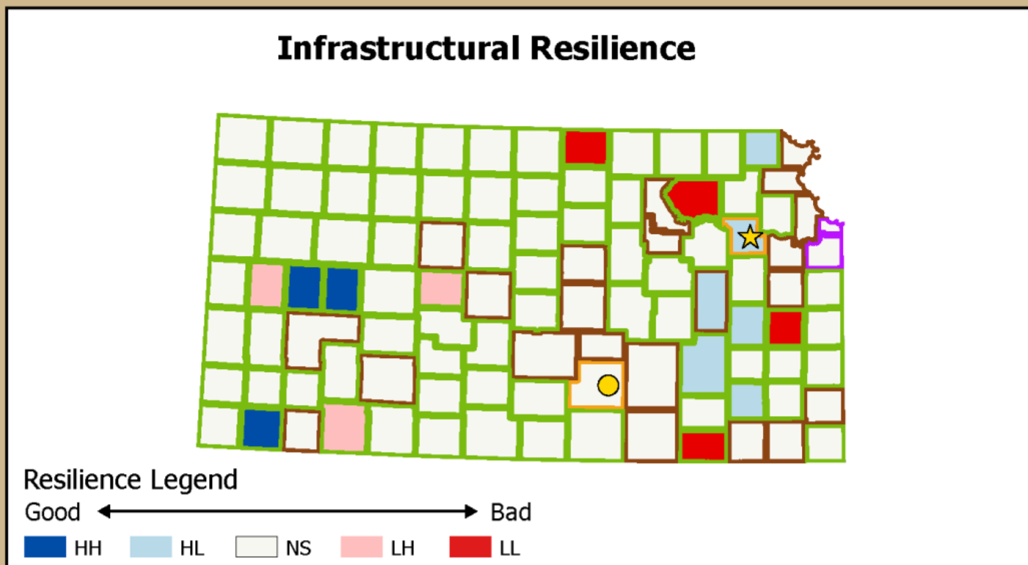
Kansas: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results

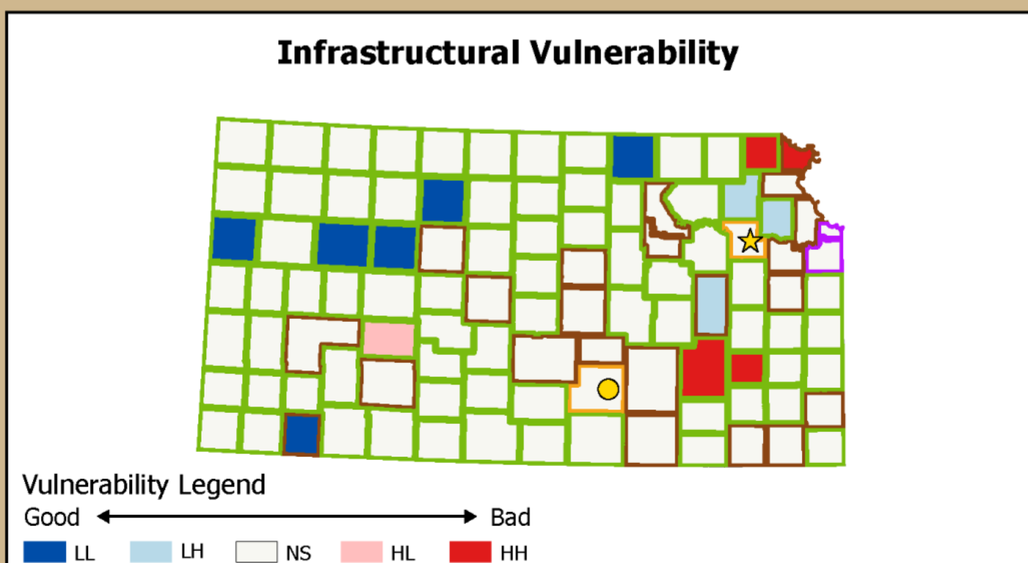


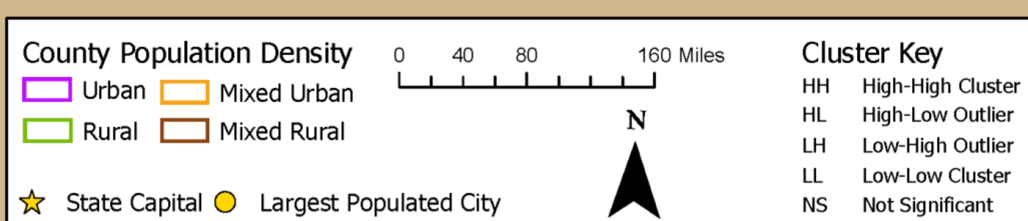




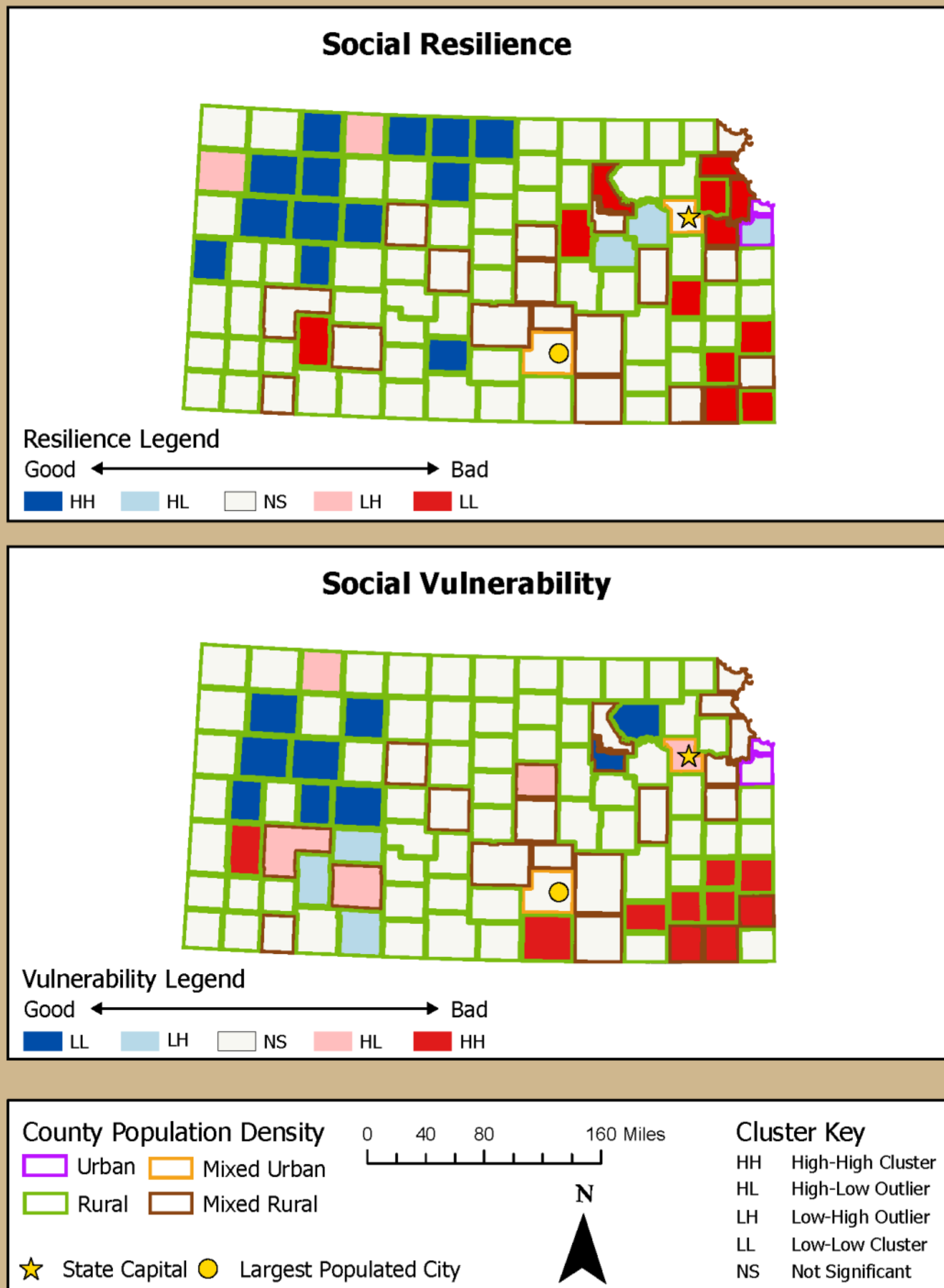
Kansas: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results

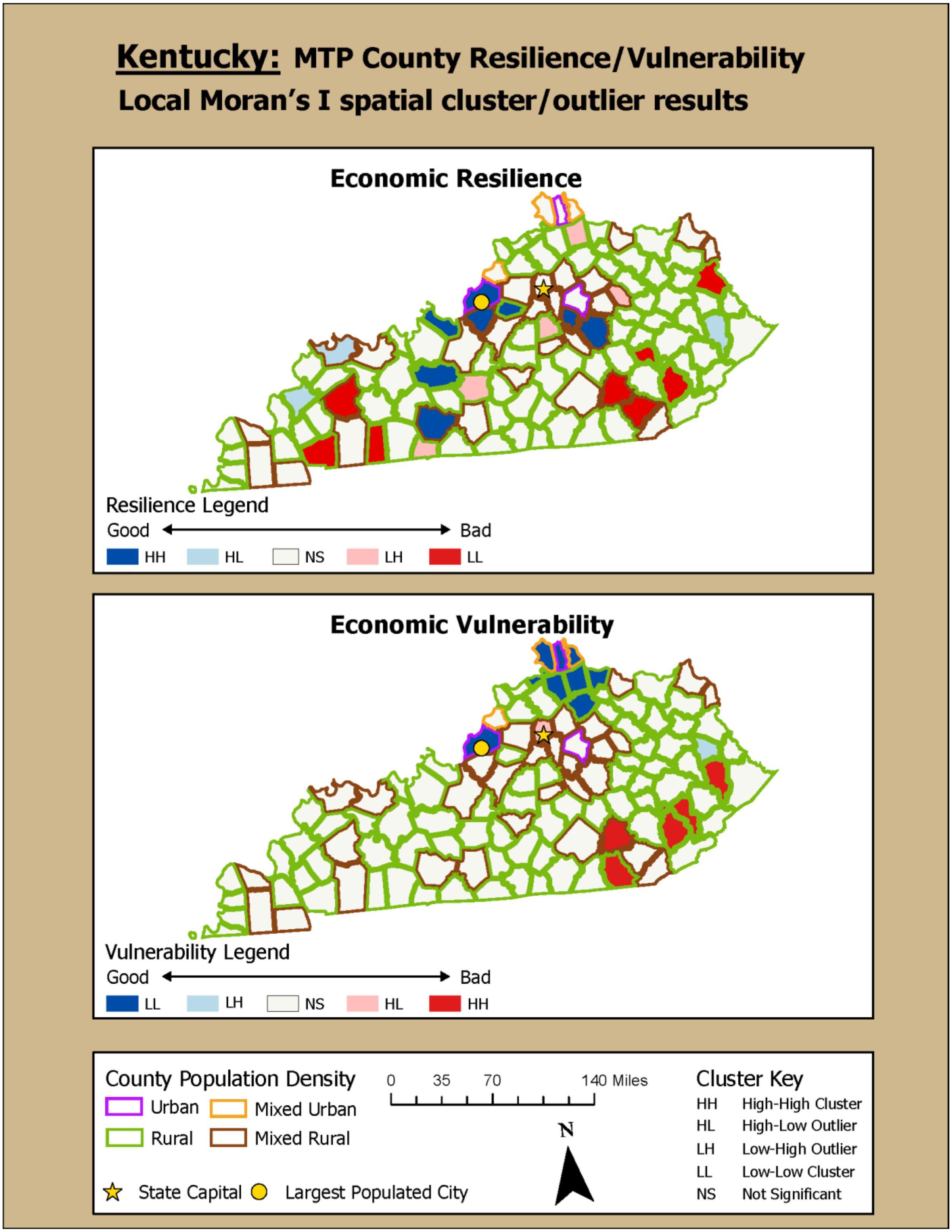


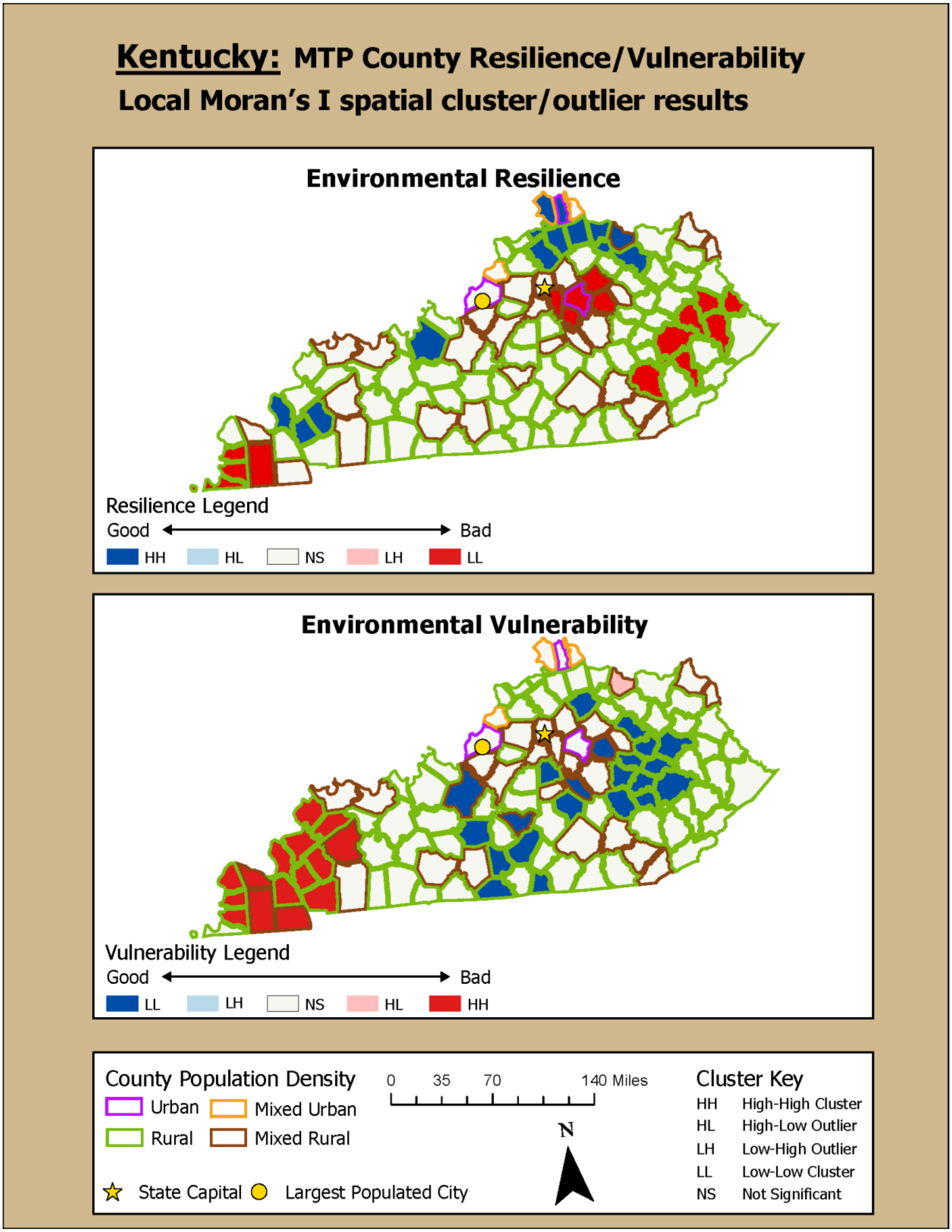


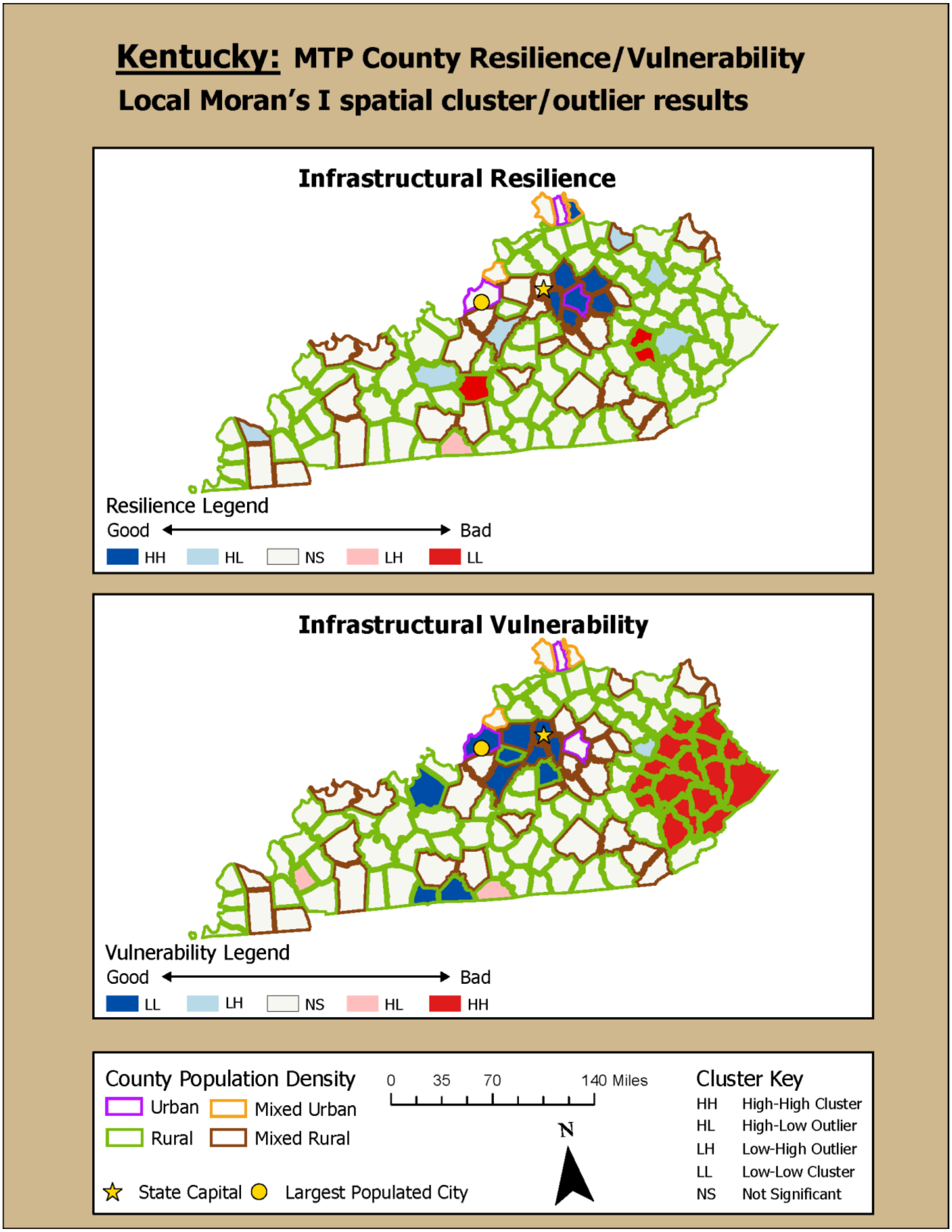


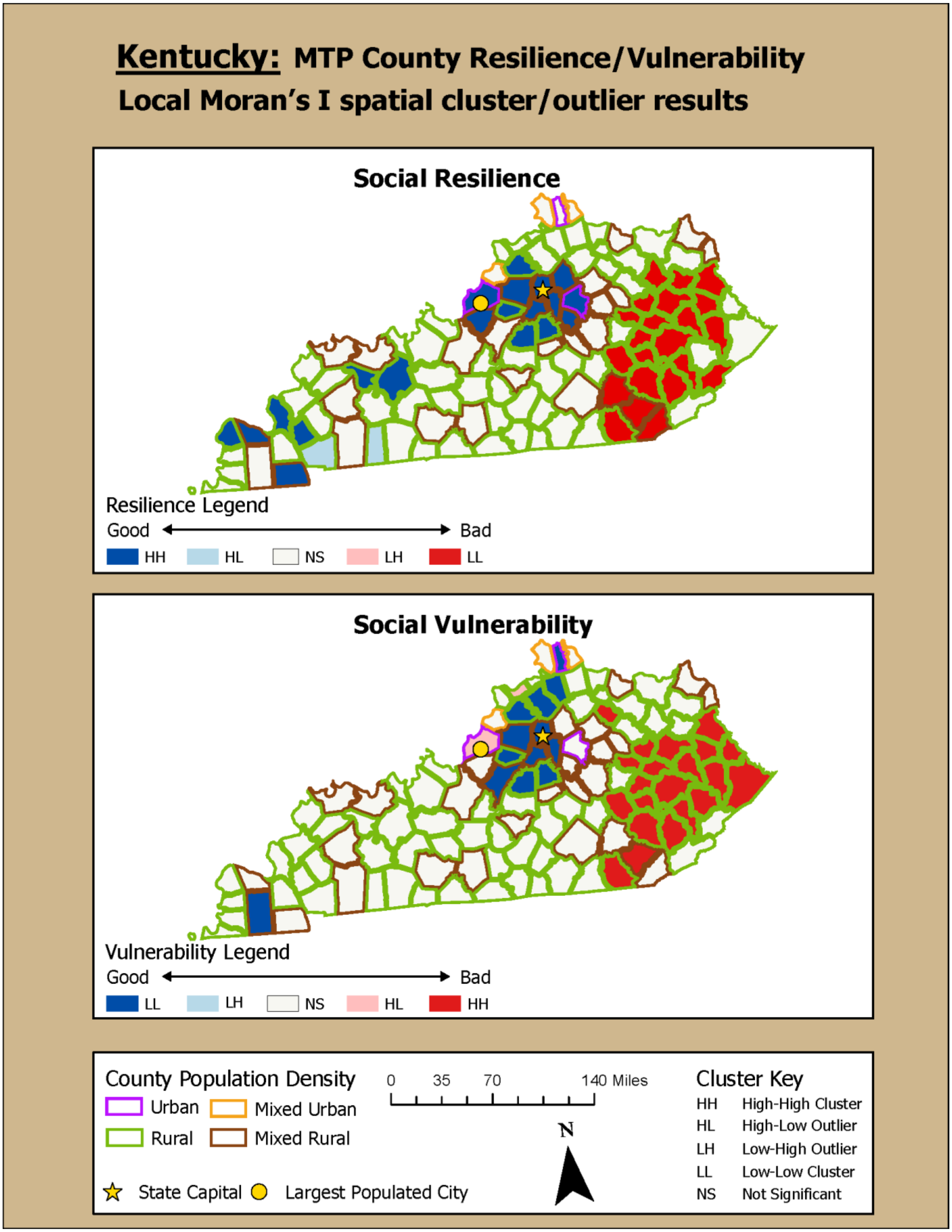
Kansas: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results

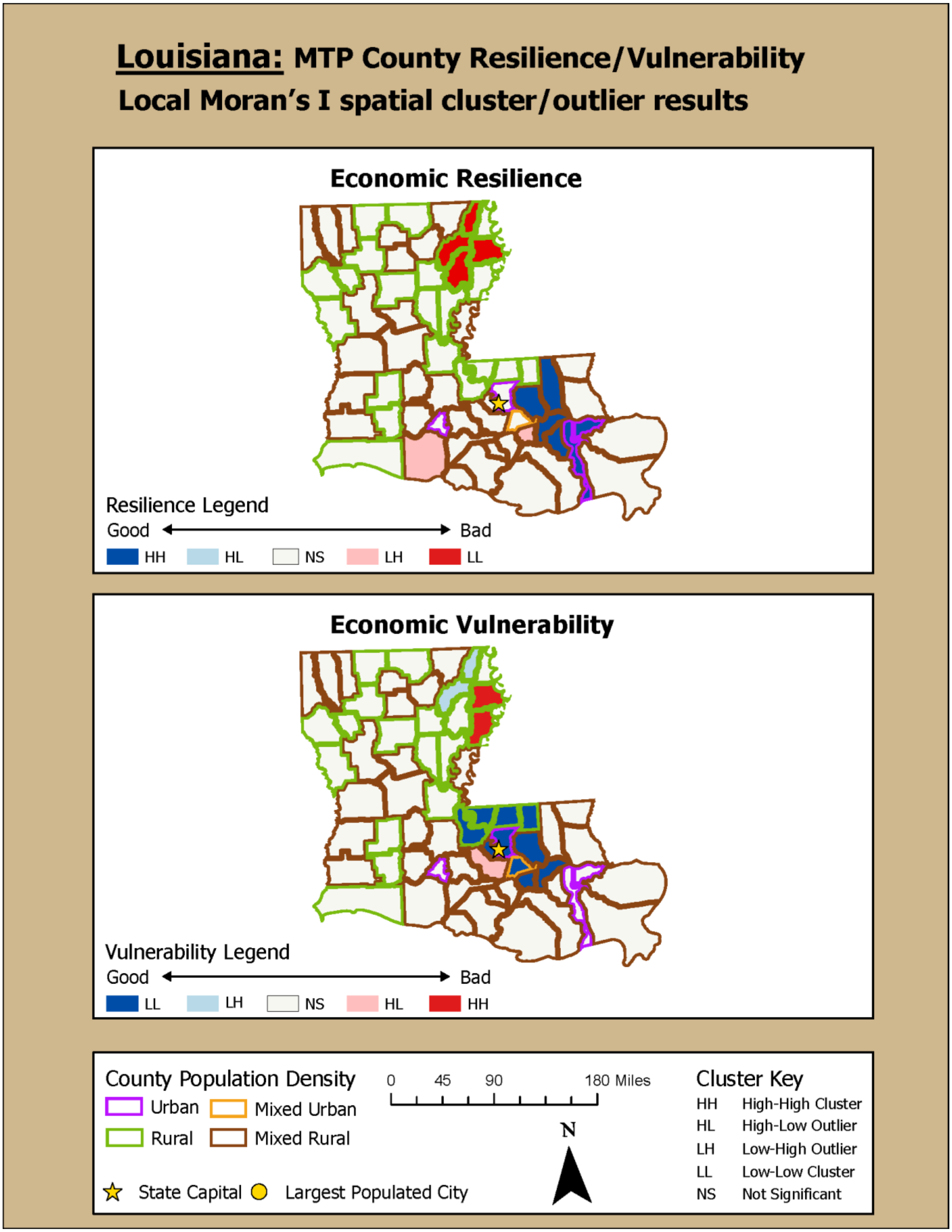



Kentucky: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results
Economic Resilience
Resilience Legend
Good
Bad
HH
HL
NS
LH
LL
Economic Vulnerability
Vulnerability Legend
Good
Bad
LL
LH
NS
HL
HH
County Population Density
Urban
Mixed Urban
Rural
Mixed Rural
State Capital
Largest Populated City
0
35
70
140 Miles
N
Cluster Key
HH High-High Cluster
HL High-Low Outlier
LH Low-High Outlier
LL Low-Low Cluster
NS Not Significant

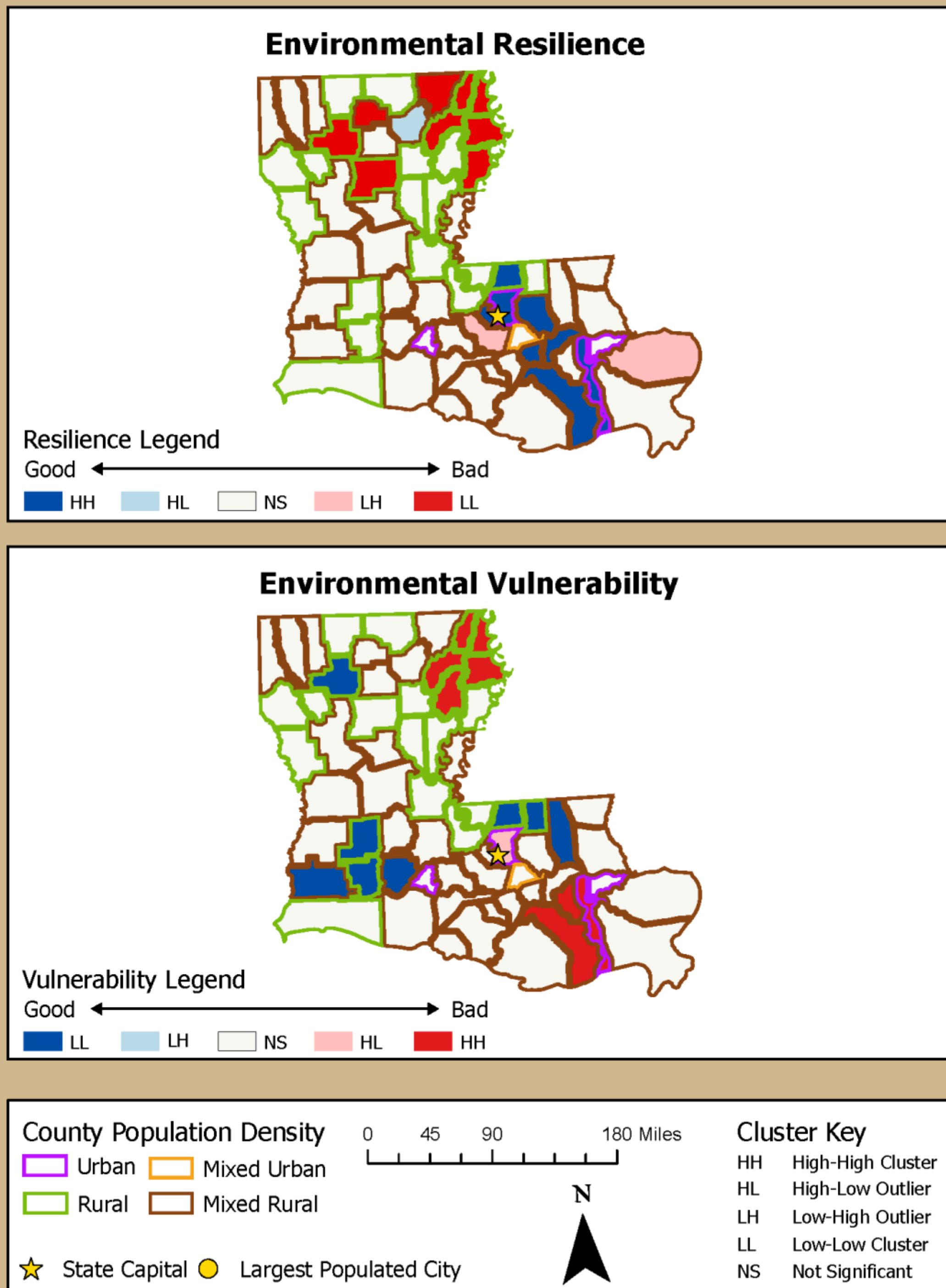

Kentucky: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results
Environmental Resilience
Resilience Legend
Good
Bad
HH
HL
NS
LH
LL
Environmental Vulnerability
Vulnerability Legend
Good
Bad
LL
LH
NS
HL
HH
County Population Density
Urban
Mixed Urban
Rural
Mixed Rural
State Capital
Largest Populated City
0
35
70
140 Miles
N
Cluster Key
HH High-High Cluster
HL High-Low Outlier
LH Low-High Outlier
LL Low-Low Cluster
NS Not Significant


Kentucky: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results
Infrastructural Resilience
Resilience Legend
Good
Bad
HH
HL
NS
LH
LL
Infrastructural Vulnerability
Vulnerability Legend
Good
Bad
LL
LH
NS
HL
HH
County Population Density
Urban
Mixed Urban
Rural
Mixed Rural
State Capital
Largest Populated City
0
35
70
140 Miles
N
Cluster Key
HH High-High Cluster
HL High-Low Outlier
LH Low-High Outlier
LL Low-Low Cluster
NS Not Significant

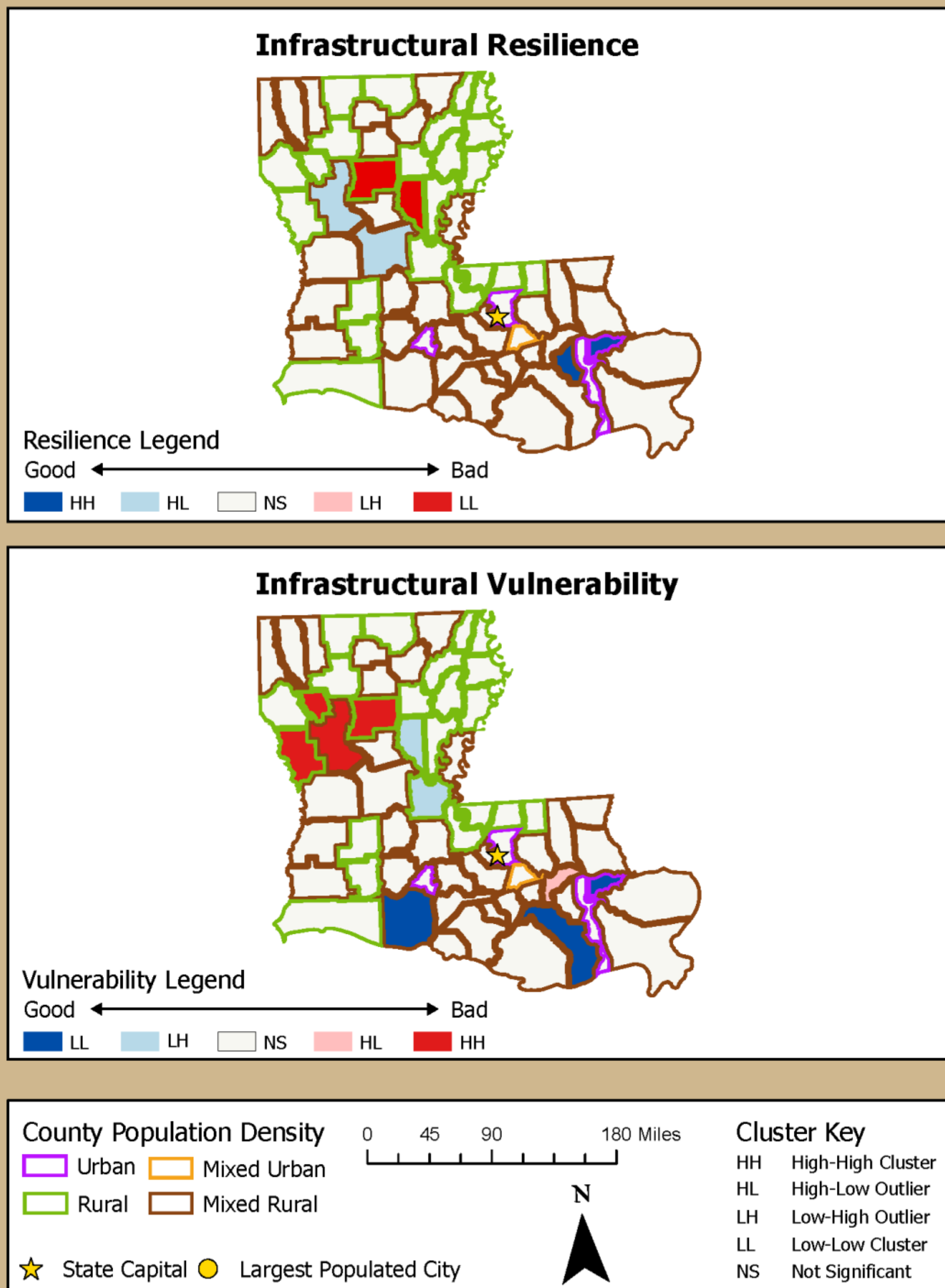

Kentucky: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results
Social Resilience
Resilience Legend
Good
Bad
HH
HL
NS
LH
LL
Social Vulnerability
Vulnerability Legend
Good
Bad
LL
LH
NS
HL
HH
County Population Density
Urban
Mixed Urban
Rural
Mixed Rural
State Capital
Largest Populated City
0
35
70
140 Miles
N
Cluster Key
HH High-High Cluster
HL High-Low Outlier
LH Low-High Outlier
LL Low-Low Cluster
NS Not Significant

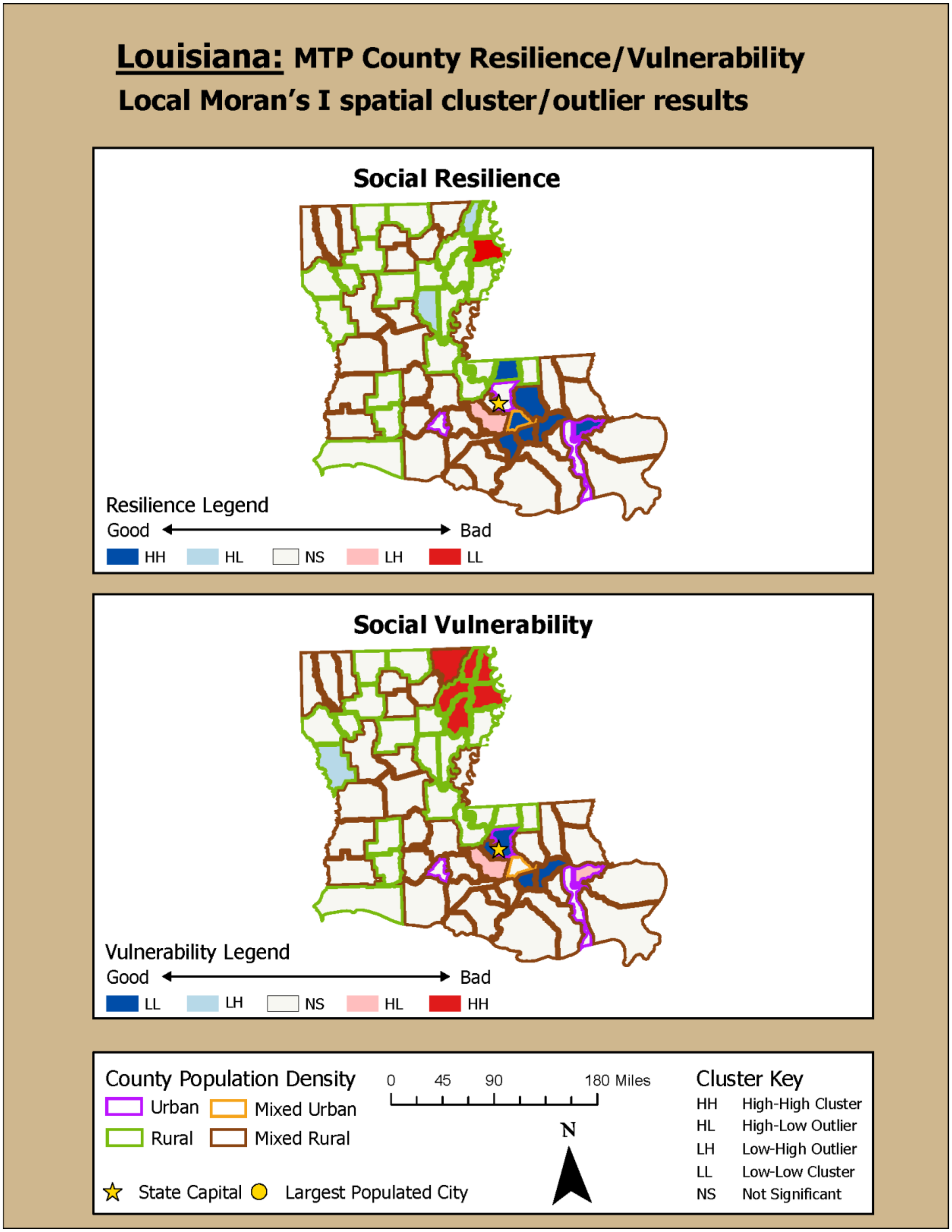

Louisiana: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results
Economic Resilience
Resilience Legend
Good
Bad
HH
HL
NS
LH
LL
Economic Vulnerability
Vulnerability Legend
Good
Bad
LL
LH
NS
HL
HH
County Population Density
Urban
Mixed Urban
Rural
Mixed Rural
State Capital
Largest Populated City
0
45
90
180 Miles
N
Cluster Key
HH High-High Cluster
HL High-Low Outlier
LH Low-High Outlier
LL Low-Low Cluster
NS Not Significant

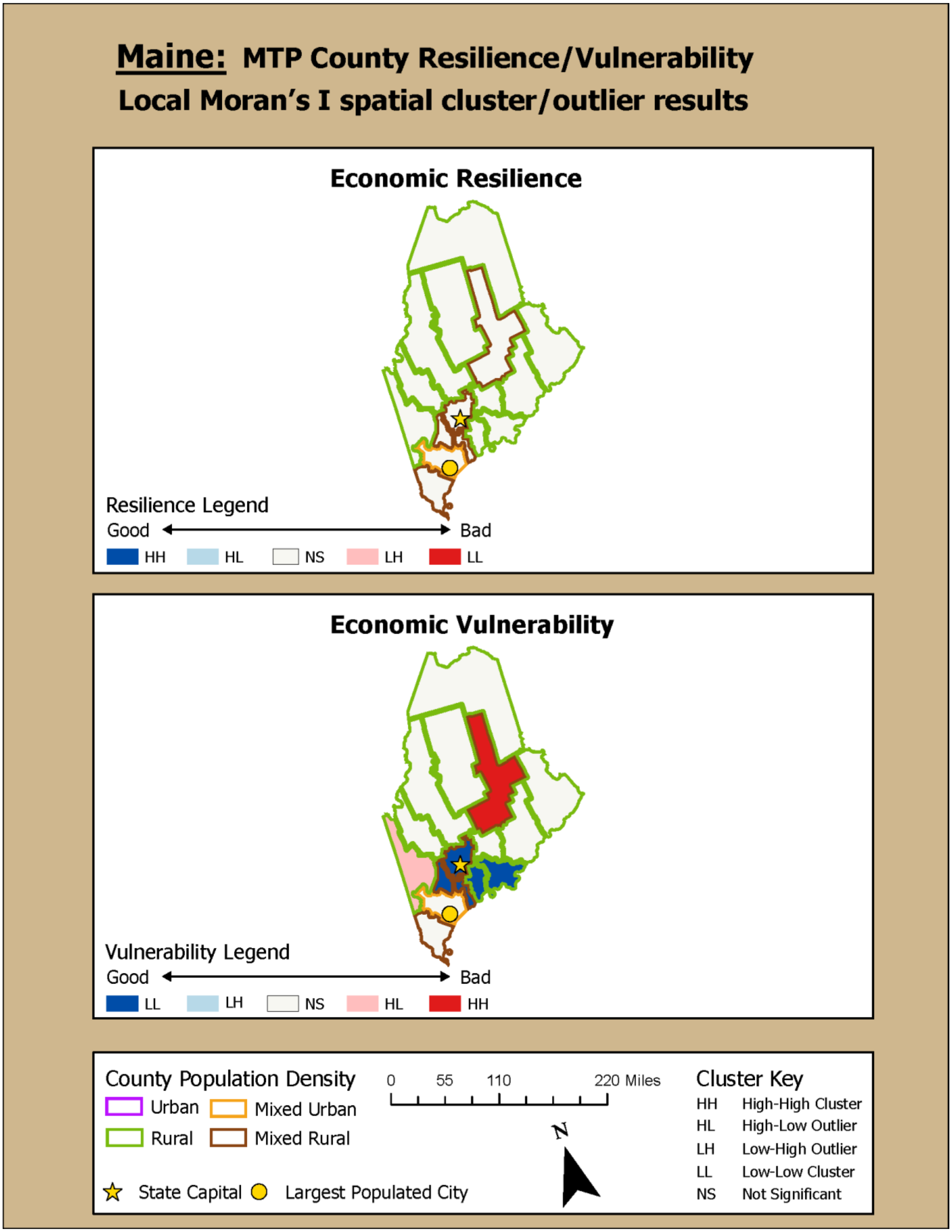
Louisiana: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results



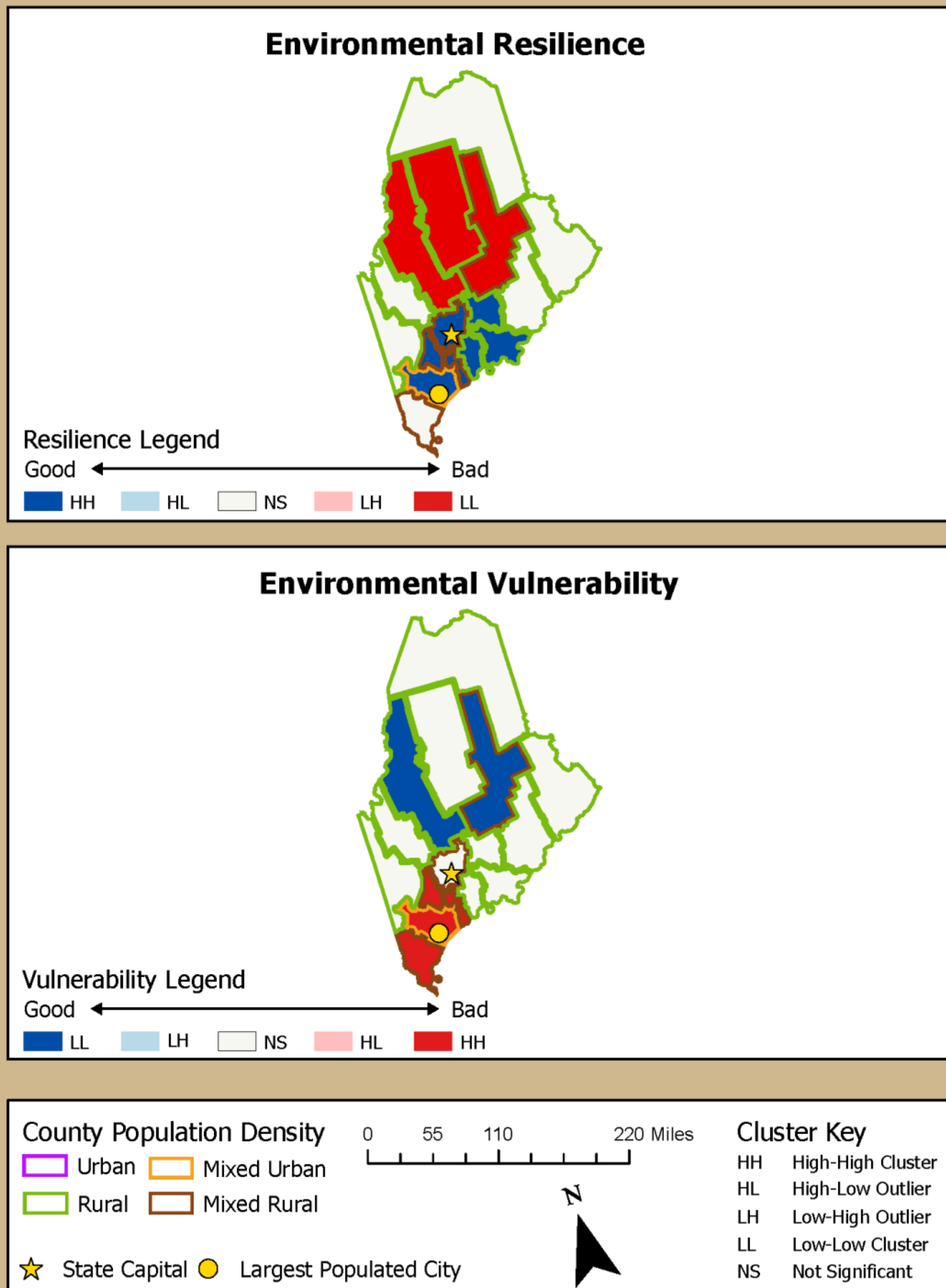
Louisiana: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results



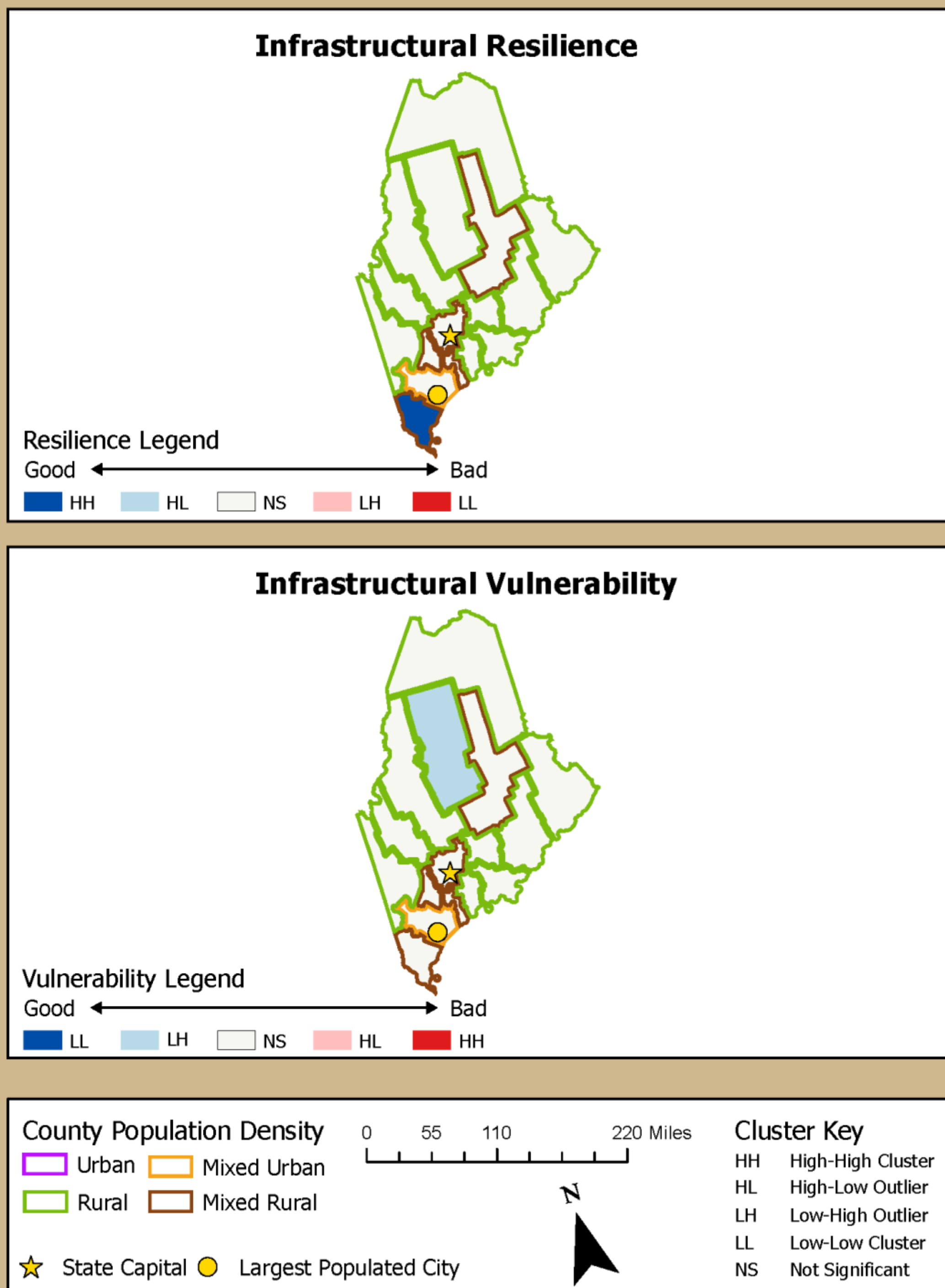

Louisiana: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results
Social Resilience
Resilience Legend
Good
Bad
HH
HL
NS
LH
LL
Social Vulnerability
Vulnerability Legend
Good
Bad
LL
LH
NS
HL
HH
County Population Density
Urban
Mixed Urban
Rural
Mixed Rural
State Capital
Largest Populated City
0
45
90
180 Miles
N
Cluster Key
HH High-High Cluster
HL High-Low Outlier
LH Low-High Outlier
LL Low-Low Cluster
NS Not Significant

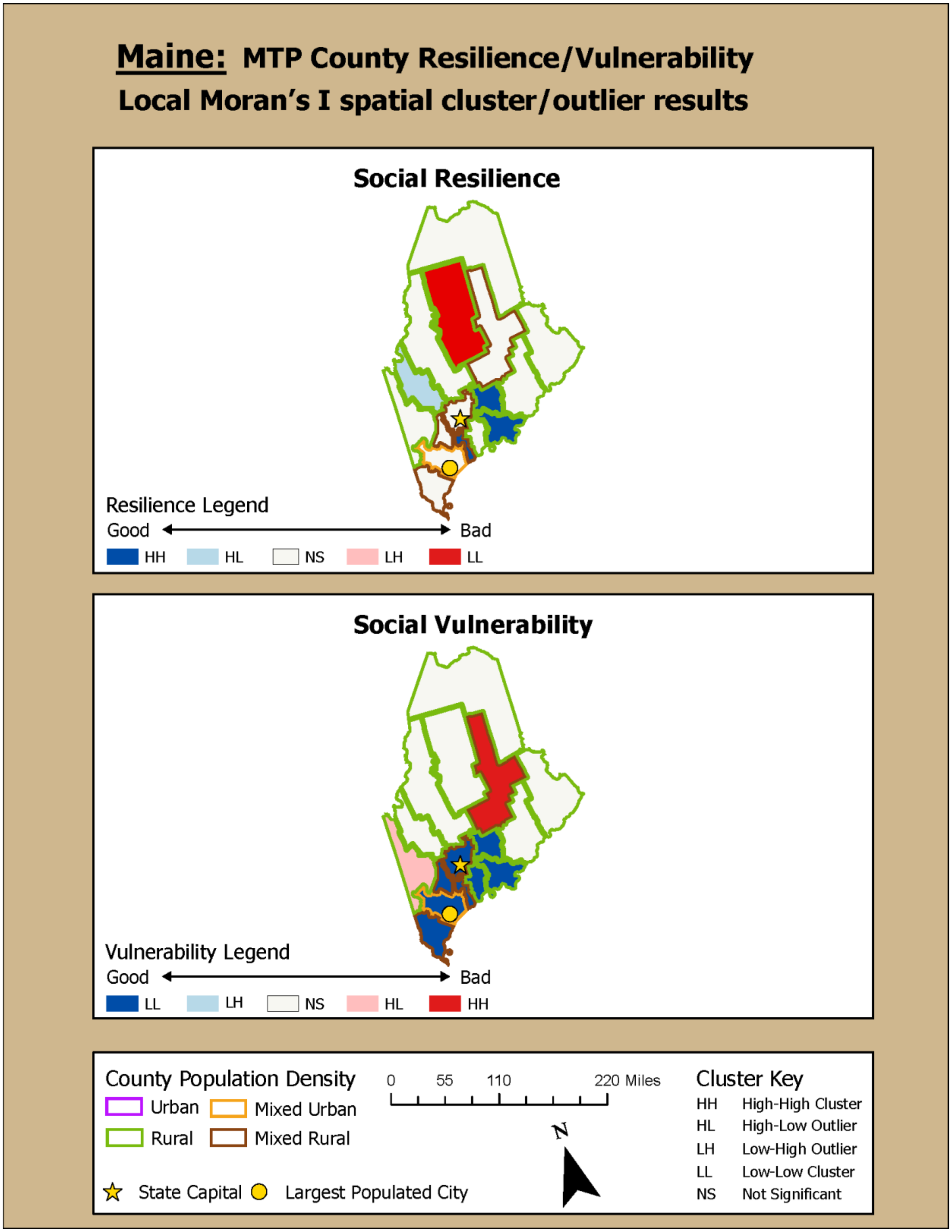

Maine: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results
Economic Resilience
Resilience Legend
Good
Bad
HH
HL
NS
LH
LL
Economic Vulnerability
Vulnerability Legend
Good
Bad
LL
LH
NS
HL
HH
County Population Density
Urban
Mixed Urban
Rural
Mixed Rural
State Capital
Largest Populated City
0
55
110
220 Miles
N
Cluster Key
HH High-High Cluster
HL High-Low Outlier
LH Low-High Outlier
LL Low-Low Cluster
NS Not Significant

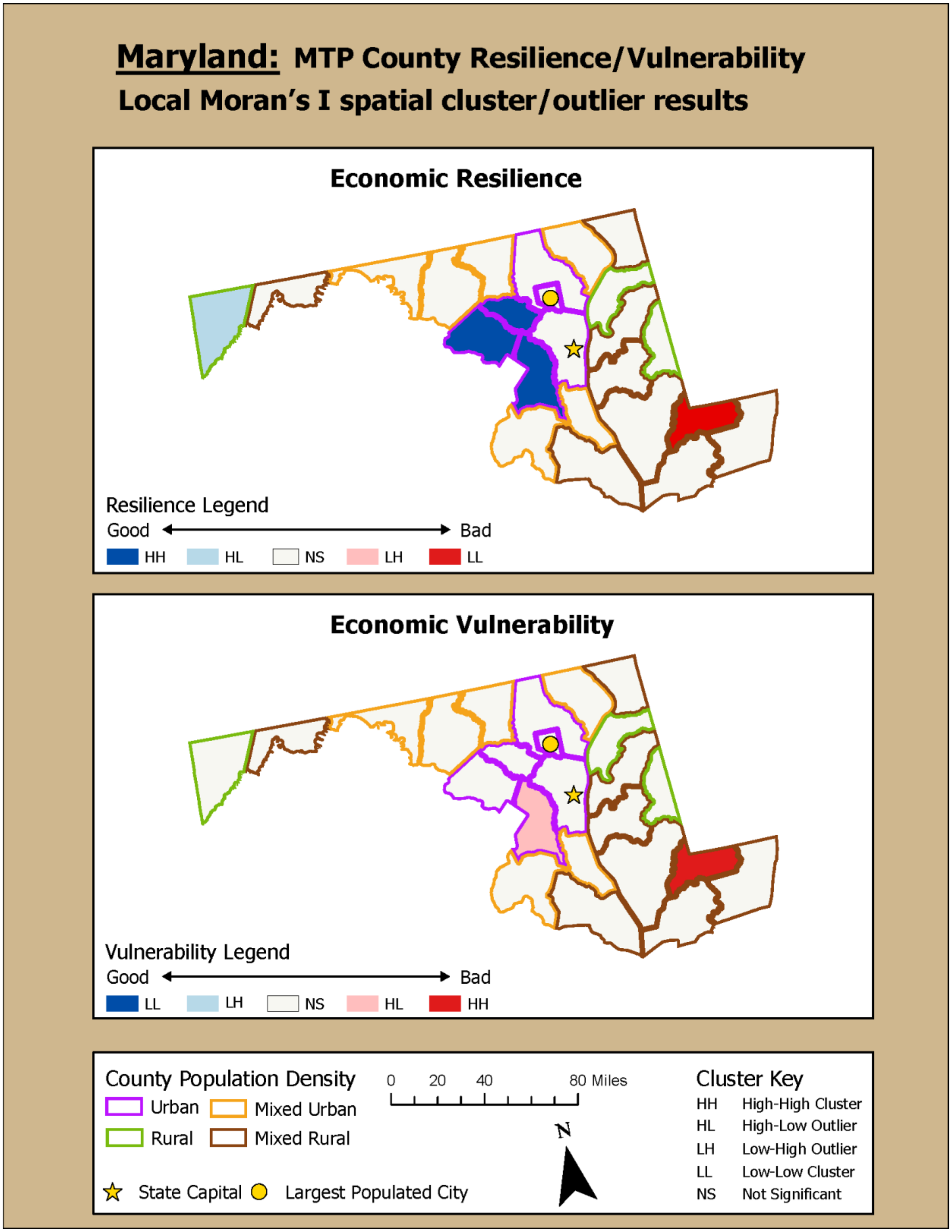
Maine: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results



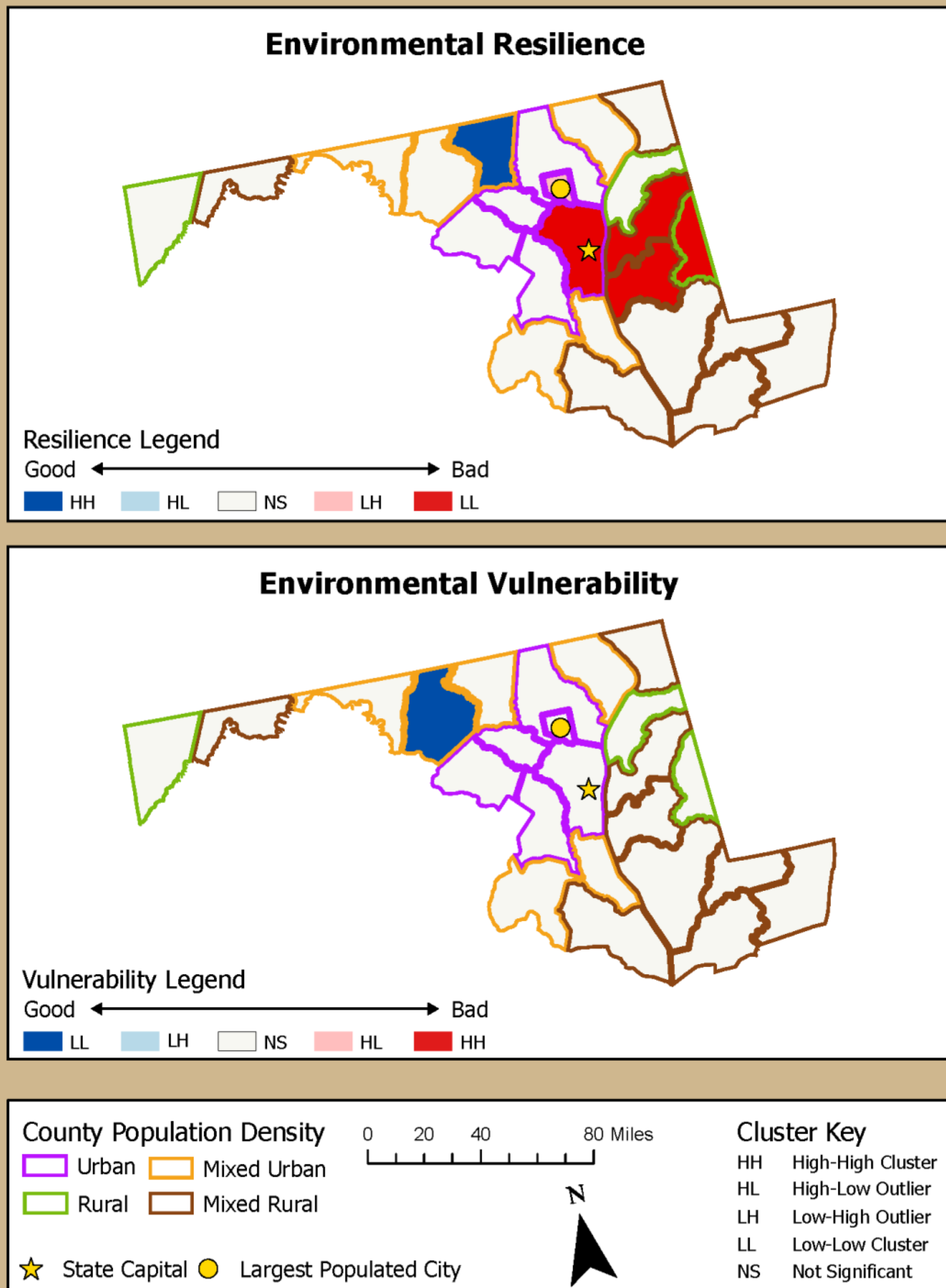
Maine: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results

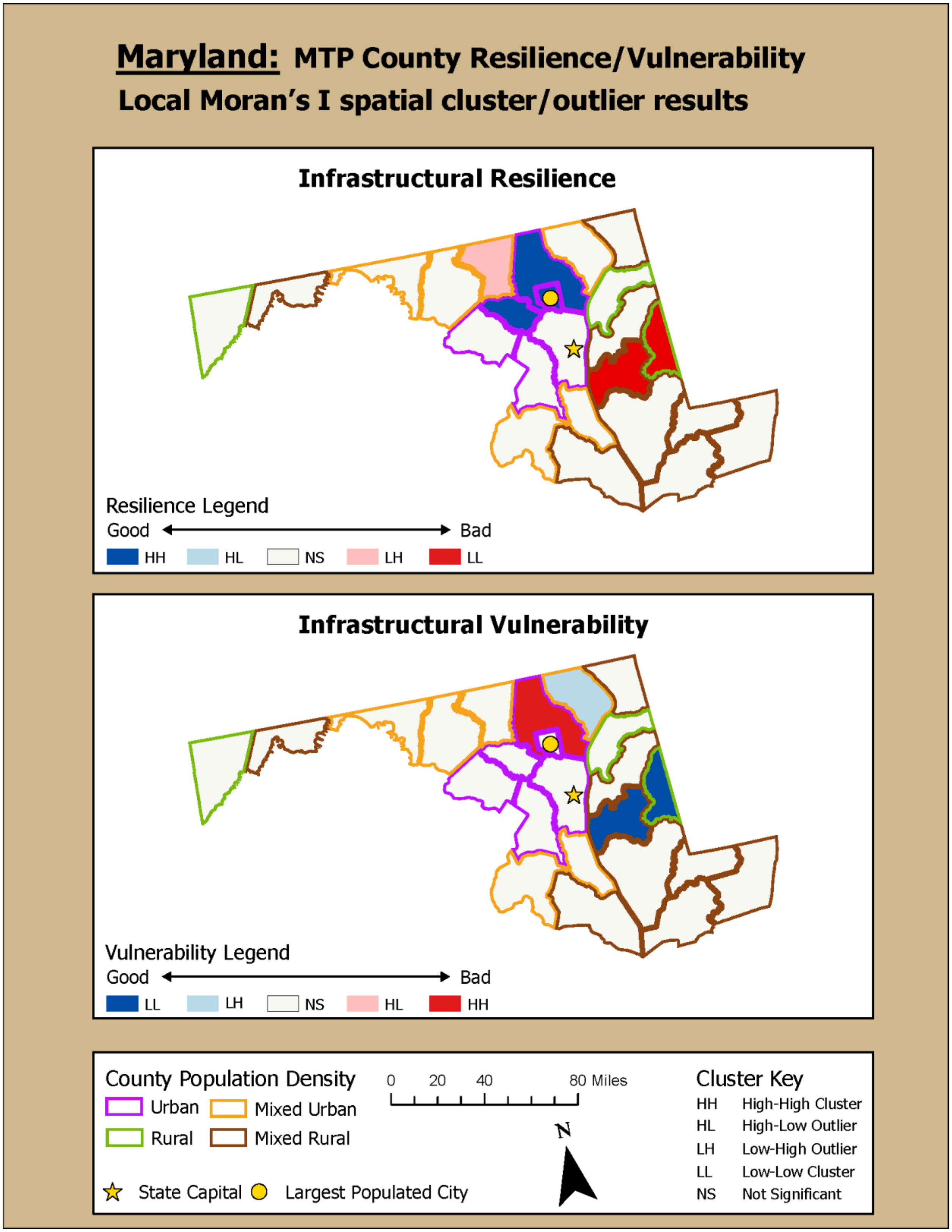


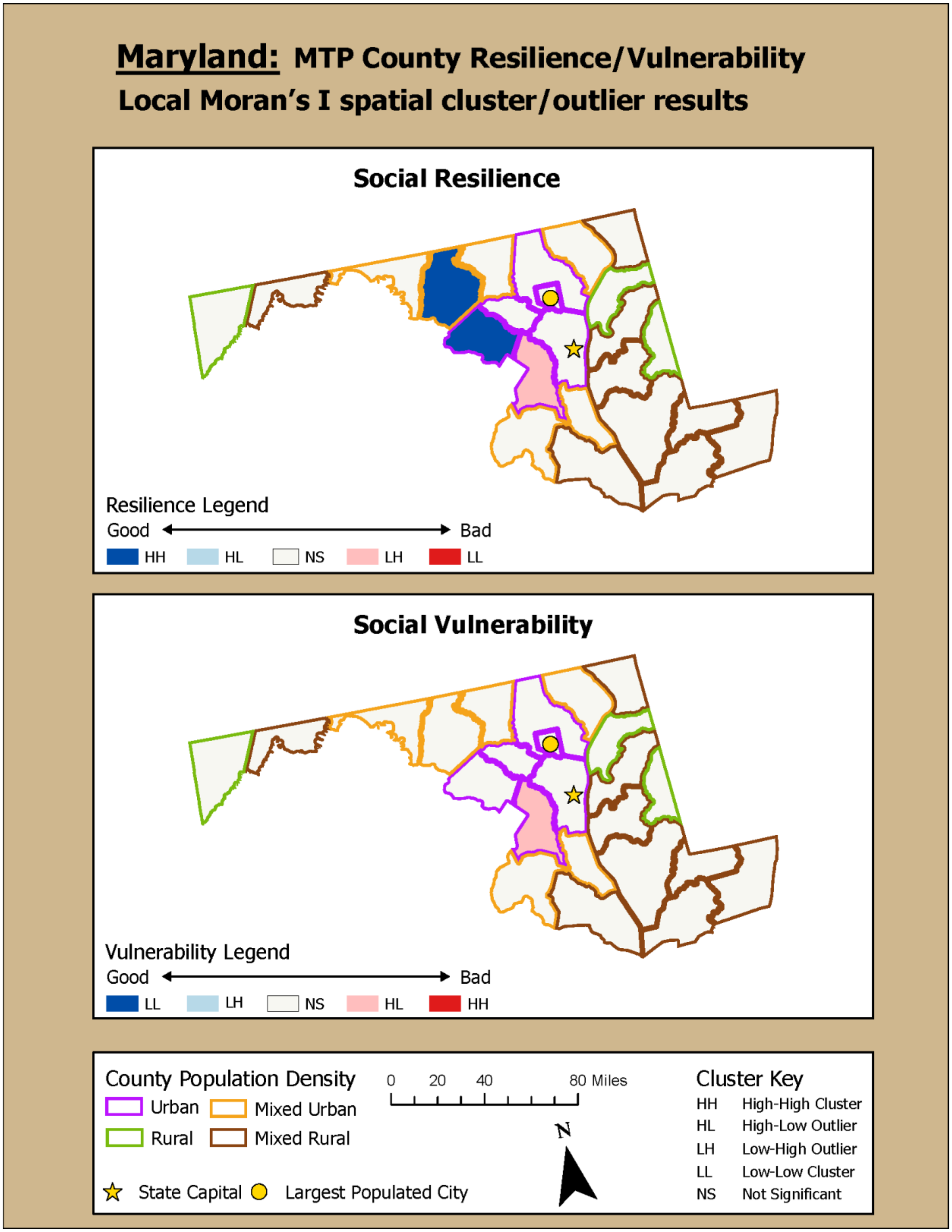

Maine: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results
Social Resilience
Resilience Legend
Good
Bad
HH
HL
NS
LH
LL
Social Vulnerability
Vulnerability Legend
Good
Bad
LL
LH
NS
HL
HH
County Population Density
Urban
Mixed Urban
Rural
Mixed Rural
State Capital
Largest Populated City
0
55
110
220 Miles
N
Cluster Key
HH High-High Cluster
HL High-Low Outlier
LH Low-High Outlier
LL Low-Low Cluster
NS Not Significant

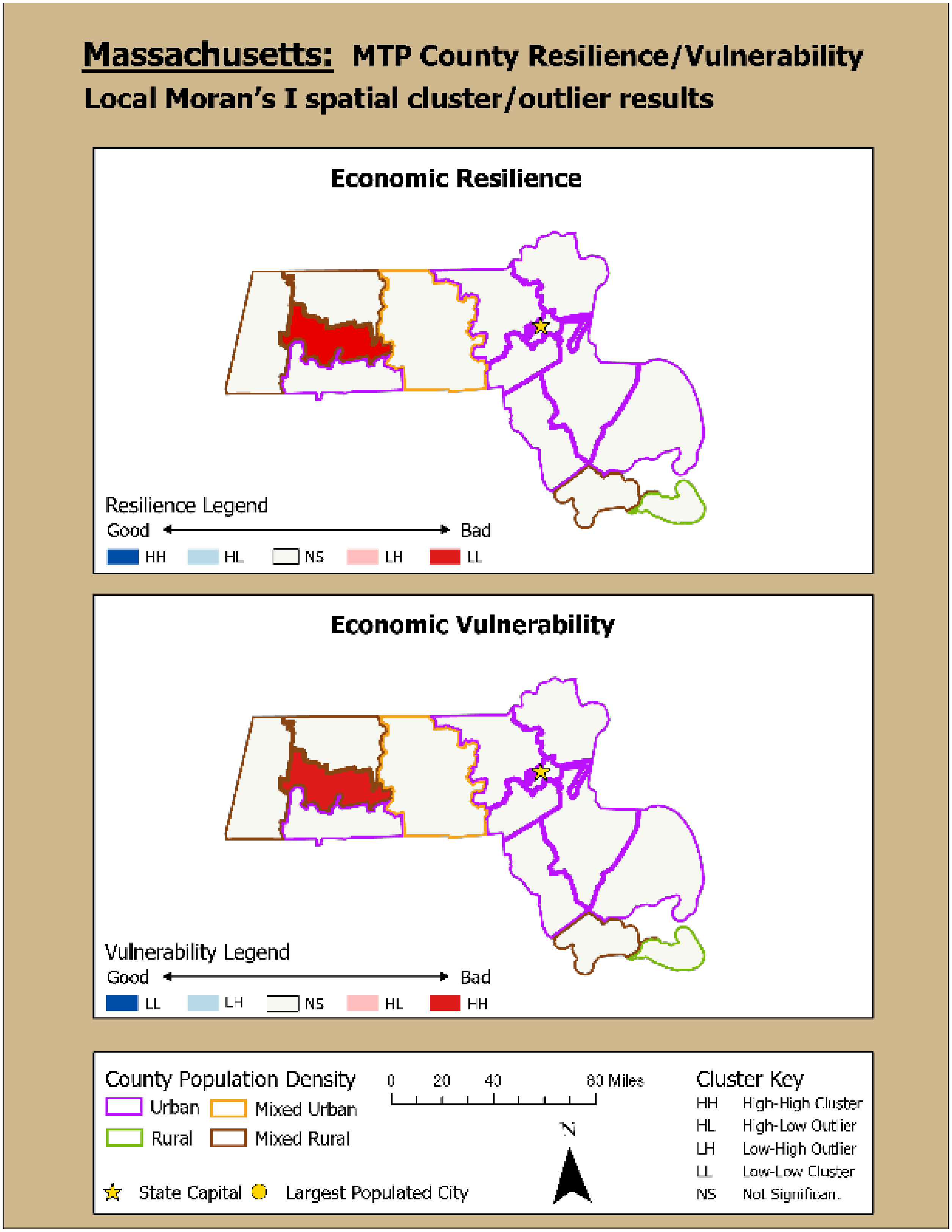

Maryland: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results
Economic Resilience
Resilience Legend
Good
Bad
HH
HL
NS
LH
LL
Economic Vulnerability
Vulnerability Legend
Good
Bad
LL
LH
NS
HL
HH
County Population Density
Urban
Mixed Urban
Rural
Mixed Rural
0
20
40
80 Miles
N
State Capital
Largest Populated City
Cluster Key
HH High-High Cluster
HL High-Low Outlier
LH Low-High Outlier
LL Low-Low Cluster
NS Not Significant

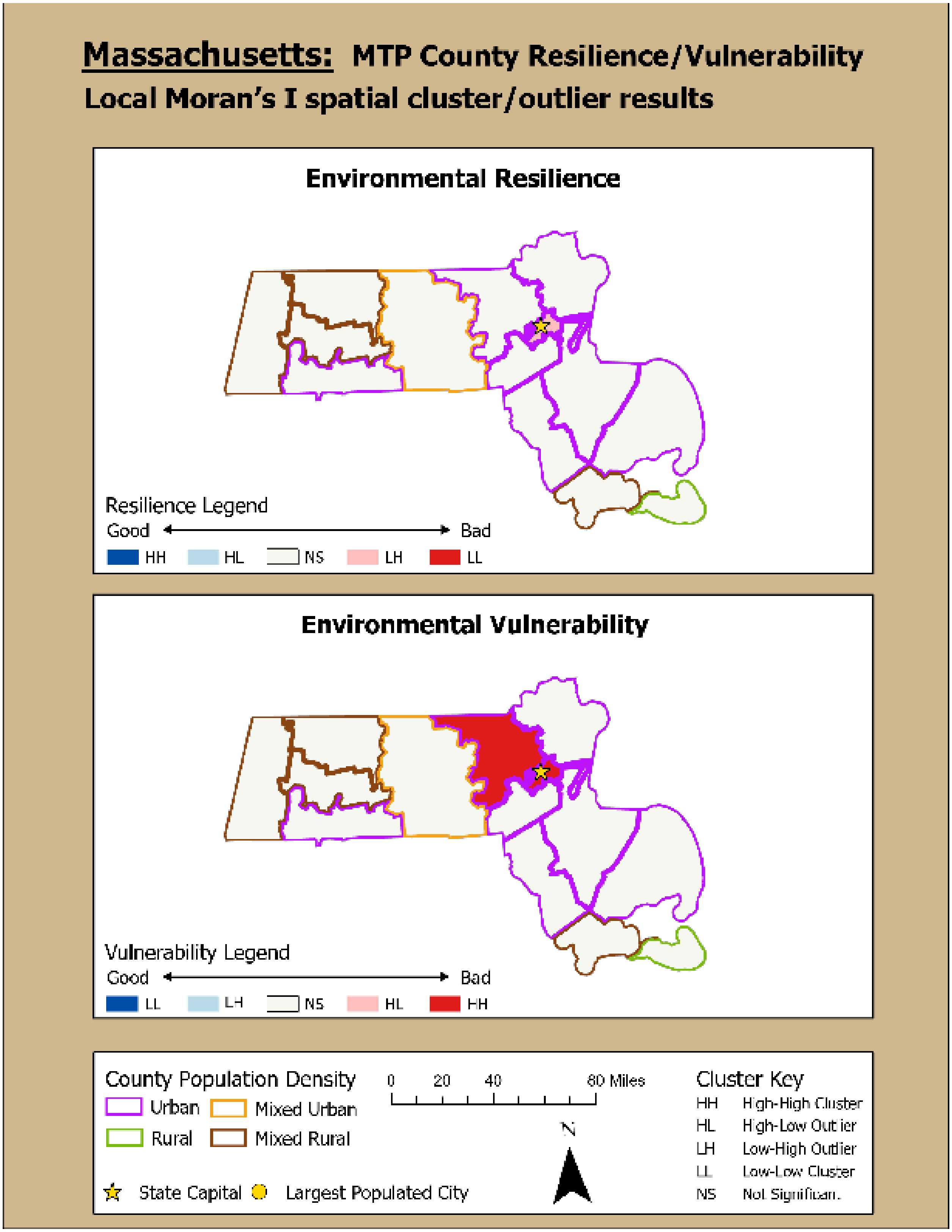
Maryland: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results

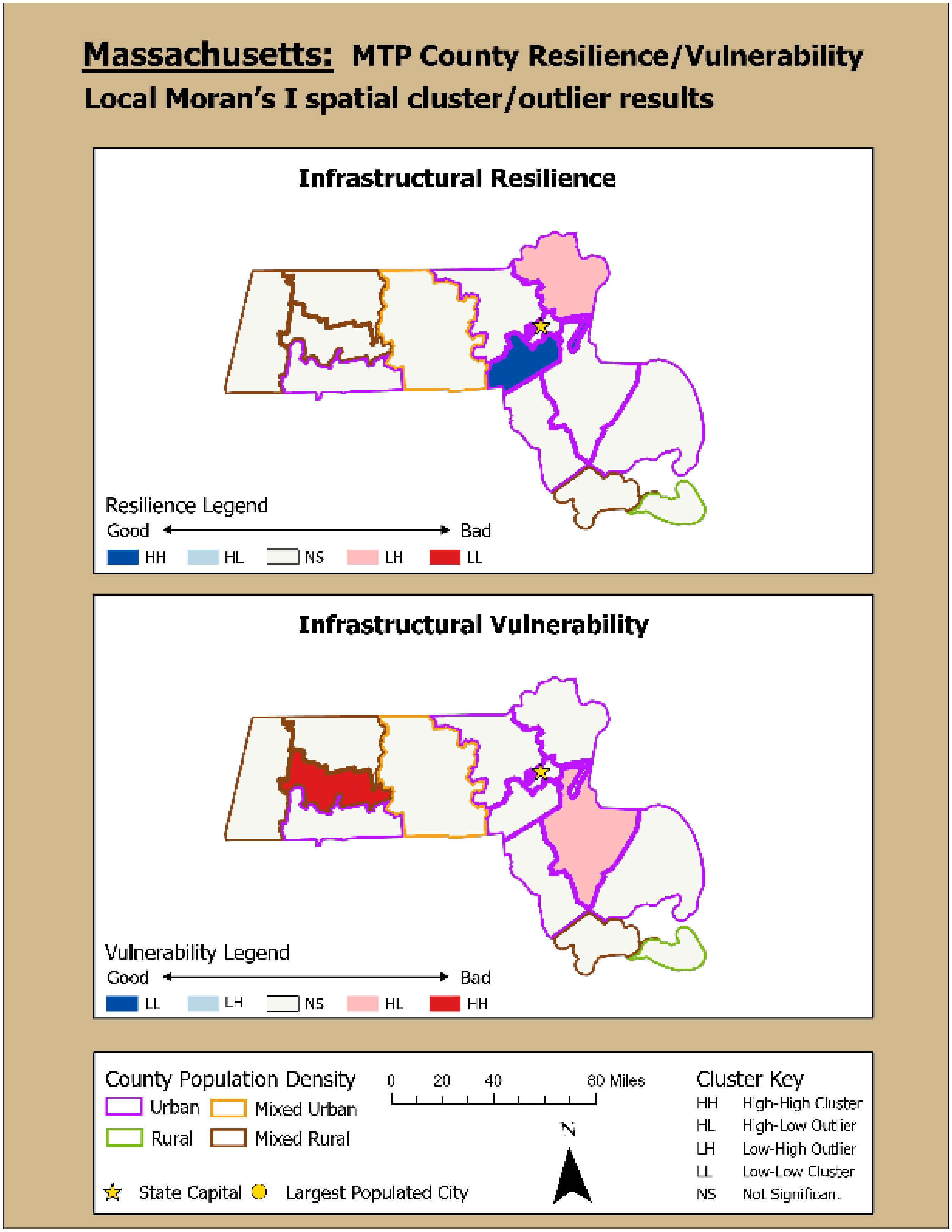



Maryland: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results
Infrastructural Resilience
Resilience Legend
Good
Bad
HH
HL
NS
LH
LL
Infrastructural Vulnerability
Vulnerability Legend
Good
Bad
LL
LH
NS
HL
HH
County Population Density
Urban
Mixed Urban
Rural
Mixed Rural
State Capital
Largest Populated City
0
20
40
80 Miles
N
Cluster Key
HH High-High Cluster
HL High-Low Outlier
LH Low-High Outlier
LL Low-Low Cluster
NS Not Significant


Maryland: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results
Social Resilience
Resilience Legend
Good
Bad
HH
HL
NS
LH
LL
Social Vulnerability
Vulnerability Legend
Good
Bad
LL
LH
NS
HL
HH
County Population Density
Urban
Mixed Urban
Rural
Mixed Rural
State Capital
Largest Populated City
0
20
40
80 Miles
N
Cluster Key
HH High-High Cluster
HL High-Low Outlier
LH Low-High Outlier
LL Low-Low Cluster
NS Not Significant

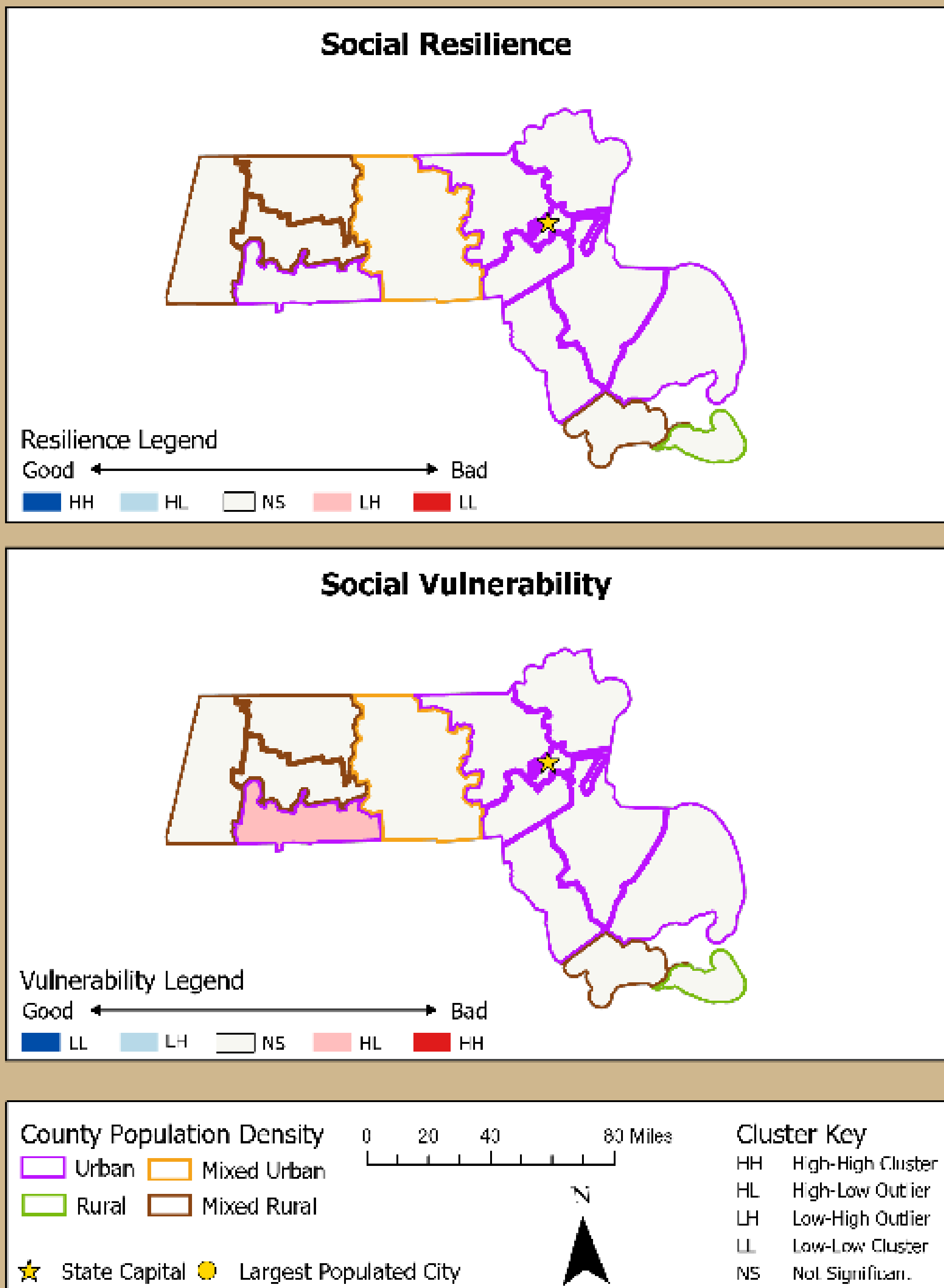

Massachusetts: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results
Economic Resilience
Resilience Legend
Good
Bad
HH
HL
NS
LH
LL
Economic Vulnerability
Vulnerability Legend
Good
Bad
LL
LH
NS
HL
HH
County Population Density
Urban
Mixed Urban
Rural
Mixed Rural
State Capital
Largest Populated City
0
20
40
80 Miles
N
Cluster Key
HH High-High Cluster
HL High-Low Outlier
LH Low-High Outlier
LL Low-Low Cluster
NS Not Significant


Massachusetts: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results
Environmental Resilience
Resilience Legend
Good
Bad
HH
HL
NS
LH
LL
Environmental Vulnerability
Vulnerability Legend
Good
Bad
LL
LH
NS
HL
HH
County Population Density
Urban
Mixed Urban
Rural
Mixed Rural
State Capital
Largest Populated City
0
20
40
80 Miles
N
Cluster Key
HH High-High Cluster
HL High-Low Outlier
LH Low-High Outlier
LL Low-Low Cluster
NS Not Significant

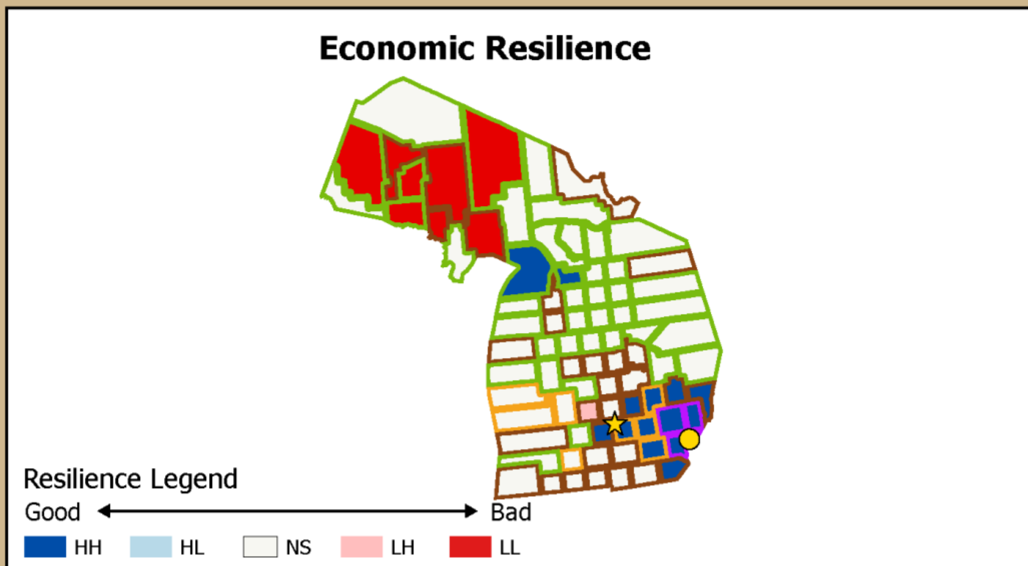

Massachusetts: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results
Infrastructural Resilience
Resilience Legend
Good
Bad
HH
HL
NS
LH
LL
Infrastructural Vulnerability
Vulnerability Legend
Good
Bad
LL
LH
NS
HL
HH
County Population Density
Urban
Mixed Urban
Rural
Mixed Rural
State Capital
Largest Populated City
0
20
40
80 Miles
N
Cluster Key
HH High-High Cluster
HL High-Low Outlier
LH Low-High Outlier
LL Low-Low Cluster
NS Not Significant

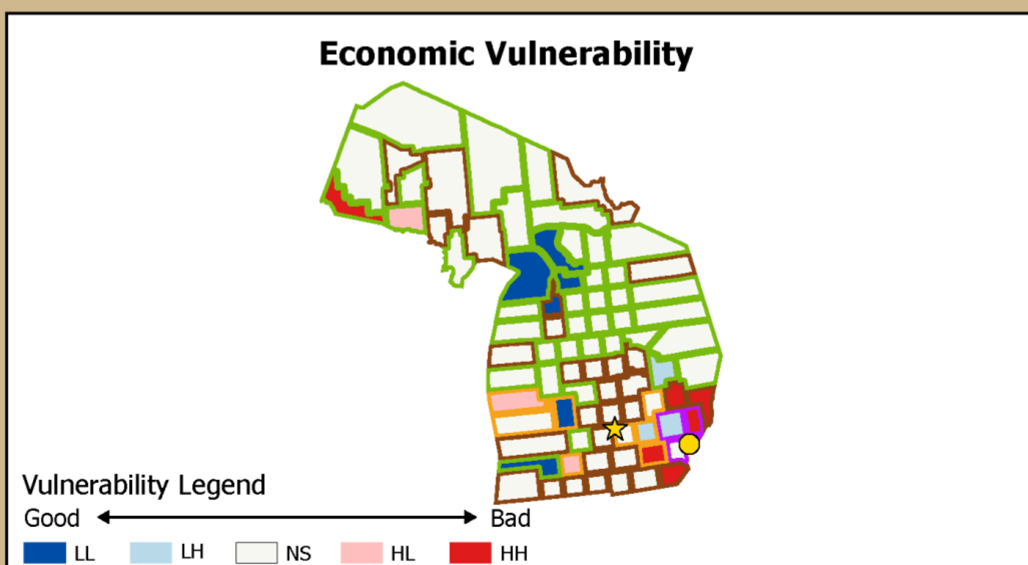
Massachusetts: MTP County Resilience/Vulnerability

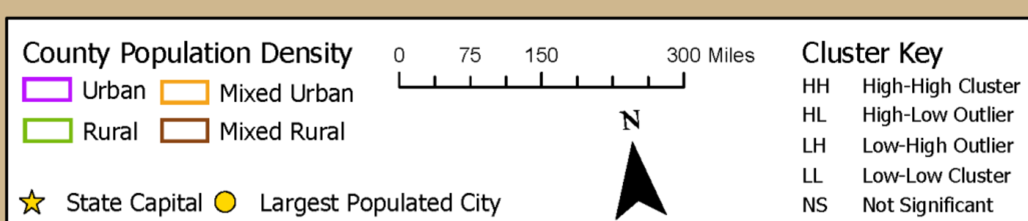
Local Moran's I spatial cluster/outlier results

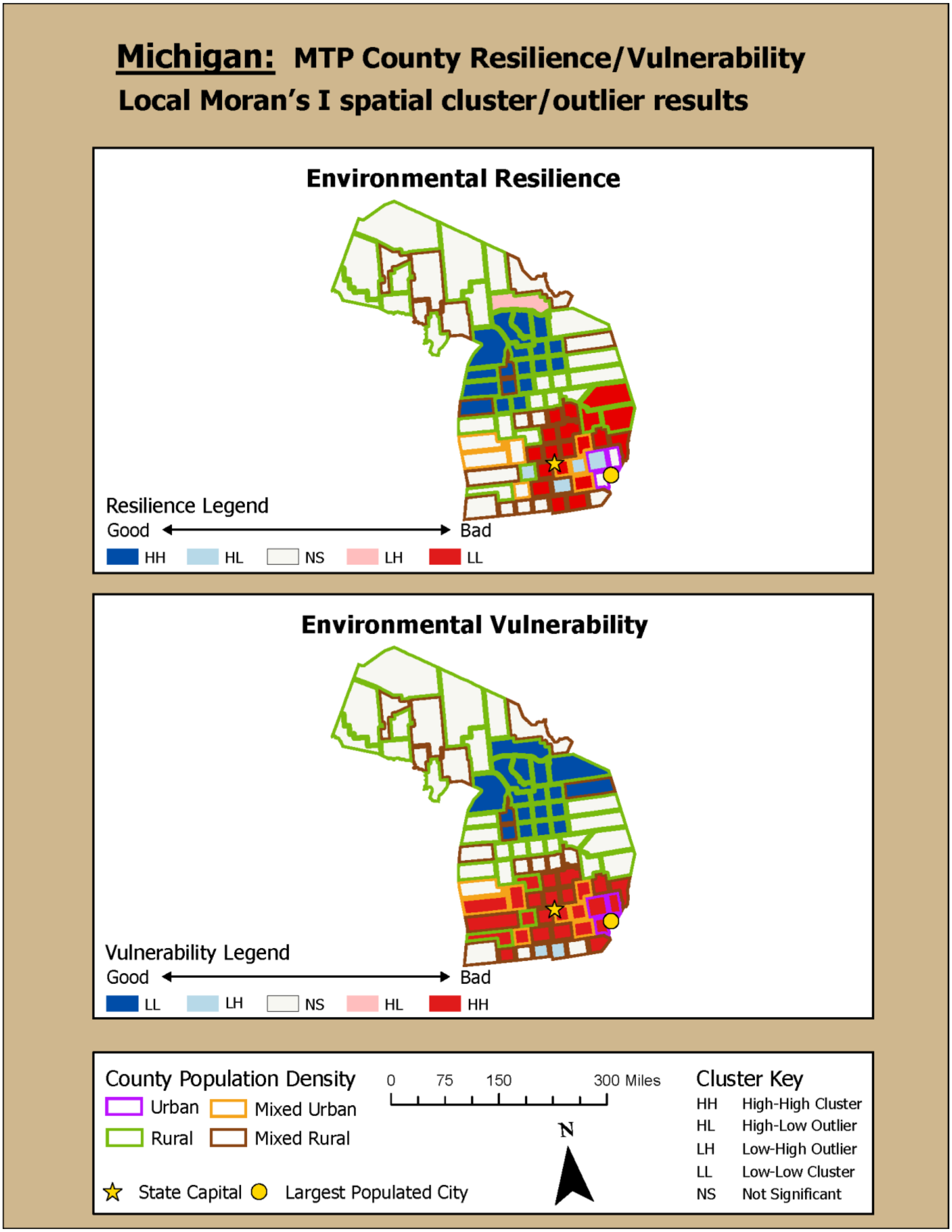


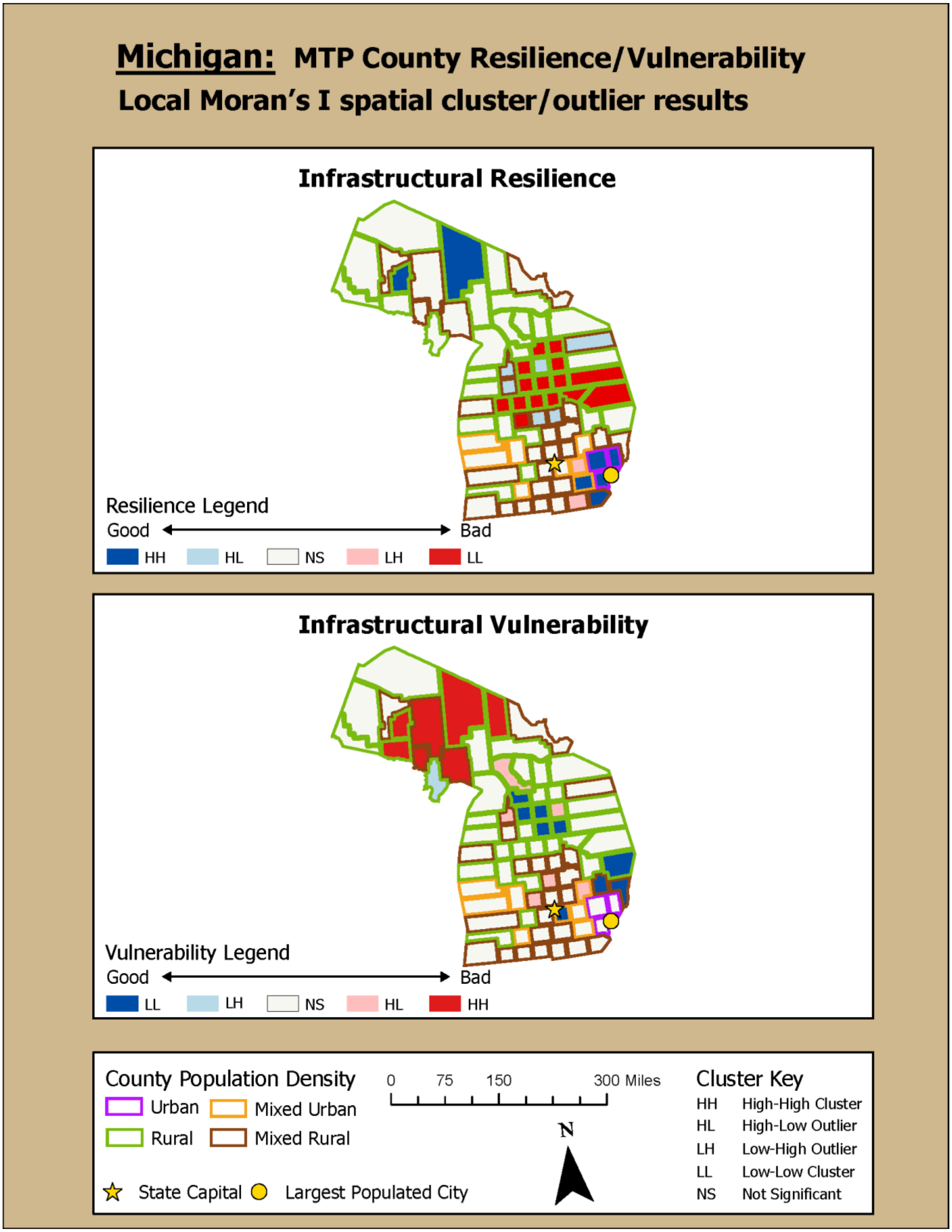
Michigan: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results



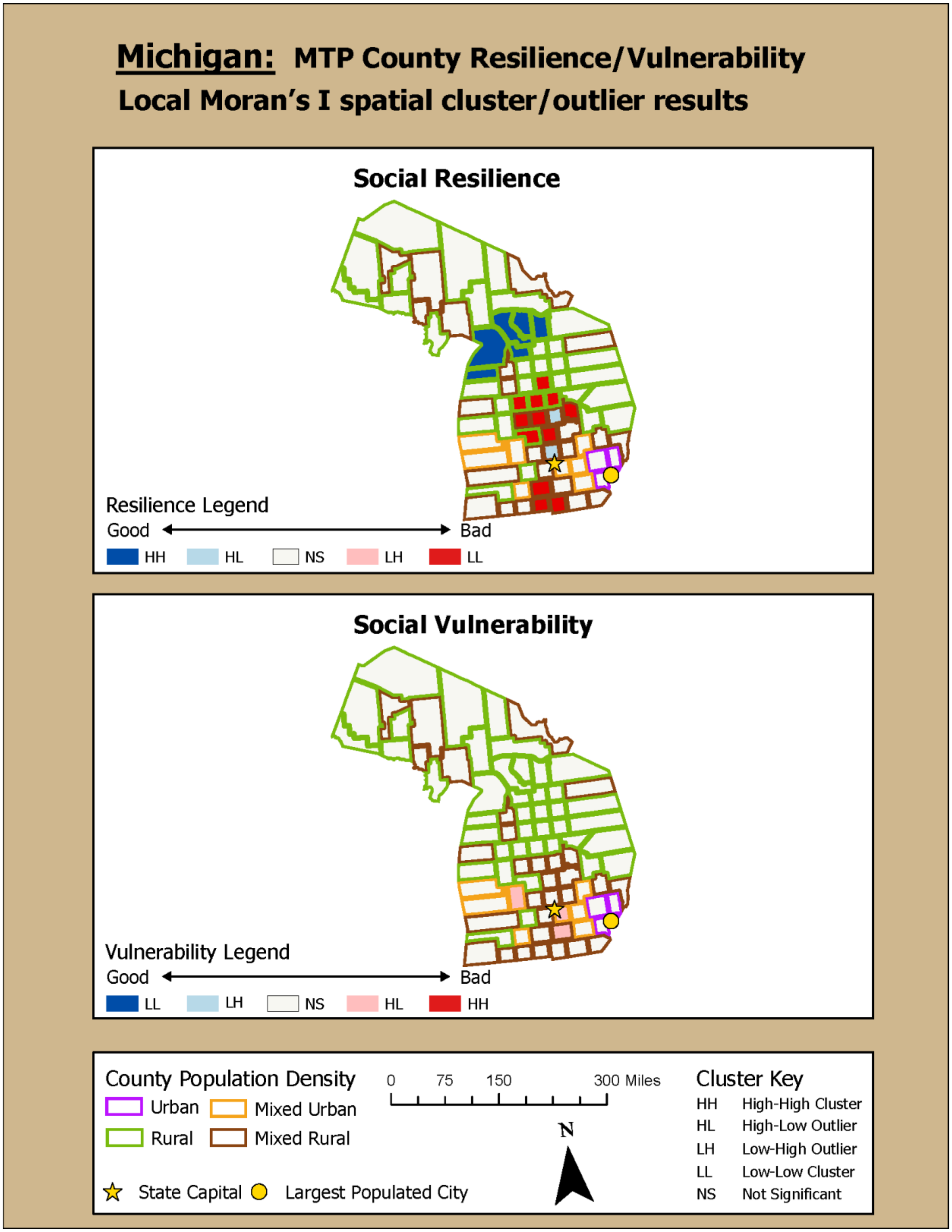




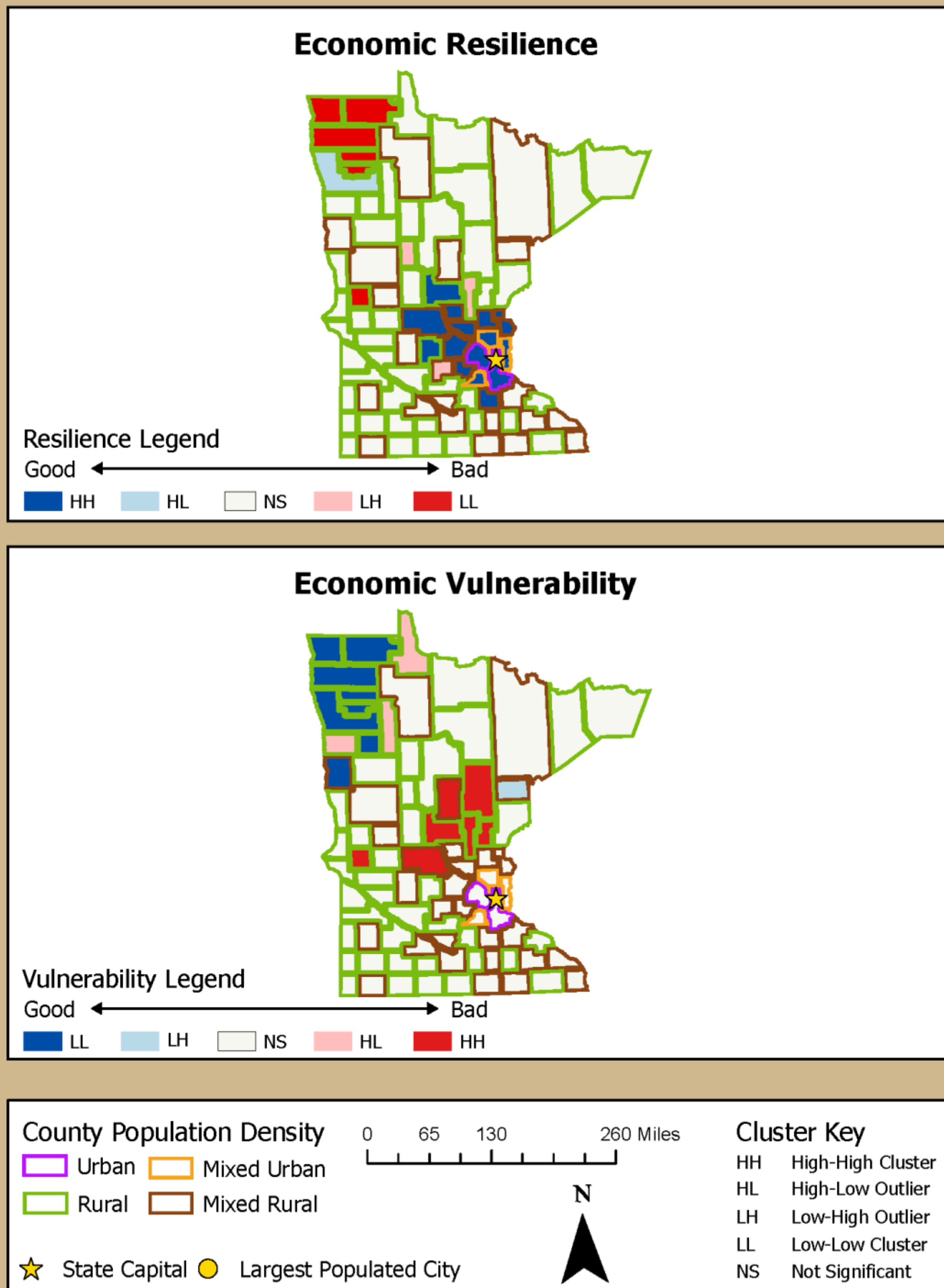

Michigan: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results
Environmental Resilience
Resilience Legend
Good
Bad
HH
HL
NS
LH
LL
Environmental Vulnerability
Vulnerability Legend
Good
Bad
LL
LH
NS
HL
HH
County Population Density
Urban
Mixed Urban
Rural
Mixed Rural
State Capital
Largest Populated City
0
75
150
300 Miles
N
Cluster Key
HH High-High Cluster
HL High-Low Outlier
LH Low-High Outlier
LL Low-Low Cluster
NS Not Significant



Michigan: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results
Infrastructural Resilience
Resilience Legend
Good
Bad
HH
HL
NS
LH
LL
Infrastructural Vulnerability
Vulnerability Legend
Good
Bad
LL
LH
NS
HL
HH
County Population Density
Urban
Mixed Urban
Rural
Mixed Rural
State Capital
Largest Populated City
0
75
150
300 Miles
N
Cluster Key
HH High-High Cluster
HL High-Low Outlier
LH Low-High Outlier
LL Low-Low Cluster
NS Not Significant

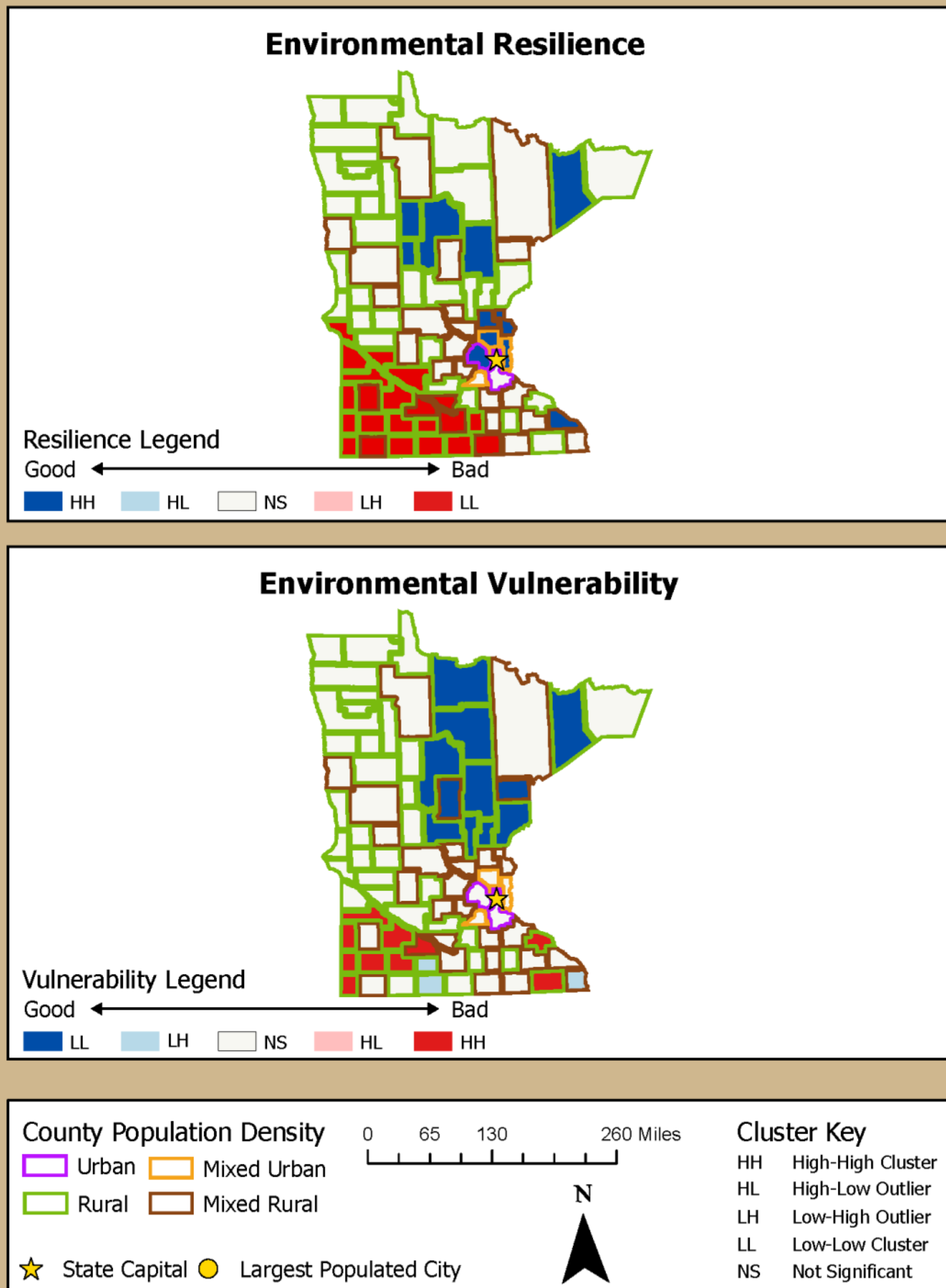

Michigan: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results
Social Resilience
Resilience Legend
Good
Bad
HH
HL
NS
LH
LL
Social Vulnerability
Vulnerability Legend
Good
Bad
LL
LH
NS
HL
HH
County Population Density
Urban
Mixed Urban
Rural
Mixed Rural
0
75
150
300 Miles
N
State Capital
Largest Populated City
Cluster Key
HH High-High Cluster
HL High-Low Outlier
LH Low-High Outlier
LL Low-Low Cluster
NS Not Significant

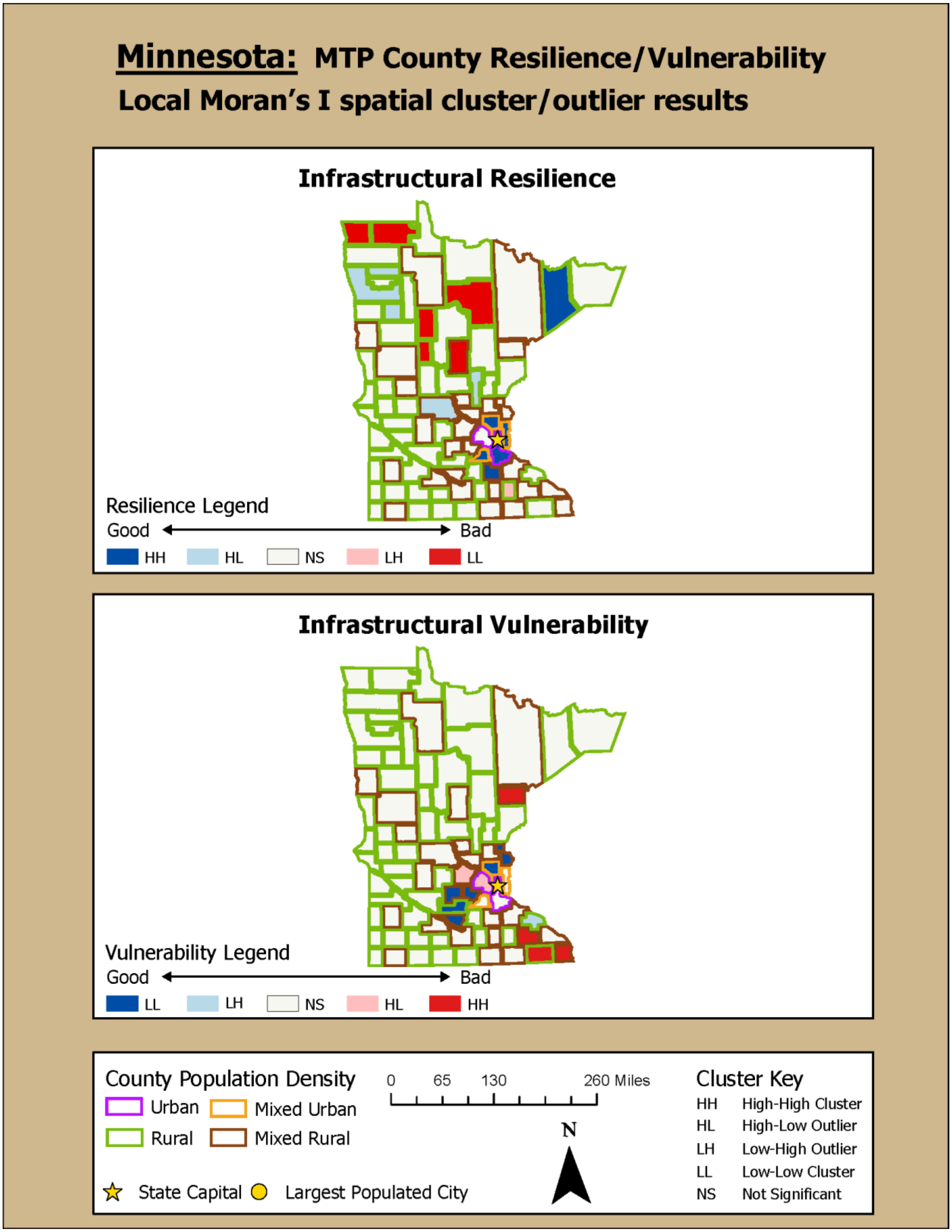
Minnesota: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results

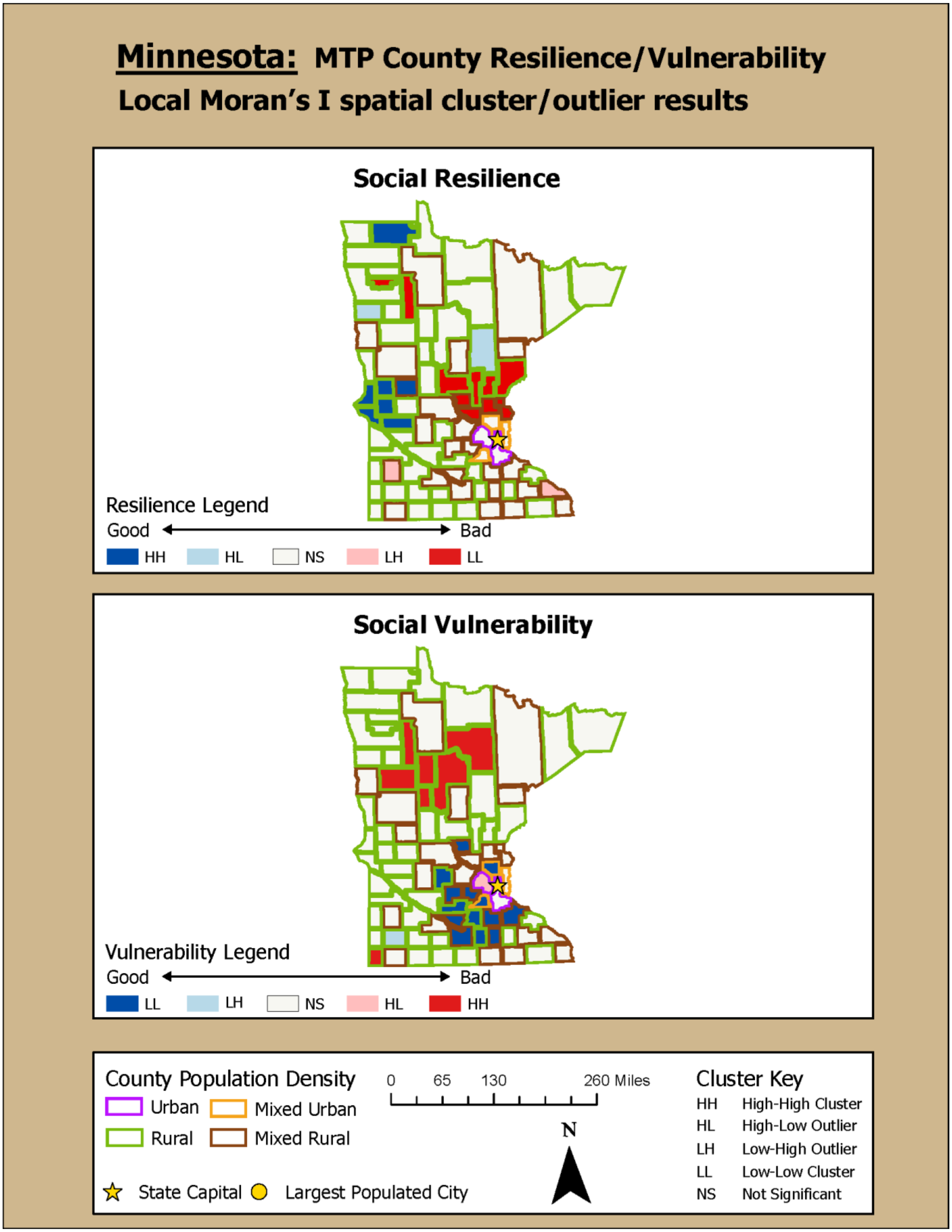


Minnesota: MTP County Resilience/Vulnerability

Local Moran's I spatial cluster/outlier results

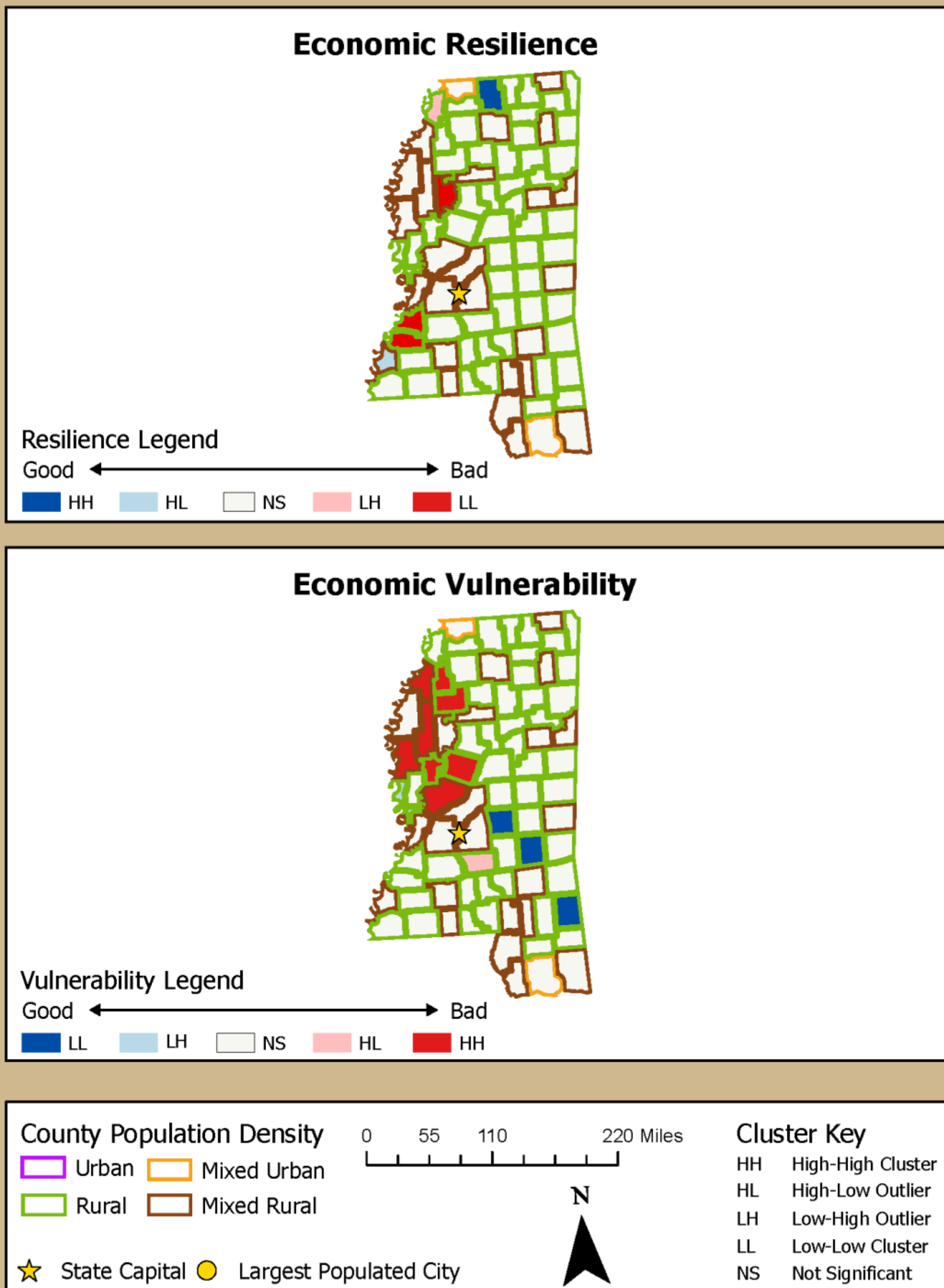


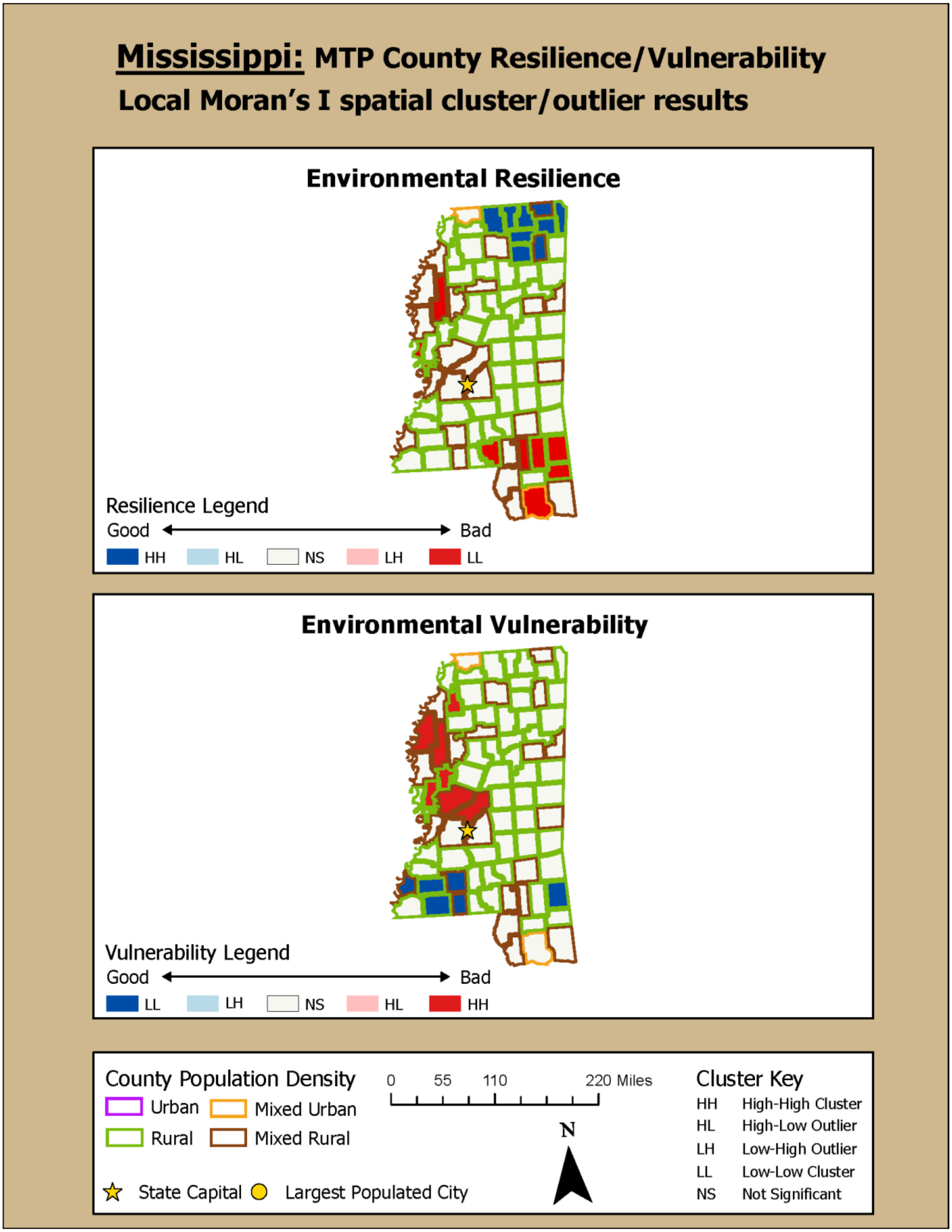

Minnesota: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results
Infrastructural Resilience
Resilience Legend
Good
Bad
HH
HL
NS
LH
LL
Infrastructural Vulnerability
Vulnerability Legend
Good
Bad
LL
LH
NS
HL
HH
County Population Density
Urban
Mixed Urban
Rural
Mixed Rural
0
65
130
260 Miles
N
State Capital
Largest Populated City
Cluster Key
HH High-High Cluster
HL High-Low Outlier
LH Low-High Outlier
LL Low-Low Cluster
NS Not Significant



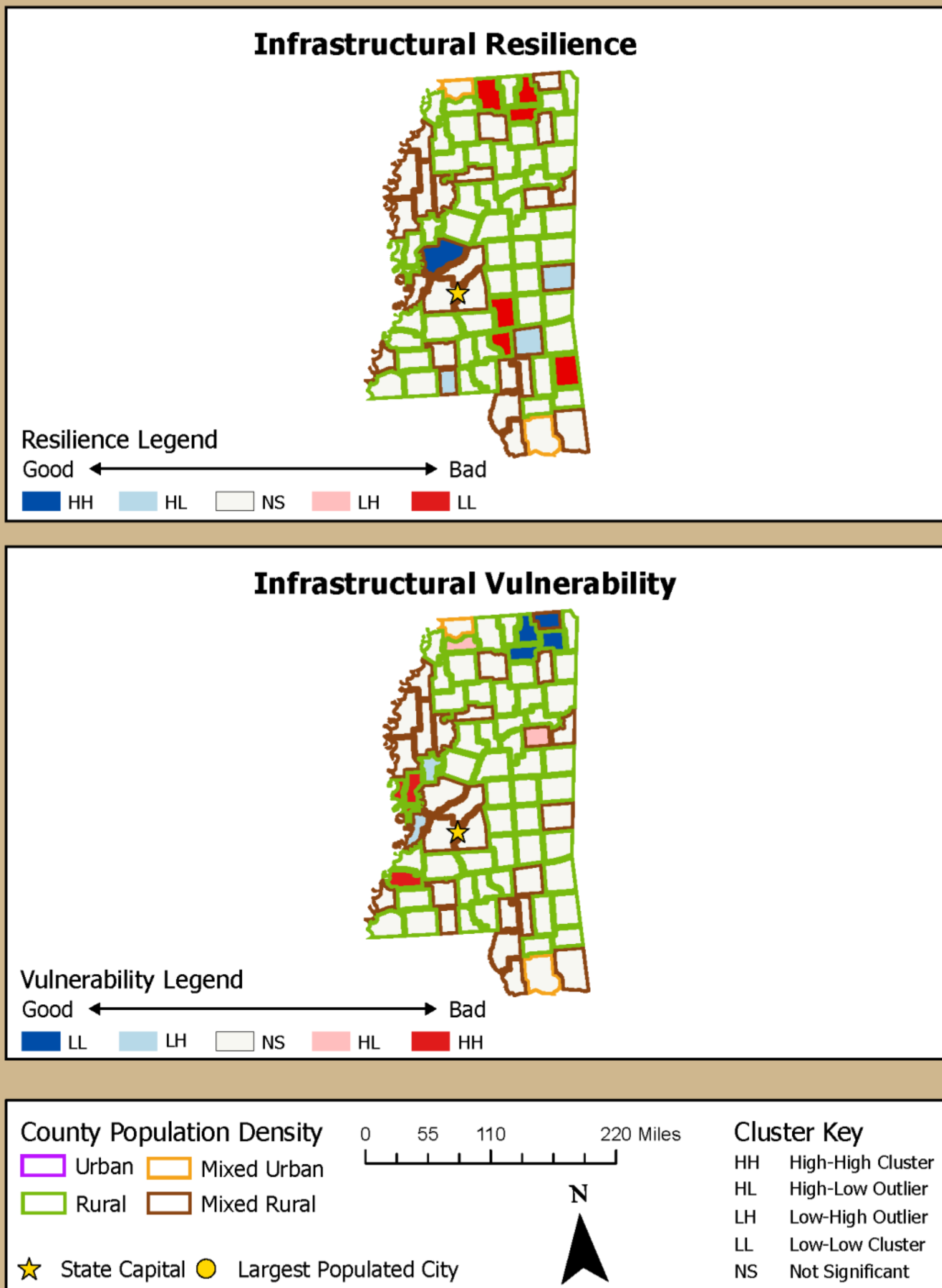
Minnesota: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results
Social Resilience
Resilience Legend
Good
Bad
HH
HL
NS
LH
LL
Social Vulnerability
Vulnerability Legend
Good
Bad
LL
LH
NS
HL
HH
County Population Density
Urban
Mixed Urban
Rural
Mixed Rural
State Capital
Largest Populated City
0
65
130
260 Miles
N
Cluster Key
HH High-High Cluster
HL High-Low Outlier
LH Low-High Outlier
LL Low-Low Cluster
NS Not Significant

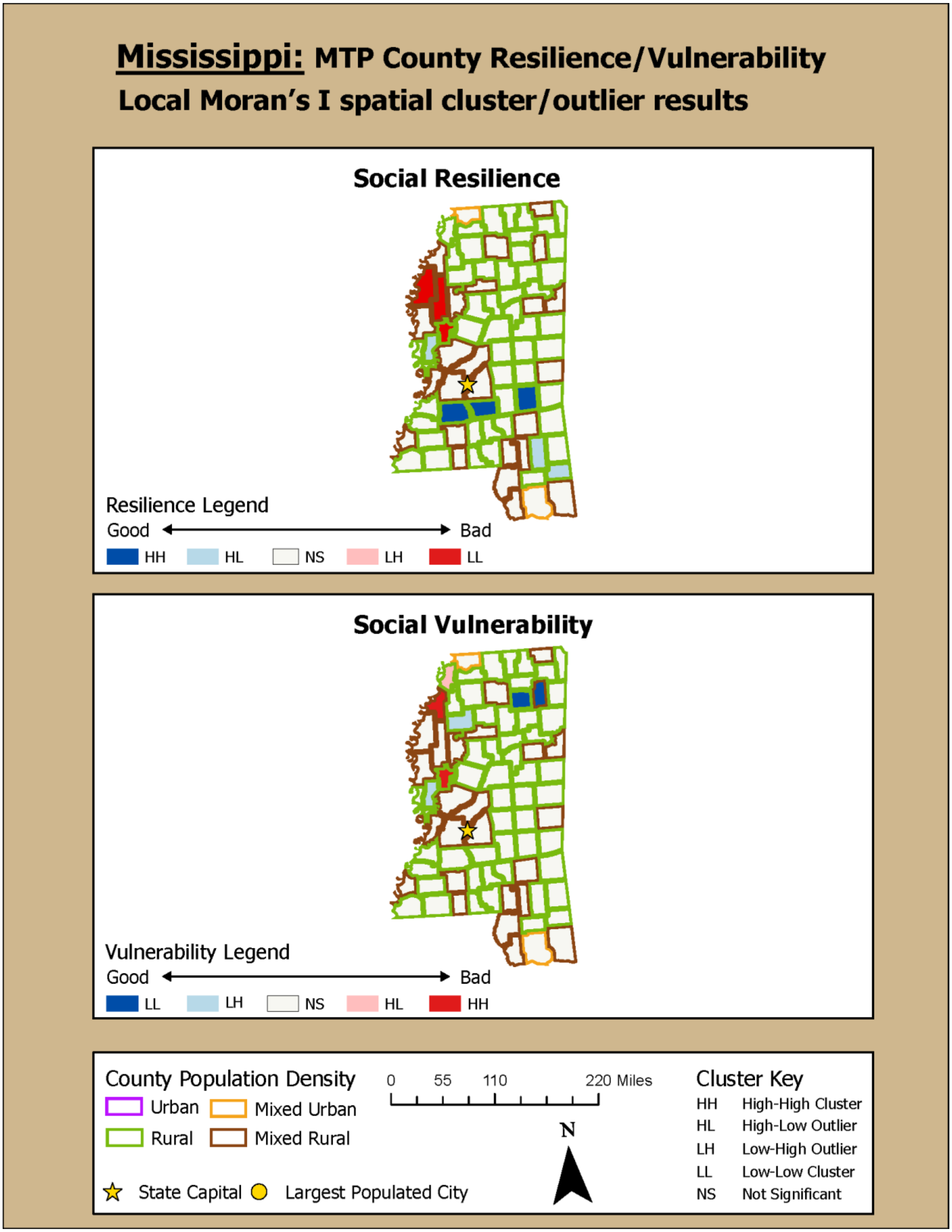
Mississippi: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results




Mississippi: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results
Environmental Resilience
Resilience Legend
Good
Bad
HH
HL
NS
LH
LL
Environmental Vulnerability
Vulnerability Legend
Good
Bad
LL
LH
NS
HL
HH
County Population Density
Urban
Mixed Urban
Rural
Mixed Rural
State Capital
Largest Populated City
0
55
110
220 Miles
N
Cluster Key
HH High-High Cluster
HL High-Low Outlier
LH Low-High Outlier
LL Low-Low Cluster
NS Not Significant

Mississippi: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results




Mississippi: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results
Social Resilience
Resilience Legend
Good
Bad
HH
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NS
LH
LL
Social Vulnerability
Vulnerability Legend
Good
Bad
LL
LH
NS
HL
HH
County Population Density
Urban
Mixed Urban
Rural
Mixed Rural
State Capital
Largest Populated City
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110
220 Miles
N
Cluster Key
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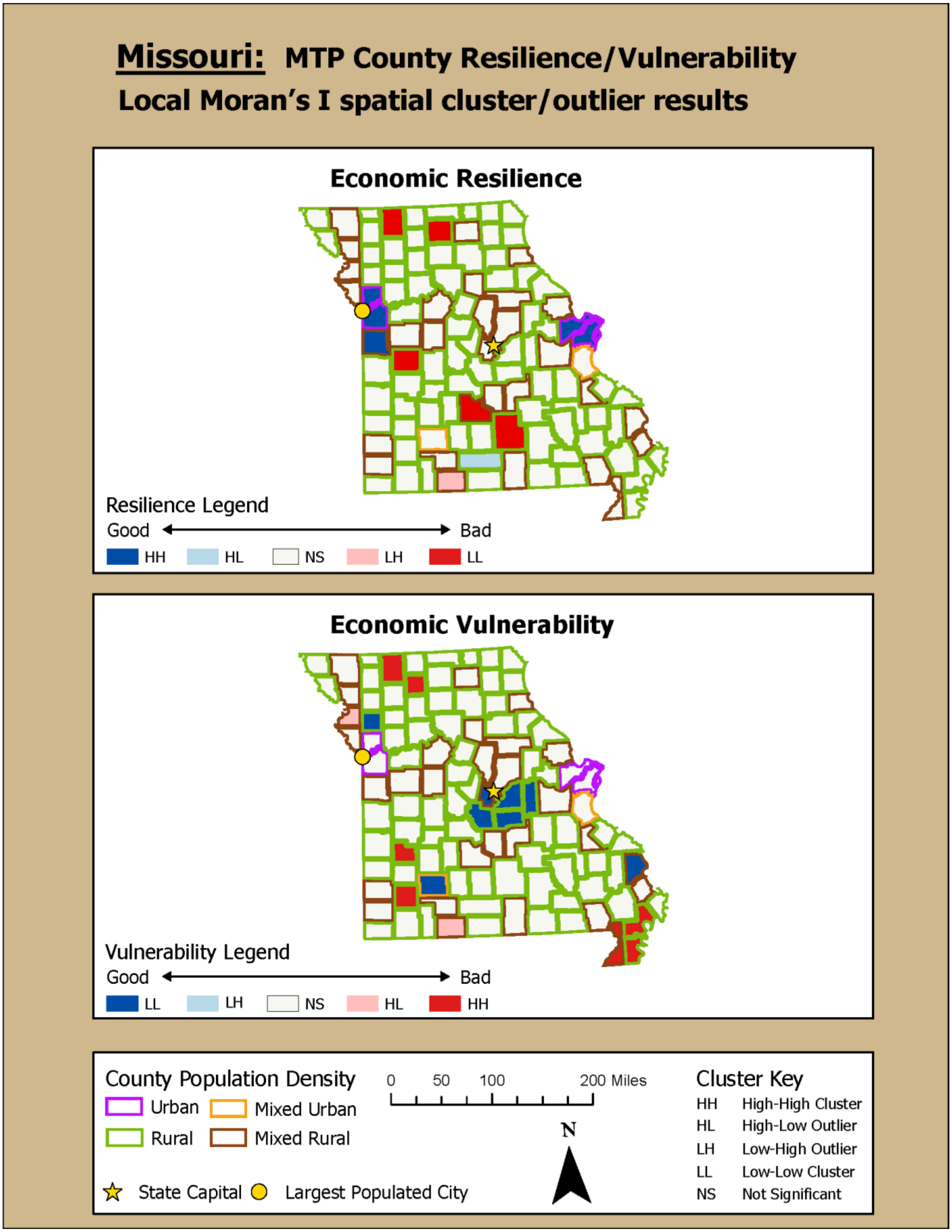
HL High-Low Outlier
LH Low-High Outlier
LL Low-Low Cluster
NS Not Significant


Missouri: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results
Economic Resilience
Resilience Legend
Good
Bad
HH
HL
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LH
LL
Economic Vulnerability
Vulnerability Legend
Good
Bad
LL
LH
NS
HL
HH
County Population Density
Urban
Mixed Urban
Rural
Mixed Rural
0
50
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State Capital
Largest Populated City
Cluster Key
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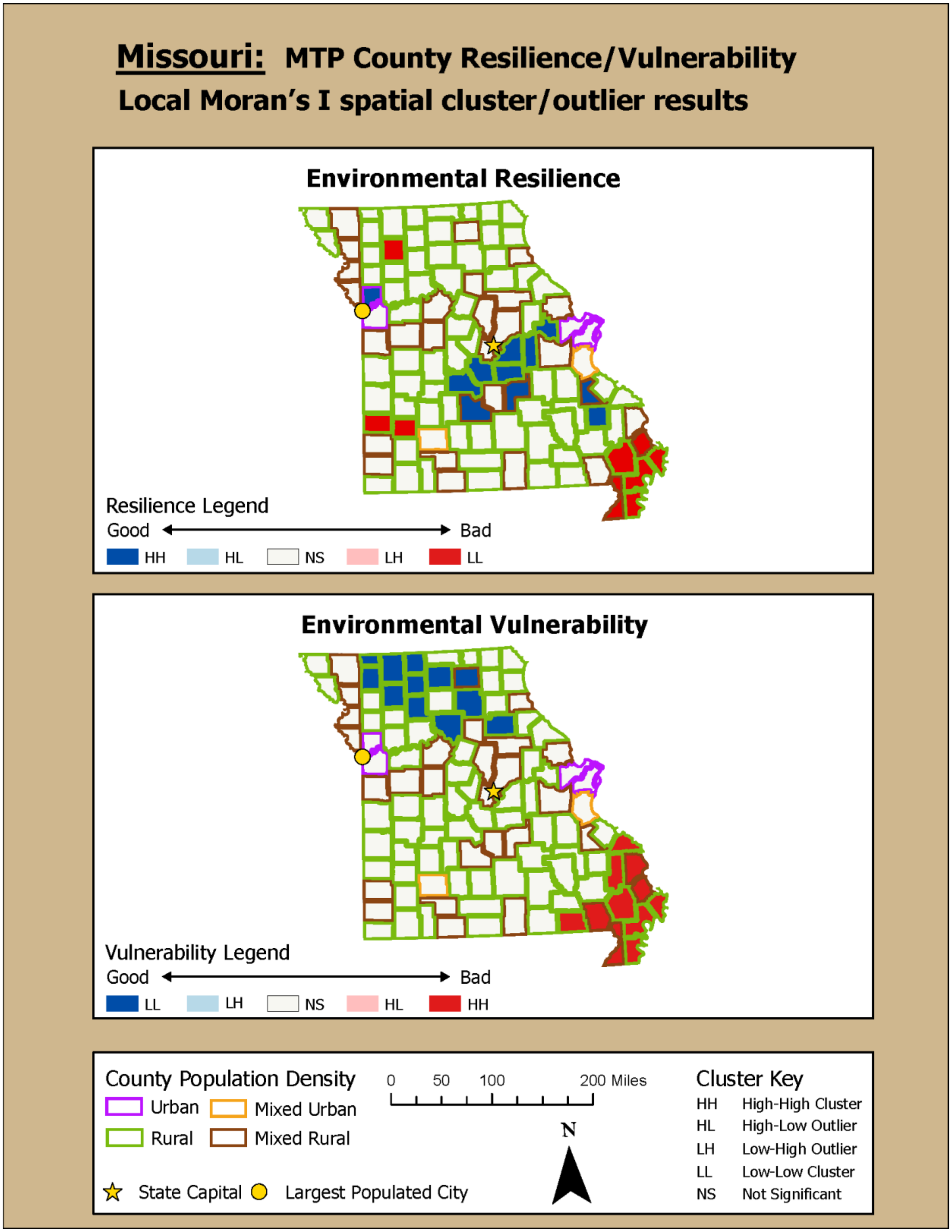
HL High-Low Outlier
LH Low-High Outlier
LL Low-Low Cluster
NS Not Significant


Missouri: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results
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Resilience Legend
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LH
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Environmental Vulnerability
Vulnerability Legend
Good
Bad
LL
LH
NS
HL
HH
County Population Density
Urban
Mixed Urban
Rural
Mixed Rural
State Capital
Largest Populated City
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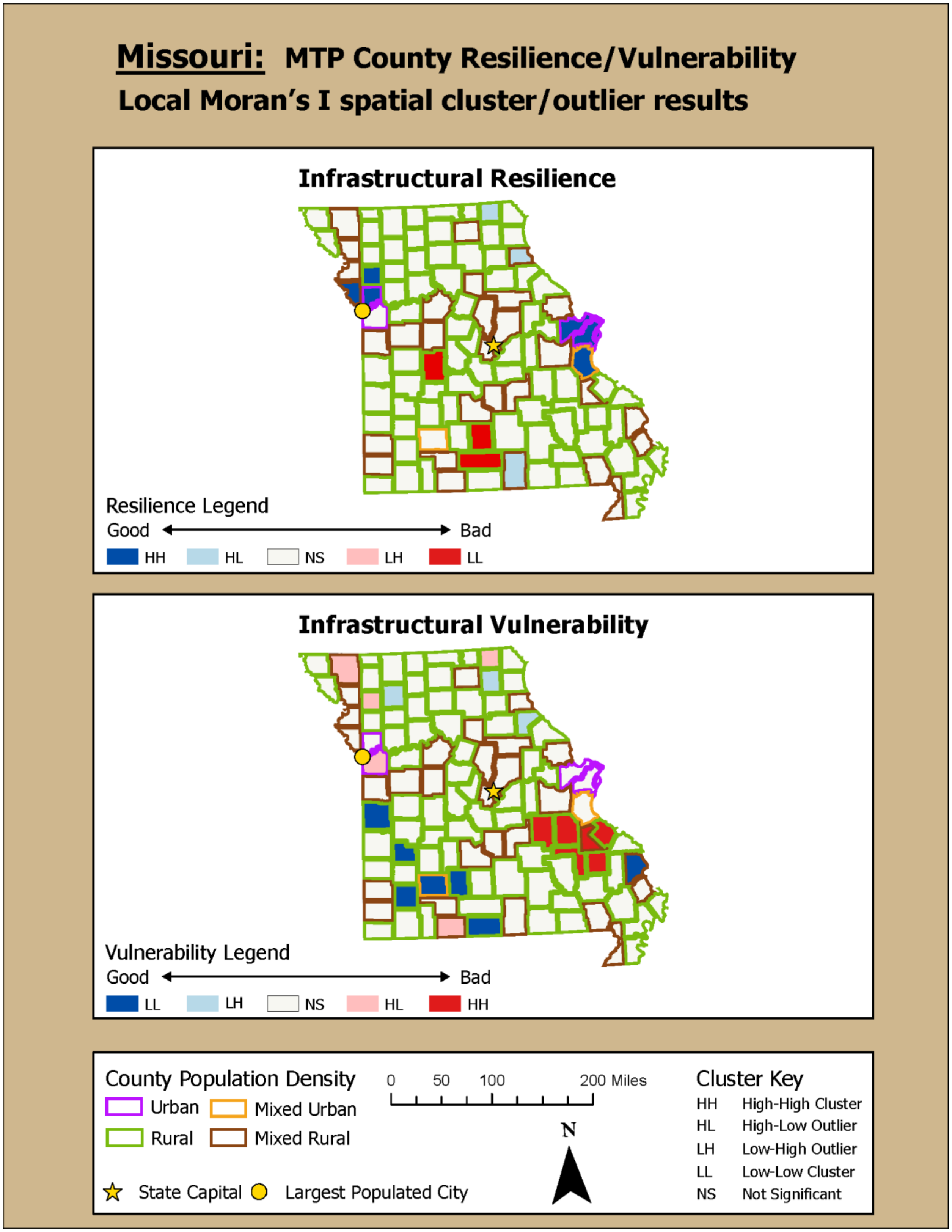
100
200 Miles
N
Cluster Key
HH High-High Cluster
HL High-Low Outlier
LH Low-High Outlier
LL Low-Low Cluster
NS Not Significant


Missouri: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results
Infrastructural Resilience
Resilience Legend
Good
Bad
HH
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NS
LH
LL
Infrastructural Vulnerability
Vulnerability Legend
Good
Bad
LL
LH
NS
HL
HH
County Population Density
Urban
Mixed Urban
Rural
Mixed Rural
0
50
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State Capital
Largest Populated City
Cluster Key
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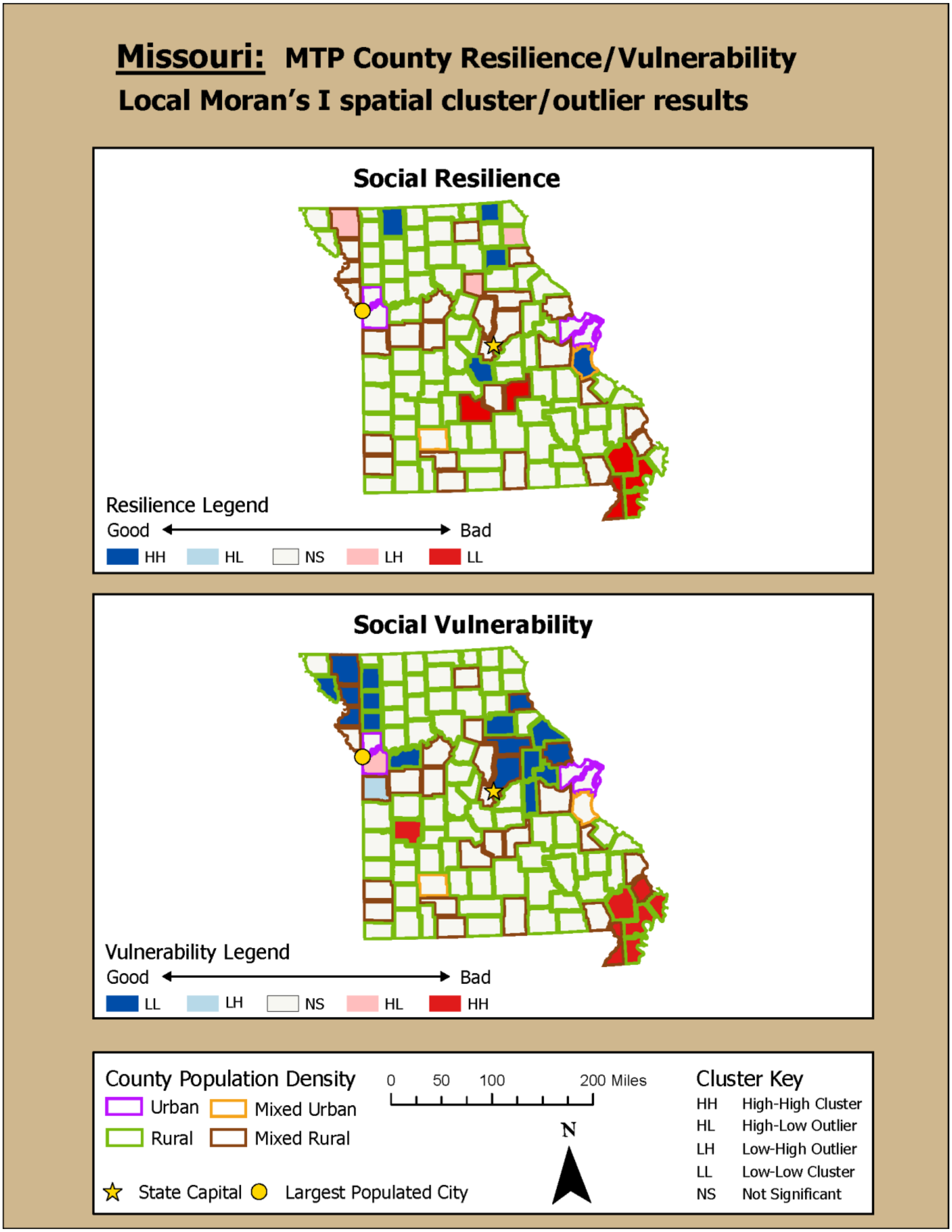
HL High-Low Outlier
LH Low-High Outlier
LL Low-Low Cluster
NS Not Significant


Missouri: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results
Social Resilience
Resilience Legend
Good
Bad
HH
HL
NS
LH
LL
Social Vulnerability
Vulnerability Legend
Good
Bad
LL
LH
NS
HL
HH
County Population Density
Urban
Mixed Urban
Rural
Mixed Rural
State Capital
Largest Populated City
0
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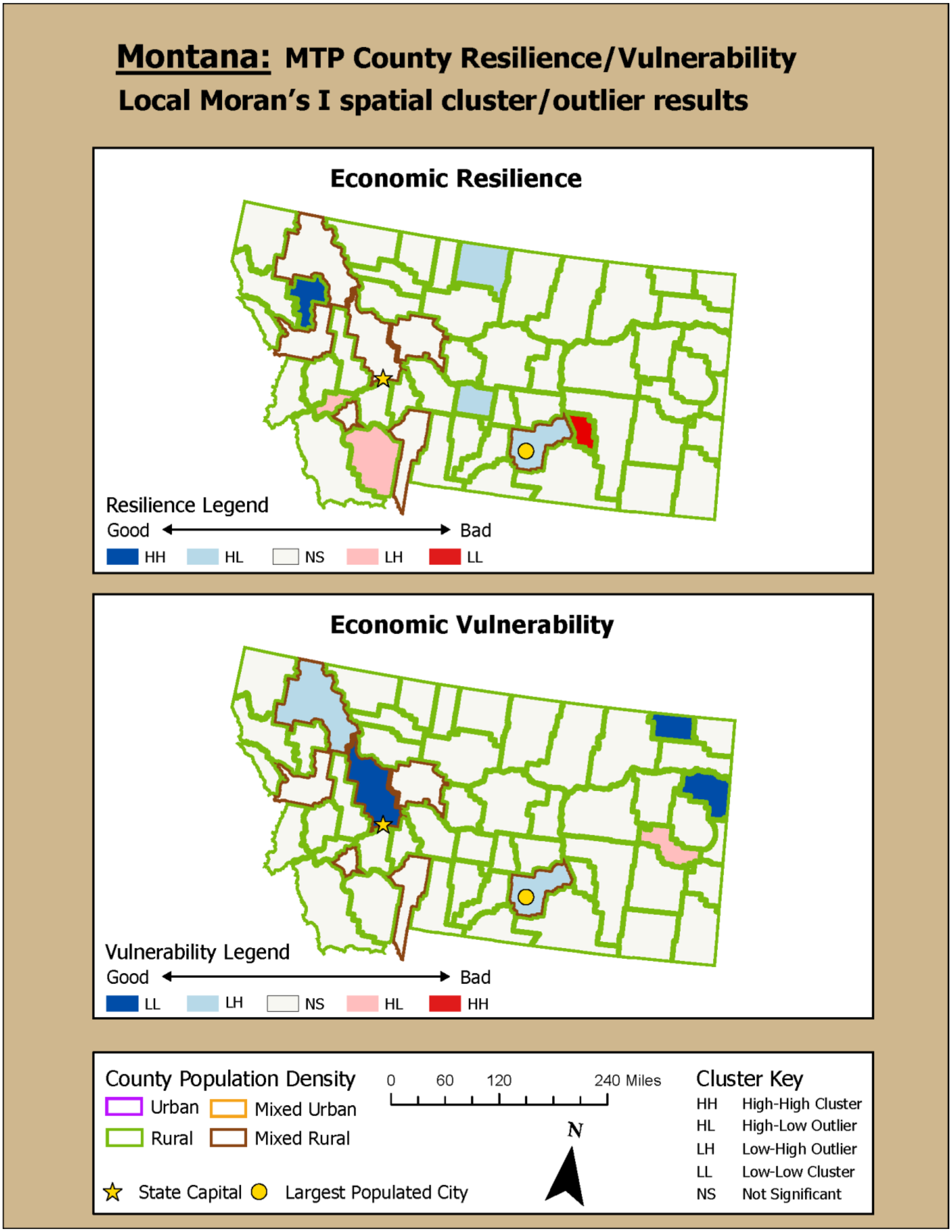
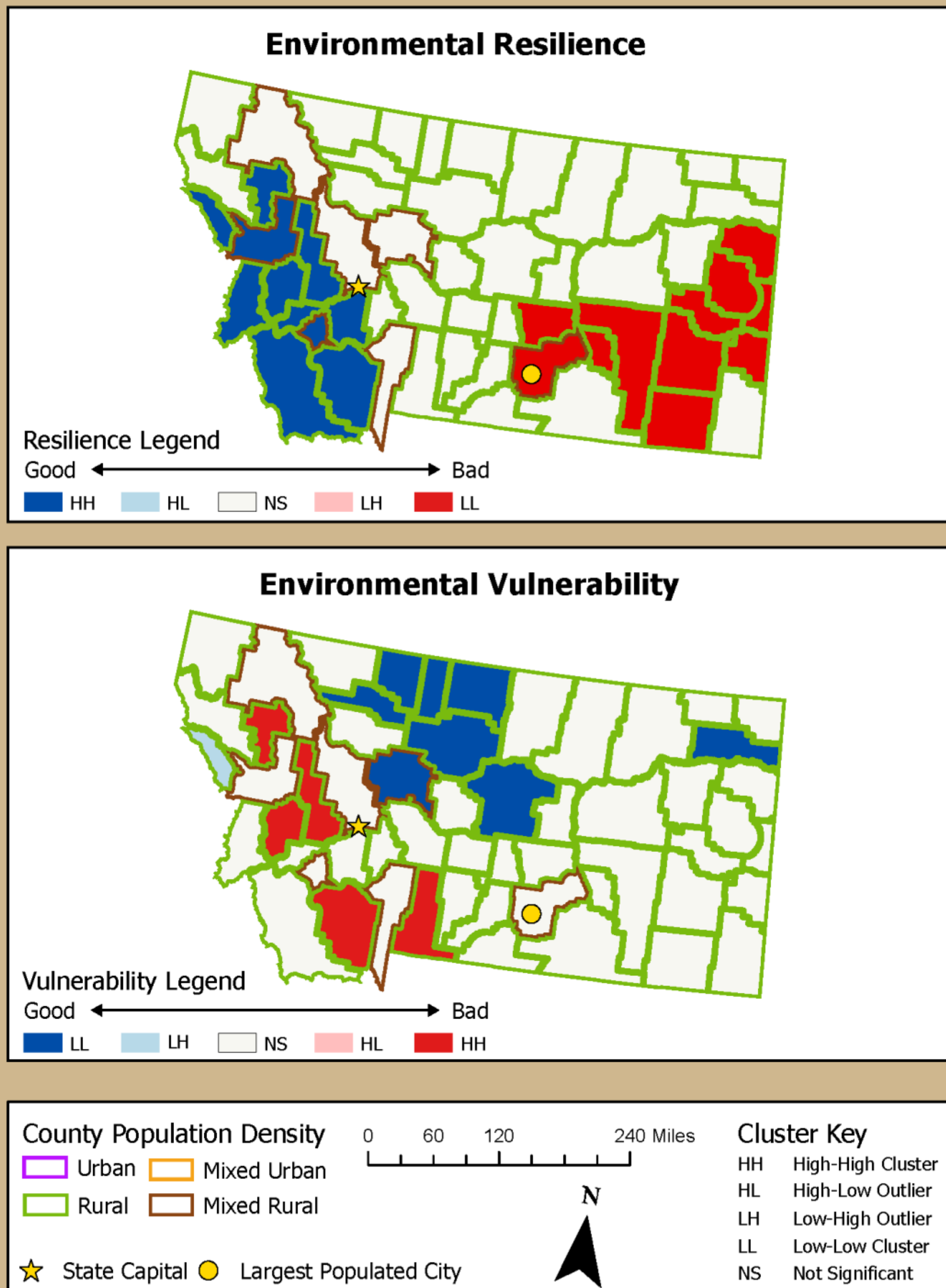
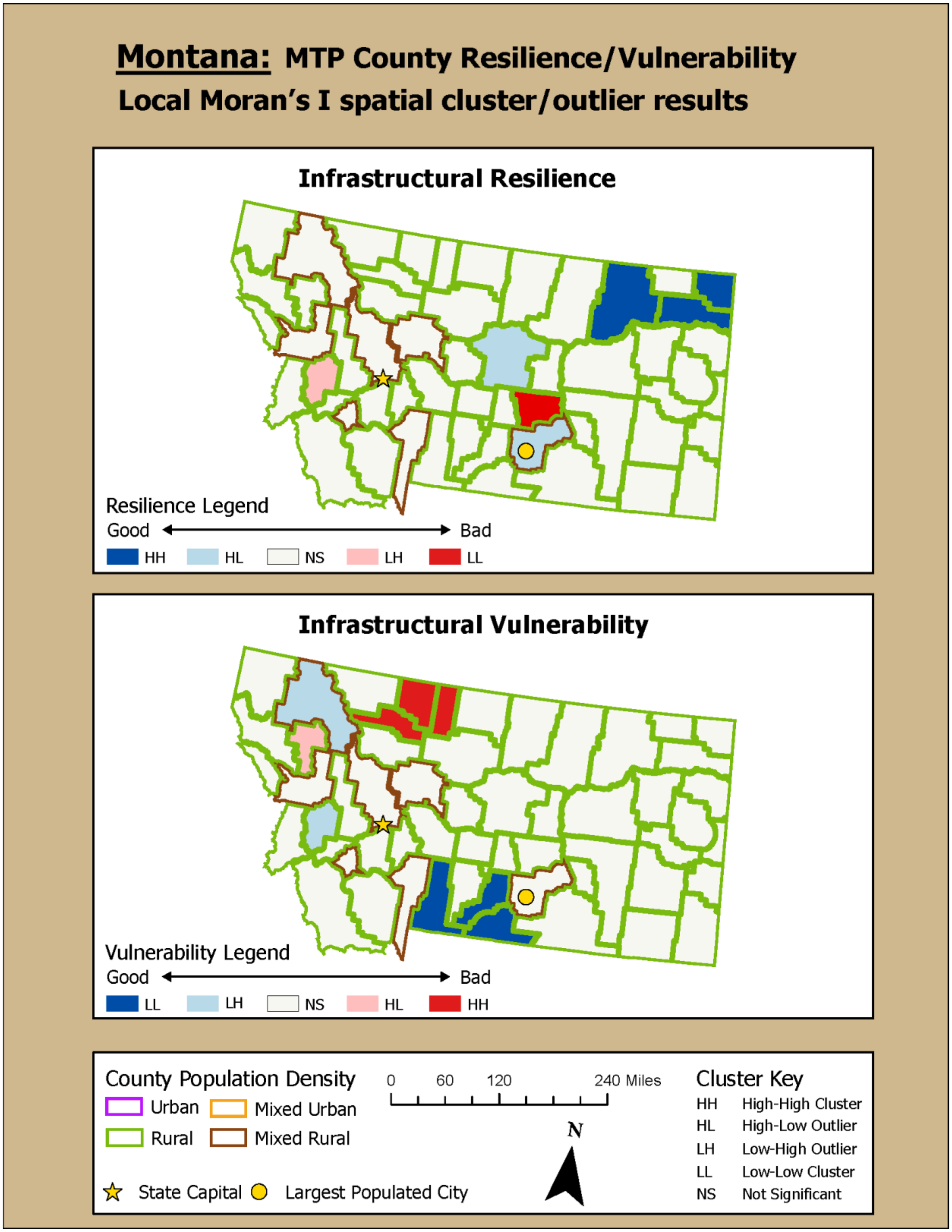
100
200 Miles
N
Cluster Key
HH High-High Cluster
HL High-Low Outlier
LH Low-High Outlier
LL Low-Low Cluster
NS Not Significant


Montana: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results
Economic Resilience
Resilience Legend
Good
Bad
HH
HL
NS
LH
LL
Economic Vulnerability
Vulnerability Legend
Good
Bad
LL
LH
NS
HL
HH
County Population Density
Urban
Mixed Urban
Rural
Mixed Rural
0
60
120
240 Miles
N
Cluster Key
HH High-High Cluster
HL High-Low Outlier
LH Low-High Outlier
LL Low-Low Cluster
NS Not Significant
State Capital
Largest Populated City

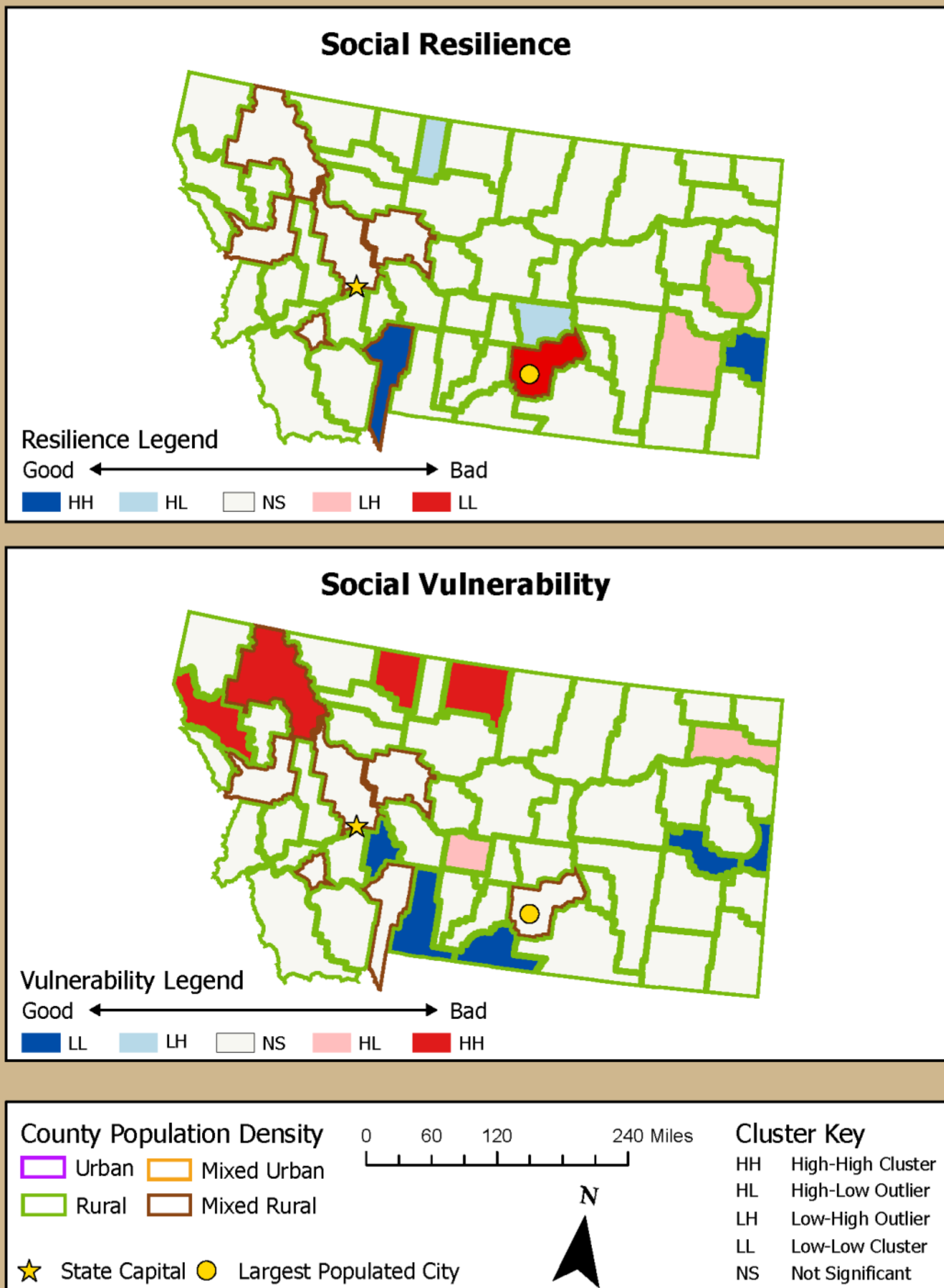
Montana: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results

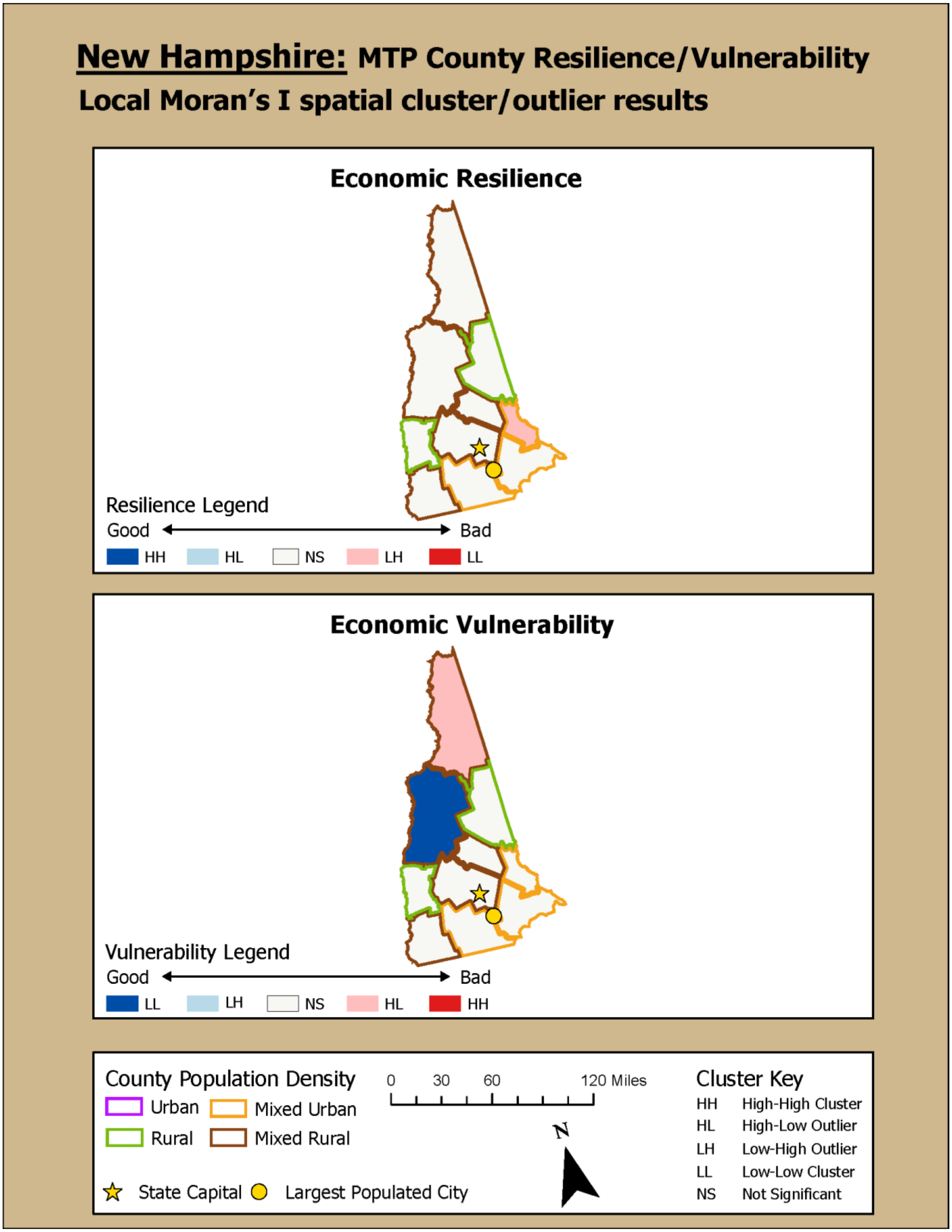




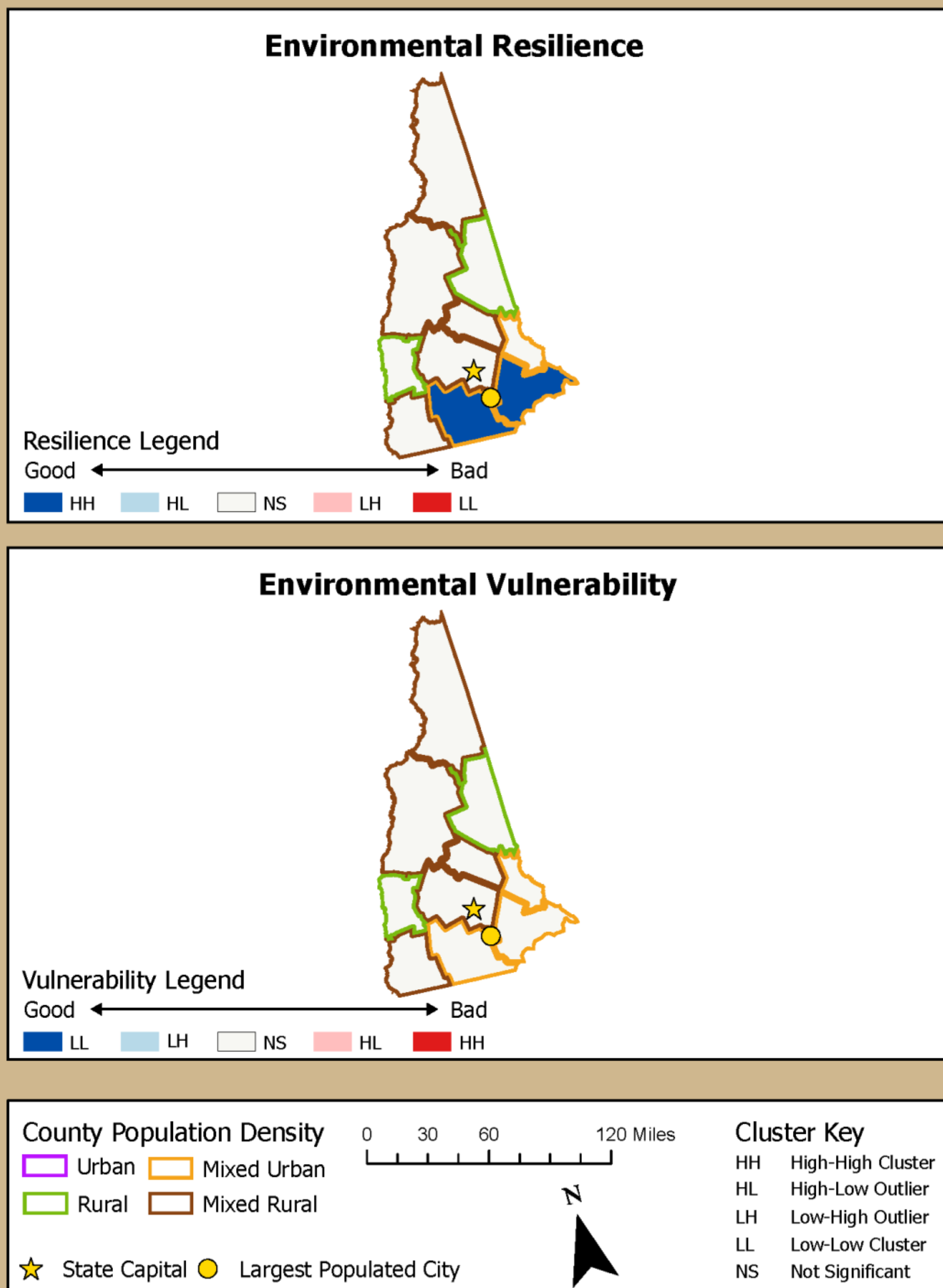
Montana: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results
Infrastructural Resilience
Resilience Legend
Good
Bad
HH
HL
NS
LH
LL
Infrastructural Vulnerability
Vulnerability Legend
Good
Bad
LL
LH
NS
HL
HH
County Population Density
Urban
Mixed Urban
Rural
Mixed Rural
State Capital
Largest Populated City
0
60
120
240 Miles
N
Cluster Key
HH High-High Cluster
HL High-Low Outlier
LH Low-High Outlier
LL Low-Low Cluster
NS Not Significant

Montana: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results

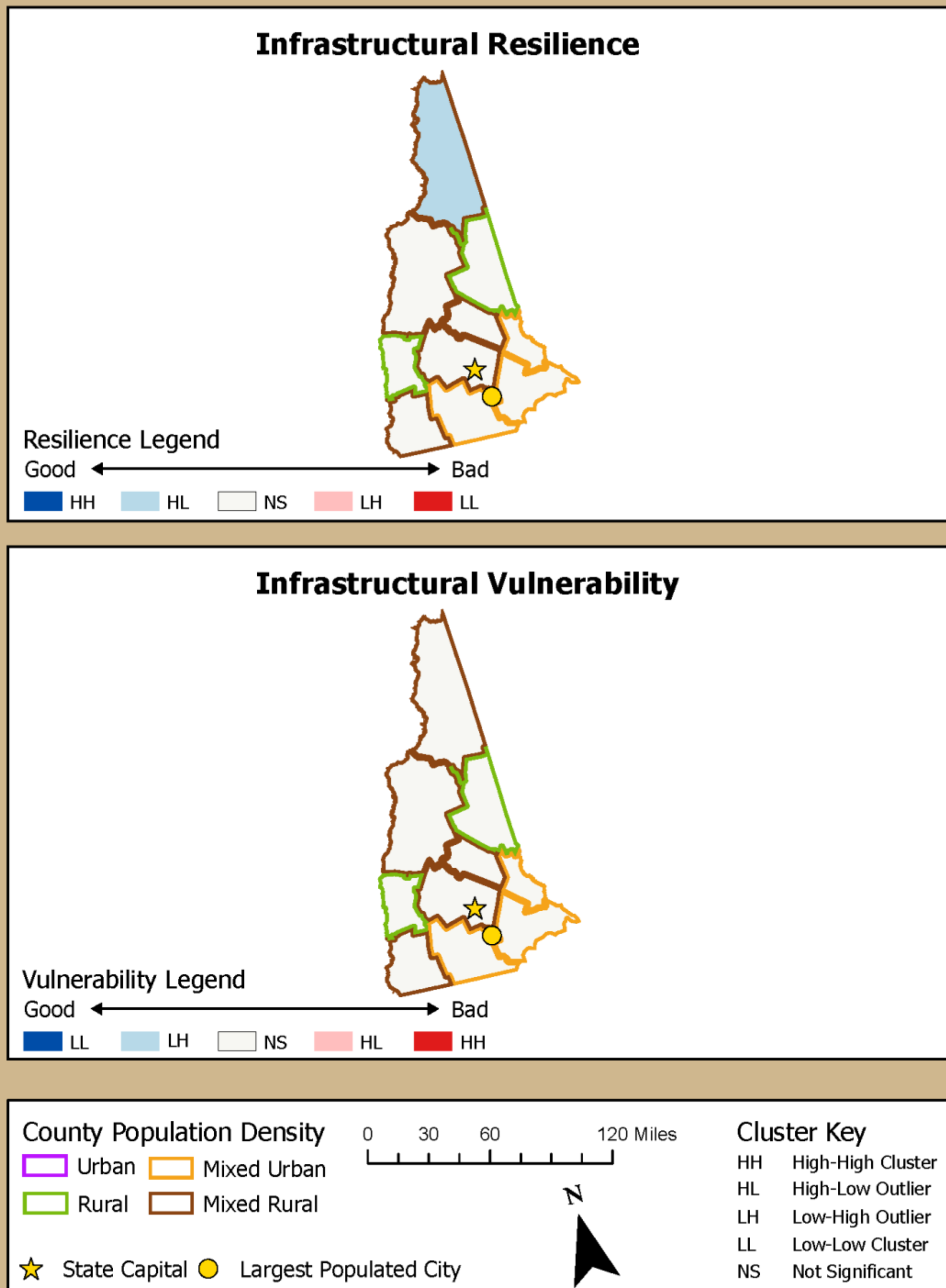



New Hampshire: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results
Economic Resilience
Resilience Legend
Good
Bad
HH
HL
NS
LH
LL
Economic Vulnerability
Vulnerability Legend
Good
Bad
LL
LH
NS
HL
HH
County Population Density
Urban
Mixed Urban
Rural
Mixed Rural
State Capital
Largest Populated City
0
30
60
120 Miles
N
Cluster Key
HH High-High Cluster
HL High-Low Outlier
LH Low-High Outlier
LL Low-Low Cluster
NS Not Significant

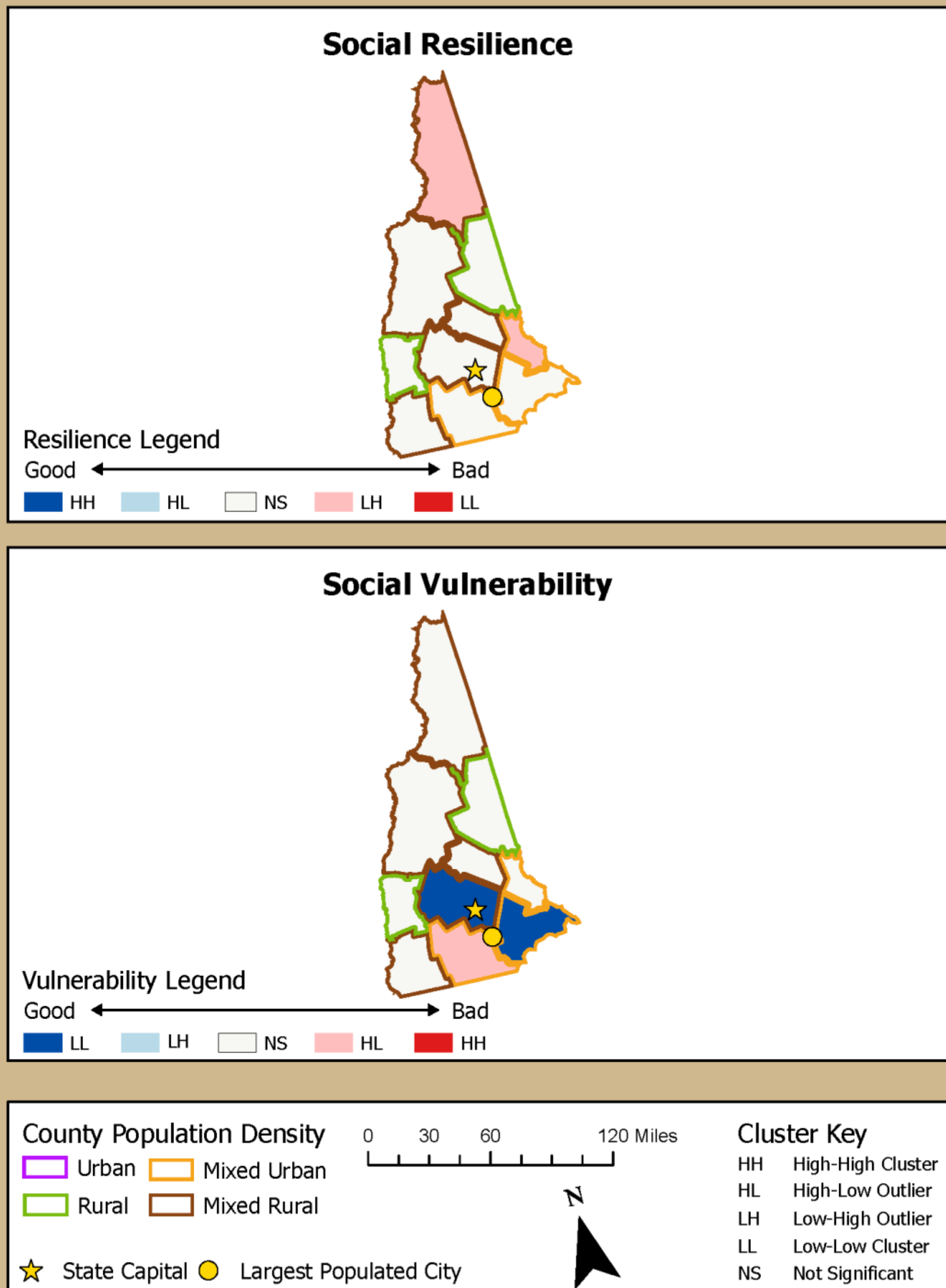
New Hampshire: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results



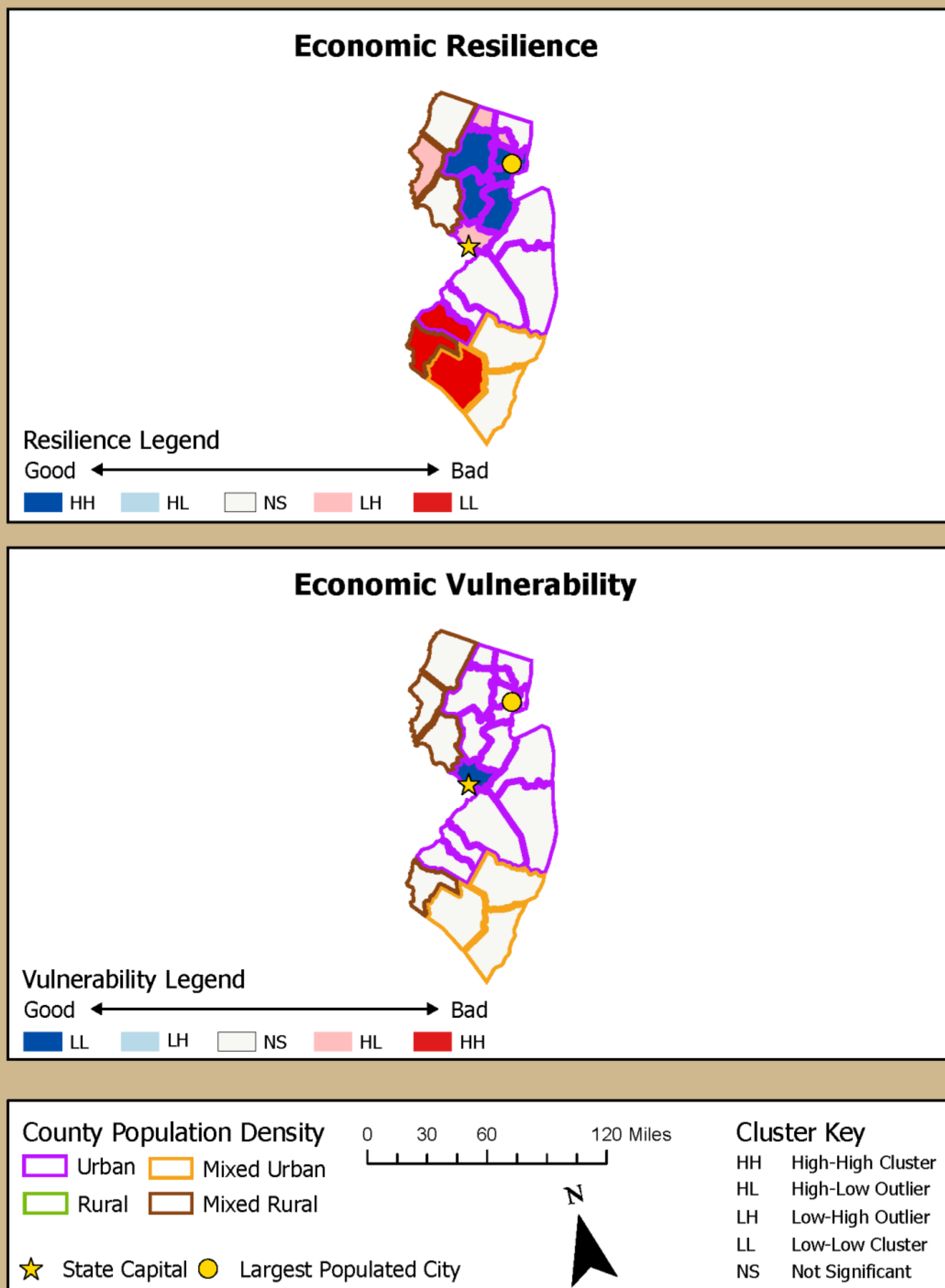
New Hampshire: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results

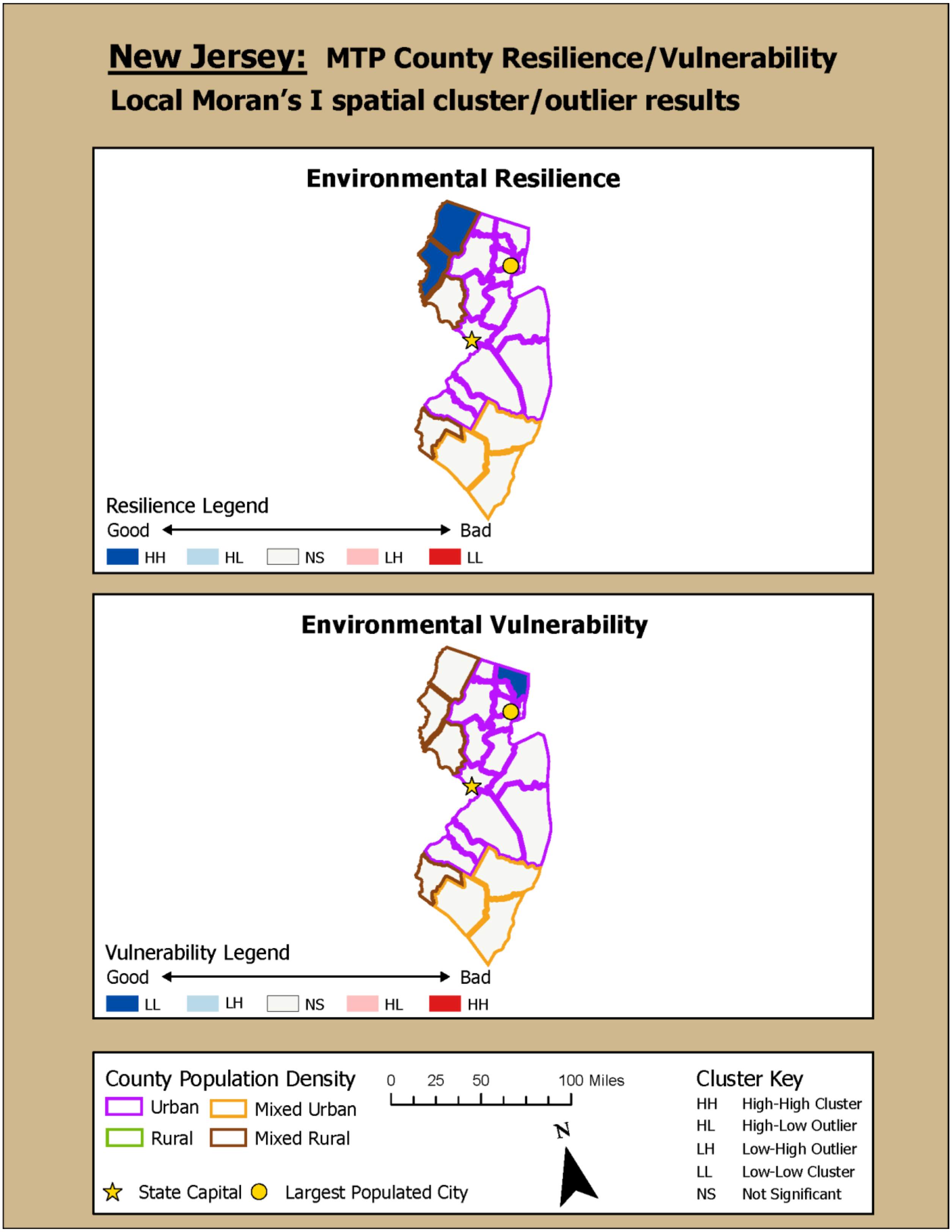


New Hampshire: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results



New Jersey: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results




New Jersey: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results
Environmental Resilience
Resilience Legend
Good
Bad
HH
HL
NS
LH
LL
Environmental Vulnerability
Vulnerability Legend
Good
Bad
LL
LH
NS
HL
HH
County Population Density
Urban
Mixed Urban
Rural
Mixed Rural
0
25
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100 Miles
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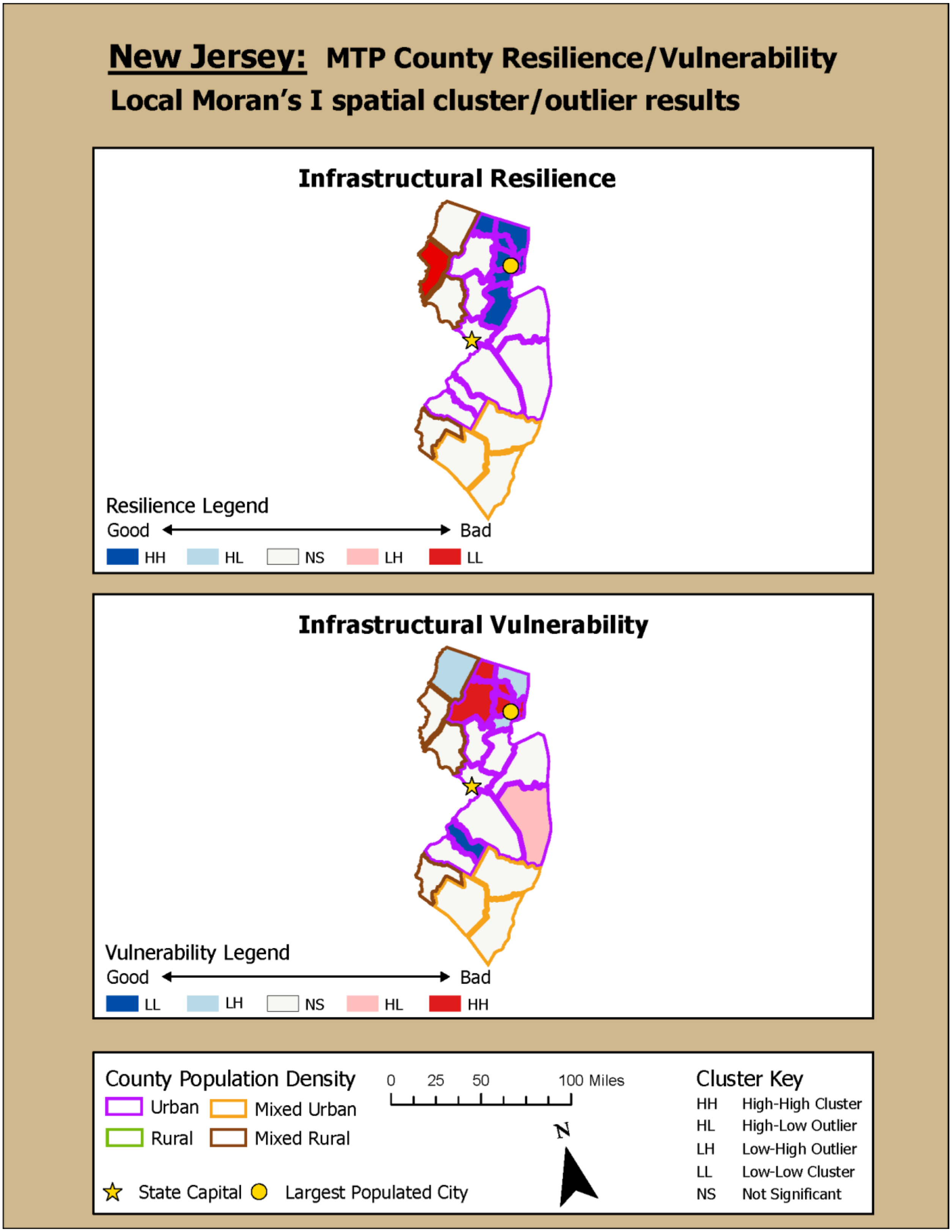
State Capital
Largest Populated City
Cluster Key
HH High-High Cluster
HL High-Low Outlier
LH Low-High Outlier
LL Low-Low Cluster
NS Not Significant


New Jersey: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results
Infrastructural Resilience
Resilience Legend
Good
Bad
HH
HL
NS
LH
LL
Infrastructural Vulnerability
Vulnerability Legend
Good
Bad
LL
LH
NS
HL
HH
County Population Density
Urban
Mixed Urban
Rural
Mixed Rural
State Capital
Largest Populated City
0
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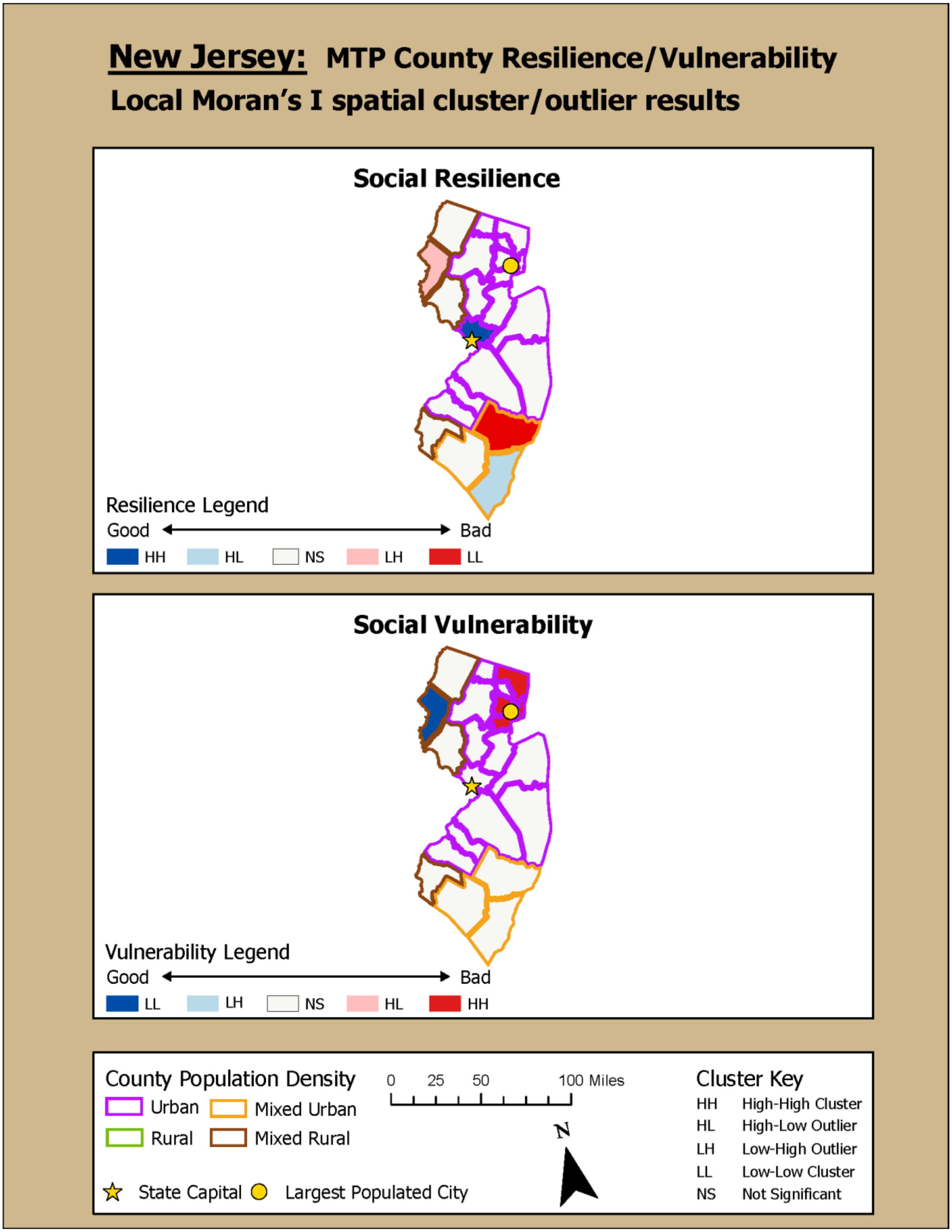
100 Miles
N
Cluster Key
HH High-High Cluster
HL High-Low Outlier
LH Low-High Outlier
LL Low-Low Cluster
NS Not Significant


New Jersey: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results
Social Resilience
Resilience Legend
Good
Bad
HH
HL
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LH
LL
Social Vulnerability
Vulnerability Legend
Good
Bad
LL
LH
NS
HL
HH
County Population Density
Urban
Mixed Urban
Rural
Mixed Rural
State Capital
Largest Populated City
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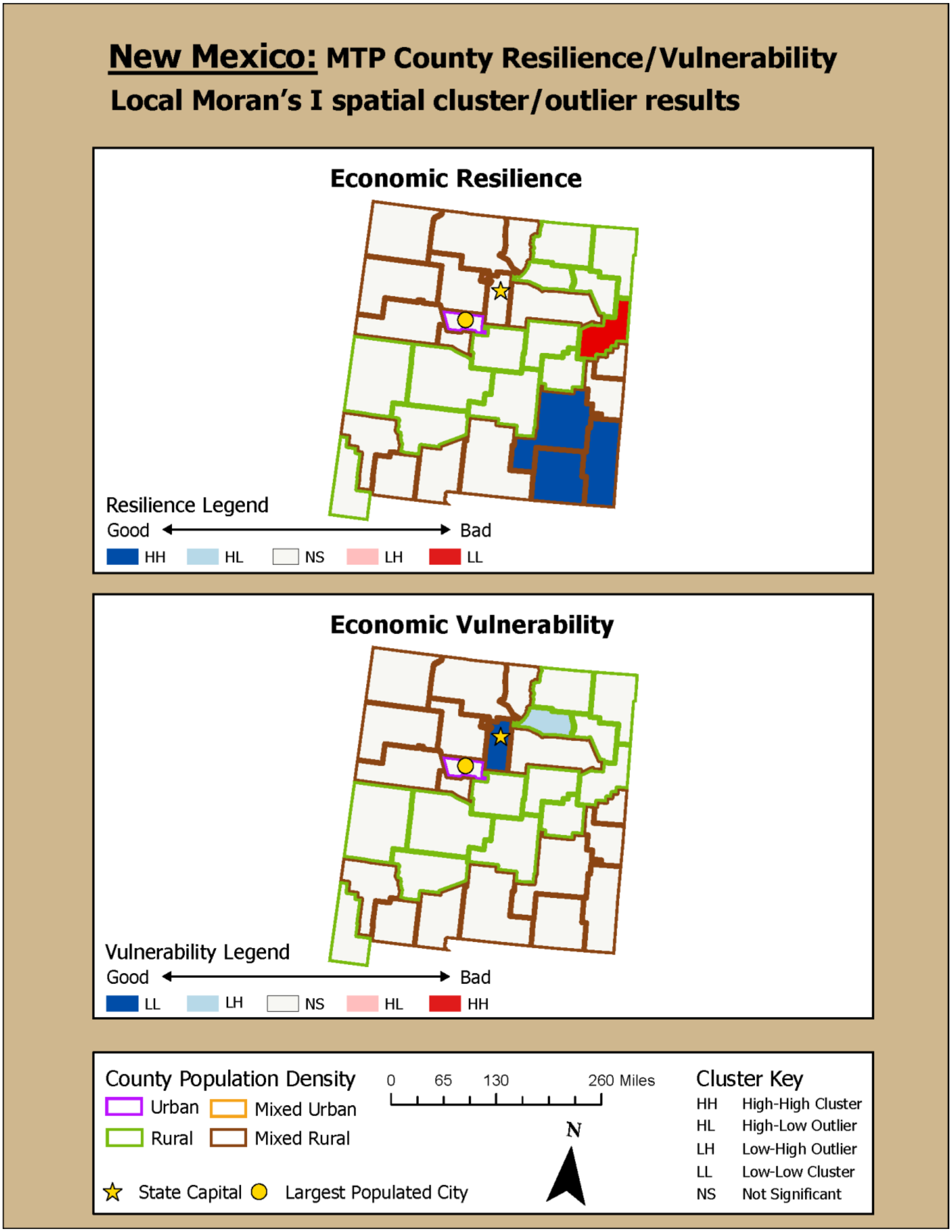
50
100 Miles
N
Cluster Key
HH High-High Cluster
HL High-Low Outlier
LH Low-High Outlier
LL Low-Low Cluster
NS Not Significant


New Mexico: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results
Economic Resilience
Resilience Legend
Good
Bad
HH
HL
NS
LH
LL
Economic Vulnerability
Vulnerability Legend
Good
Bad
LL
LH
NS
HL
HH
County Population Density
Urban
Mixed Urban
Rural
Mixed Rural
State Capital
Largest Populated City
0
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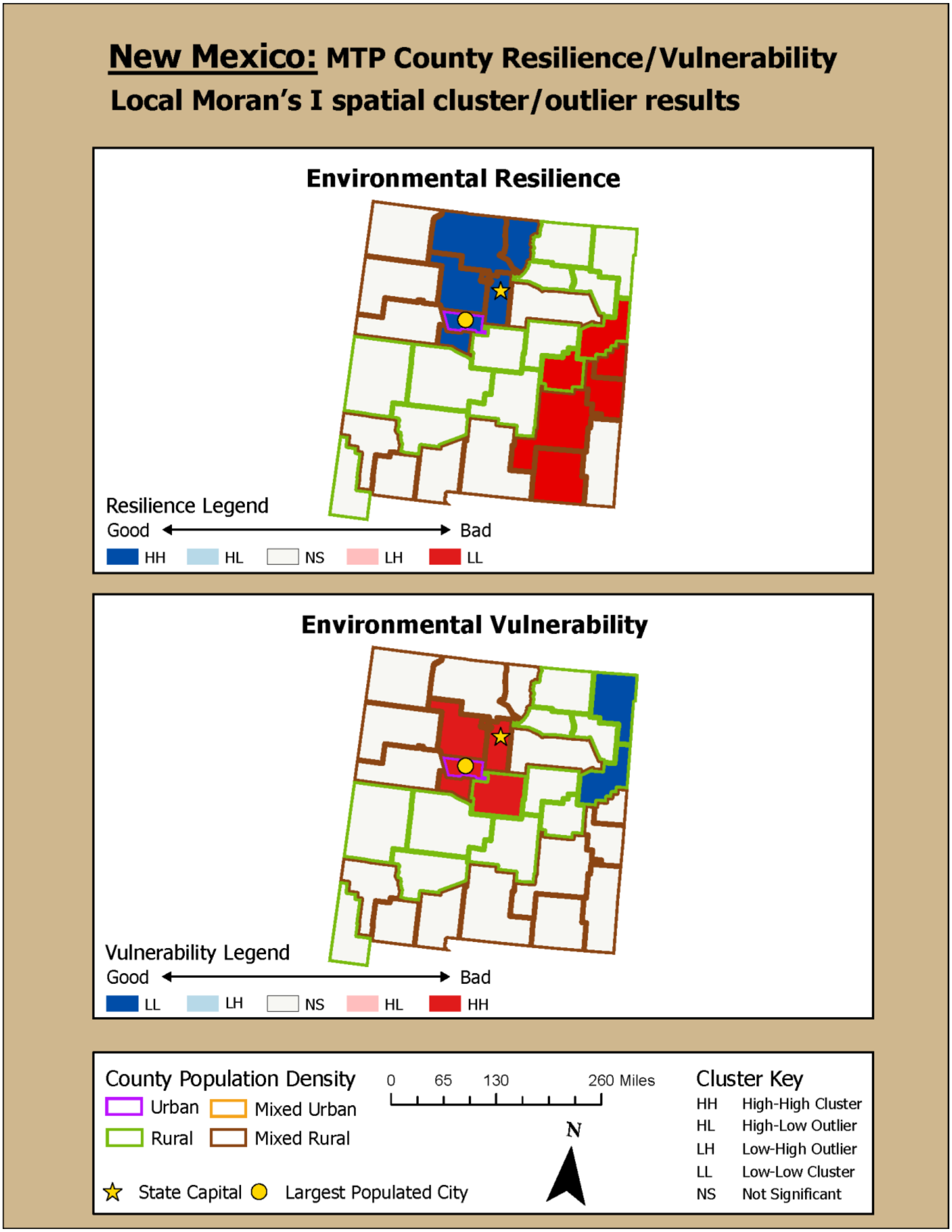
130
260 Miles
N
Cluster Key
HH High-High Cluster
HL High-Low Outlier
LH Low-High Outlier
LL Low-Low Cluster
NS Not Significant


New Mexico: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results
Environmental Resilience
Resilience Legend
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Environmental Vulnerability
Vulnerability Legend
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LL
LH
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HL
HH
County Population Density
Urban
Mixed Urban
Rural
Mixed Rural
State Capital
Largest Populated City
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260 Miles
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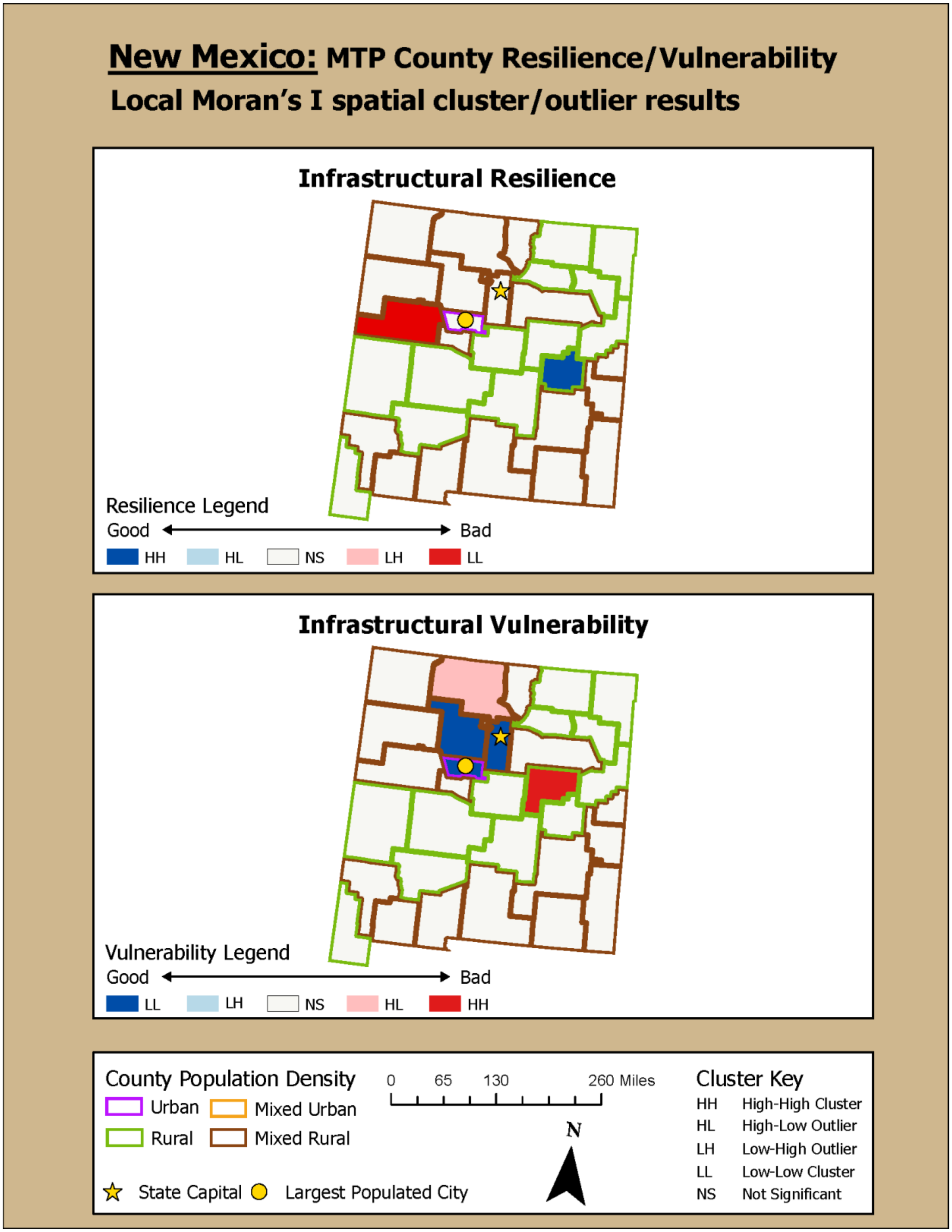
Cluster Key
HH High-High Cluster
HL High-Low Outlier
LH Low-High Outlier
LL Low-Low Cluster
NS Not Significant


New Mexico: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results
Infrastructural Resilience
Resilience Legend
Good
Bad
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LH
LL
Infrastructural Vulnerability
Vulnerability Legend
Good
Bad
LL
LH
NS
HL
HH
County Population Density
Urban
Mixed Urban
Rural
Mixed Rural
State Capital
Largest Populated City
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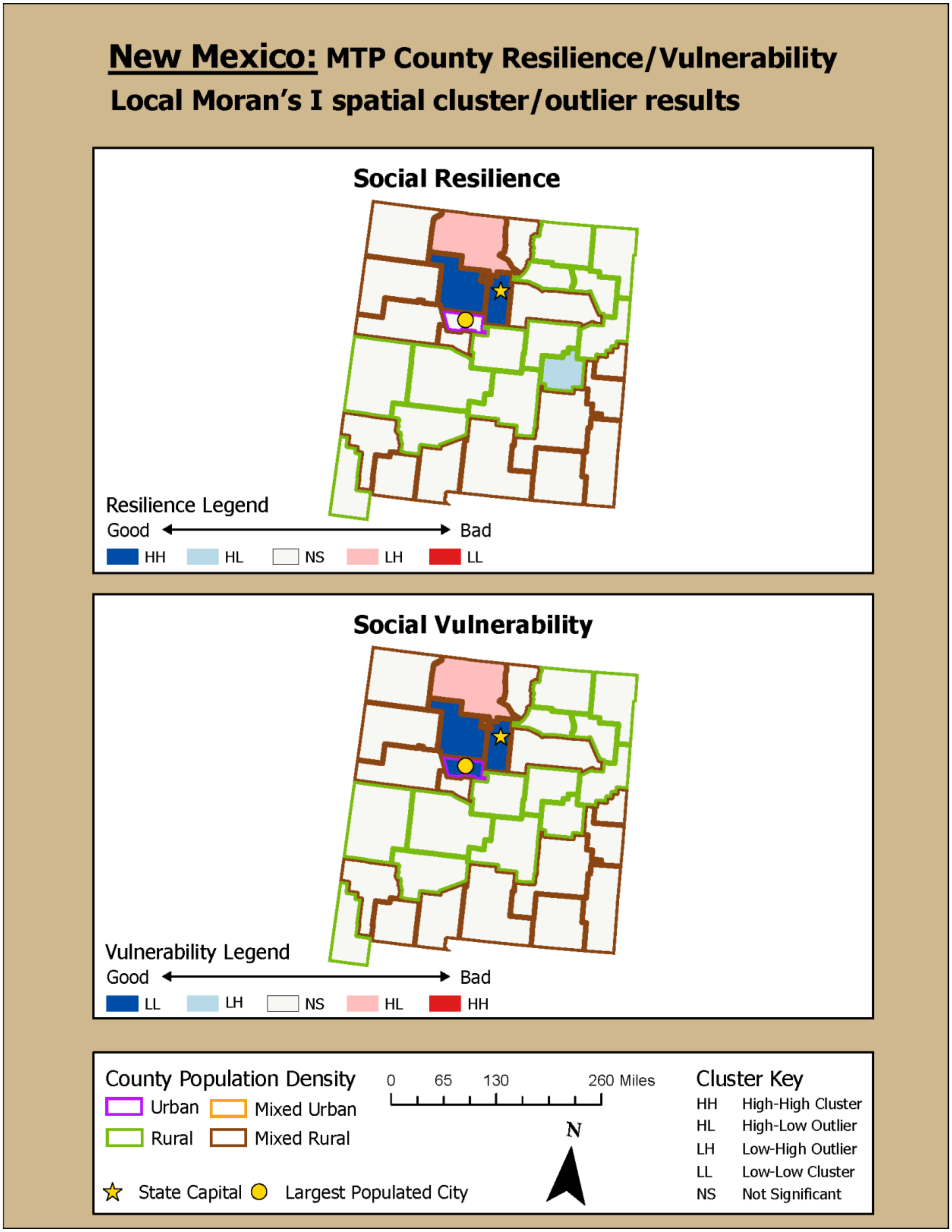
130
260 Miles
N
Cluster Key
HH High-High Cluster
HL High-Low Outlier
LH Low-High Outlier
LL Low-Low Cluster
NS Not Significant


New Mexico: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results
Social Resilience
Resilience Legend
Good
Bad
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HL
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LH
LL
Social Vulnerability
Vulnerability Legend
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Bad
LL
LH
NS
HL
HH
County Population Density
Urban
Mixed Urban
Rural
Mixed Rural
State Capital
Largest Populated City
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260 Miles
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Cluster Key
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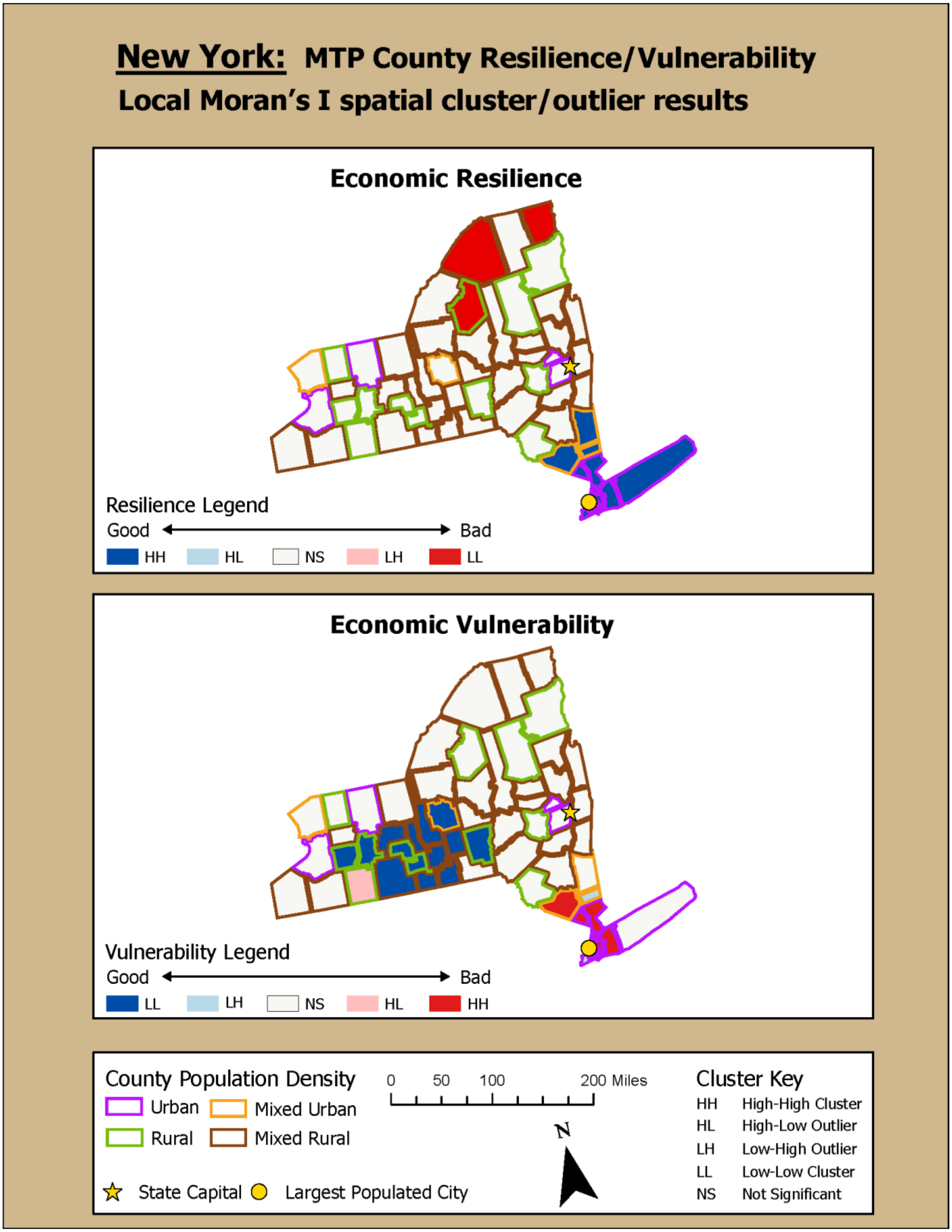
HL High-Low Outlier
LH Low-High Outlier
LL Low-Low Cluster
NS Not Significant


New York: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results
Economic Resilience
Resilience Legend
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Bad
HH
HL
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LH
LL
Economic Vulnerability
Vulnerability Legend
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Bad
LL
LH
NS
HL
HH
County Population Density
Urban
Mixed Urban
Rural
Mixed Rural
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State Capital
Largest Populated City
Cluster Key
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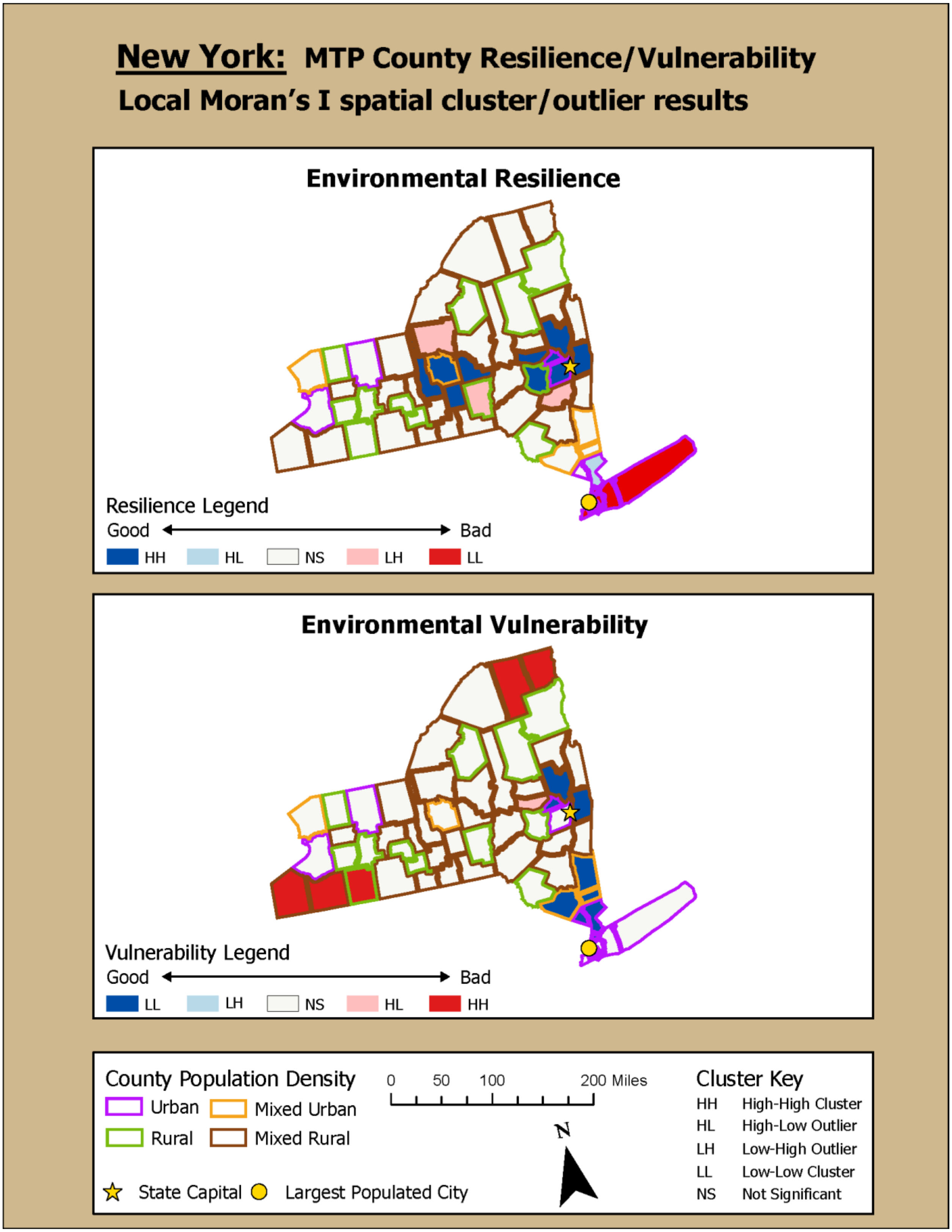
HL High-Low Outlier
LH Low-High Outlier
LL Low-Low Cluster
NS Not Significant


New York: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results
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Resilience Legend
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Environmental Vulnerability
Vulnerability Legend
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LL
LH
NS
HL
HH
County Population Density
Urban
Mixed Urban
Rural
Mixed Rural
State Capital
Largest Populated City
0
50
100
200 Miles
N
Cluster Key
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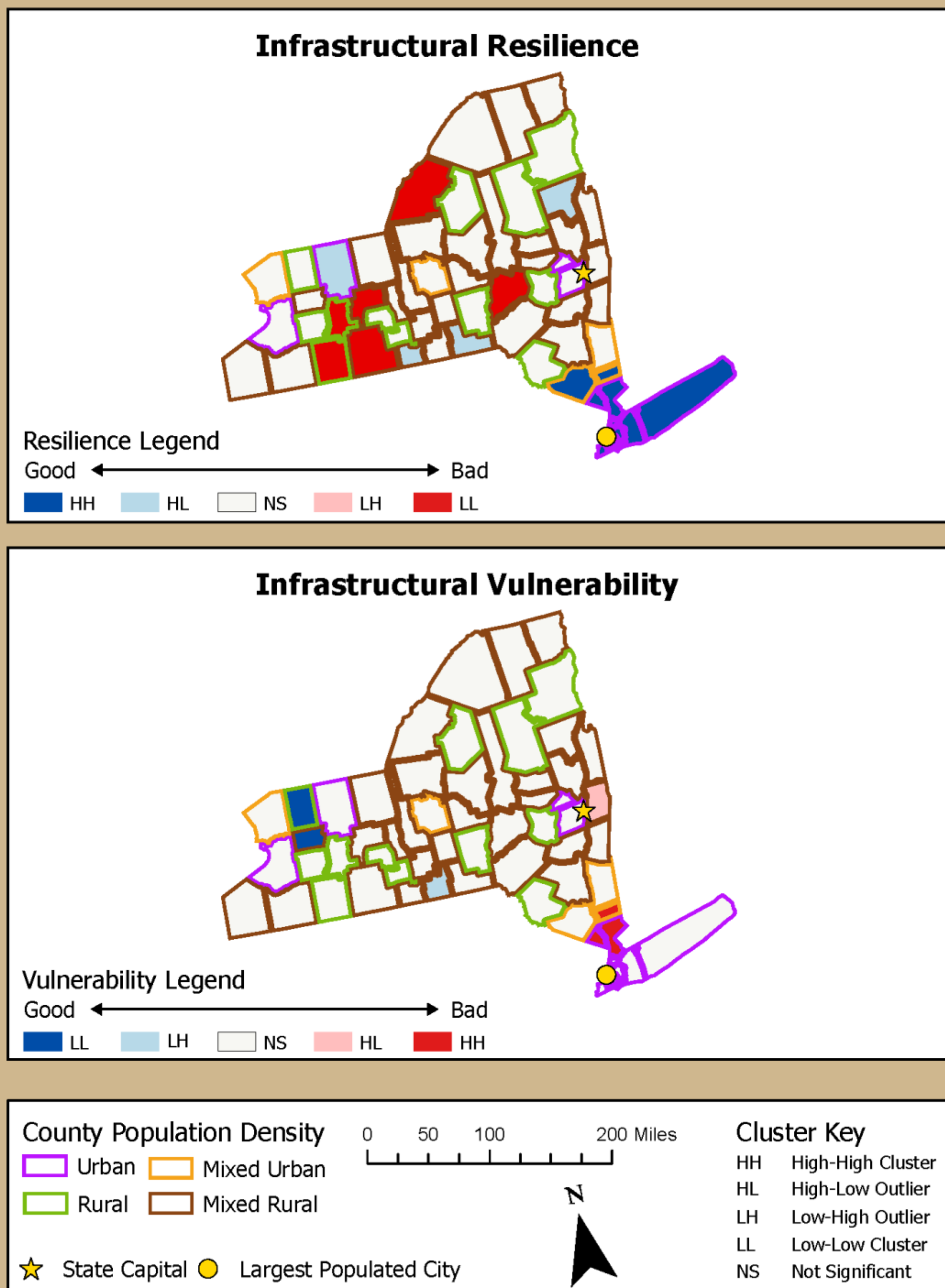
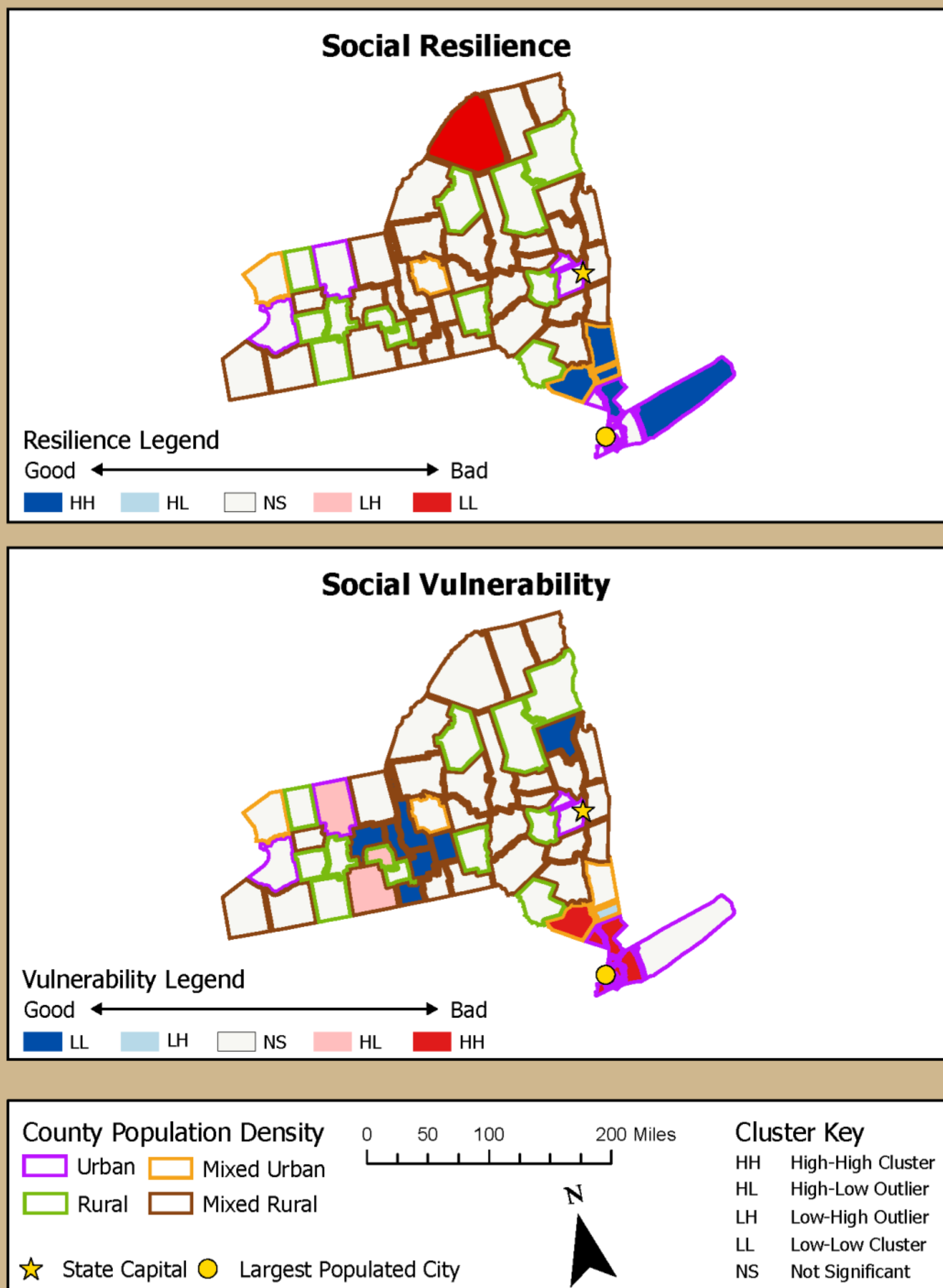
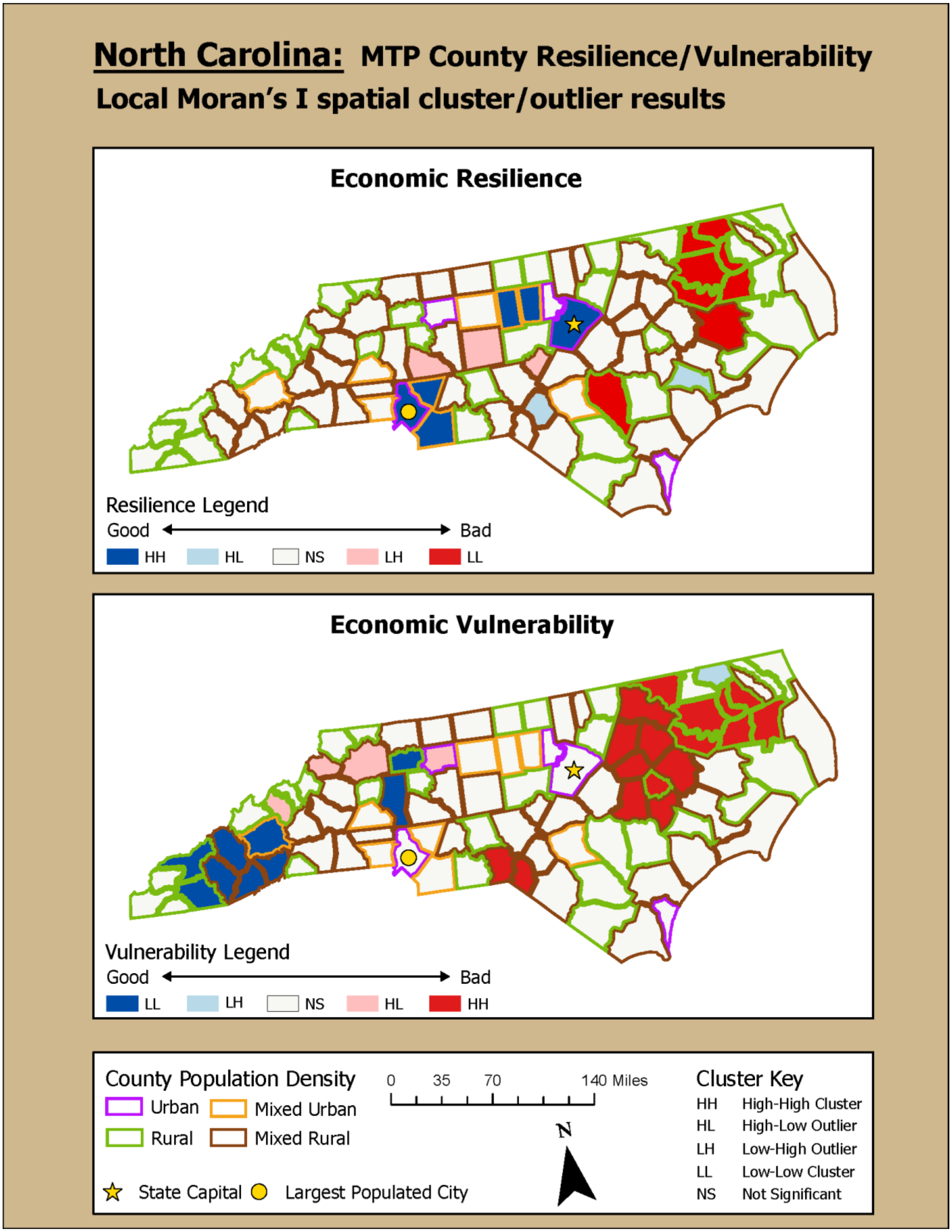
LH Low-High Outlier
LL Low-Low Cluster
NS Not Significant

New York: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results



New York: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results




North Carolina: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results
Economic Resilience
Resilience Legend
Good
Bad
HH
HL
NS
LH
LL
Economic Vulnerability
Vulnerability Legend
Good
Bad
LL
LH
NS
HL
HH
County Population Density
Urban
Mixed Urban
Rural
Mixed Rural
State Capital
Largest Populated City
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140 Miles
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Cluster Key
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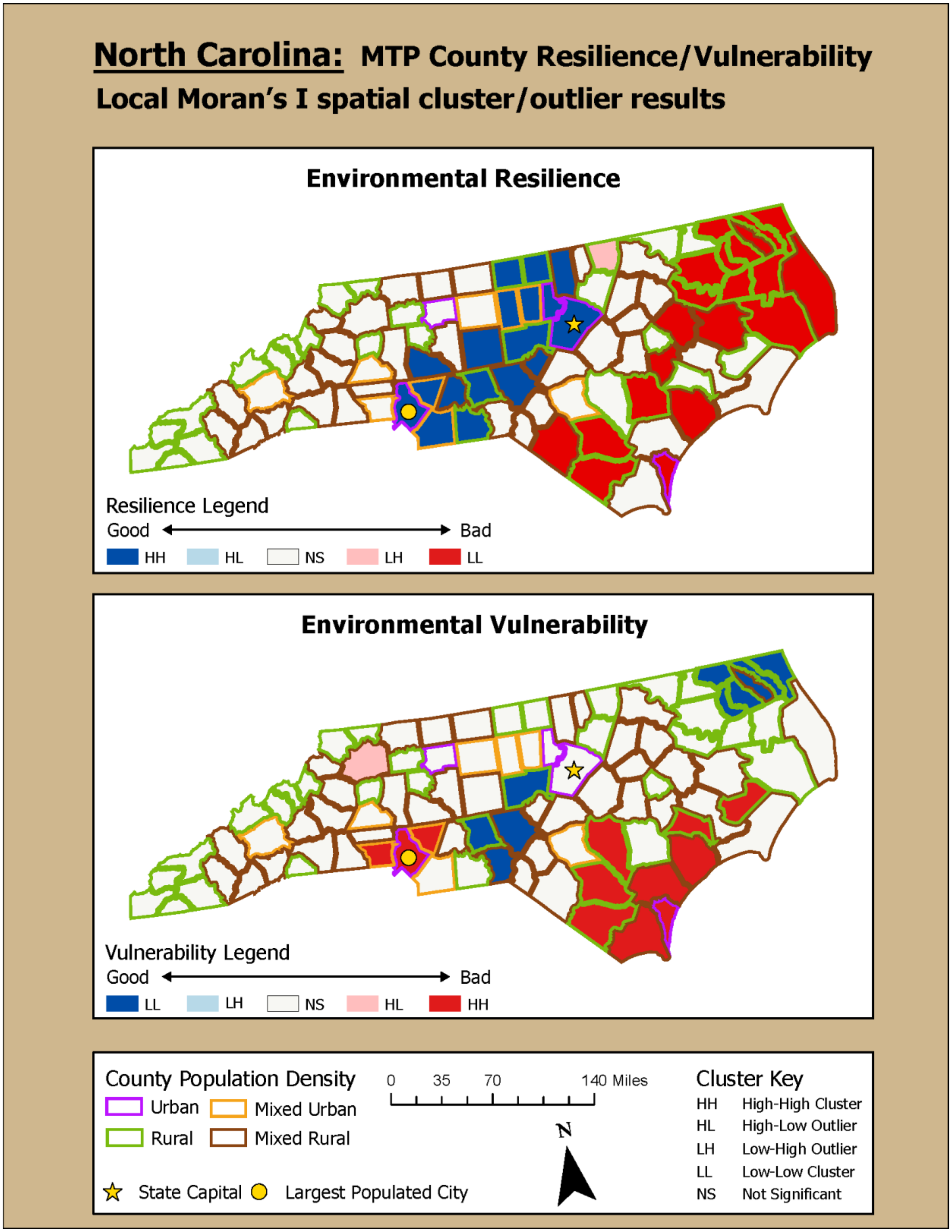
HL High-Low Outlier
LH Low-High Outlier
LL Low-Low Cluster
NS Not Significant


North Carolina: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results
Environmental Resilience
Resilience Legend
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HH
HL
NS
LH
LL
Environmental Vulnerability
Vulnerability Legend
Good
Bad
LL
LH
NS
HL
HH
County Population Density
Urban
Mixed Urban
Rural
Mixed Rural
State Capital
Largest Populated City
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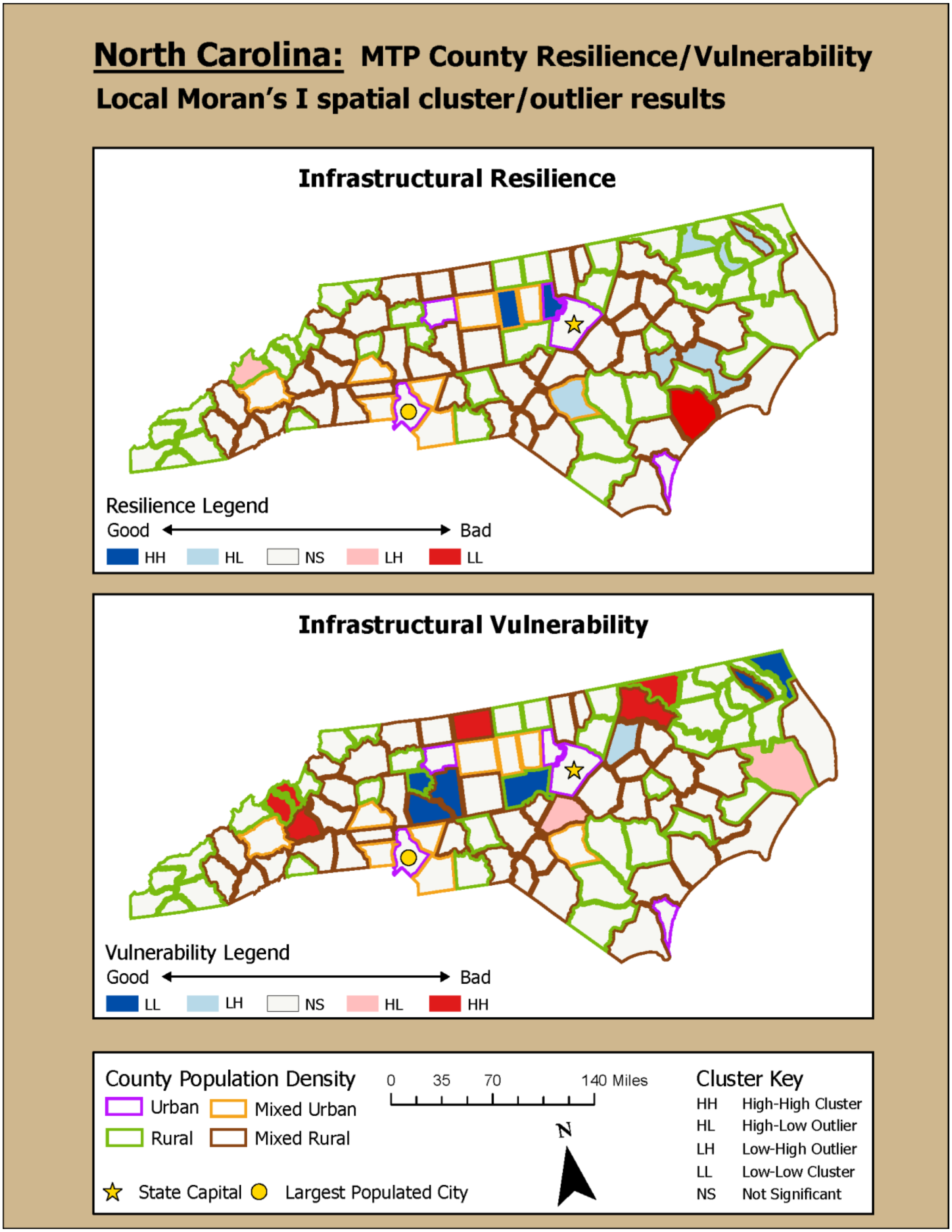
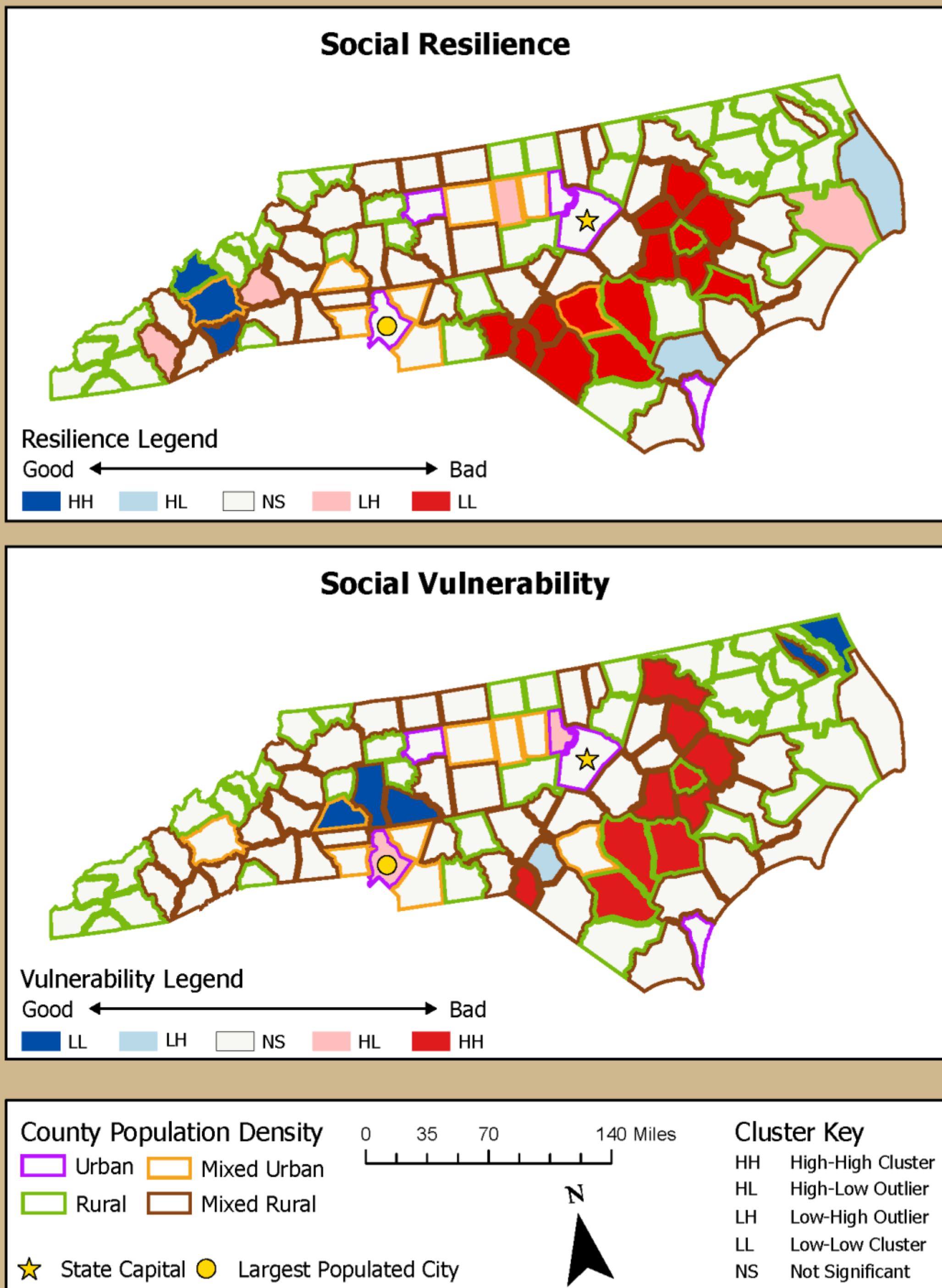
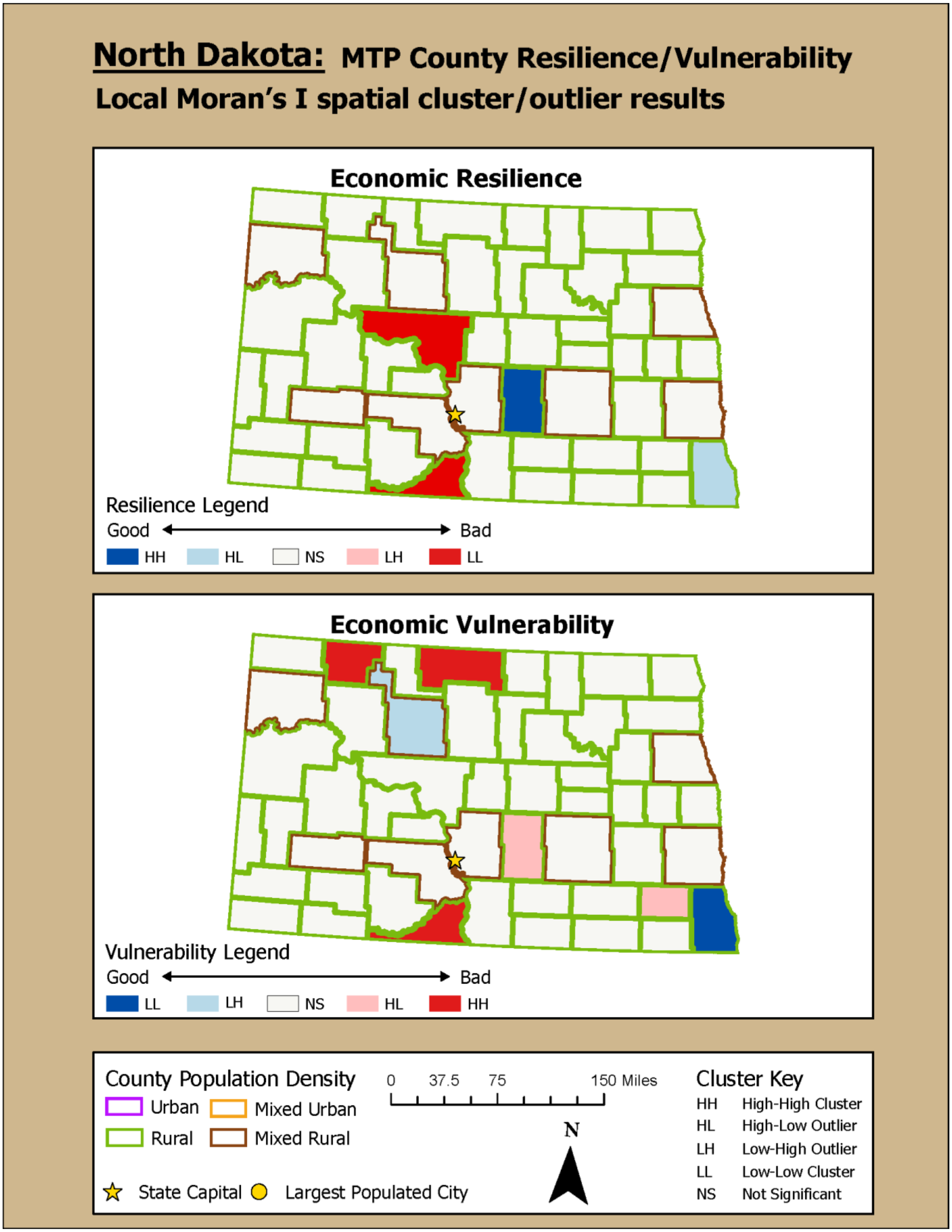
140 Miles
N
Cluster Key
HH High-High Cluster
HL High-Low Outlier
LH Low-High Outlier
LL Low-Low Cluster
NS Not Significant


North Carolina: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results
Infrastructural Resilience
Resilience Legend
Good
Bad
HH
HL
NS
LH
LL
Infrastructural Vulnerability
Vulnerability Legend
Good
Bad
LL
LH
NS
HL
HH
County Population Density
Urban
Mixed Urban
Rural
Mixed Rural
State Capital
Largest Populated City
0
35
70
140 Miles
N
Cluster Key
HH High-High Cluster
HL High-Low Outlier
LH Low-High Outlier
LL Low-Low Cluster
NS Not Significant

North Carolina: MTP County Resilience/Vulnerability

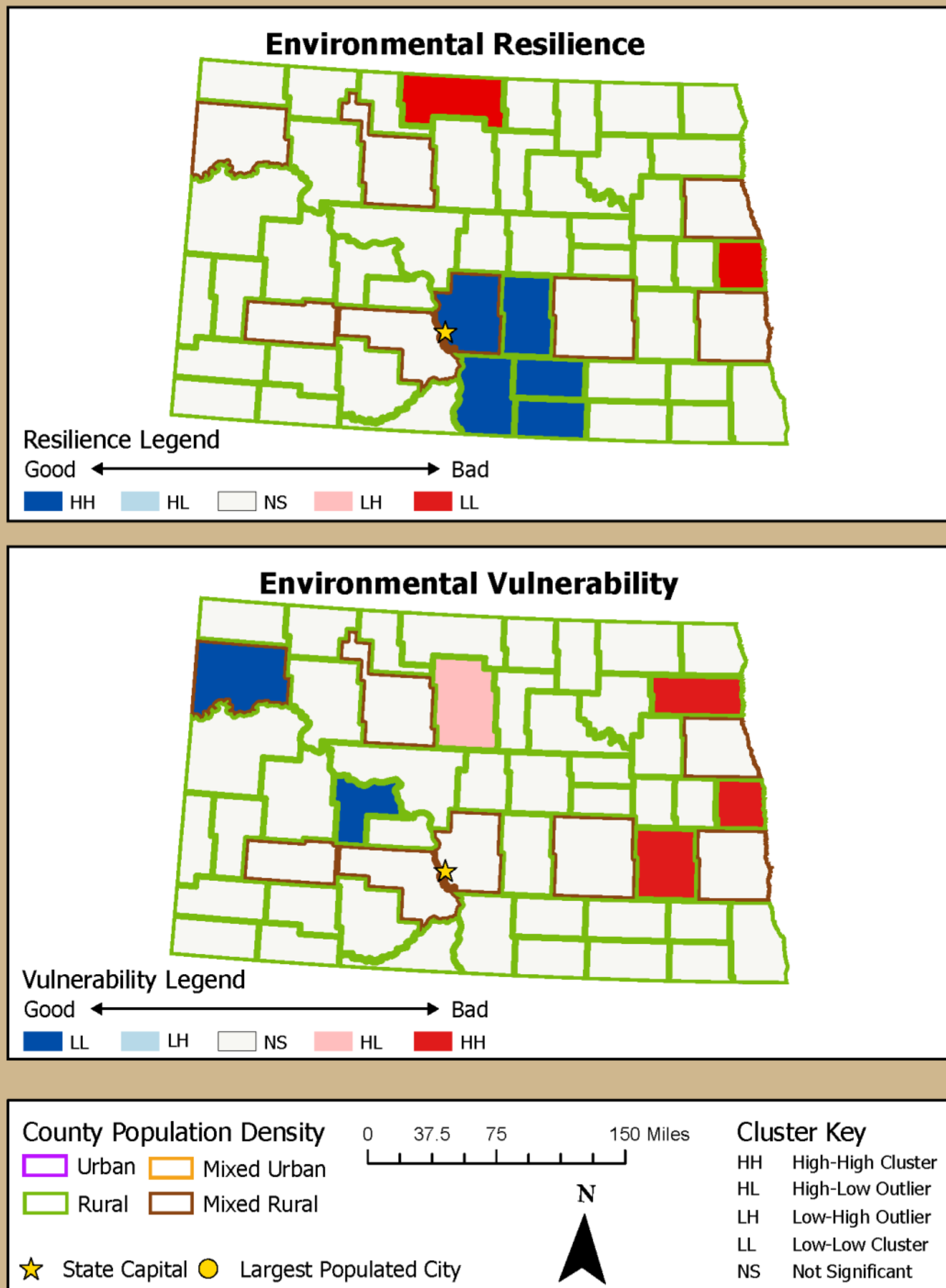
Local Moran's I spatial cluster/outlier results



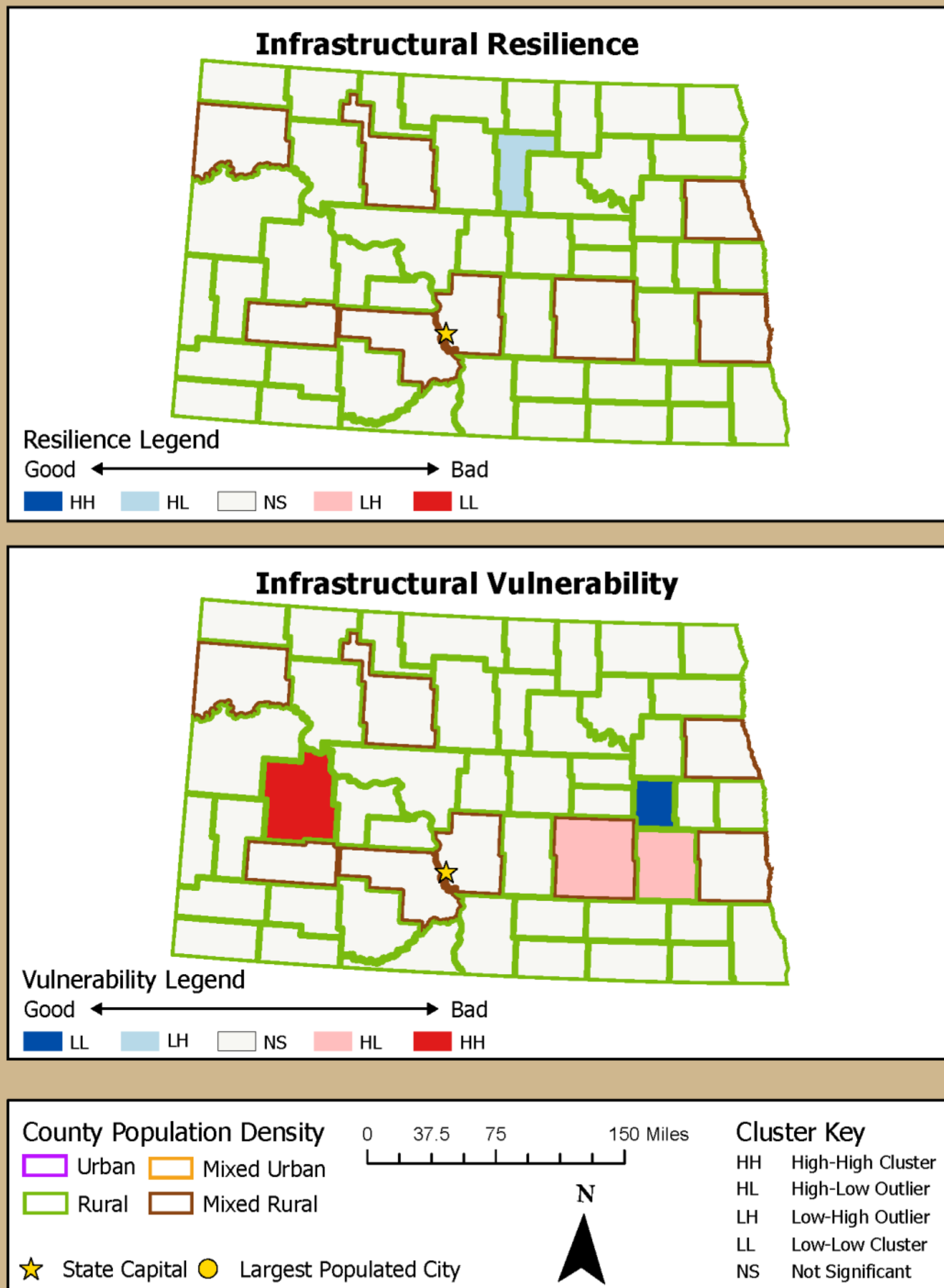

North Dakota: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results
Economic Resilience
Resilience Legend
Good
Bad
HH
HL
NS
LH
LL
Economic Vulnerability
Vulnerability Legend
Good
Bad
LL
LH
NS
HL
HH
County Population Density
Urban
Mixed Urban
Rural
Mixed Rural
State Capital
Largest Populated City
0
37.5
75
150 Miles
N
Cluster Key
HH High-High Cluster
HL High-Low Outlier
LH Low-High Outlier
LL Low-Low Cluster
NS Not Significant

North Dakota: MTP County Resilience/Vulnerability

Local Moran's I spatial cluster/outlier results

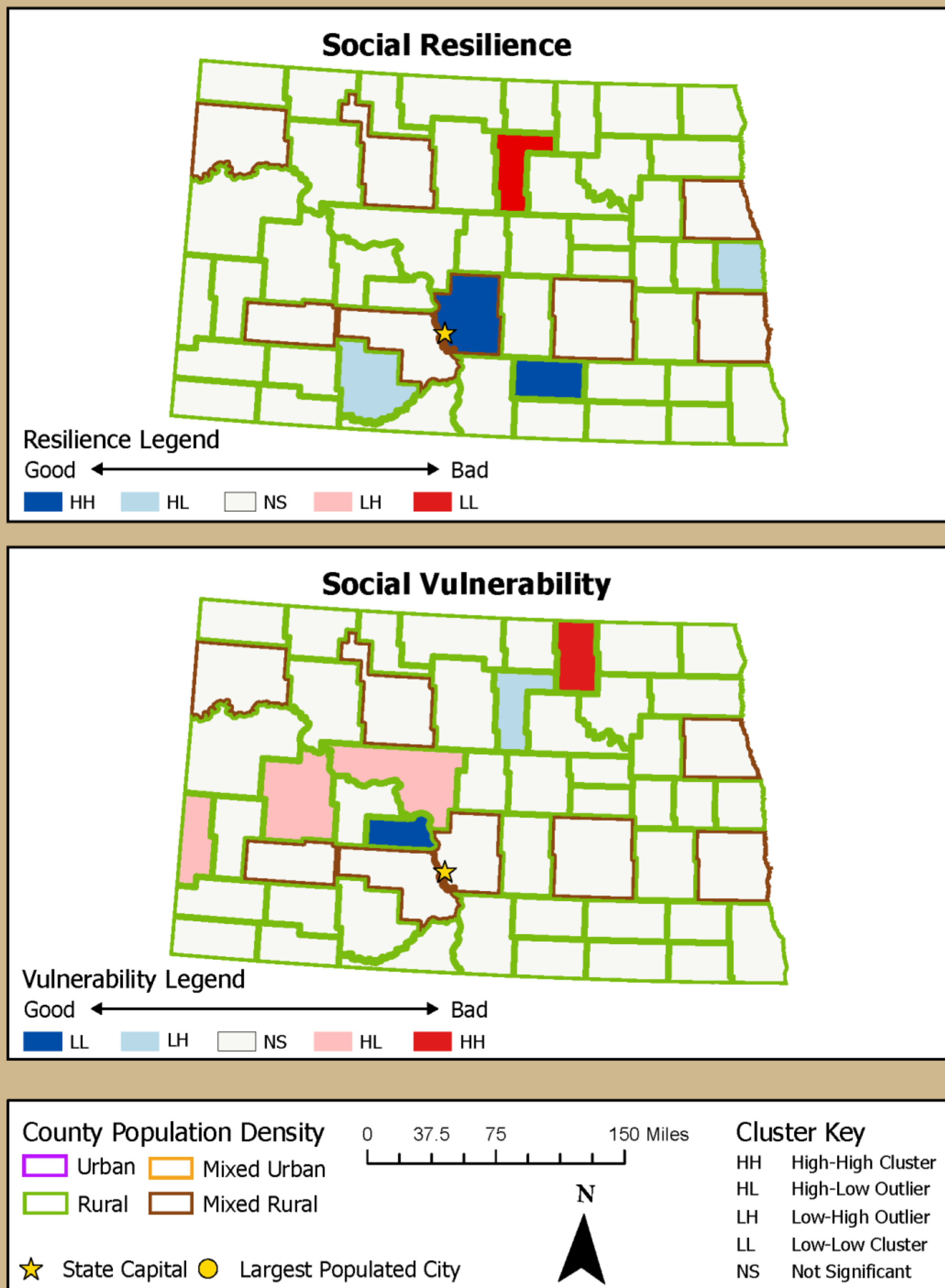


North Dakota: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results



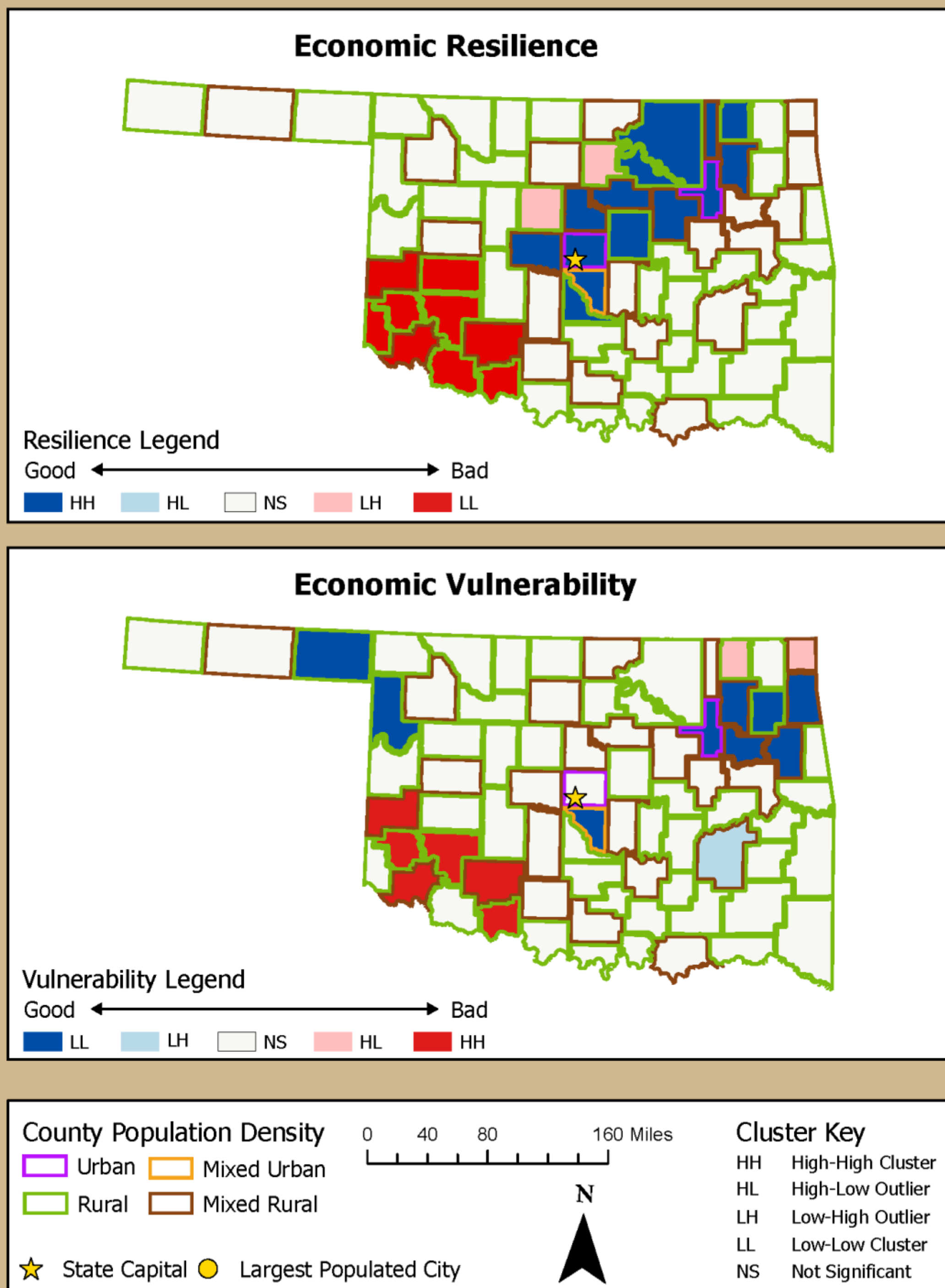
North Dakota: MTP County Resilience/Vulnerability

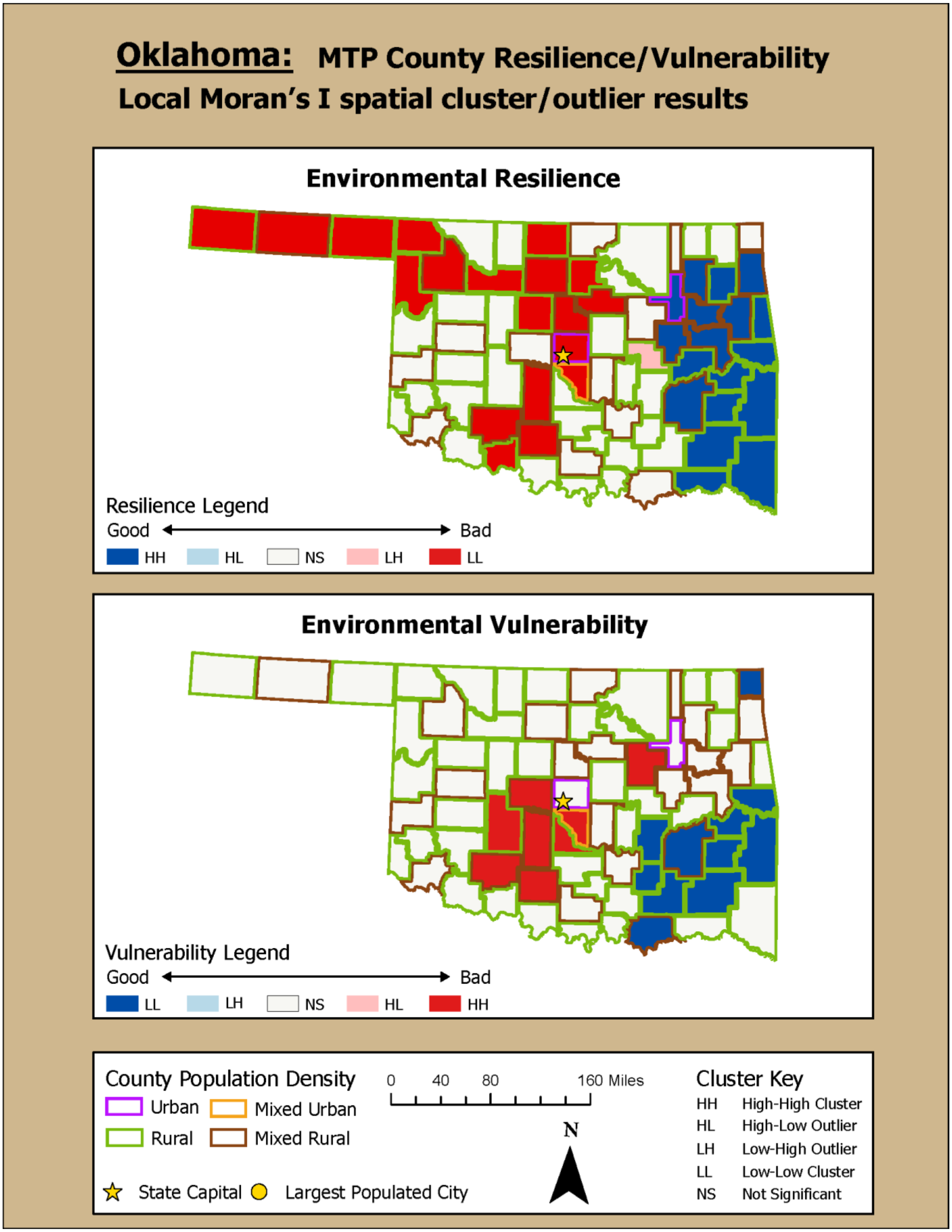
Local Moran's I spatial cluster/outlier results

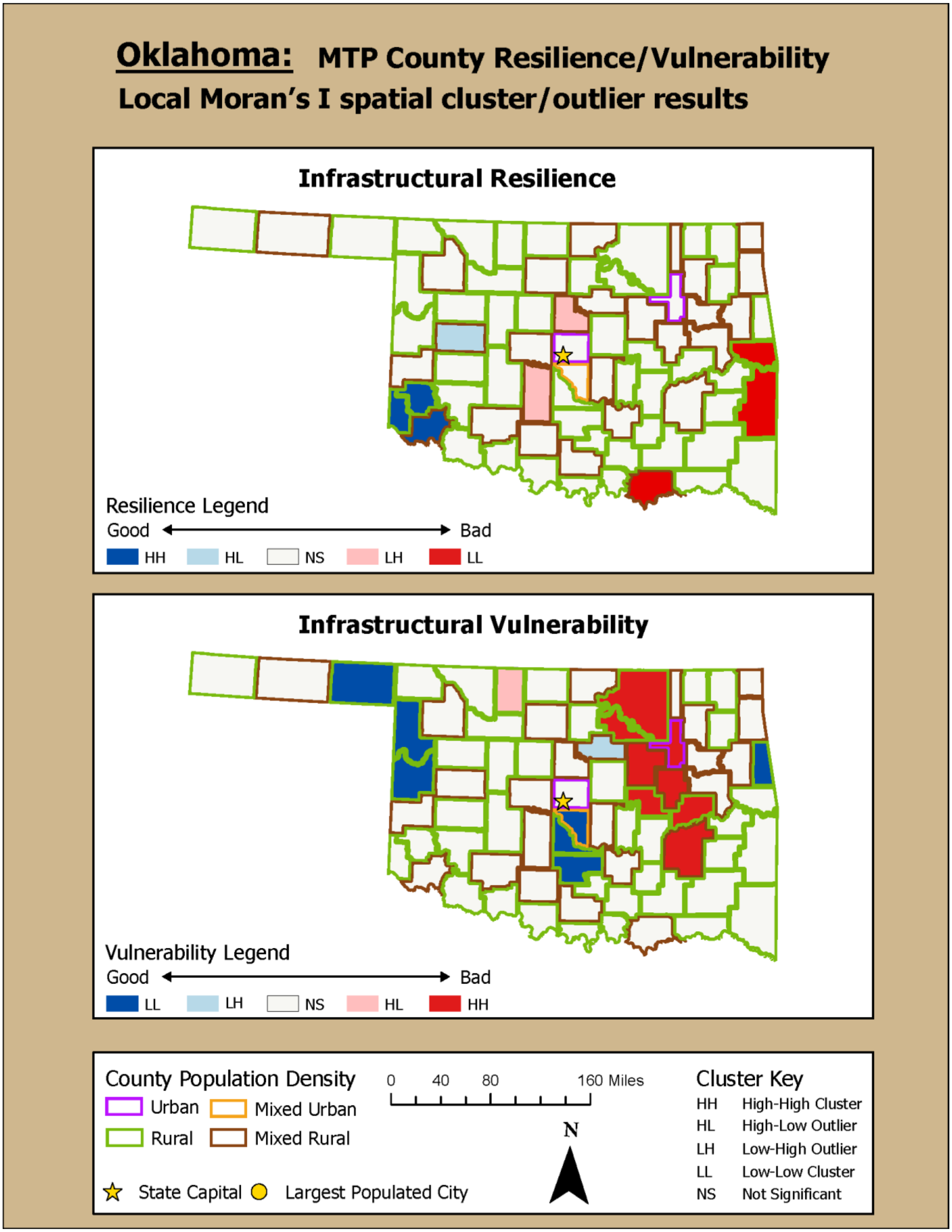


Oklahoma: MTP County Resilience/Vulnerability

Local Moran's I spatial cluster/outlier results




Oklahoma: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results
Environmental Resilience
Resilience Legend
Good
Bad
HH
HL
NS
LH
LL
Environmental Vulnerability
Vulnerability Legend
Good
Bad
LL
LH
NS
HL
HH
County Population Density
Urban
Mixed Urban
Rural
Mixed Rural
State Capital
Largest Populated City
0
40
80
160 Miles
N
Cluster Key
HH High-High Cluster
HL High-Low Outlier
LH Low-High Outlier
LL Low-Low Cluster
NS Not Significant


Oklahoma: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results
Infrastructural Resilience
Resilience Legend
Good
Bad
HH
HL
NS
LH
LL
Infrastructural Vulnerability
Vulnerability Legend
Good
Bad
LL
LH
NS
HL
HH
County Population Density
Urban
Mixed Urban
Rural
Mixed Rural
State Capital
Largest Populated City
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80
160 Miles
N
Cluster Key
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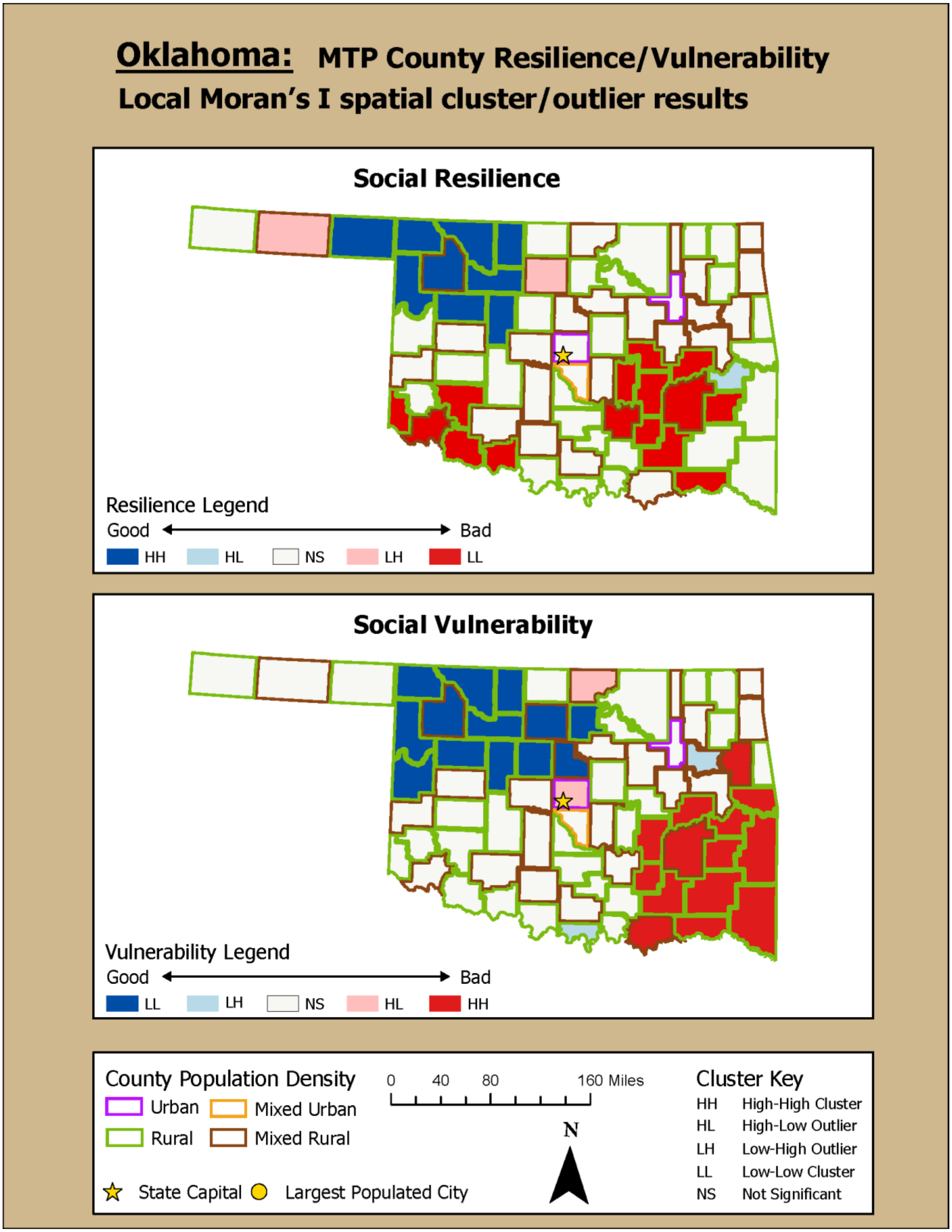
HL High-Low Outlier
LH Low-High Outlier
LL Low-Low Cluster
NS Not Significant


Oklahoma: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results
Social Resilience
Resilience Legend
Good
Bad
HH
HL
NS
LH
LL
Social Vulnerability
Vulnerability Legend
Good
Bad
LL
LH
NS
HL
HH
County Population Density
Urban
Mixed Urban
Rural
Mixed Rural
State Capital
Largest Populated City
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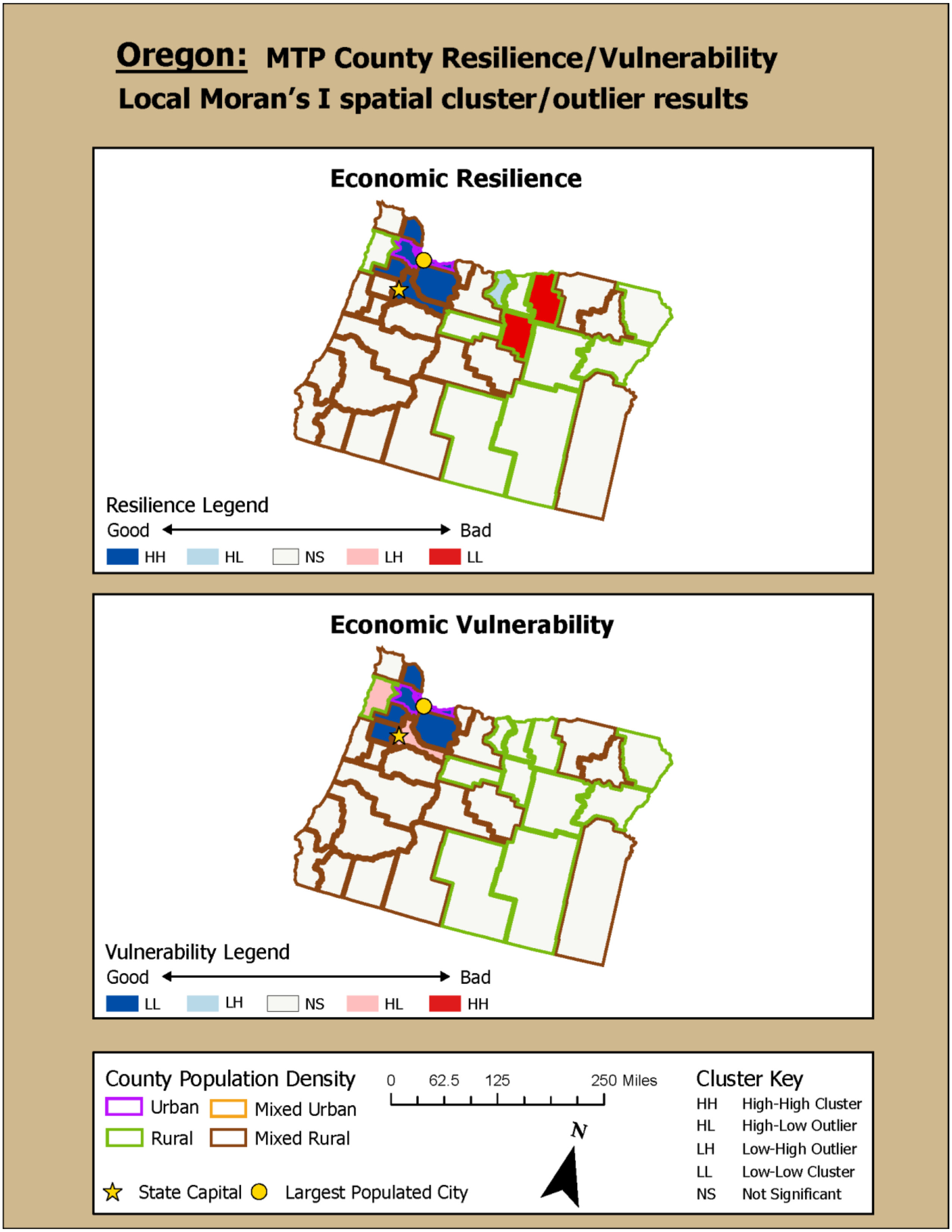
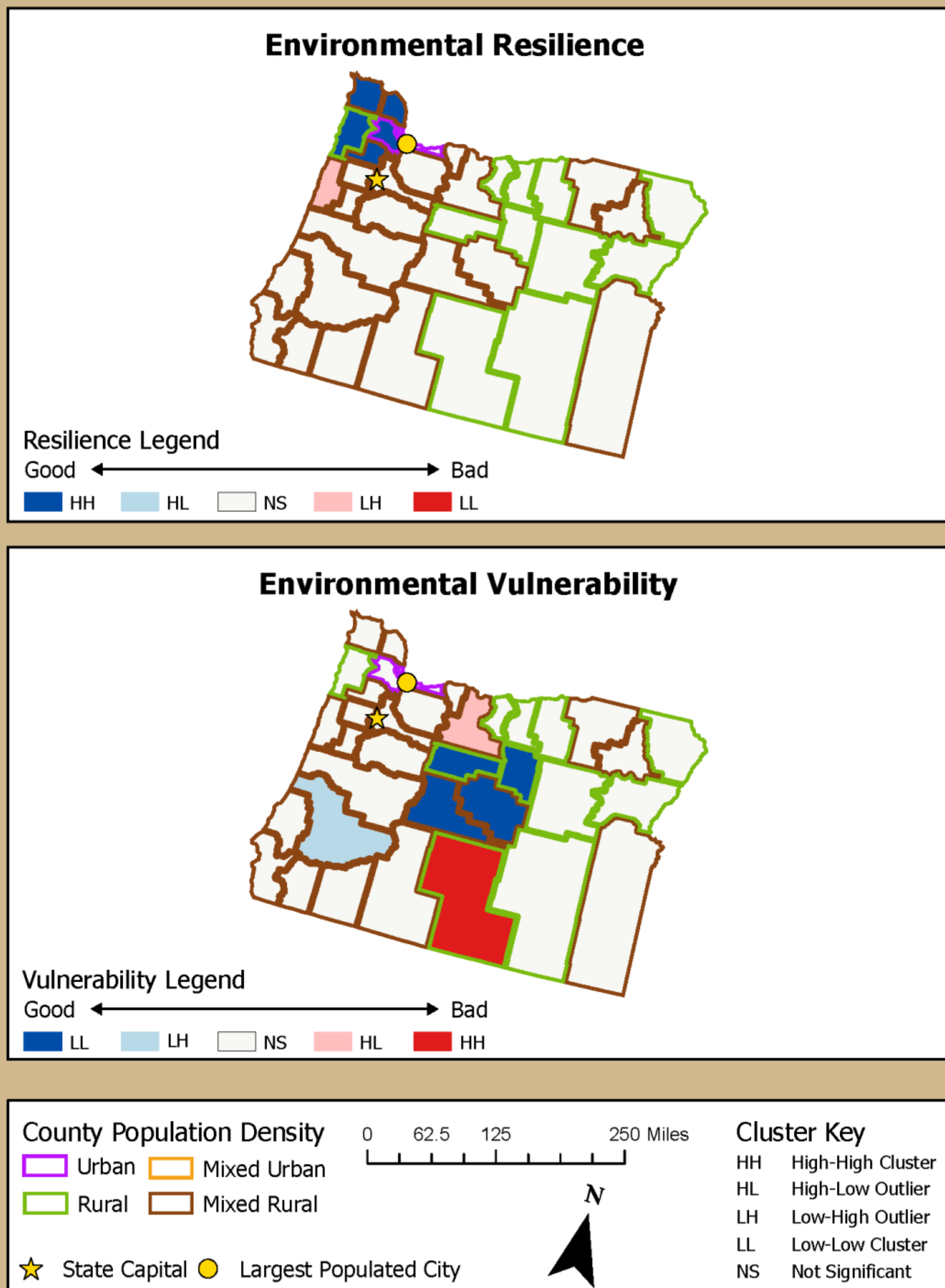
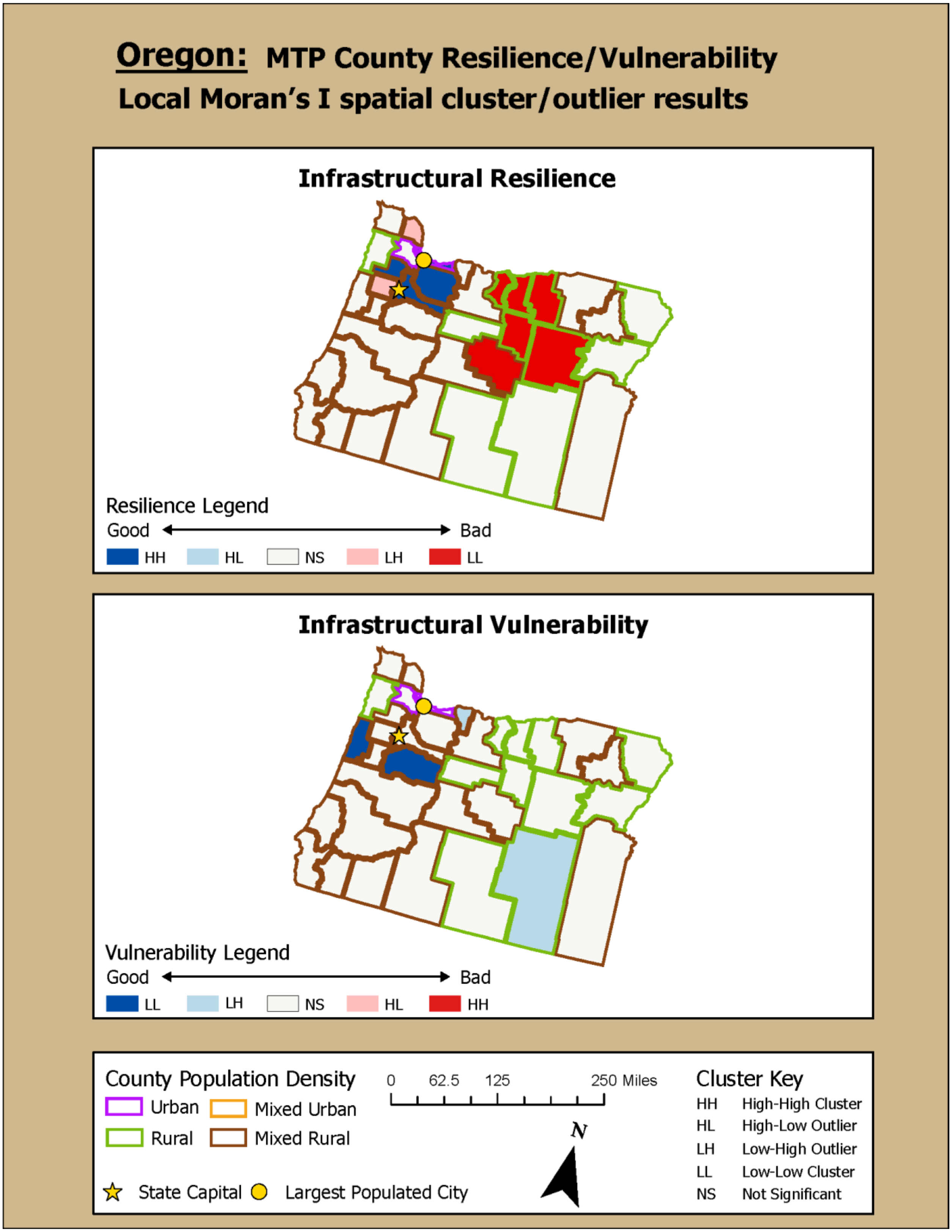
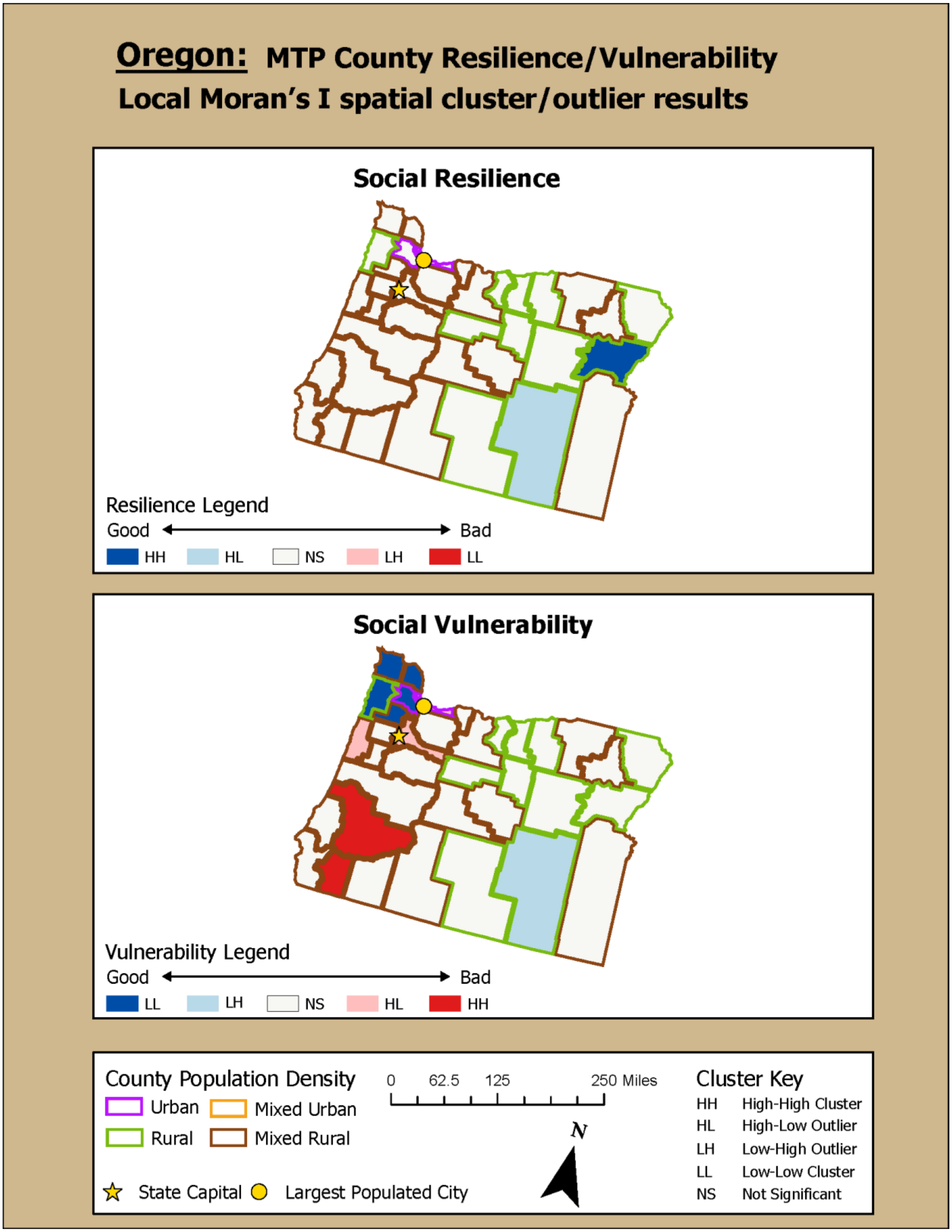
40
80
160 Miles
N
Cluster Key
HH High-High Cluster
HL High-Low Outlier
LH Low-High Outlier
LL Low-Low Cluster
NS Not Significant

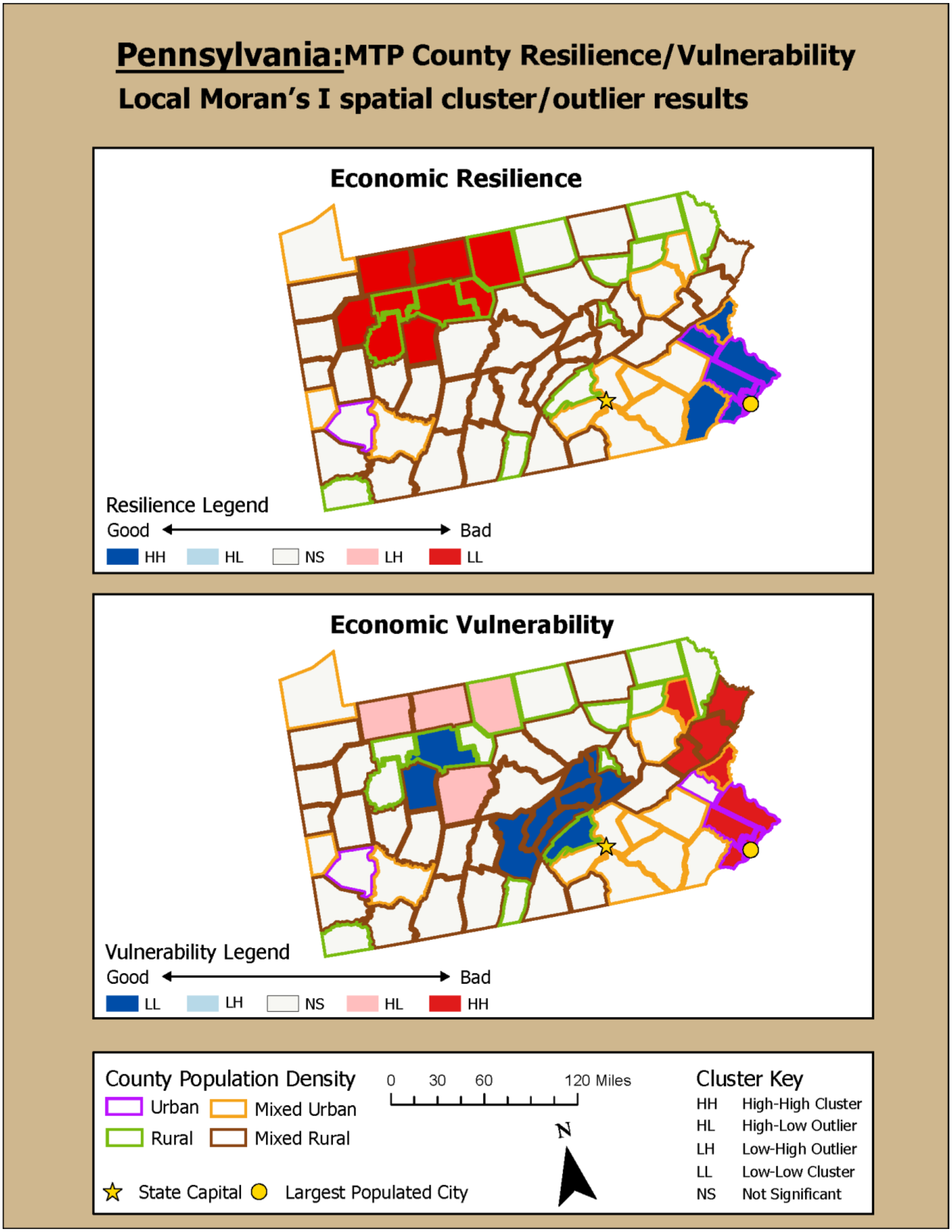

Oregon: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results
Economic Resilience
Resilience Legend
Good
Bad
HH
HL
NS
LH
LL
Economic Vulnerability
Vulnerability Legend
Good
Bad
LL
LH
NS
HL
HH
County Population Density
Urban
Mixed Urban
Rural
Mixed Rural
State Capital
Largest Populated City
0
62.5
125
250 Miles
N
Cluster Key
HH High-High Cluster
HL High-Low Outlier
LH Low-High Outlier
LL Low-Low Cluster
NS Not Significant

Oregon: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results




Oregon: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results
Infrastructural Resilience
Resilience Legend
Good
Bad
HH
HL
NS
LH
LL
Infrastructural Vulnerability
Vulnerability Legend
Good
Bad
LL
LH
NS
HL
HH
County Population Density
Urban
Mixed Urban
Rural
Mixed Rural
State Capital
Largest Populated City
0
62.5
125
250 Miles
N
Cluster Key
HH High-High Cluster
HL High-Low Outlier
LH Low-High Outlier
LL Low-Low Cluster
NS Not Significant


Oregon: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results
Social Resilience
Resilience Legend
Good
Bad
HH
HL
NS
LH
LL
Social Vulnerability
Vulnerability Legend
Good
Bad
LL
LH
NS
HL
HH
County Population Density
Urban
Mixed Urban
Rural
Mixed Rural
State Capital
Largest Populated City
0
62.5
125
250 Miles
N
Cluster Key
HH High-High Cluster
HL High-Low Outlier
LH Low-High Outlier
LL Low-Low Cluster
NS Not Significant


Pennsylvania: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results
Economic Resilience
Resilience Legend
Good
Bad
HH
HL
NS
LH
LL
Economic Vulnerability
Vulnerability Legend
Good
Bad
LL
LH
NS
HL
HH
County Population Density
Urban
Mixed Urban
Rural
Mixed Rural
State Capital
Largest Populated City
0
30
60
120 Miles
N
Cluster Key
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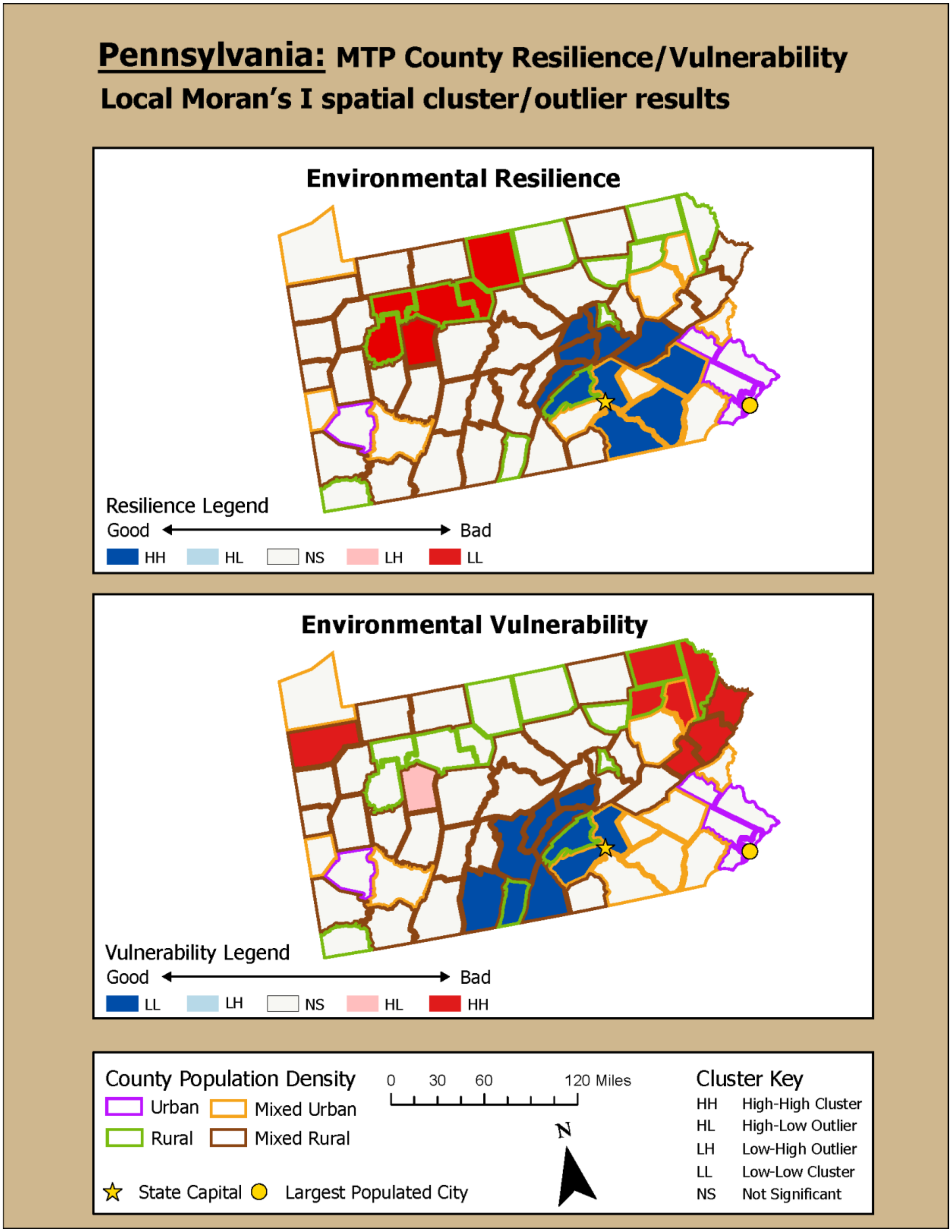
HL High-Low Outlier
LH Low-High Outlier
LL Low-Low Cluster
NS Not Significant


Pennsylvania: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results
Environmental Resilience
Resilience Legend
Good
Bad
HH
HL
NS
LH
LL
Environmental Vulnerability
Vulnerability Legend
Good
Bad
LL
LH
NS
HL
HH
County Population Density
Urban
Mixed Urban
Rural
Mixed Rural
State Capital
Largest Populated City
0
30
60
120 Miles
N
Cluster Key
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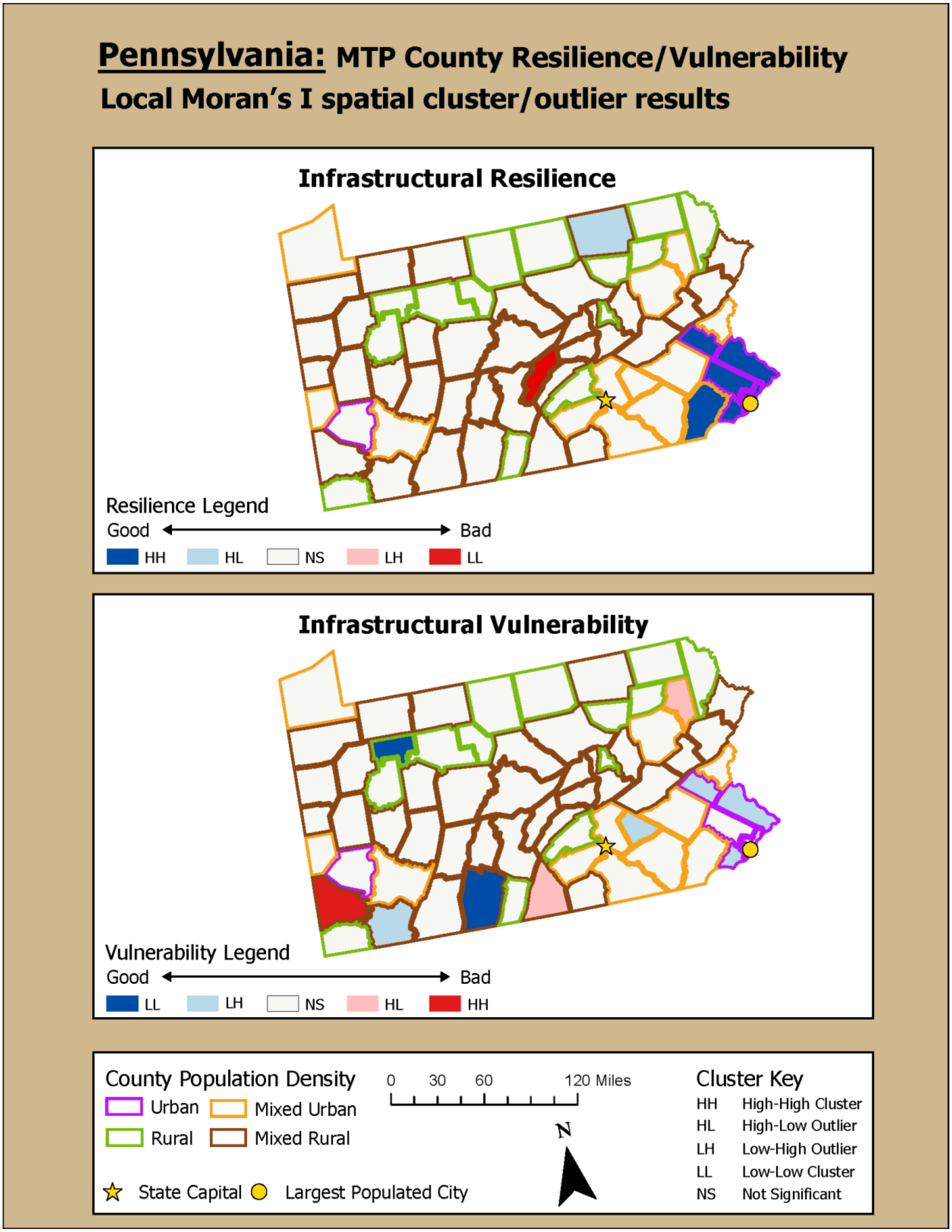
HL High-Low Outlier
LH Low-High Outlier
LL Low-Low Cluster
NS Not Significant


Pennsylvania: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results
Infrastructural Resilience
Resilience Legend
Good
Bad
HH
HL
NS
LH
LL
Infrastructural Vulnerability
Vulnerability Legend
Good
Bad
LL
LH
NS
HL
HH
County Population Density
Urban
Mixed Urban
Rural
Mixed Rural
State Capital
Largest Populated City
0
30
60
120 Miles
N
Cluster Key
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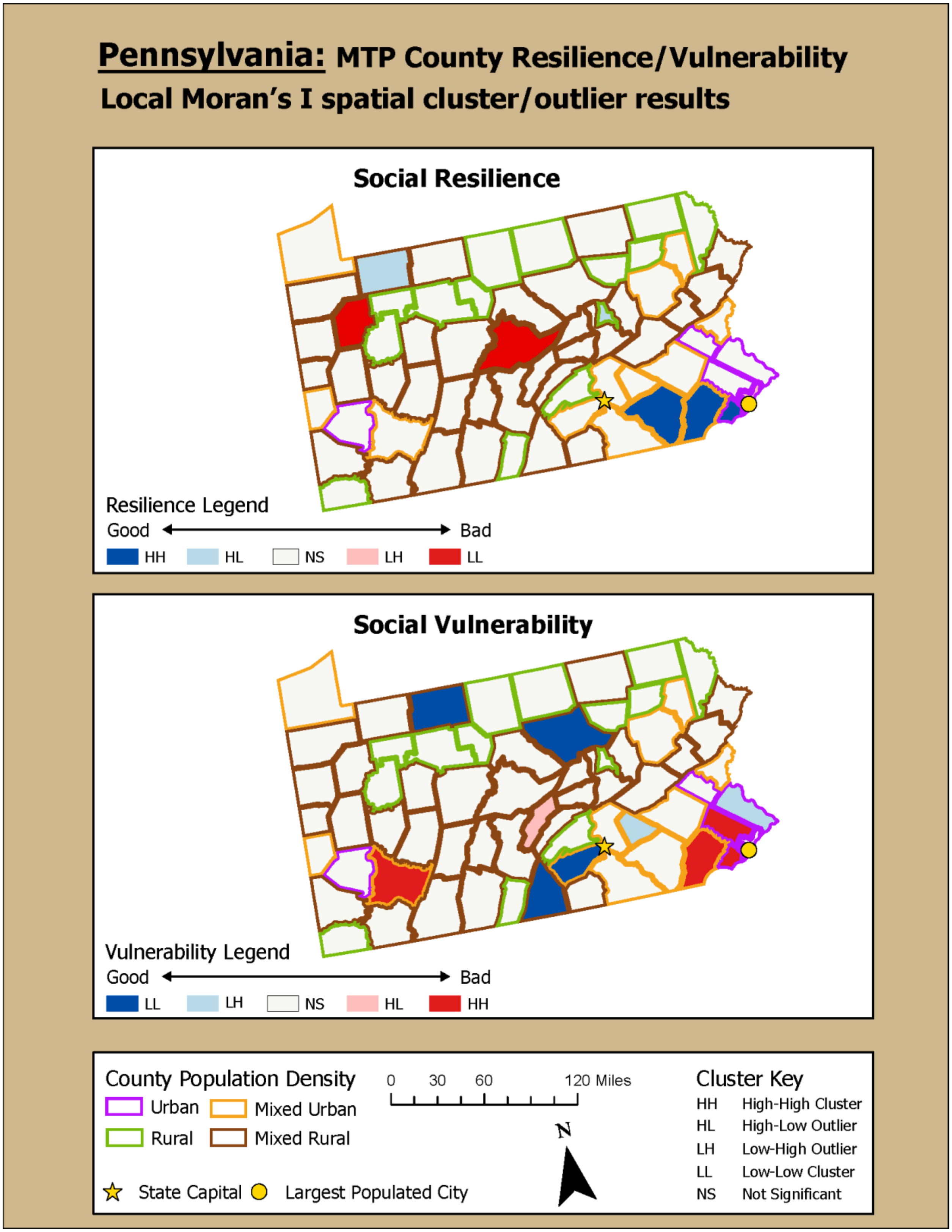
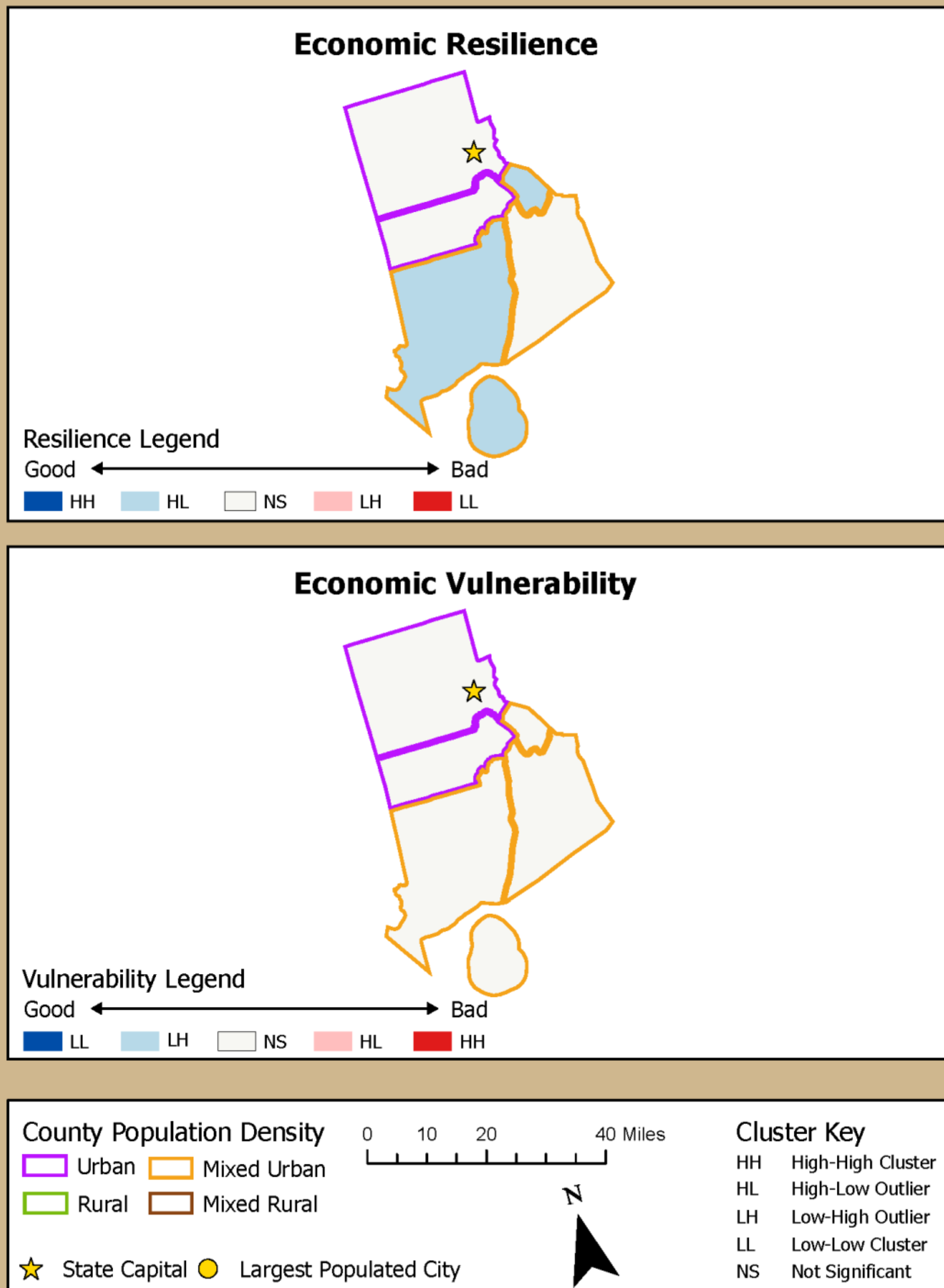
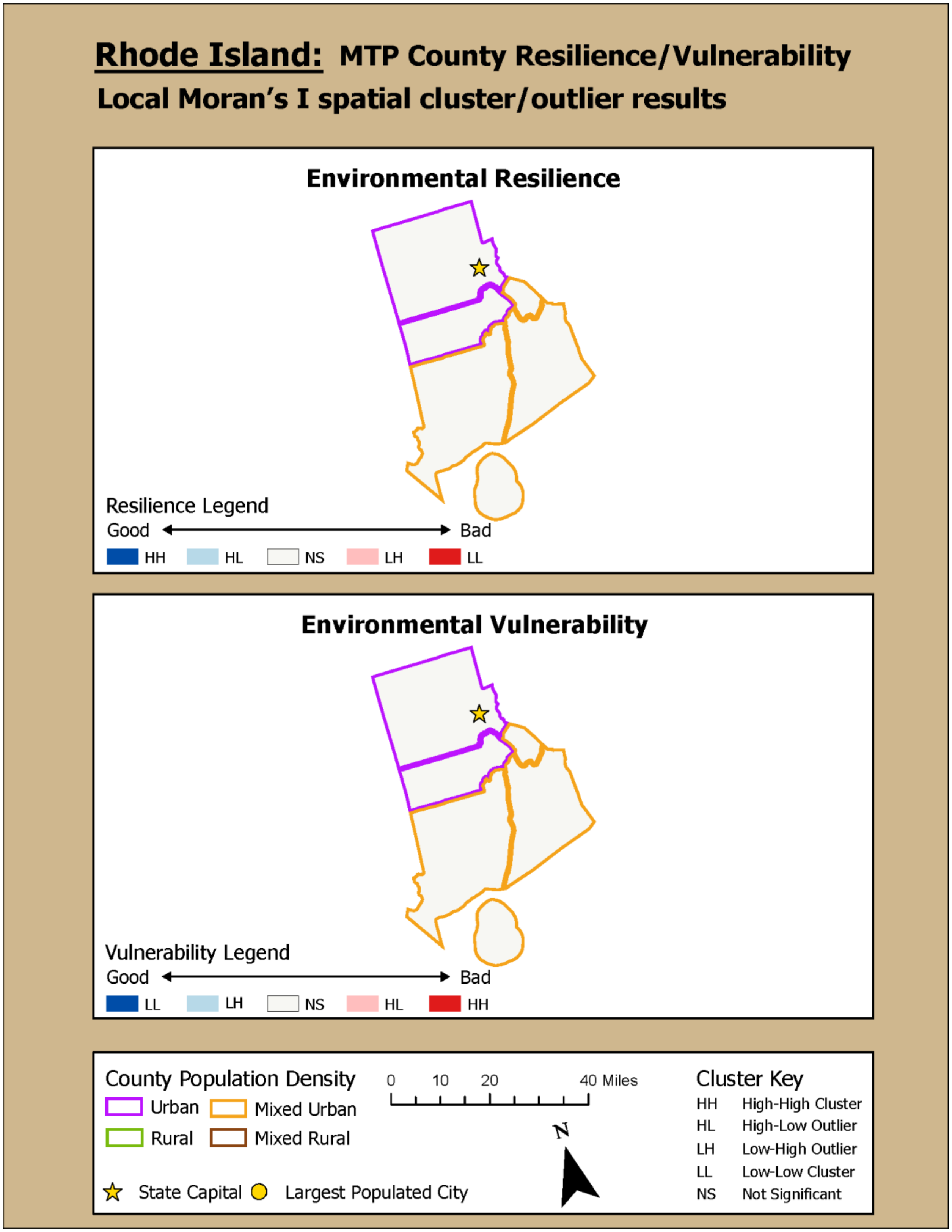
HL High-Low Outlier
LH Low-High Outlier
LL Low-Low Cluster
NS Not Significant


Pennsylvania: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results
Social Resilience
Resilience Legend
Good
Bad
HH
HL
NS
LH
LL
Social Vulnerability
Vulnerability Legend
Good
Bad
LL
LH
NS
HL
HH
County Population Density
Urban
Mixed Urban
Rural
Mixed Rural
State Capital
Largest Populated City
0 30 60 120 Miles
N
Cluster Key
HH High-High Cluster
HL High-Low Outlier
LH Low-High Outlier
LL Low-Low Cluster
NS Not Significant

Rhode Island: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results




Rhode Island: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results
Environmental Resilience
Resilience Legend
Good
Bad
HH
HL
NS
LH
LL
Environmental Vulnerability
Vulnerability Legend
Good
Bad
LL
LH
NS
HL
HH
County Population Density
Urban
Mixed Urban
Rural
Mixed Rural
State Capital
Largest Populated City
0
10
20
40 Miles
N
Cluster Key
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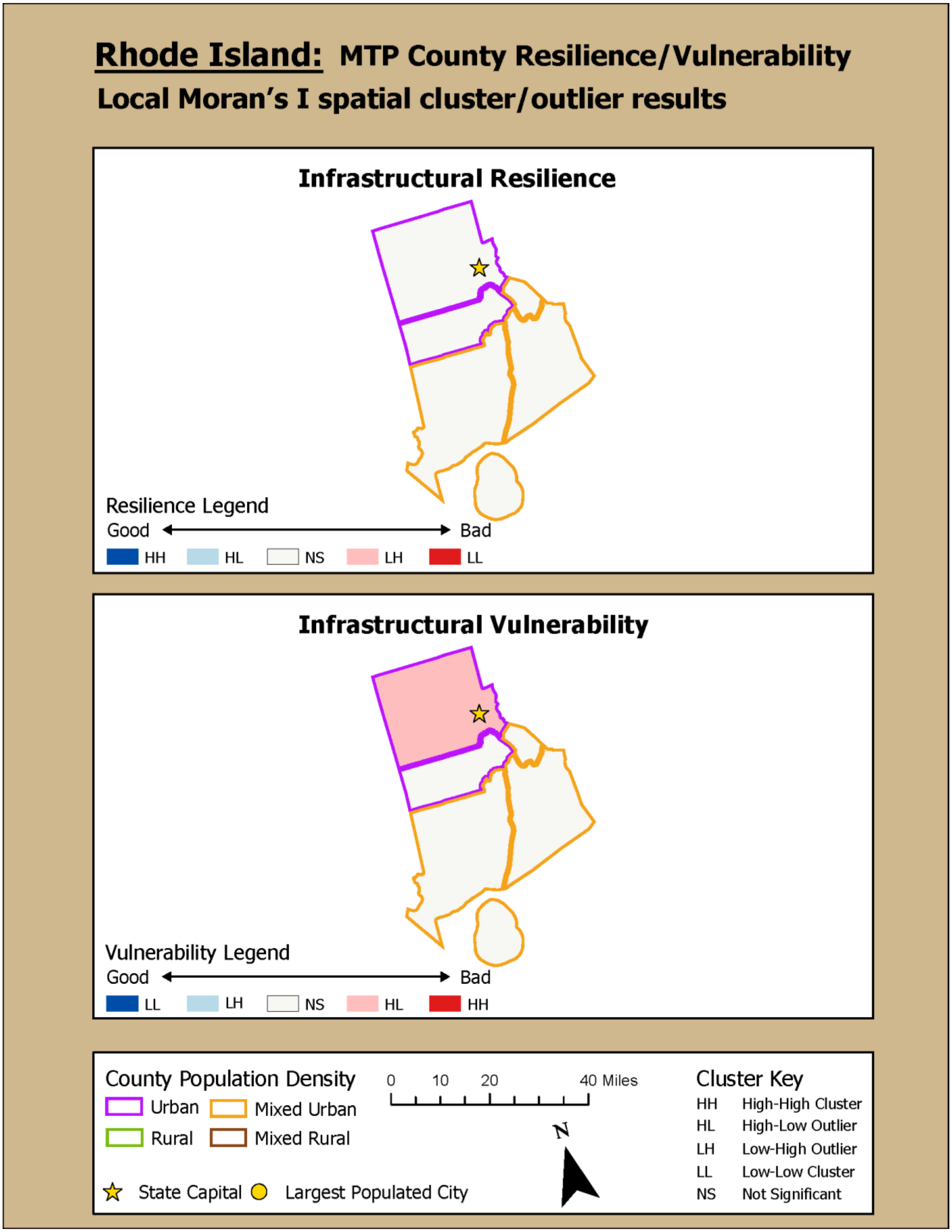
HL High-Low Outlier
LH Low-High Outlier
LL Low-Low Cluster
NS Not Significant


Rhode Island: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results
Infrastructural Resilience
Resilience Legend
Good
Bad
HH
HL
NS
LH
LL
Infrastructural Vulnerability
Vulnerability Legend
Good
Bad
LL
LH
NS
HL
HH
County Population Density
Urban
Mixed Urban
Rural
Mixed Rural
State Capital
Largest Populated City
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20
40 Miles
N
Cluster Key
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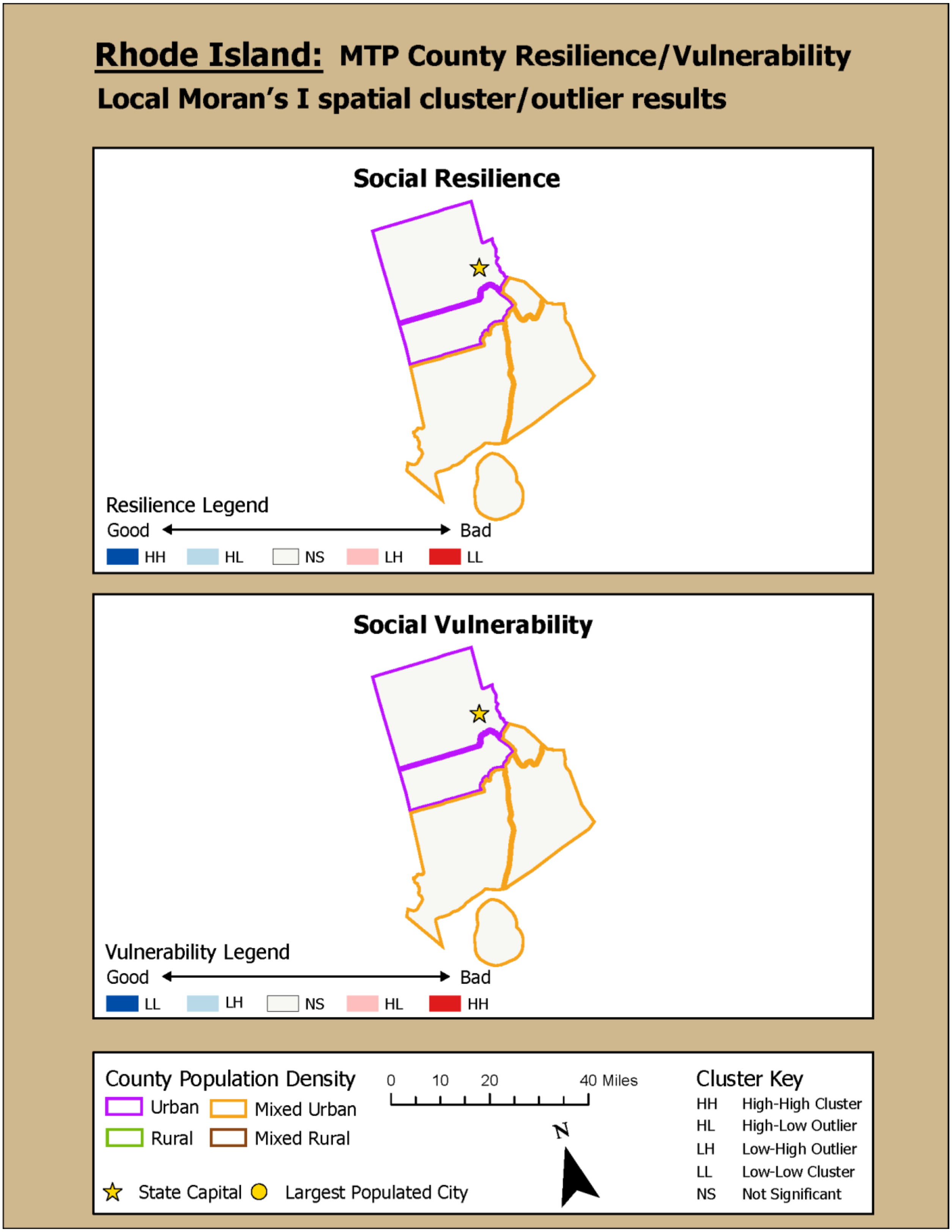
HL High-Low Outlier
LH Low-High Outlier
LL Low-Low Cluster
NS Not Significant


Rhode Island: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results
Social Resilience
Resilience Legend
Good
Bad
HH
HL
NS
LH
LL
Social Vulnerability
Vulnerability Legend
Good
Bad
LL
LH
NS
HL
HH
County Population Density
Urban
Mixed Urban
Rural
Mixed Rural
State Capital
Largest Populated City
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20
40 Miles
N
Cluster Key
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HL High-Low Outlier
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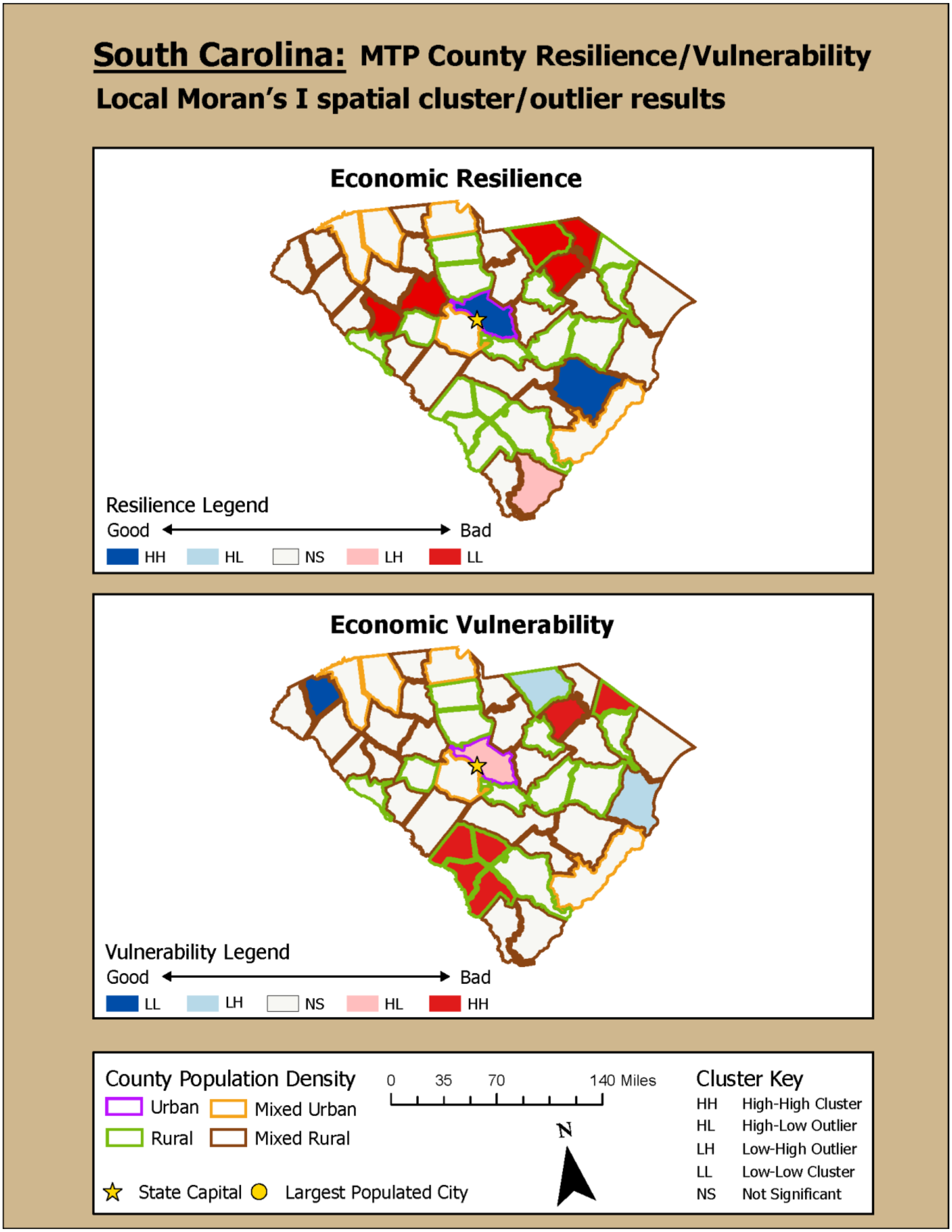
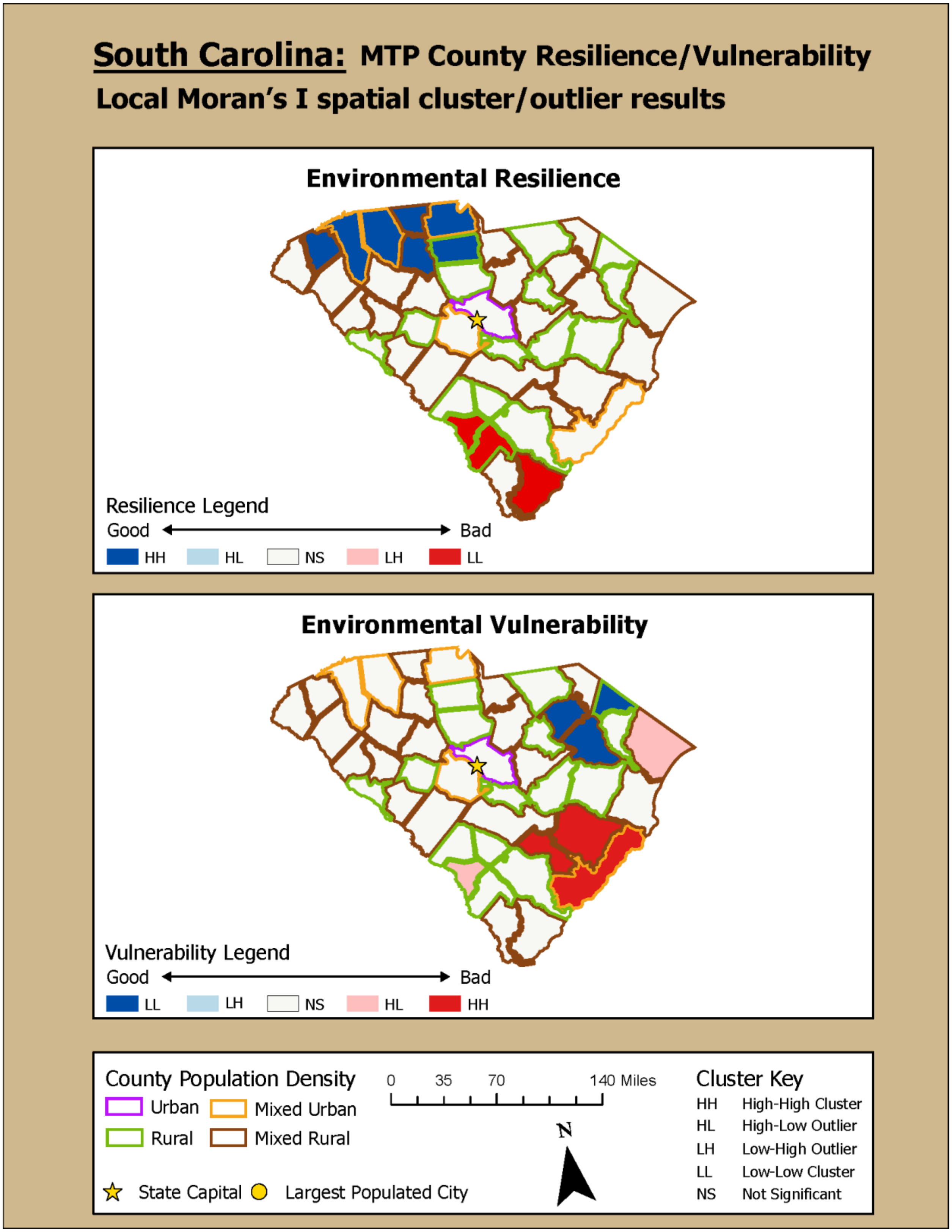
LL Low-Low Cluster
NS Not Significant


South Carolina: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results
Economic Resilience
Resilience Legend
Good
Bad
HH
HL
NS
LH
LL
Economic Vulnerability
Vulnerability Legend
Good
Bad
LL
LH
NS
HL
HH
County Population Density
Urban
Mixed Urban
Rural
Mixed Rural
State Capital
Largest Populated City
0
35
70
140 Miles
N
Cluster Key
HH High-High Cluster
HL High-Low Outlier
LH Low-High Outlier
LL Low-Low Cluster
NS Not Significant


South Carolina: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results
Environmental Resilience
Resilience Legend
Good
Bad
HH
HL
NS
LH
LL
Environmental Vulnerability
Vulnerability Legend
Good
Bad
LL
LH
NS
HL
HH
County Population Density
Urban
Mixed Urban
Rural
Mixed Rural
State Capital
Largest Populated City
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35
70
140 Miles
N
Cluster Key
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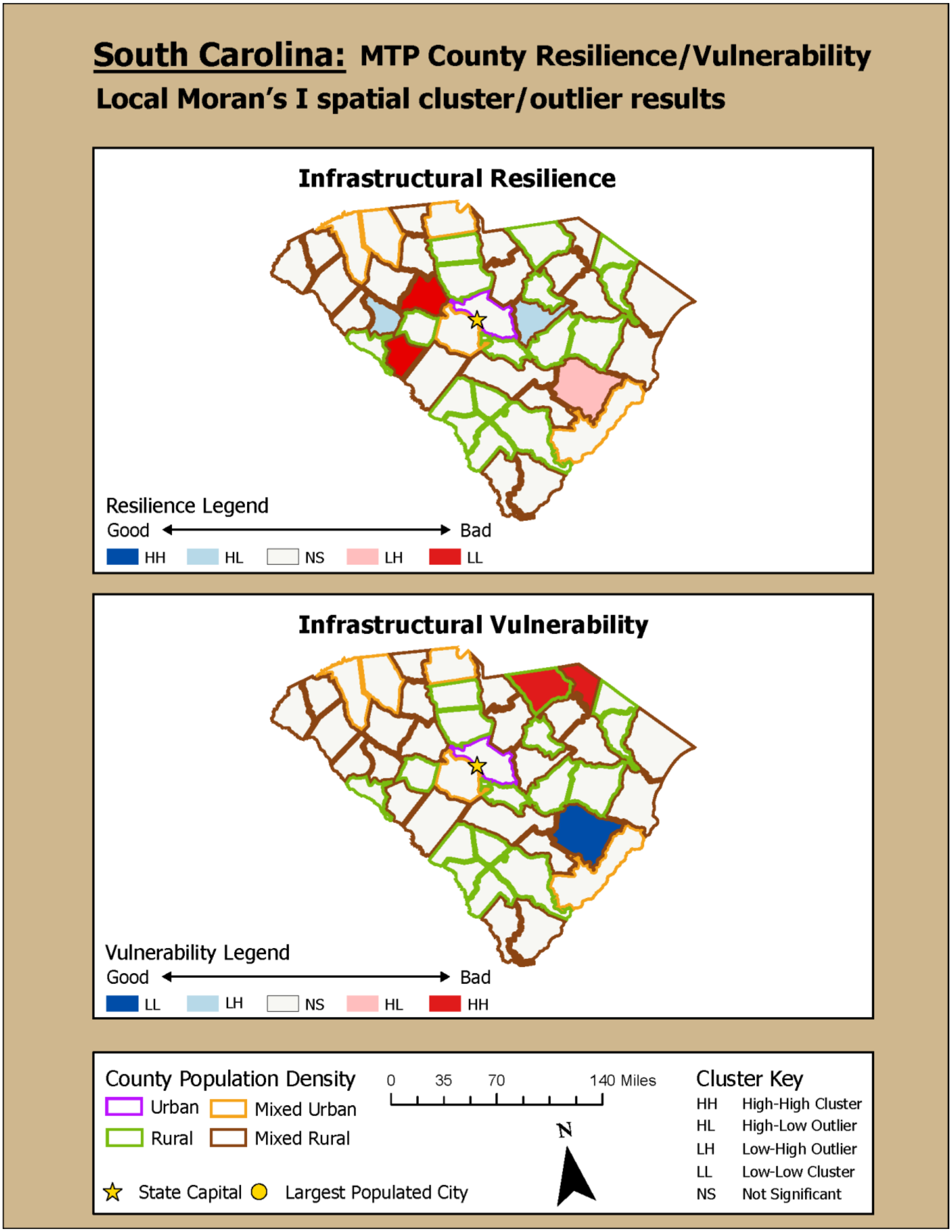
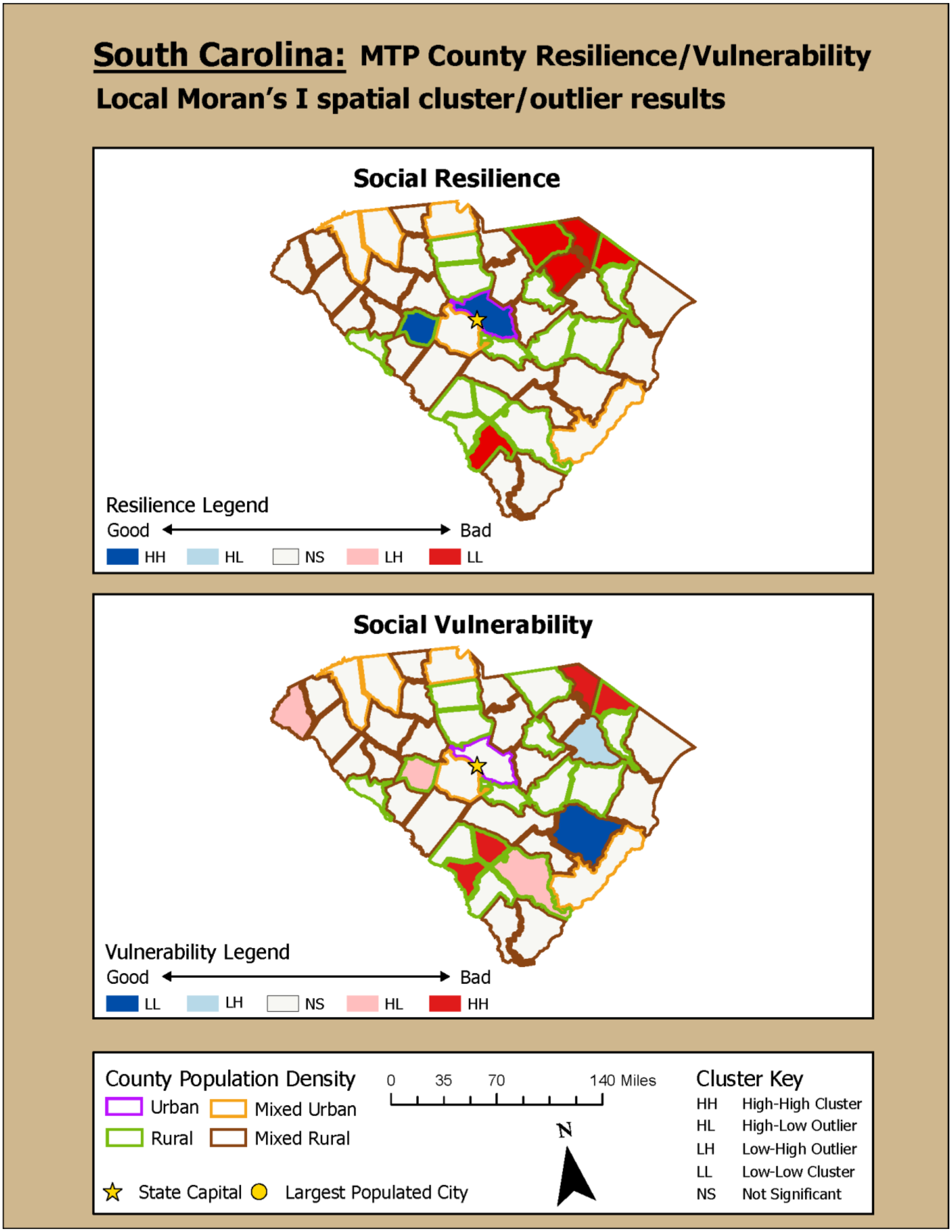
HL High-Low Outlier
LH Low-High Outlier
LL Low-Low Cluster
NS Not Significant


South Carolina: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results
Infrastructural Resilience
Resilience Legend
Good
Bad
HH
HL
NS
LH
LL
Infrastructural Vulnerability
Vulnerability Legend
Good
Bad
LL
LH
NS
HL
HH
County Population Density
Urban
Mixed Urban
Rural
Mixed Rural
State Capital
Largest Populated City
0
35
70
140 Miles
N
Cluster Key
HH High-High Cluster
HL High-Low Outlier
LH Low-High Outlier
LL Low-Low Cluster
NS Not Significant


South Carolina: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results
Social Resilience
Resilience Legend
Good
Bad
HH
HL
NS
LH
LL
Social Vulnerability
Vulnerability Legend
Good
Bad
LL
LH
NS
HL
HH
County Population Density
Urban
Mixed Urban
Rural
Mixed Rural
State Capital
Largest Populated City
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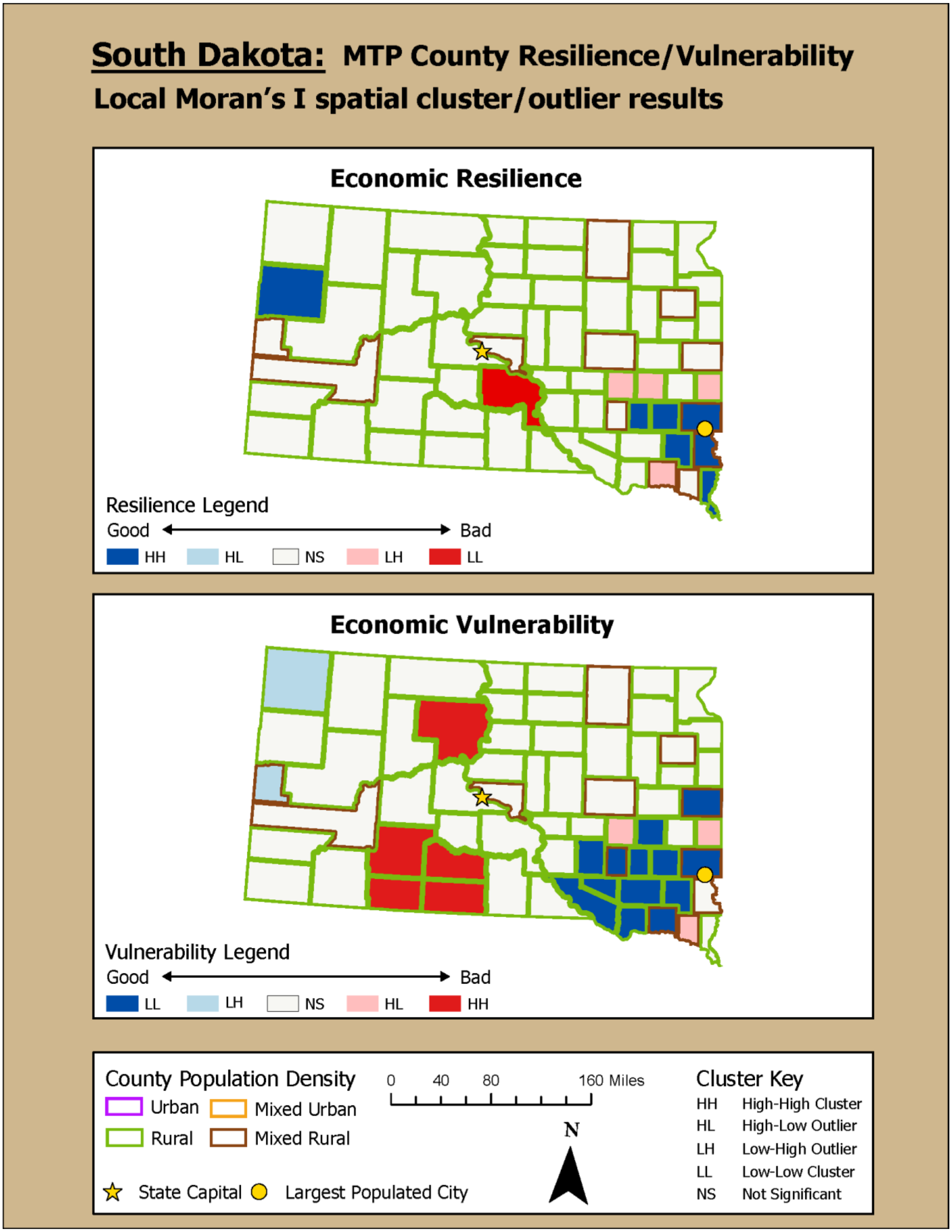
70
140 Miles
N
Cluster Key
HH High-High Cluster
HL High-Low Outlier
LH Low-High Outlier
LL Low-Low Cluster
NS Not Significant


South Dakota: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results
Economic Resilience
Resilience Legend
Good
Bad
HH
HL
NS
LH
LL
Economic Vulnerability
Vulnerability Legend
Good
Bad
LL
LH
NS
HL
HH
County Population Density
Urban
Mixed Urban
Rural
Mixed Rural
0
40
80
160 Miles
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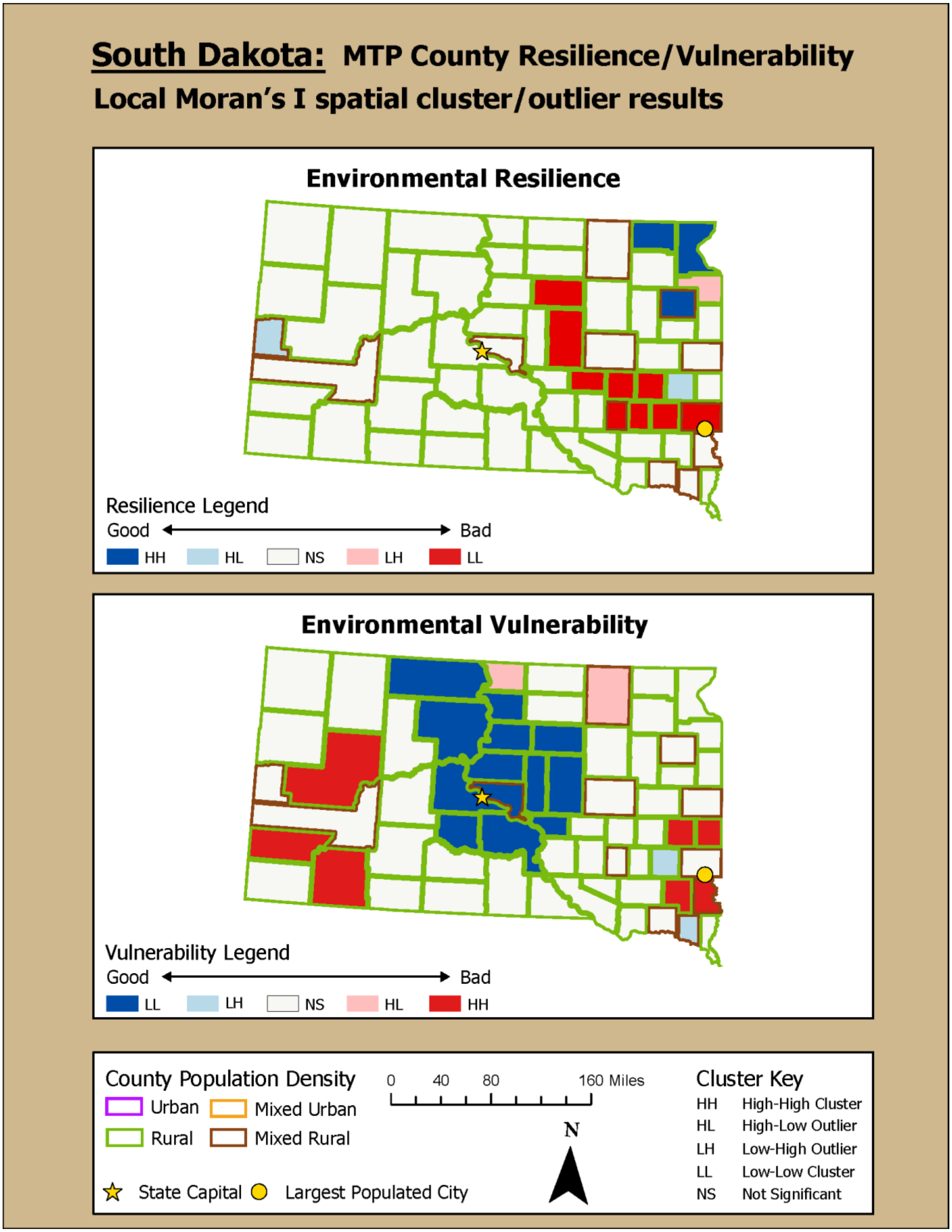
State Capital
Largest Populated City
Cluster Key
HH High-High Cluster
HL High-Low Outlier
LH Low-High Outlier
LL Low-Low Cluster
NS Not Significant



South Dakota: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results
Environmental Resilience
Resilience Legend
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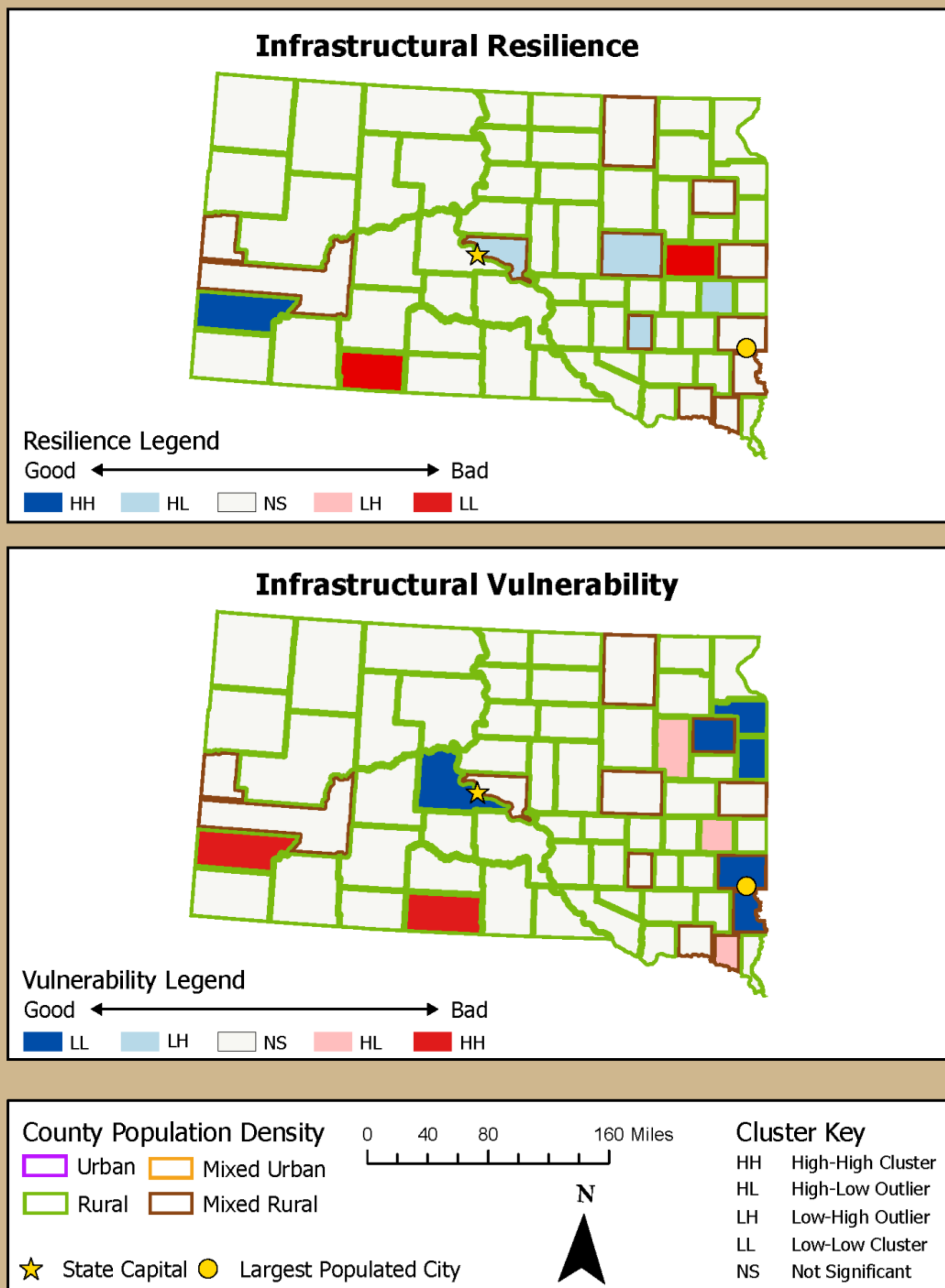
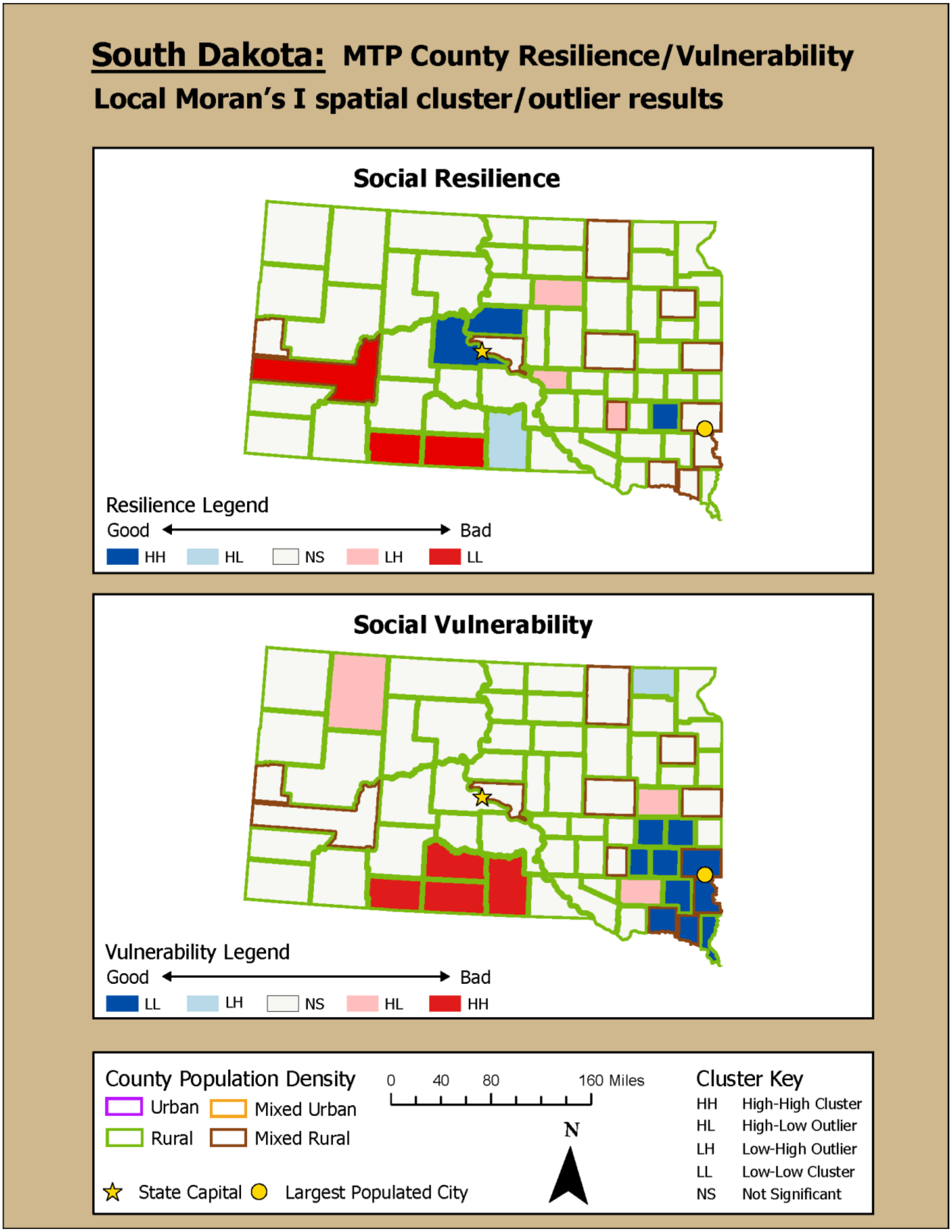
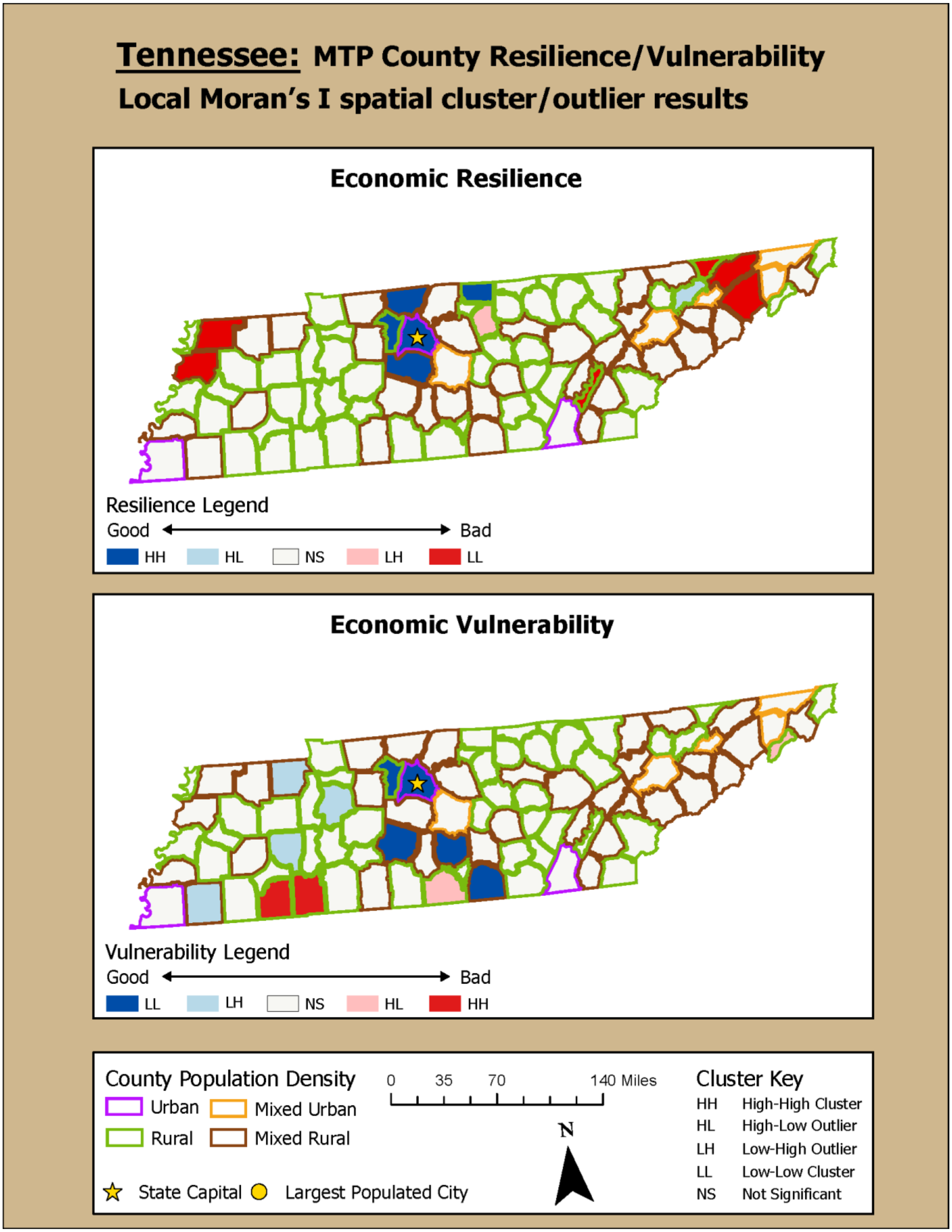
Bad
HH
HL
NS
LH
LL
Environmental Vulnerability
Vulnerability Legend
Good
Bad
LL
LH
NS
HL
HH
County Population Density
Urban
Mixed Urban
Rural
Mixed Rural
State Capital
Largest Populated City
0 40 80 160 Miles
N
Cluster Key
HH High-High Cluster
HL High-Low Outlier
LH Low-High Outlier
LL Low-Low Cluster
NS Not Significant

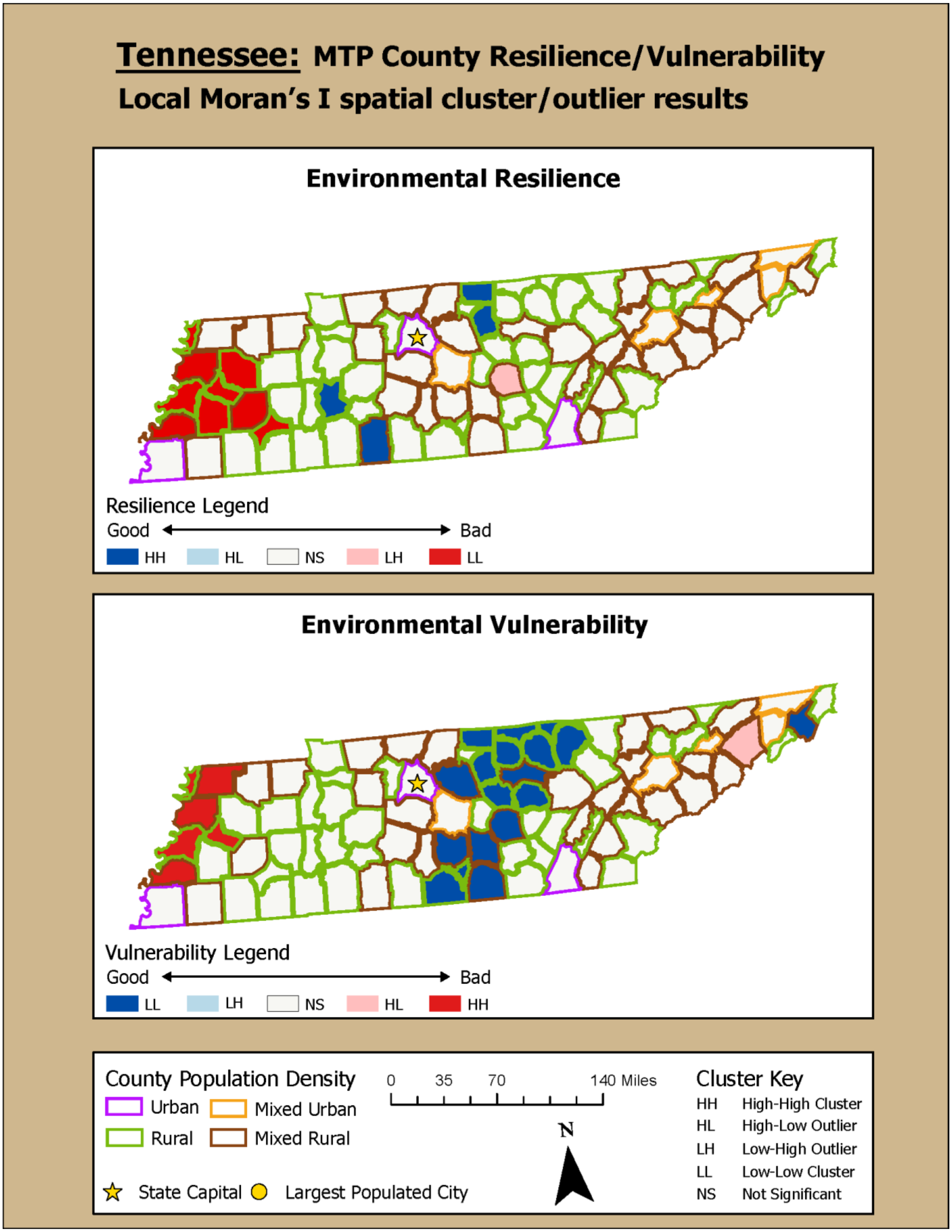
South Dakota: MTP County Resilience/Vulnerability

Local Moran's I spatial cluster/outlier results




South Dakota: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results
Social Resilience
Resilience Legend
Good
Bad
HH
HL
NS
LH
LL
Social Vulnerability
Vulnerability Legend
Good
Bad
LL
LH
NS
HL
HH
County Population Density
Urban
Mixed Urban
Rural
Mixed Rural
0
40
80
160 Miles
N
State Capital
Largest Populated City
Cluster Key
HH High-High Cluster
HL High-Low Outlier
LH Low-High Outlier
LL Low-Low Cluster
NS Not Significant


Tennessee: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results
Economic Resilience
Resilience Legend
Good
Bad
HH
HL
NS
LH
LL
Economic Vulnerability
Vulnerability Legend
Good
Bad
LL
LH
NS
HL
HH
County Population Density
Urban
Mixed Urban
Rural
Mixed Rural
State Capital
Largest Populated City
0
35
70
140 Miles
N
Cluster Key
HH High-High Cluster
HL High-Low Outlier
LH Low-High Outlier
LL Low-Low Cluster
NS Not Significant


Tennessee: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results
Environmental Resilience
Resilience Legend
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Bad
HH
HL
NS
LH
LL
Environmental Vulnerability
Vulnerability Legend
Good
Bad
LL
LH
NS
HL
HH
County Population Density
Urban
Mixed Urban
Rural
Mixed Rural
State Capital
Largest Populated City
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140 Miles
N
Cluster Key
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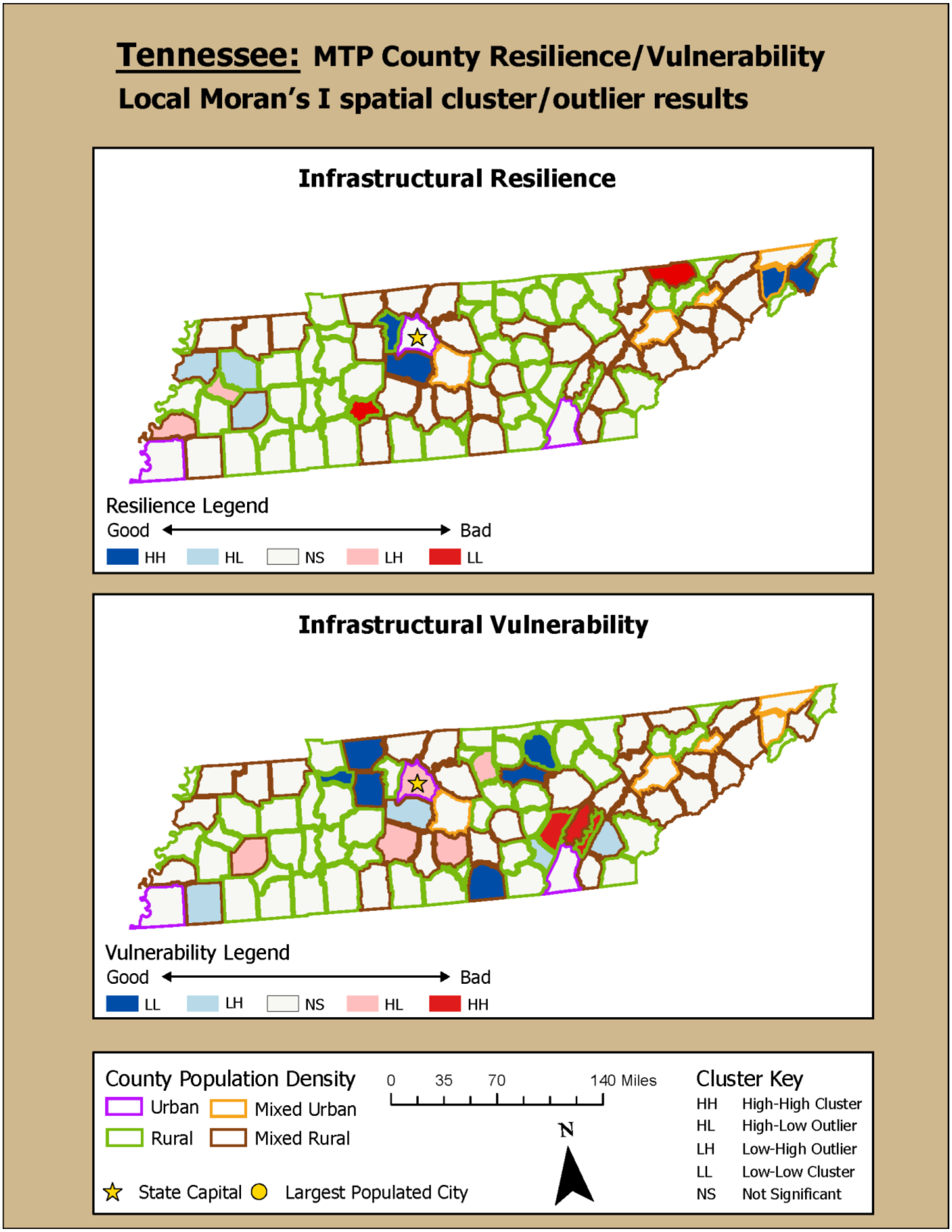
HL High-Low Outlier
LH Low-High Outlier
LL Low-Low Cluster
NS Not Significant


Tennessee: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results
Infrastructural Resilience
Resilience Legend
Good
Bad
HH
HL
NS
LH
LL
Infrastructural Vulnerability
Vulnerability Legend
Good
Bad
LL
LH
NS
HL
HH
County Population Density
Urban
Mixed Urban
Rural
Mixed Rural
State Capital
Largest Populated City
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140 Miles
N
Cluster Key
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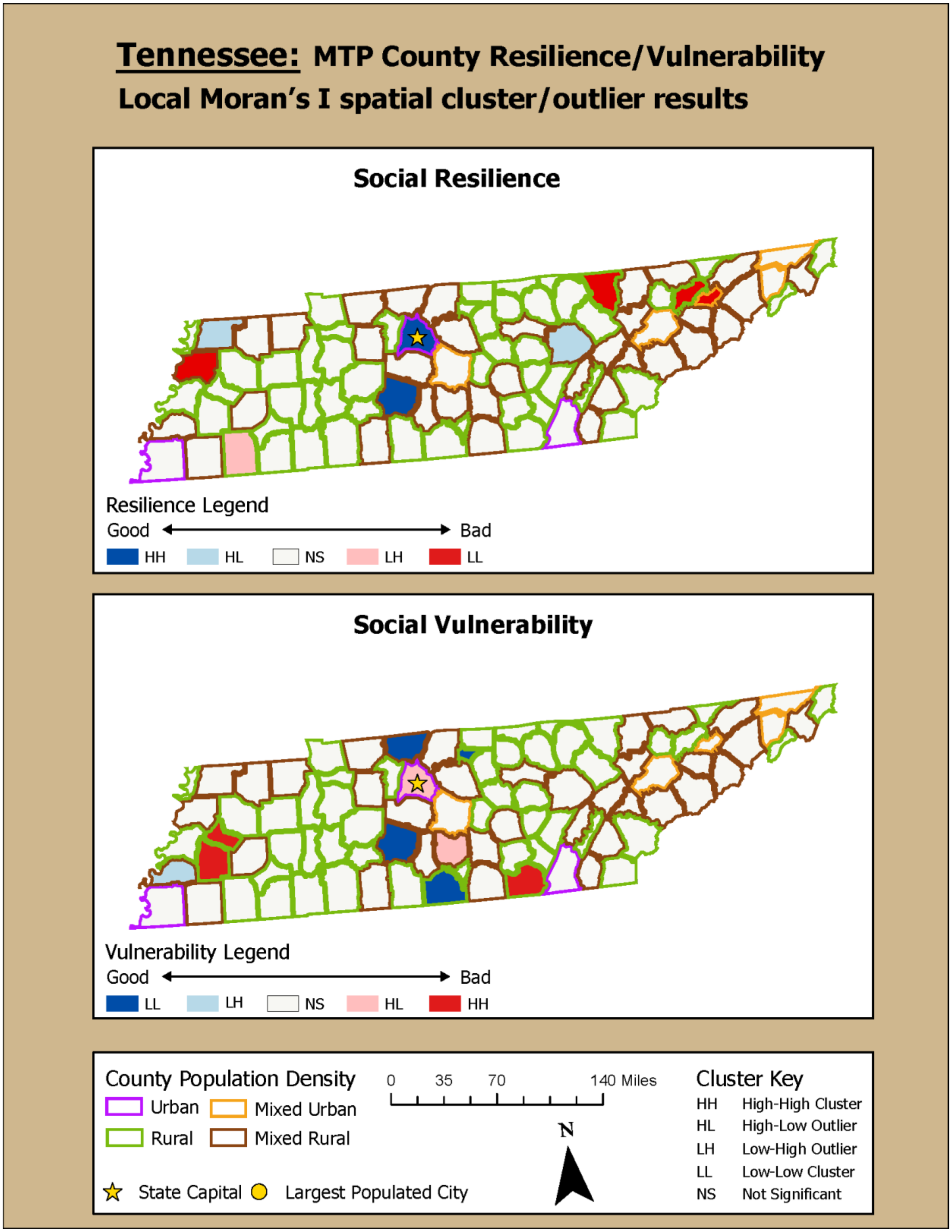
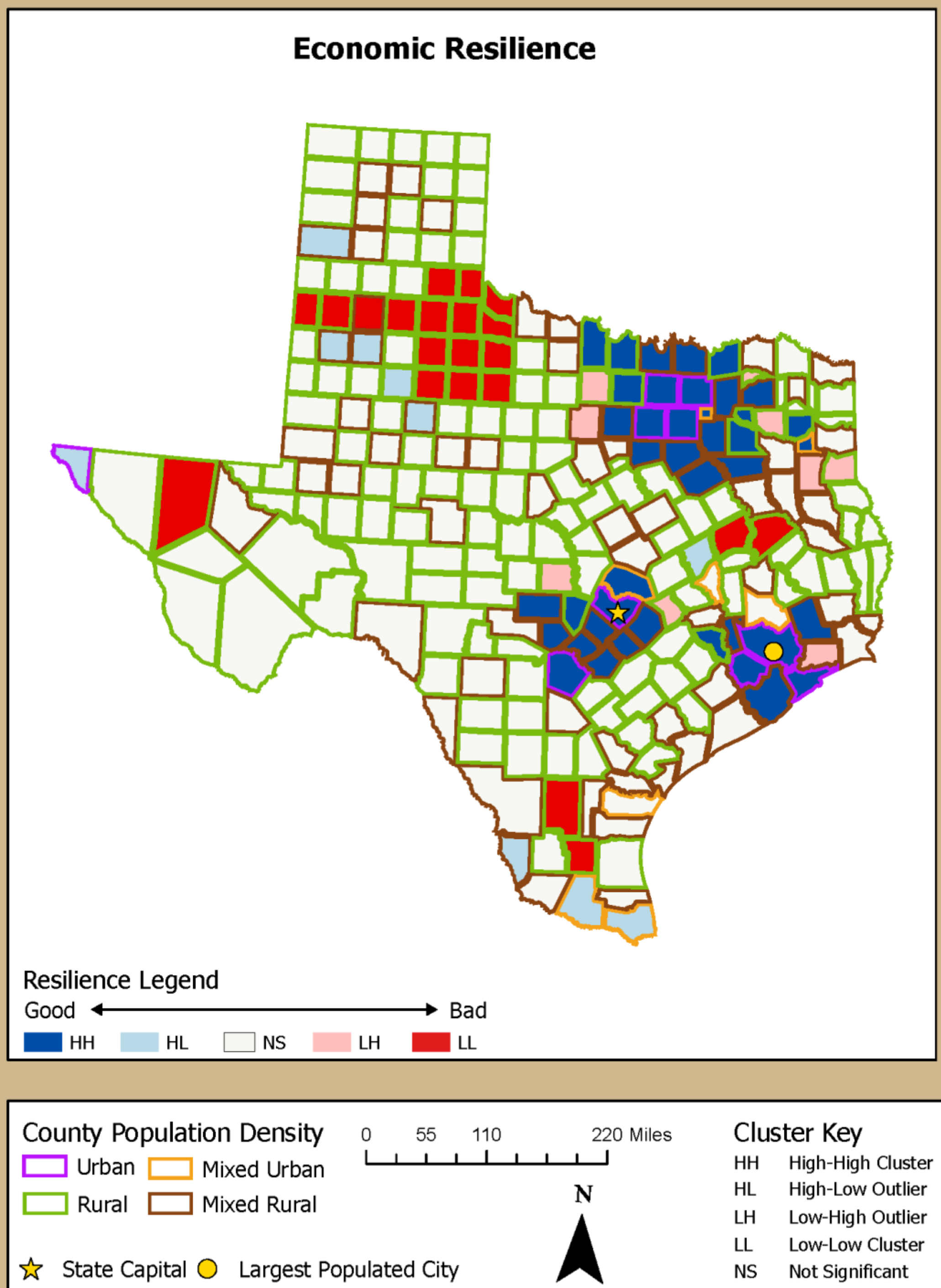
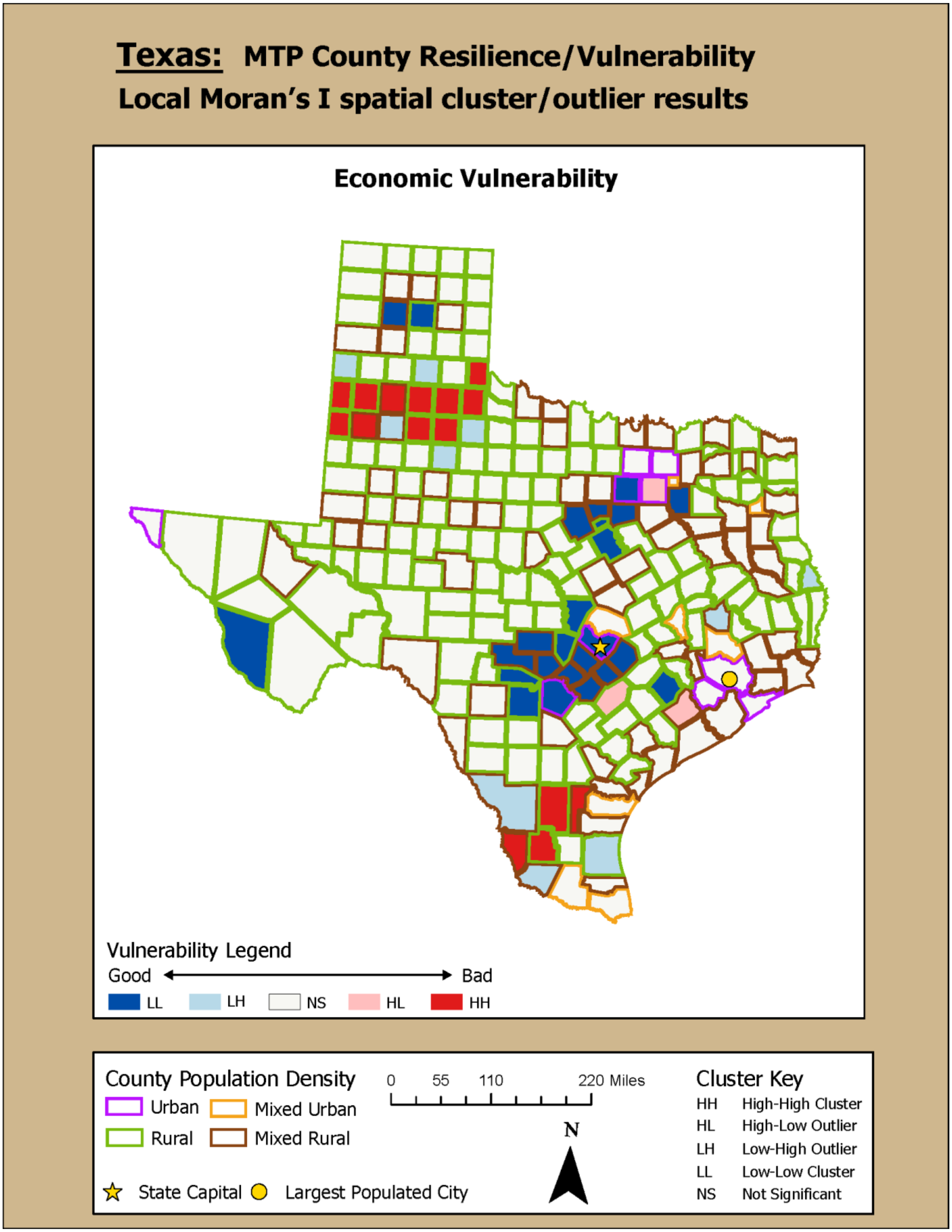
HL High-Low Outlier
LH Low-High Outlier
LL Low-Low Cluster
NS Not Significant


Tennessee: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results
Social Resilience
Resilience Legend
Good
Bad
HH
HL
NS
LH
LL
Social Vulnerability
Vulnerability Legend
Good
Bad
LL
LH
NS
HL
HH
County Population Density
Urban
Mixed Urban
Rural
Mixed Rural
State Capital
Largest Populated City
0
35
70
140 Miles
N
Cluster Key
HH High-High Cluster
HL High-Low Outlier
LH Low-High Outlier
LL Low-Low Cluster
NS Not Significant

Texas: MTP County Resilience/Vulnerability

Local Moran's I spatial cluster/outlier results





Texas: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results
Economic Vulnerability
Vulnerability Legend
Good
Bad
LL
LH
NS
HL
HH
County Population Density
Urban
Mixed Urban
Rural
Mixed Rural
State Capital
Largest Populated City
0
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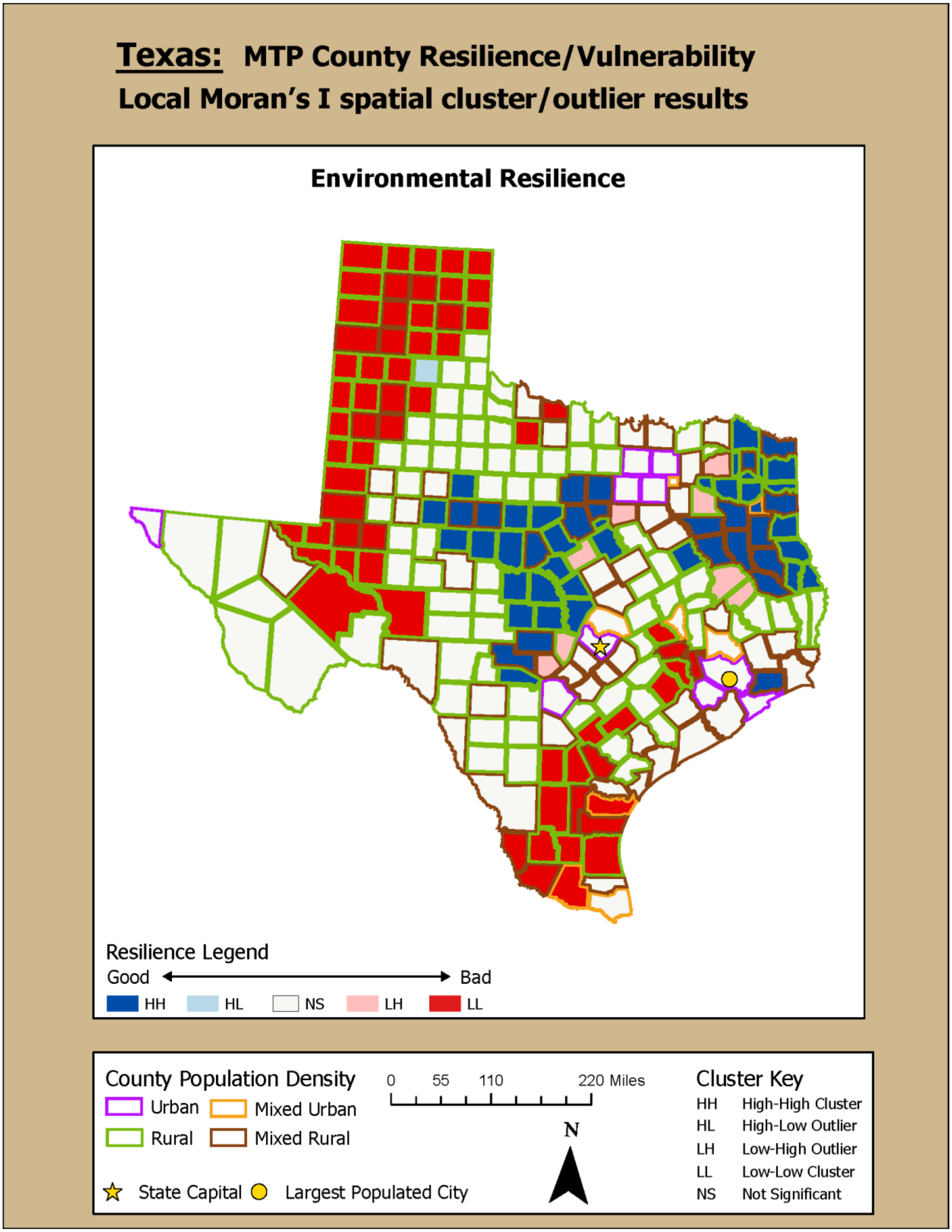
110
220 Miles
N
Cluster Key
HH High-High Cluster
HL High-Low Outlier
LH Low-High Outlier
LL Low-Low Cluster
NS Not Significant


Texas: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results
Environmental Resilience
Resilience Legend
Good
Bad
HH
HL
NS
LH
LL
County Population Density
Urban
Mixed Urban
Rural
Mixed Rural
State Capital
Largest Populated City
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220 Miles
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Cluster Key
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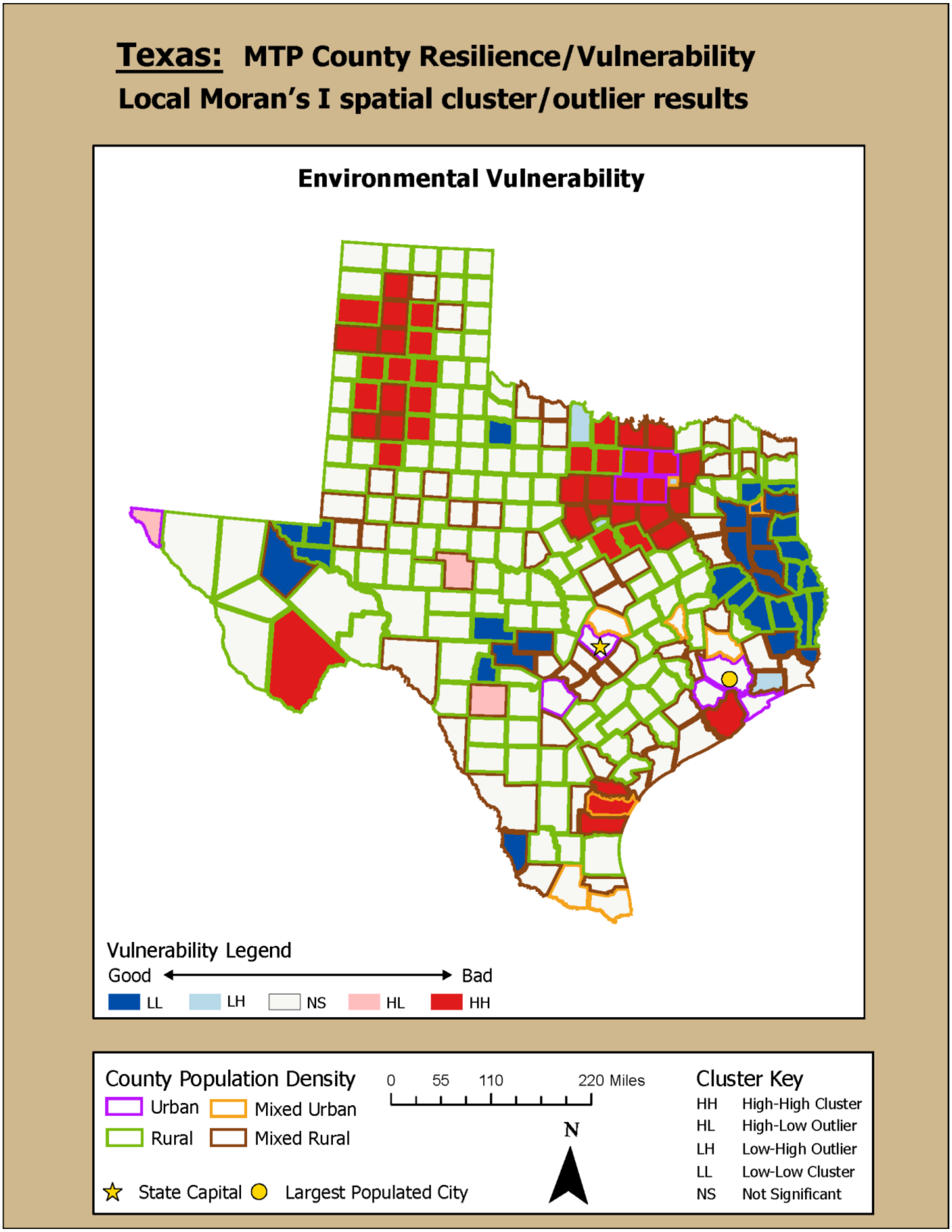
HL High-Low Outlier
LH Low-High Outlier
LL Low-Low Cluster
NS Not Significant


Texas: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results
Environmental Vulnerability
Vulnerability Legend
Good
Bad
LL
LH
NS
HL
HH
County Population Density
Urban
Mixed Urban
Rural
Mixed Rural
State Capital
Largest Populated City
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Cluster Key
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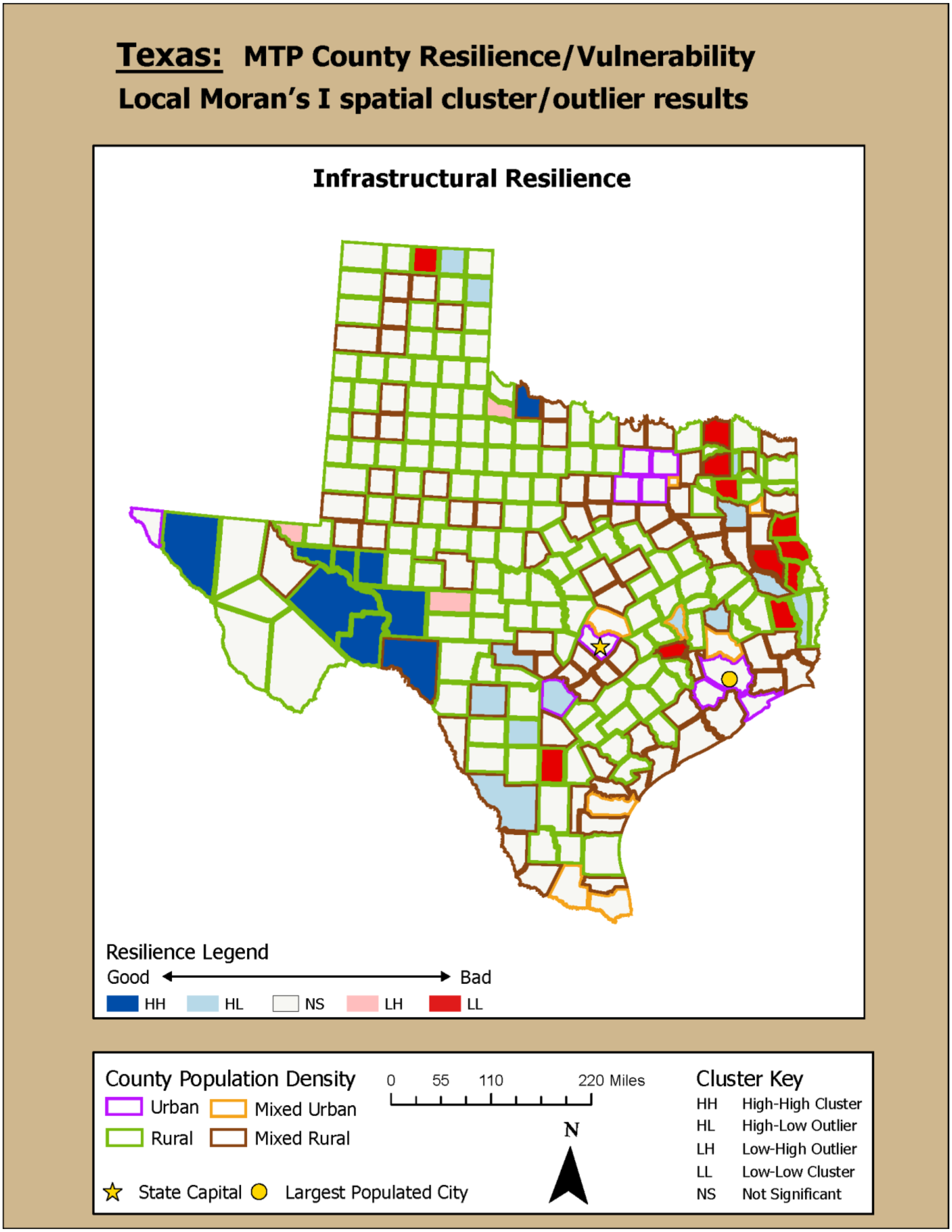
LH Low-High Outlier
LL Low-Low Cluster
NS Not Significant


Texas: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results
Infrastructural Resilience
Resilience Legend
Good
Bad
HH
HL
NS
LH
LL
County Population Density
Urban
Mixed Urban
Rural
Mixed Rural
State Capital
Largest Populated City
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Cluster Key
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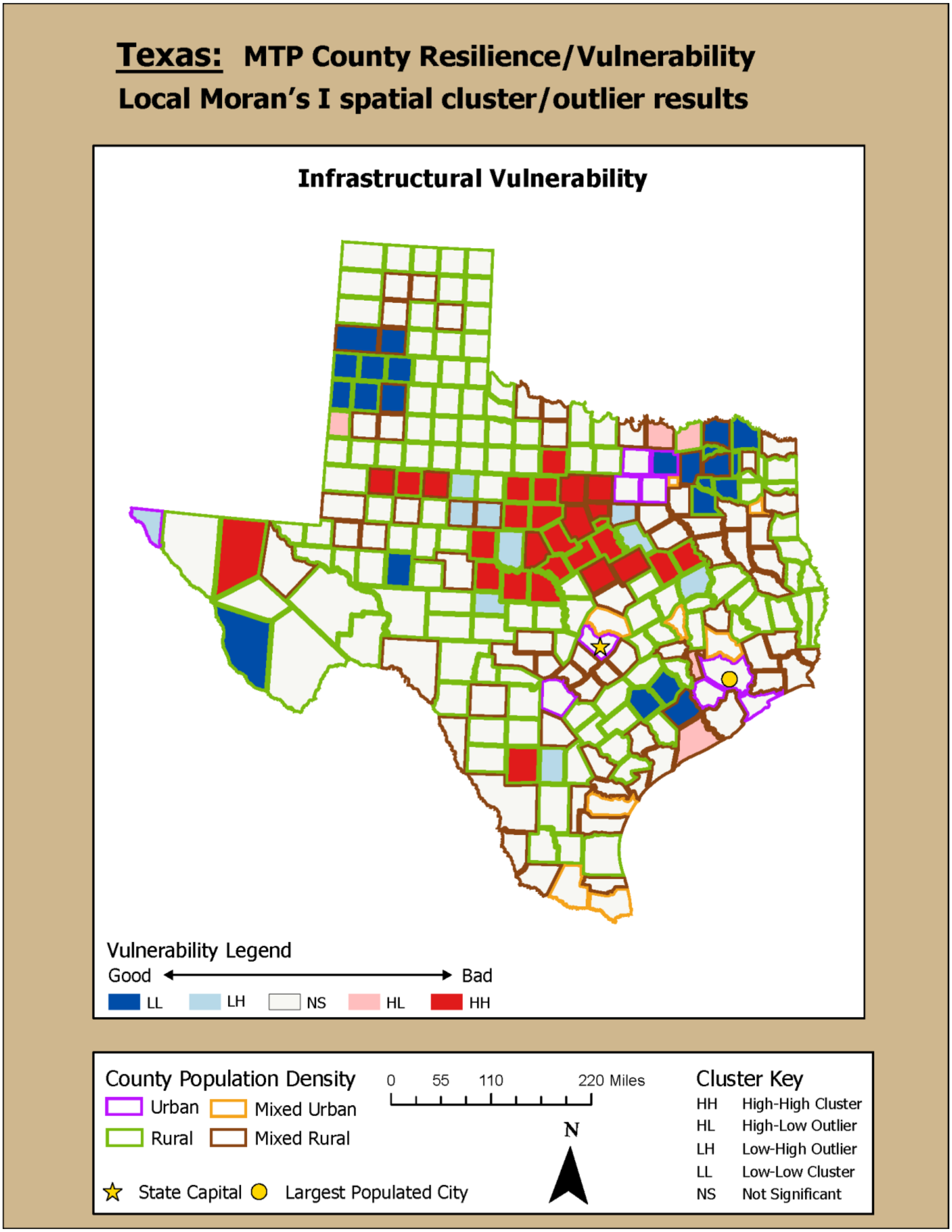
LL Low-Low Cluster
NS Not Significant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Local Moran's I spatial cluster/outlier results
Infrastructural Vulnerability
Vulnerability Legend
Good
Bad
LL
LH
NS
HL
HH
County Population Density
Urban
Mixed Urban
Rural
Mixed Rural
0
55
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Largest Populated City
Cluster Key
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HL High-Low Outlier
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LL Low-Low Cluster
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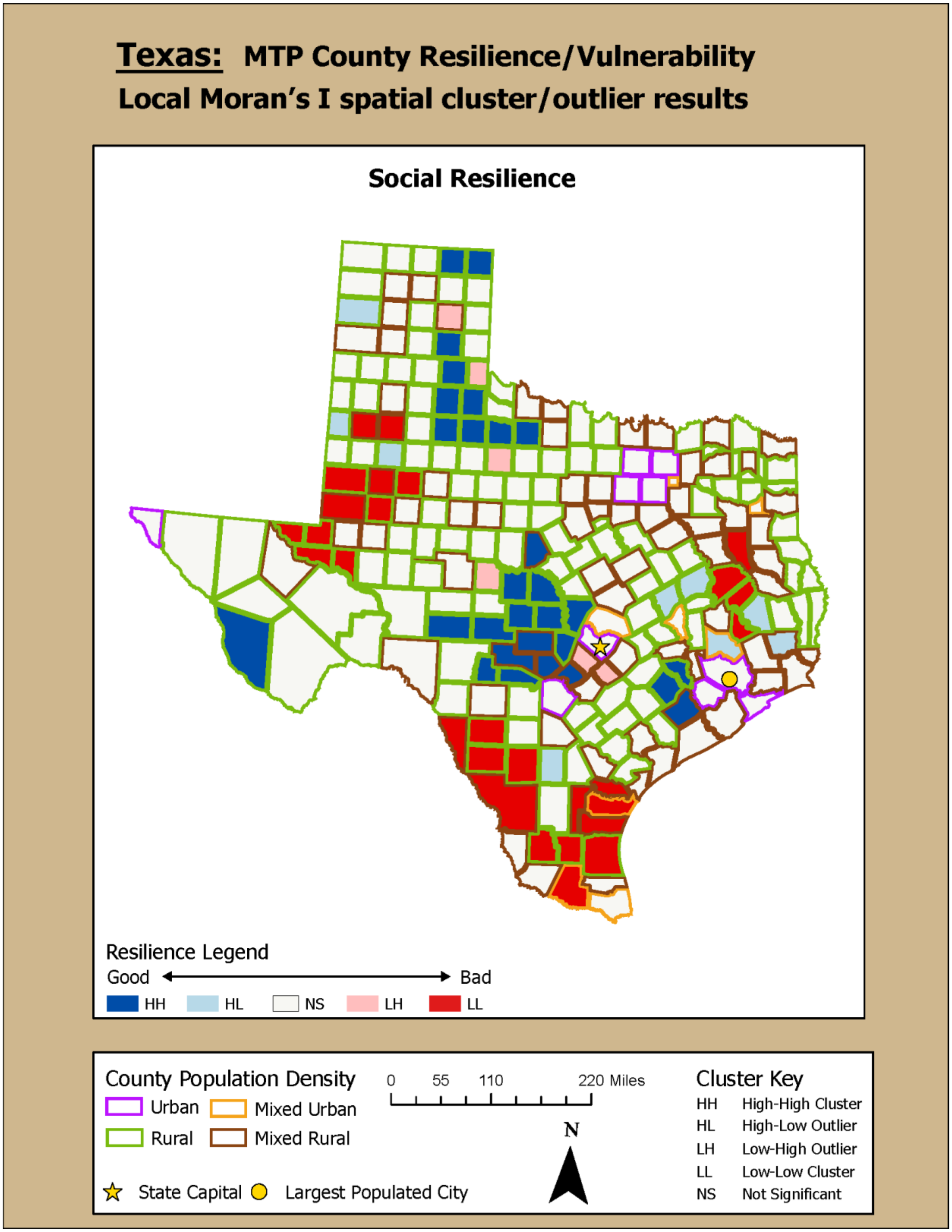
Texas: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results
Social Resilience
Resilience Legend
Good
Bad
HH
HL
NS
LH
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County Population Density
Urban
Mixed Urban
Rural
Mixed Rural
0
55
110
220 Miles
N
State Capital
Largest Populated City
Cluster Key
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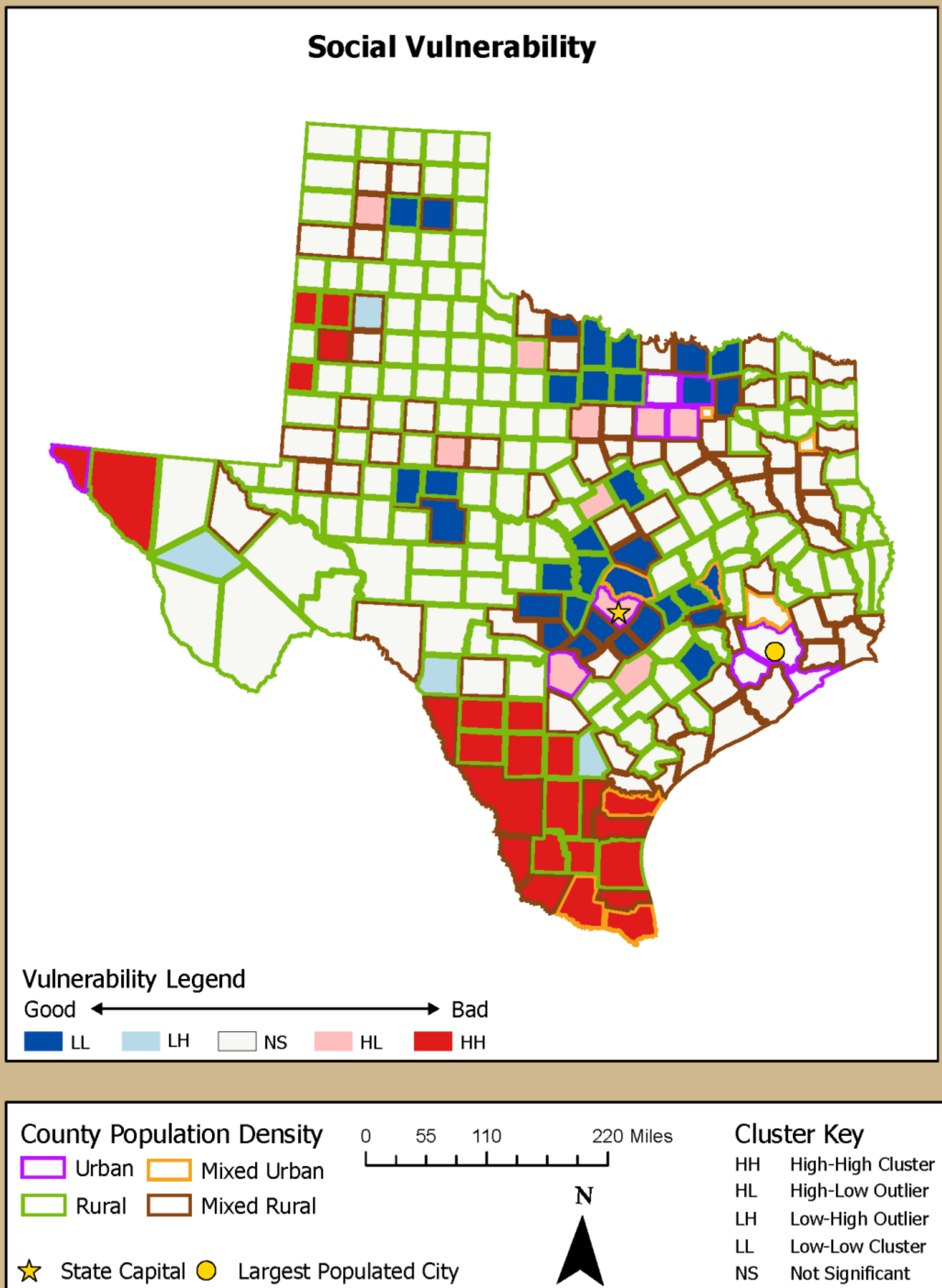
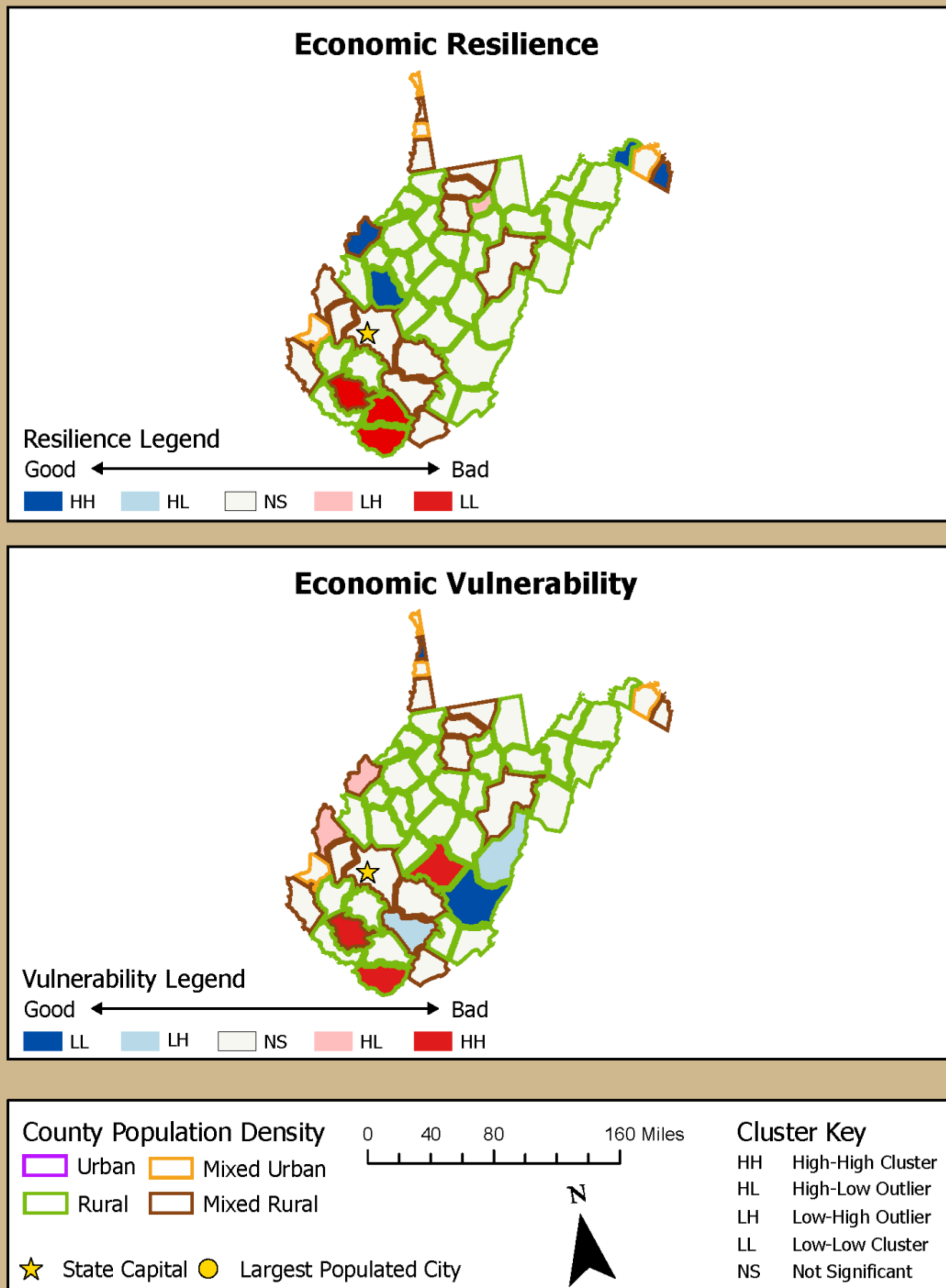
LH Low-High Outlier
LL Low-Low Cluster
NS Not Significant

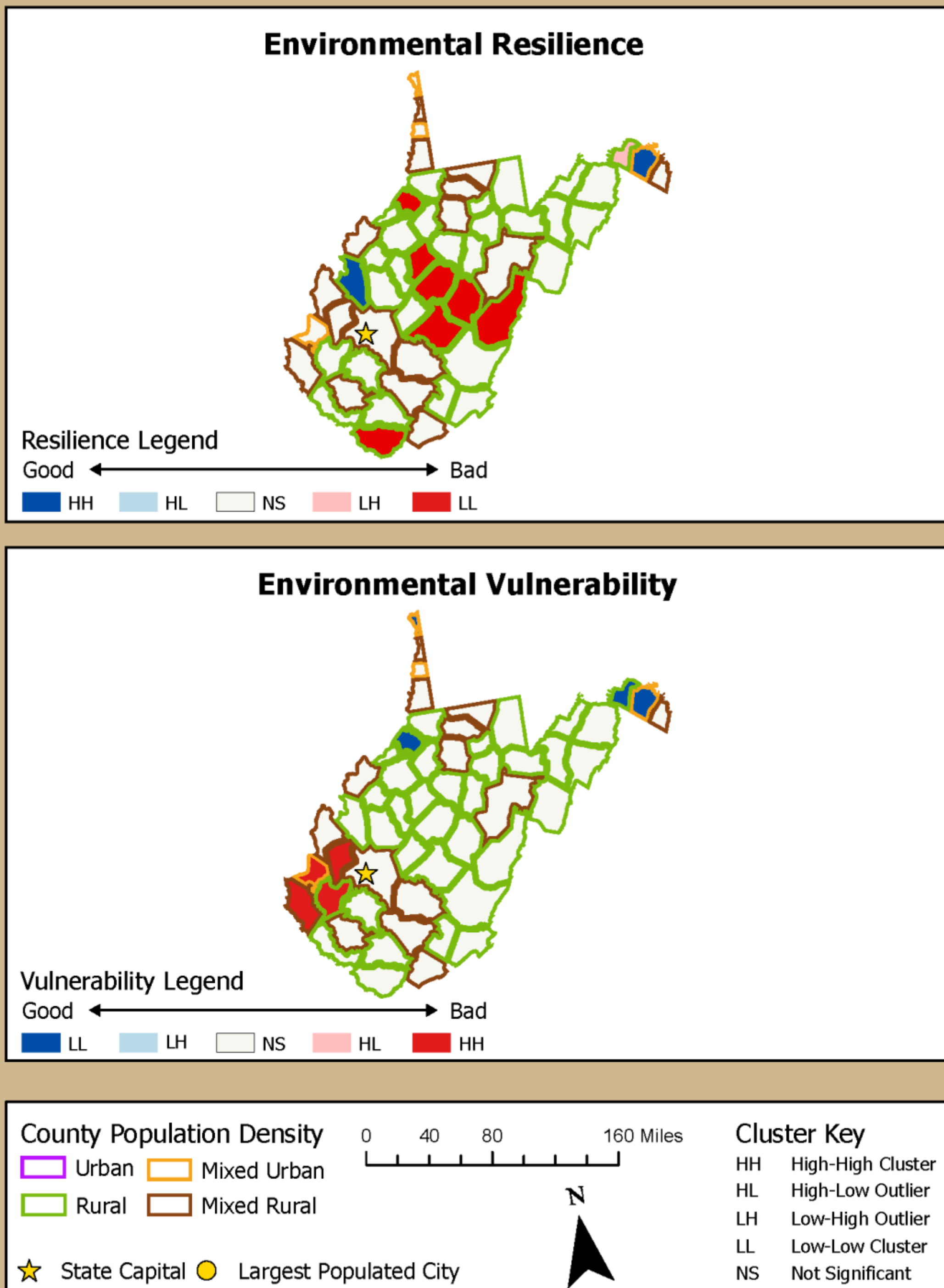
Texas: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results

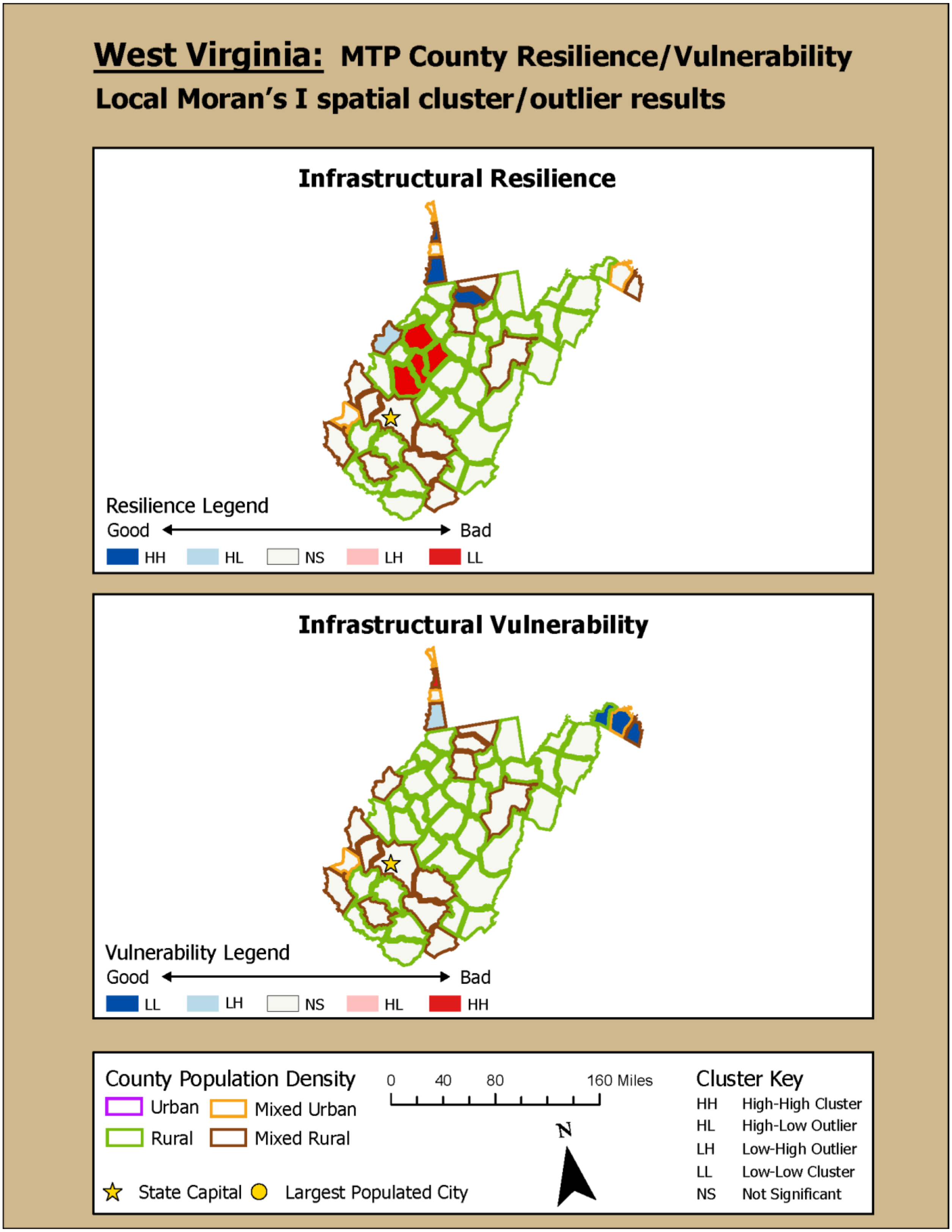


West Virginia: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results



West Virginia: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results




West Virginia: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results
Infrastructural Resilience
Resilience Legend
Good
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HH
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NS
LH
LL
Infrastructural Vulnerability
Vulnerability Legend
Good
Bad
LL
LH
NS
HL
HH
County Population Density
Urban
Mixed Urban
Rural
Mixed Rural
State Capital
Largest Populated City
0
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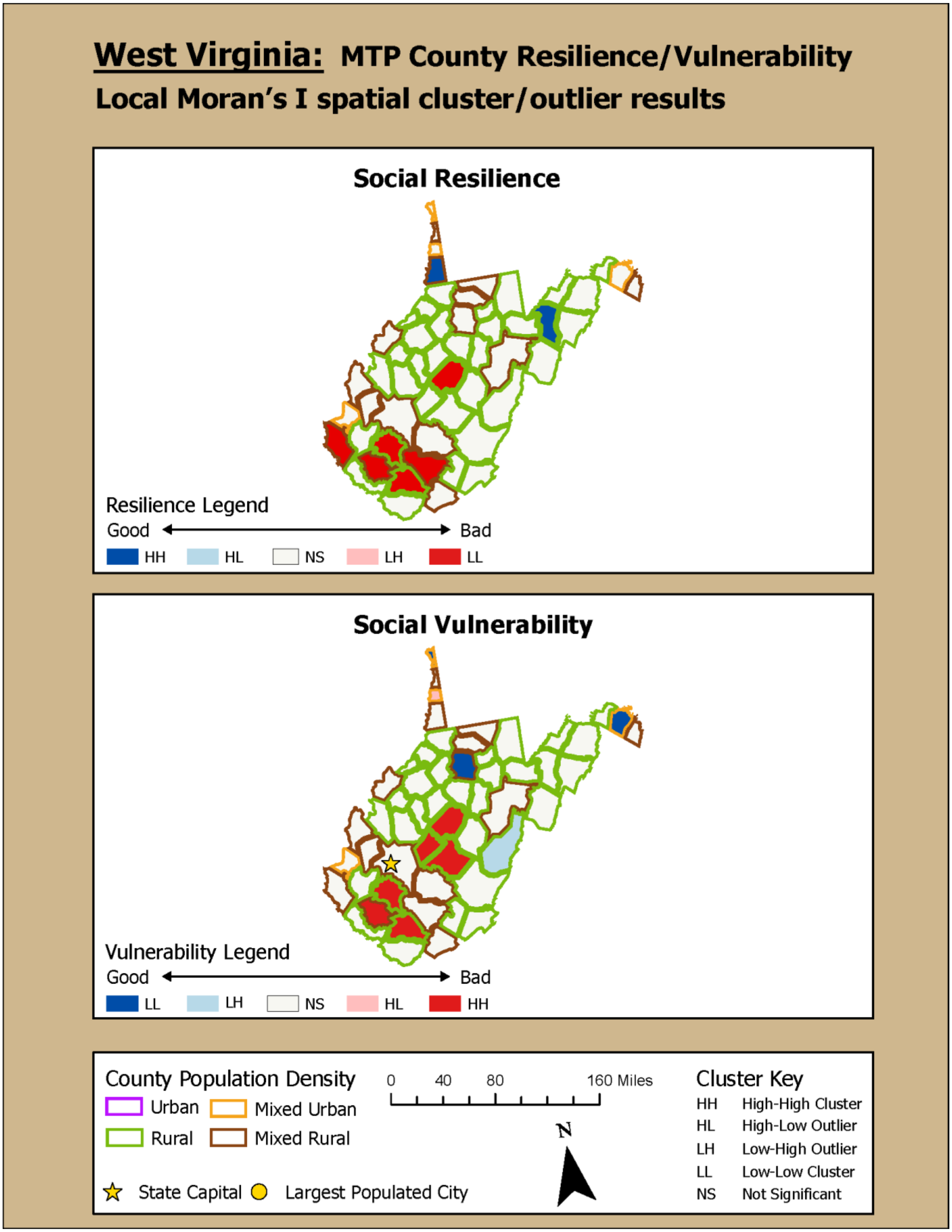
80
160 Miles
N
Cluster Key
HH High-High Cluster
HL High-Low Outlier
LH Low-High Outlier
LL Low-Low Cluster
NS Not Significant


West Virginia: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results
Social Resilience
Resilience Legend
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Social Vulnerability
Vulnerability Legend
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Bad
LL
LH
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HL
HH
County Population Density
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Mixed Urban
Rural
Mixed Rural
State Capital
Largest Populated City
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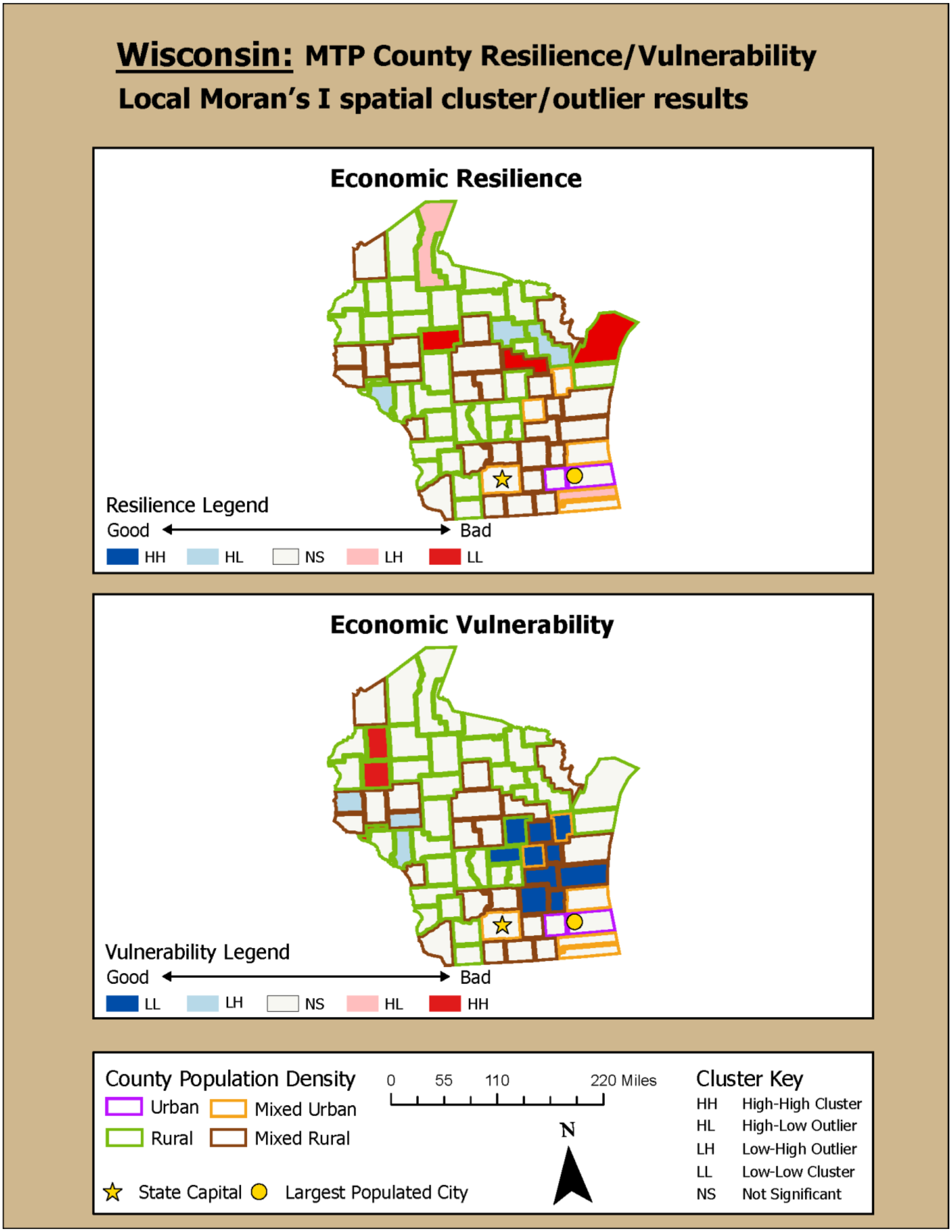
LL Low-Low Cluster
NS Not Significant


Wisconsin: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results
Economic Resilience
Resilience Legend
Good
Bad
HH
HL
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LH
LL
Economic Vulnerability
Vulnerability Legend
Good
Bad
LL
LH
NS
HL
HH
County Population Density
Urban
Mixed Urban
Rural
Mixed Rural
State Capital
Largest Populated City
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220 Miles
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Cluster Key
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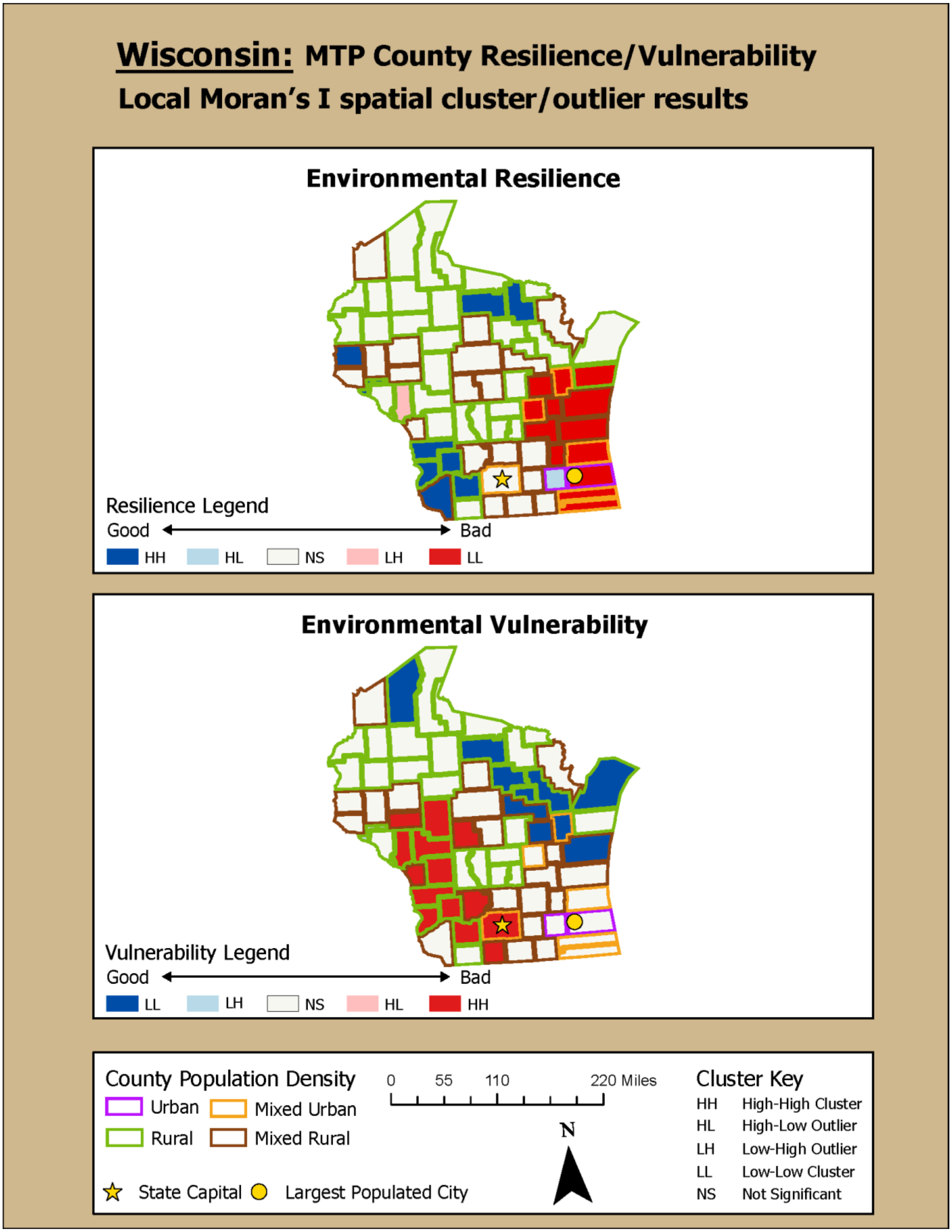
HL High-Low Outlier
LH Low-High Outlier
LL Low-Low Cluster
NS Not Significant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Local Moran's I spatial cluster/outlier results
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Resilience Legend
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Environmental Vulnerability
Vulnerability Legend
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Bad
LL
LH
NS
HL
HH
County Population Density
Urban
Mixed Urban
Rural
Mixed Rural
0
55
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220 Miles
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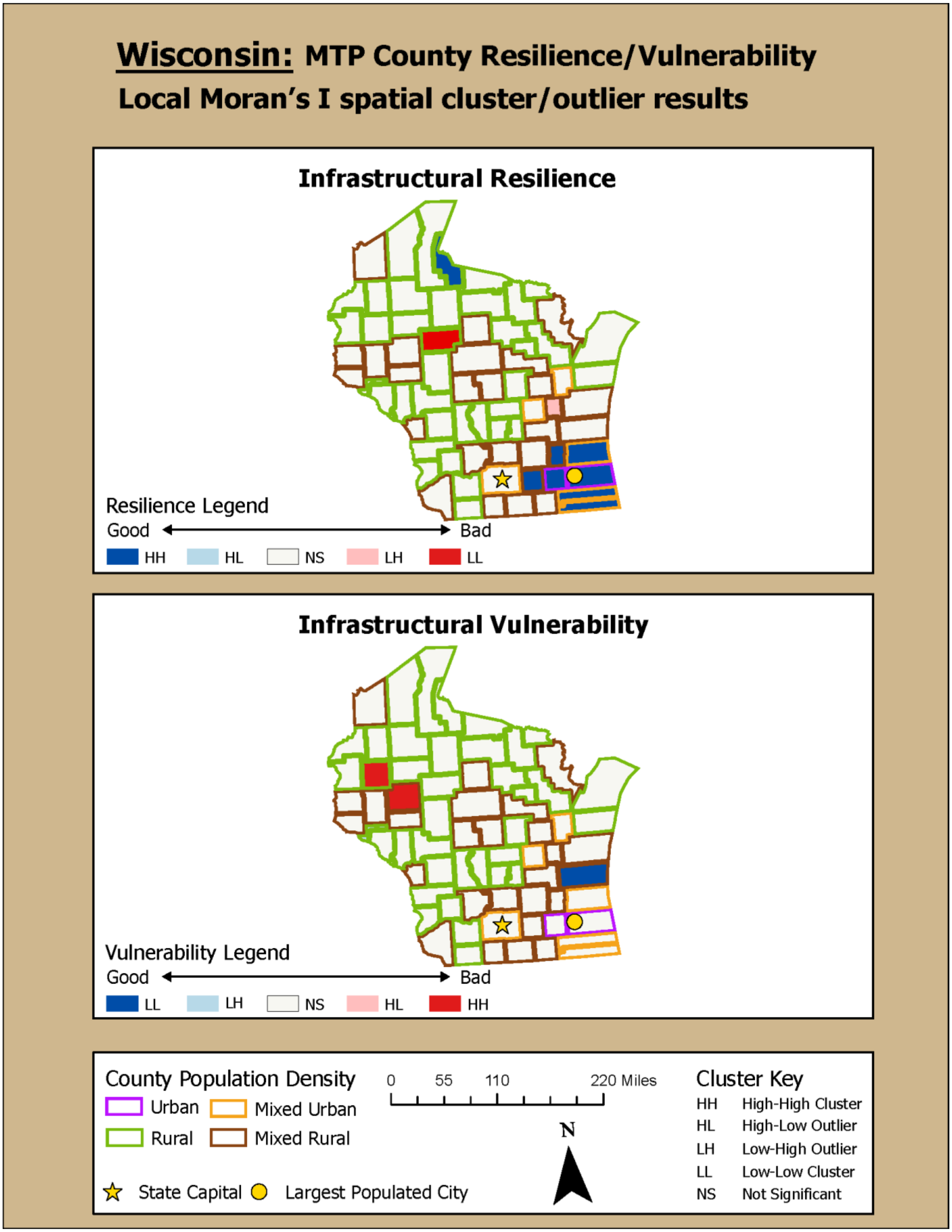
HL High-Low Outlier
LH Low-High Outlier
LL Low-Low Cluster
NS Not Significant
State Capital
Largest Populated City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Local Moran's I spatial cluster/outlier results
Infrastructural Resilience
Resilience Legend
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LL
Infrastructural Vulnerability
Vulnerability Legend
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NS
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HH
County Population Density
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Mixed Urban
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Mixed Rural
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Largest Populated City
Cluster Key
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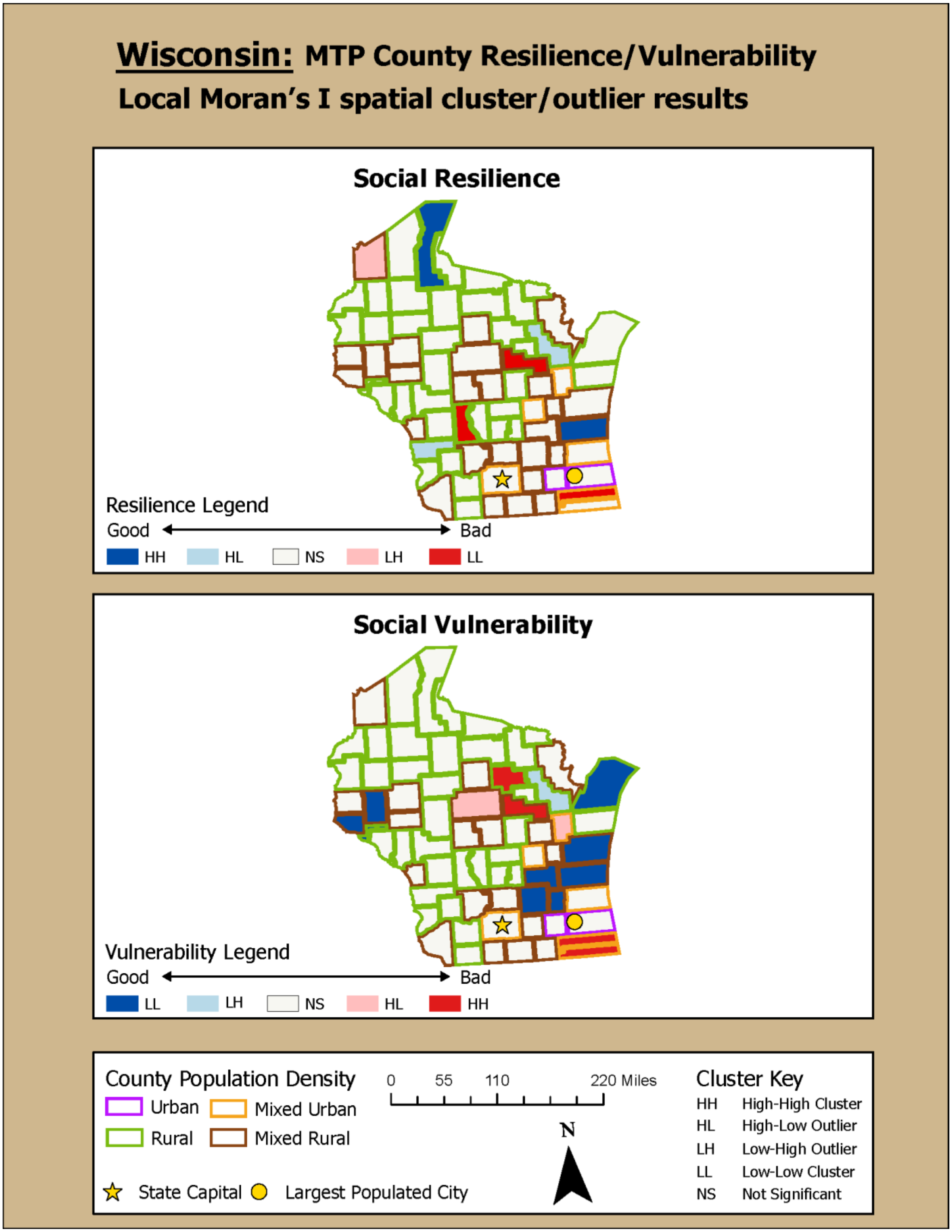
NS Not Significant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Local Moran's I spatial cluster/outlier results
Social Resilience
Resilience Legend
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Social Vulnerability
Vulnerability Legend
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LH
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HH
County Population Density
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Mixed Urban
Rural
Mixed Rural
State Capital
Largest Populated City
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LL Low-Low Cluster
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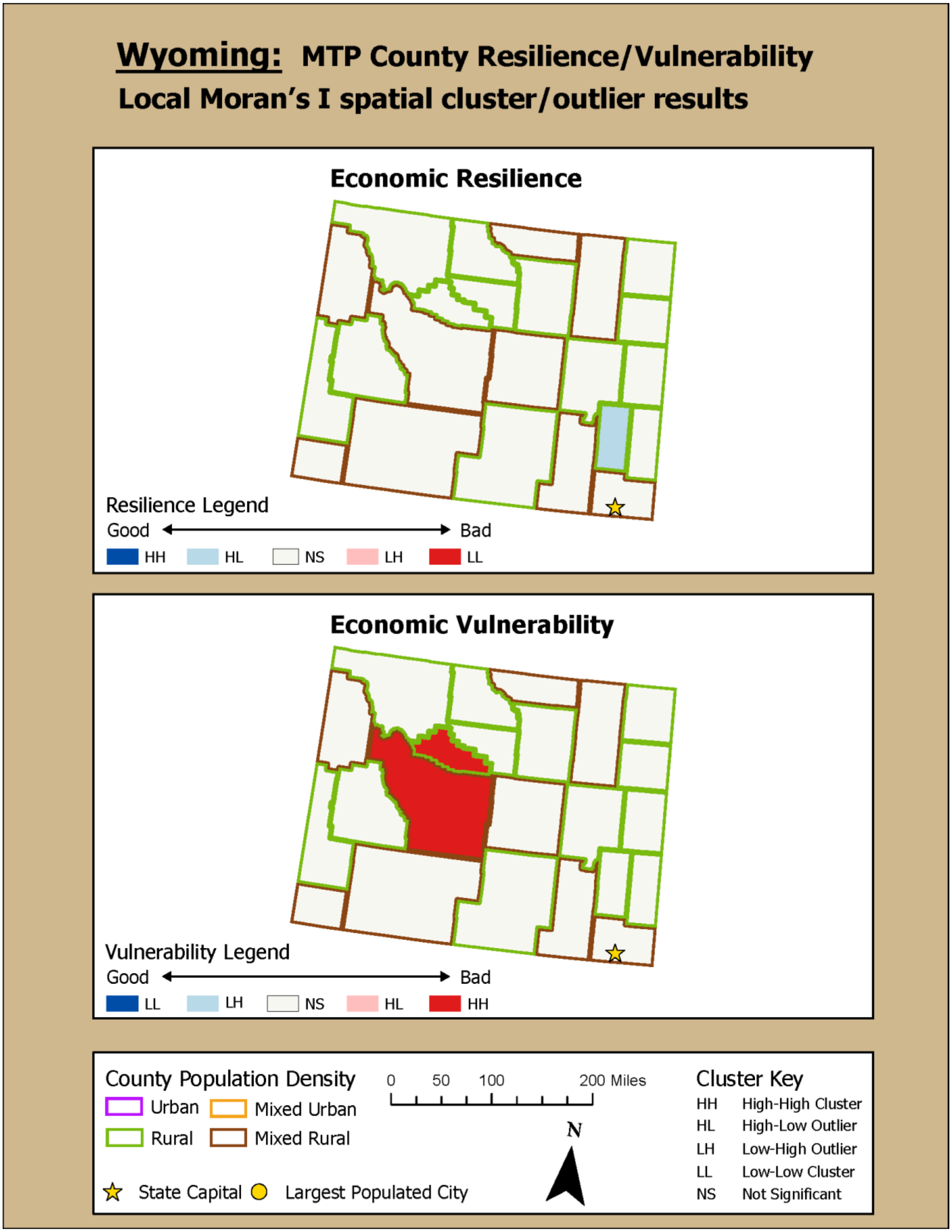
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Local Moran's I spatial cluster/outlier results
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Resilience Legend
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Economic Vulnerability
Vulnerability Legend
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Bad
LL
LH
NS
HL
HH
County Population Density
Urban
Mixed Urban
Rural
Mixed Rural
State Capital
Largest Populated City
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200 Miles
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Cluster Key
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HL High-Low Outlier
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LL Low-Low Cluster
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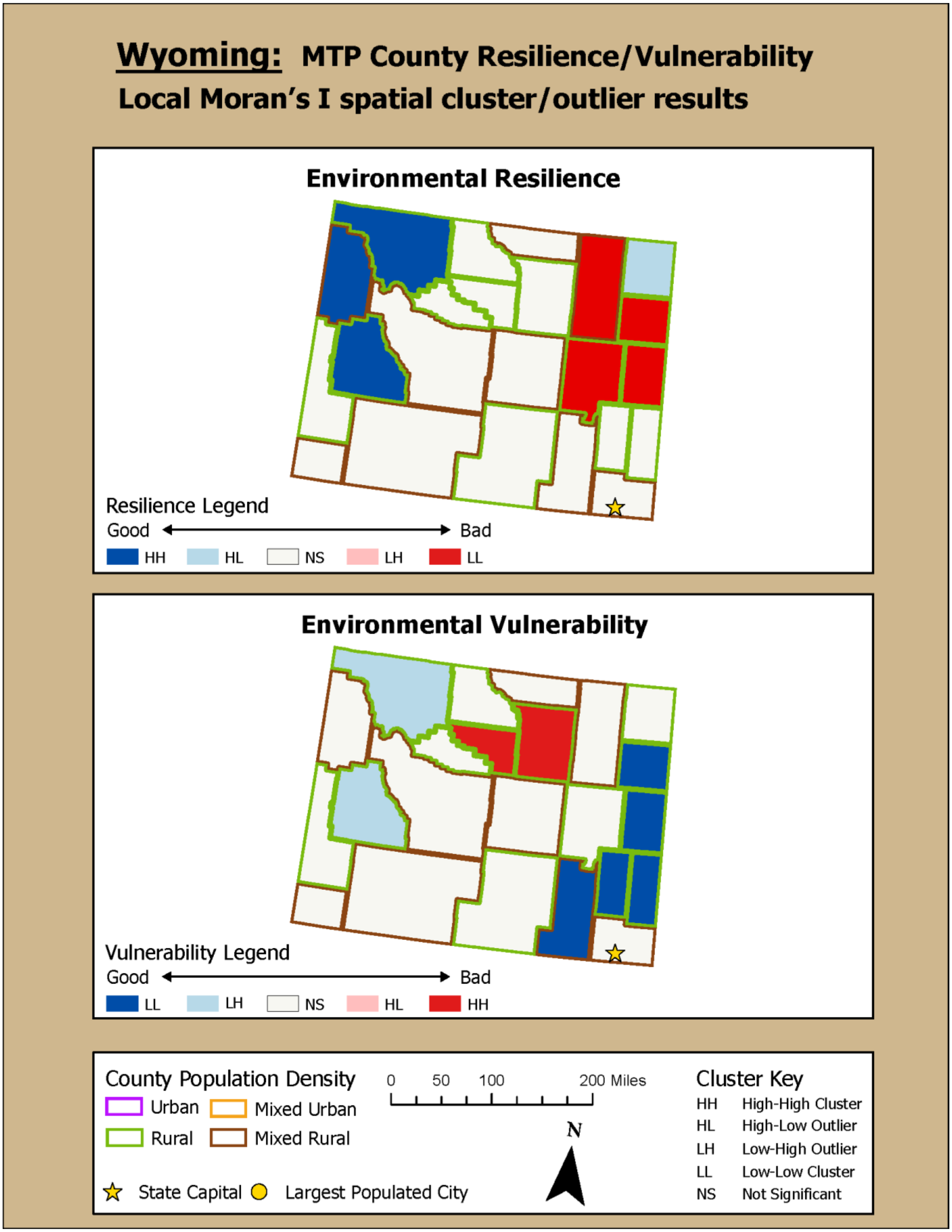
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Local Moran's I spatial cluster/outlier results
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Resilience Legend
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Environmental Vulnerability
Vulnerability Legend
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LL
LH
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HL
HH
County Population Density
Urban
Mixed Urban
Rural
Mixed Rural
State Capital
Largest Populated City
0
50
100
200 Miles
N
Cluster Key
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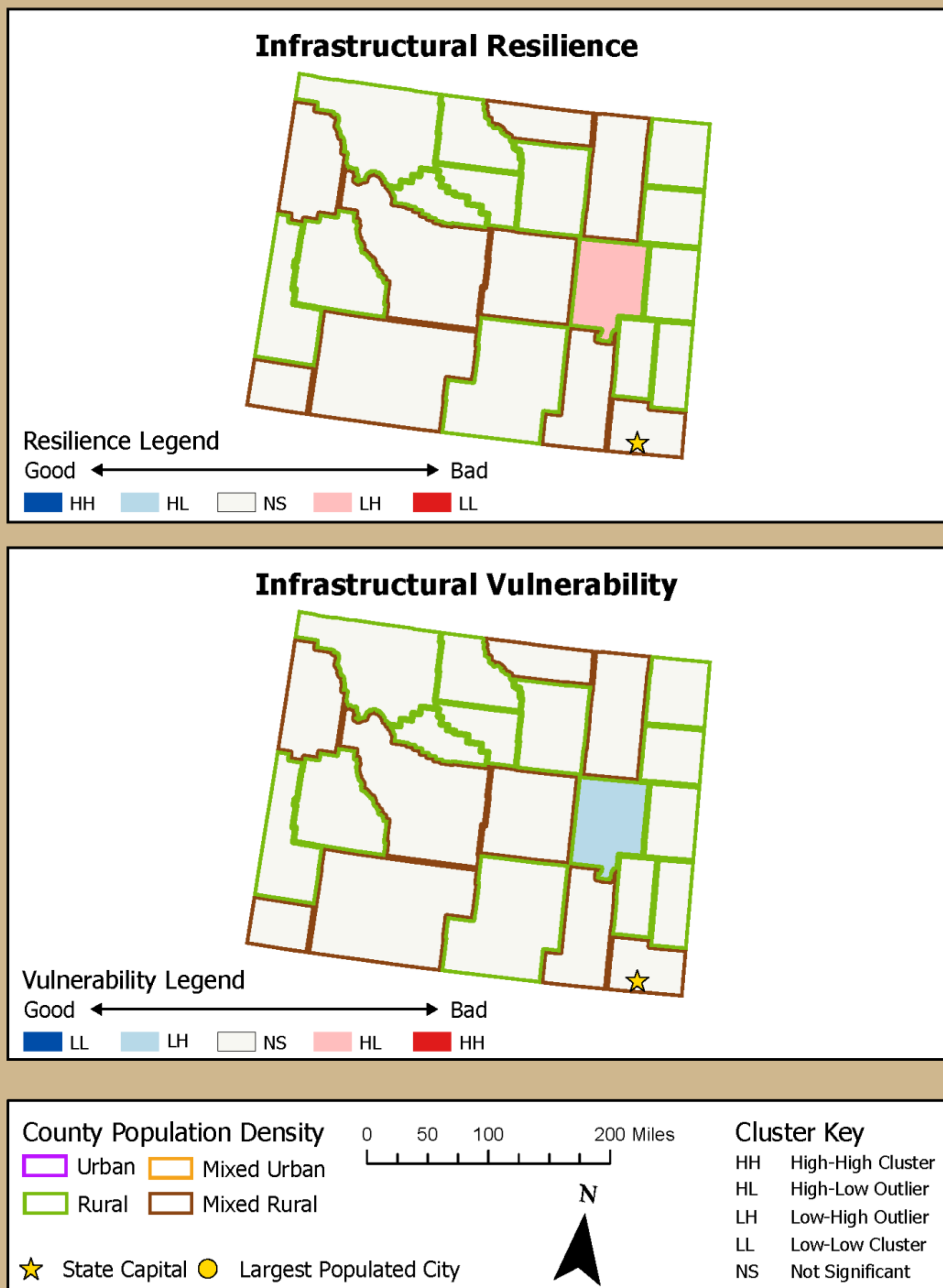
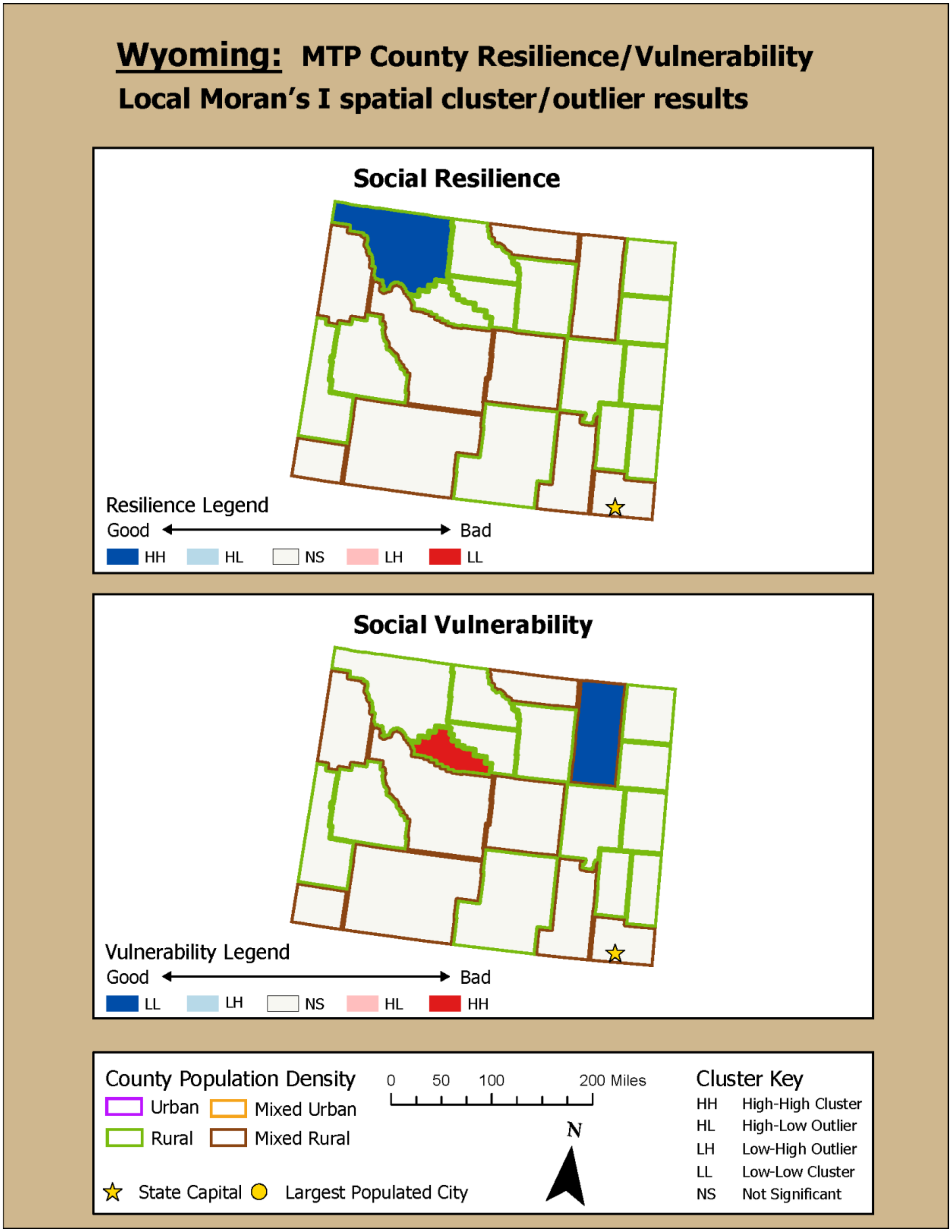
LL Low-Low Cluster
NS Not Significant

Wyoming: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results

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Local Moran's I spatial cluster/outlier results
Social Resilience
Resilience Legend
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LH
LL
Social Vulnerability
Vulnerability Legend
Good
Bad
LL
LH
NS
HL
HH
County Population Density
Urban
Mixed Urban
Rural
Mixed Rural
State Capital
Largest Populated City
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200 Miles
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Cluster Key
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HL High-Low Outlier
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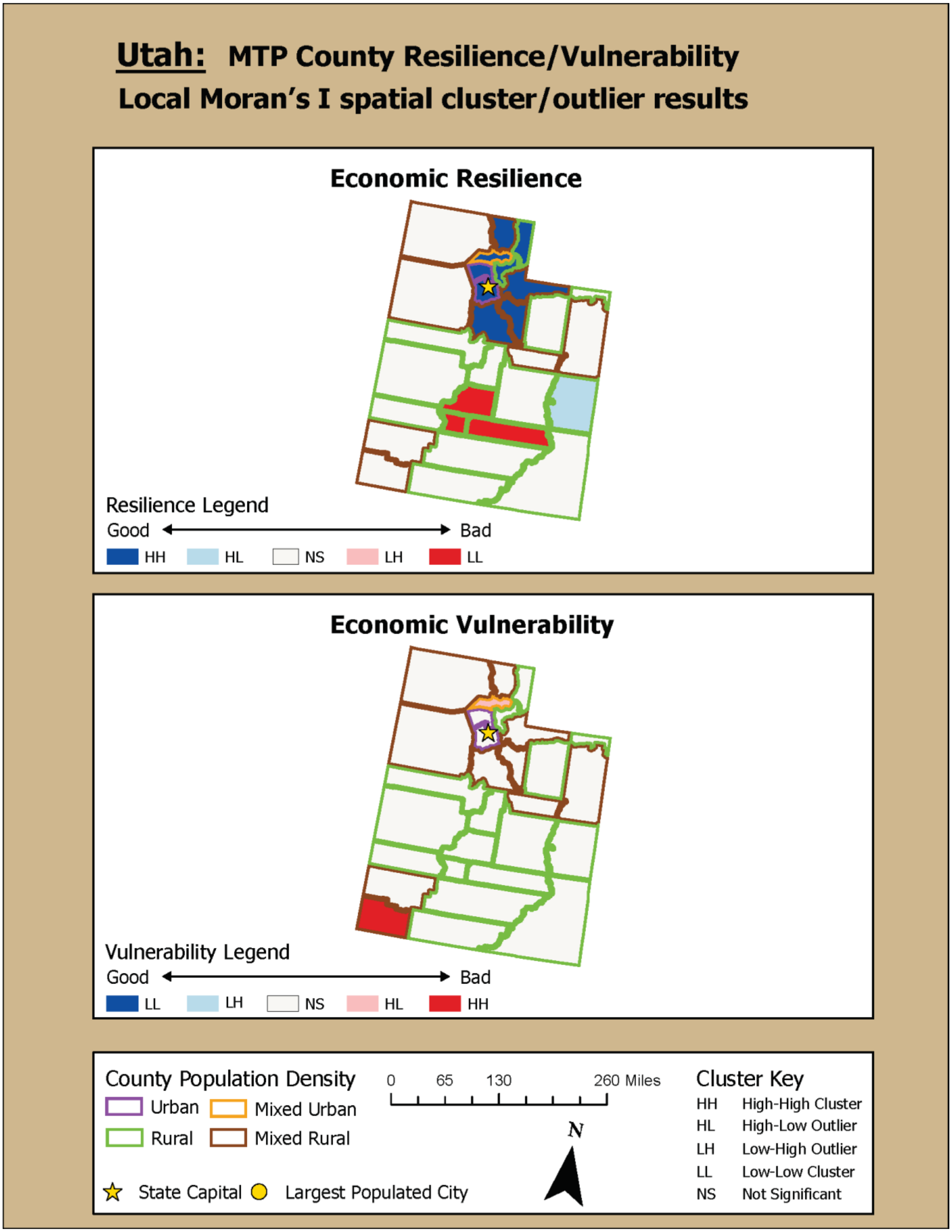
LL Low-Low Cluster
NS Not Significant


Utah: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results
Economic Resilience
Resilience Legend
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Bad
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HL
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LL
Economic Vulnerability
Vulnerability Legend
Good
Bad
LL
LH
NS
HL
HH
County Population Density
Urban
Mixed Urban
Rural
Mixed Rural
State Capital
Largest Populated City
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260 Miles
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Cluster Key
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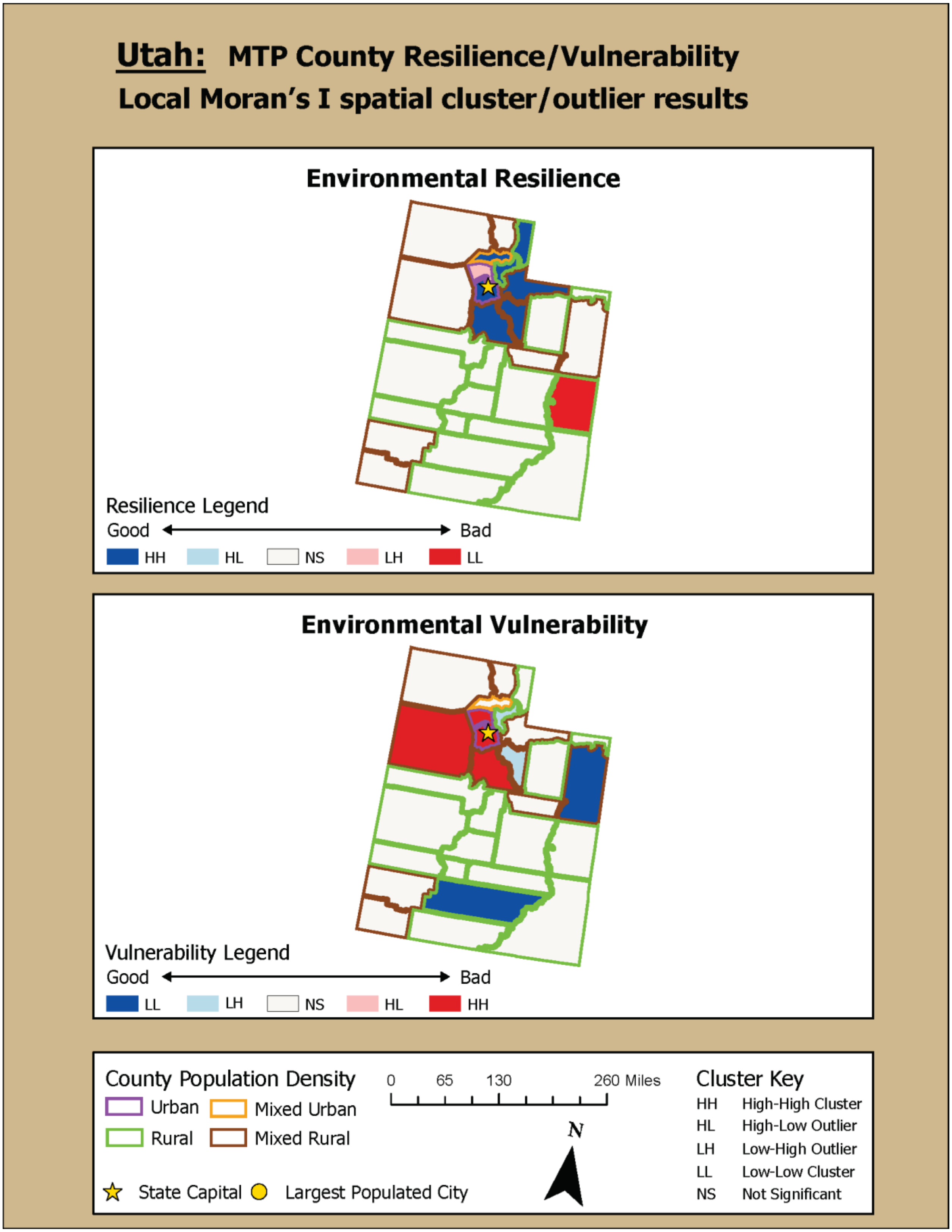
LH Low-High Outlier
LL Low-Low Cluster
NS Not Significant


Utah: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results
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Environmental Vulnerability
Vulnerability Legend
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Bad
LL
LH
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HH
County Population Density
Urban
Mixed Urban
Rural
Mixed Rural
State Capital
Largest Populated City
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65
130
260 Miles
N
Cluster Key
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LL Low-Low Cluster
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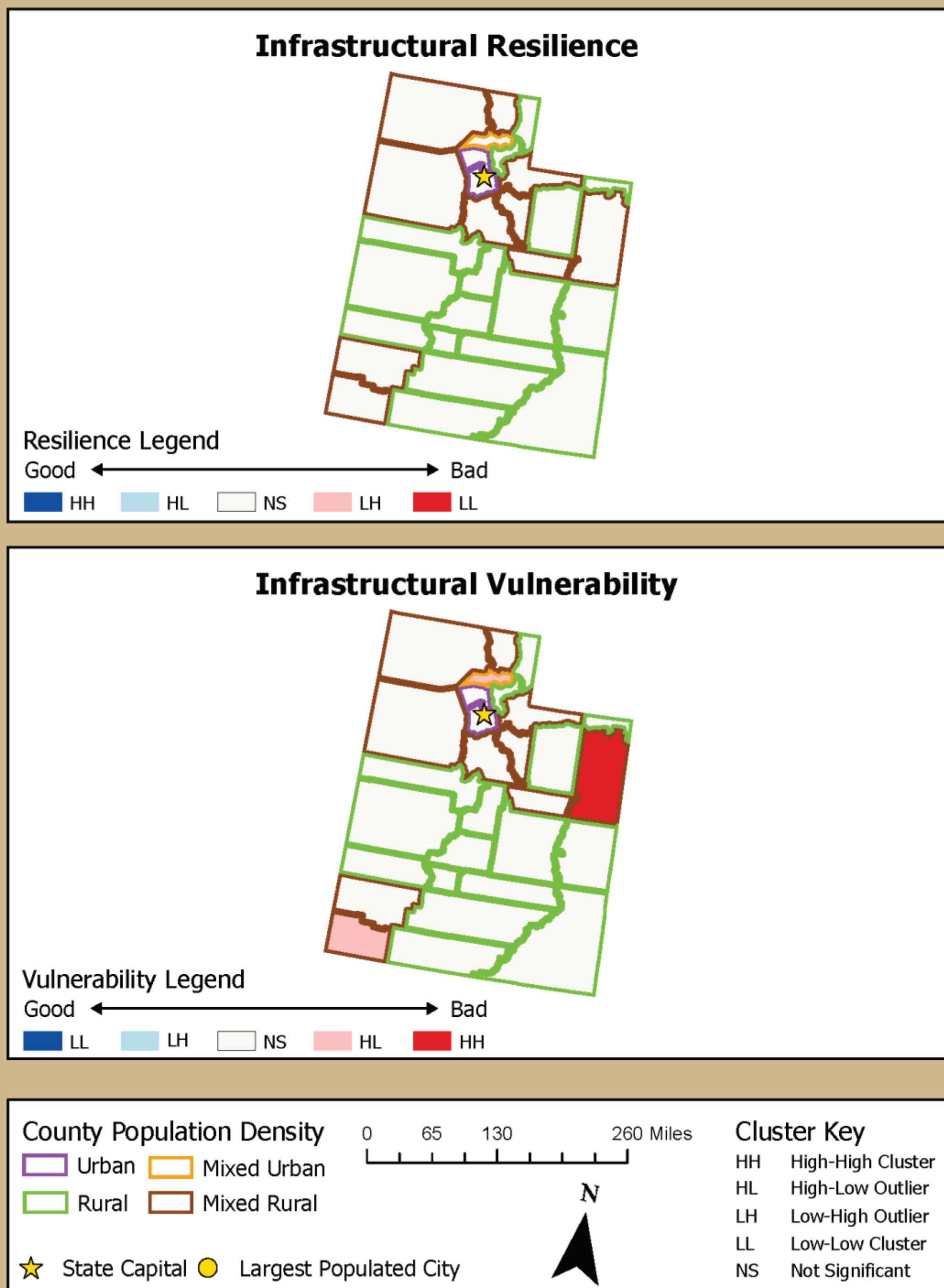
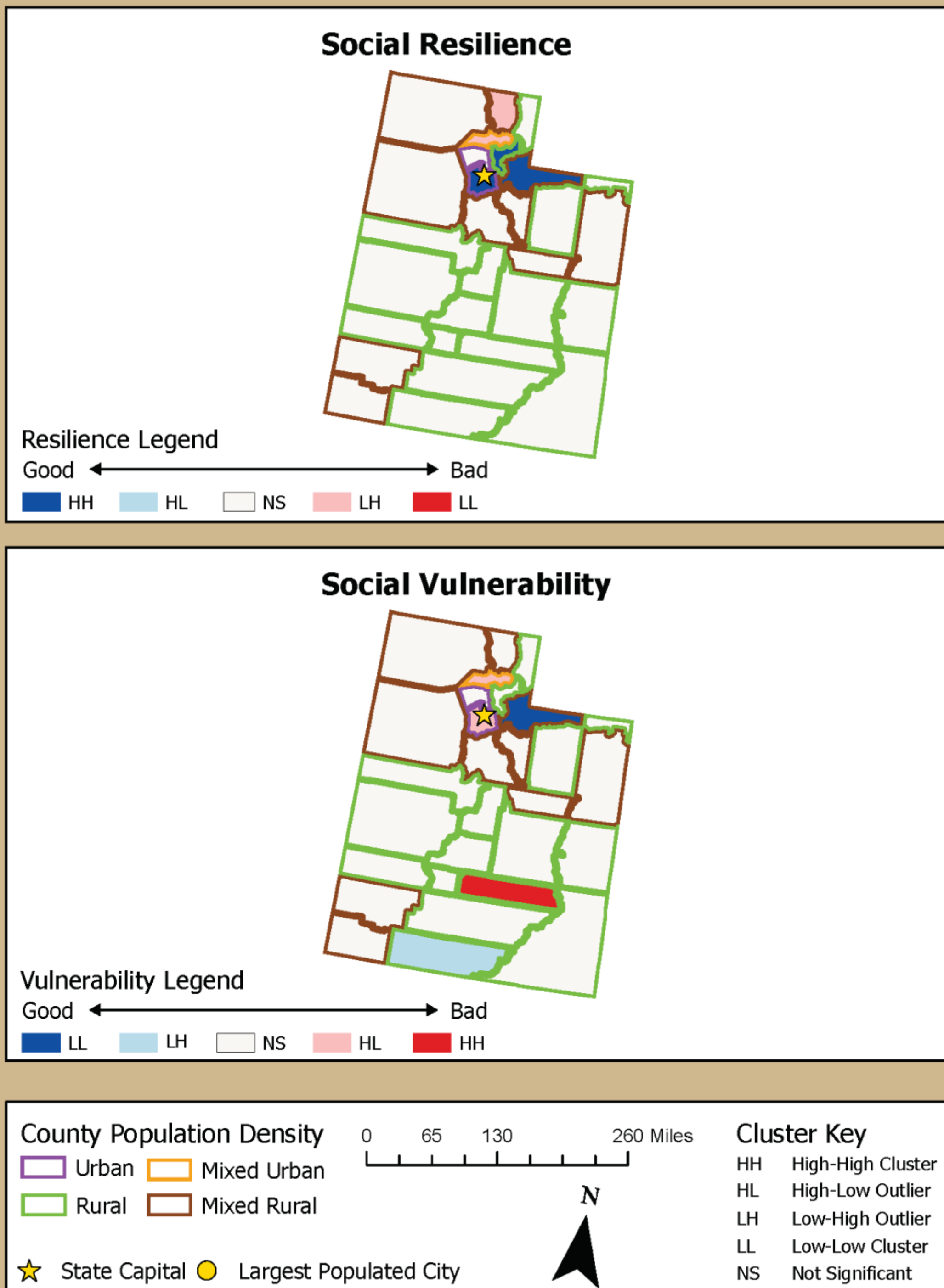
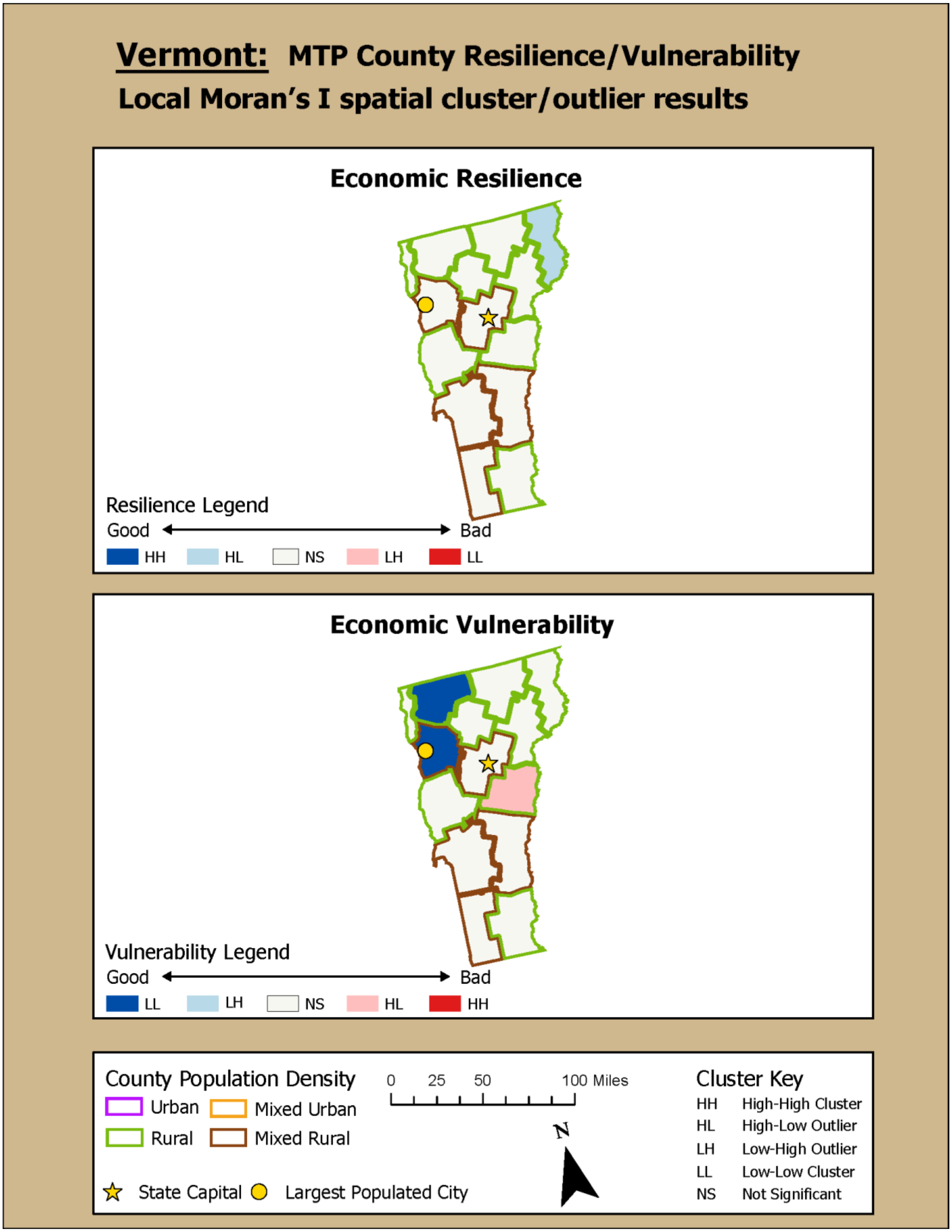
Utah: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results



Utah: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results




Vermont: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results
Economic Resilience
Resilience Legend
Good
Bad
HH
HL
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LH
LL
Economic Vulnerability
Vulnerability Legend
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Bad
LL
LH
NS
HL
HH
County Population Density
Urban
Mixed Urban
Rural
Mixed Rural
State Capital
Largest Populated City
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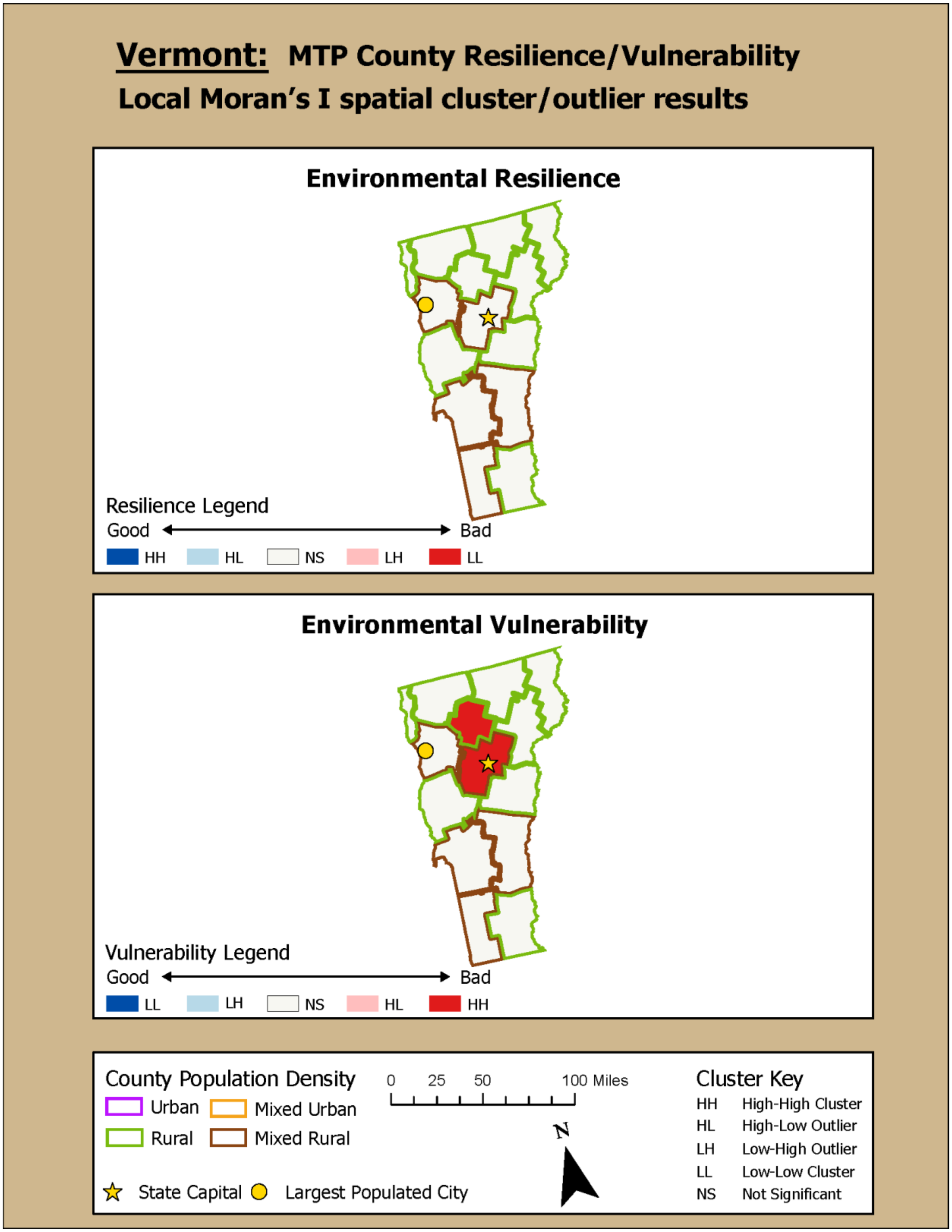
NS Not Significant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Local Moran's I spatial cluster/outlier results
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Resilience Legend
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Environmental Vulnerability
Vulnerability Legend
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County Population Density
Urban
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Rural
Mixed Rural
State Capital
Largest Populated City
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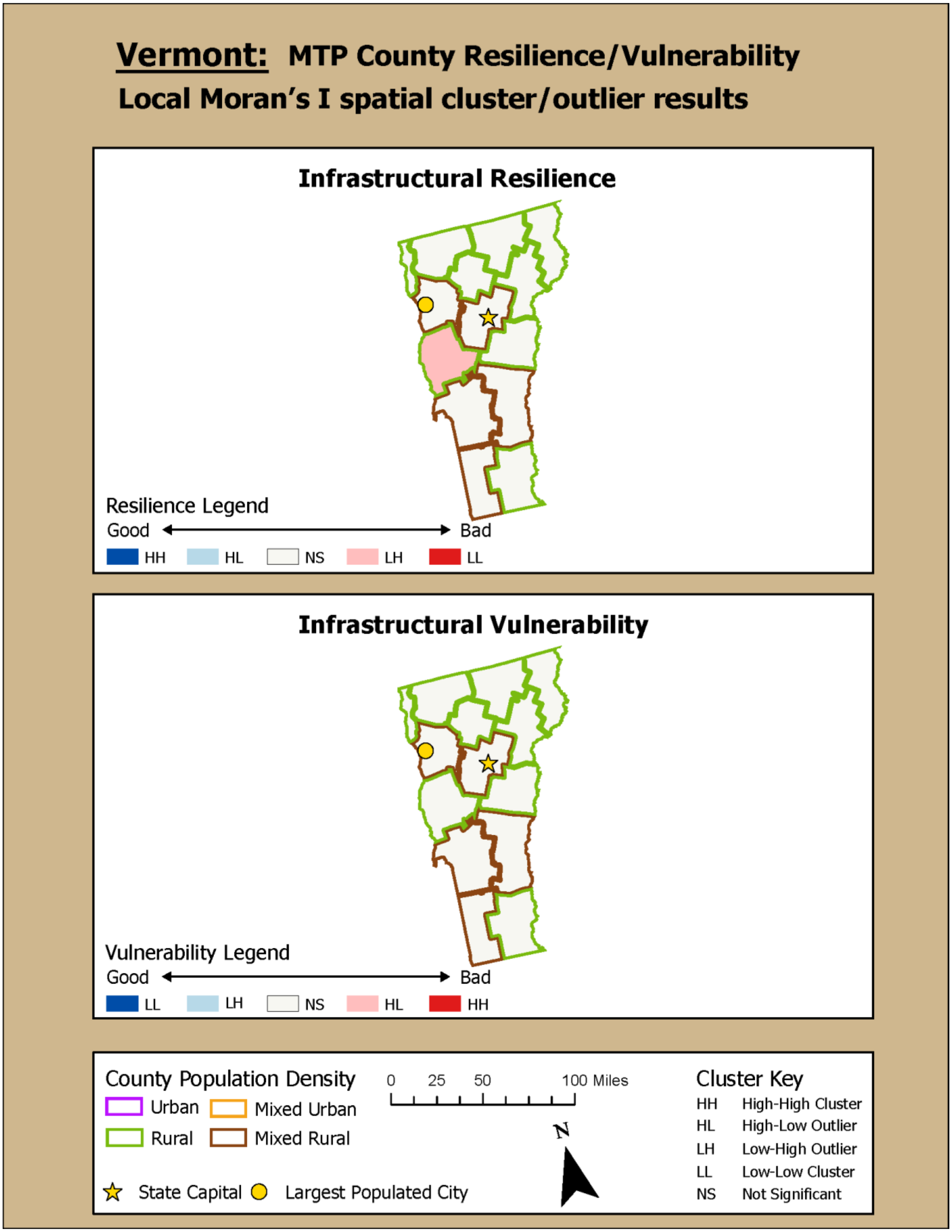
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Local Moran's I spatial cluster/outlier results
Infrastructural Resilience
Resilience Legend
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HH
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Infrastructural Vulnerability
Vulnerability Legend
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LH
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County Population Density
Urban
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Rural
Mixed Rural
State Capital
Largest Populated City
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Cluster Key
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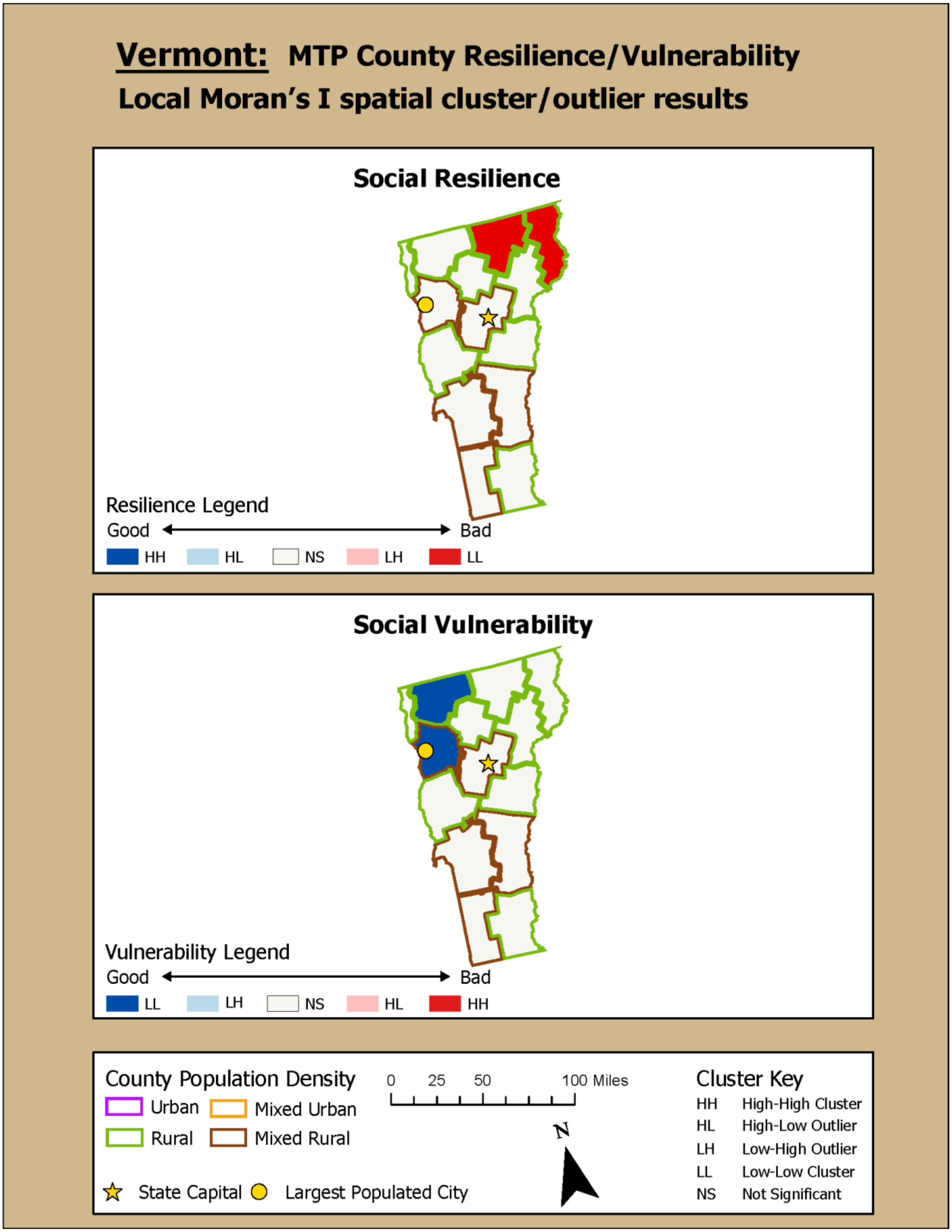
Vermont: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results
Social Resilience
Resilience Legend
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Bad
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Social Vulnerability
Vulnerability Legend
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Bad
LL
LH
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HL
HH
County Population Density
Urban
Mixed Urban
Rural
Mixed Rural
State Capital
Largest Populated City
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Cluster Key
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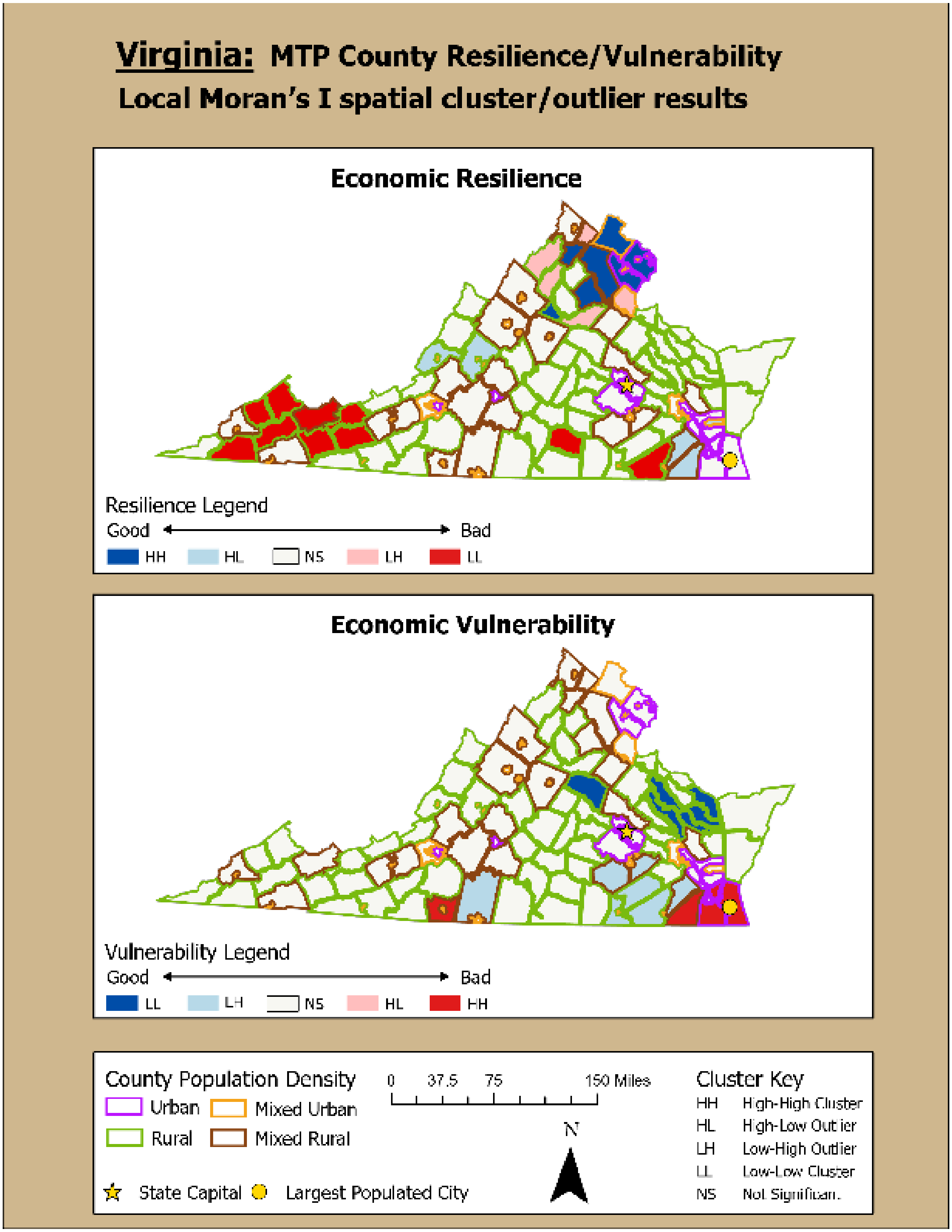
Virginia: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results
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Resilience Legend
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Economic Vulnerability
Vulnerability Legend
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Bad
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LH
NS
HL
HH
County Population Density
Urban
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Rural
Mixed Rural
State Capital
Largest Populated City
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Cluster Key
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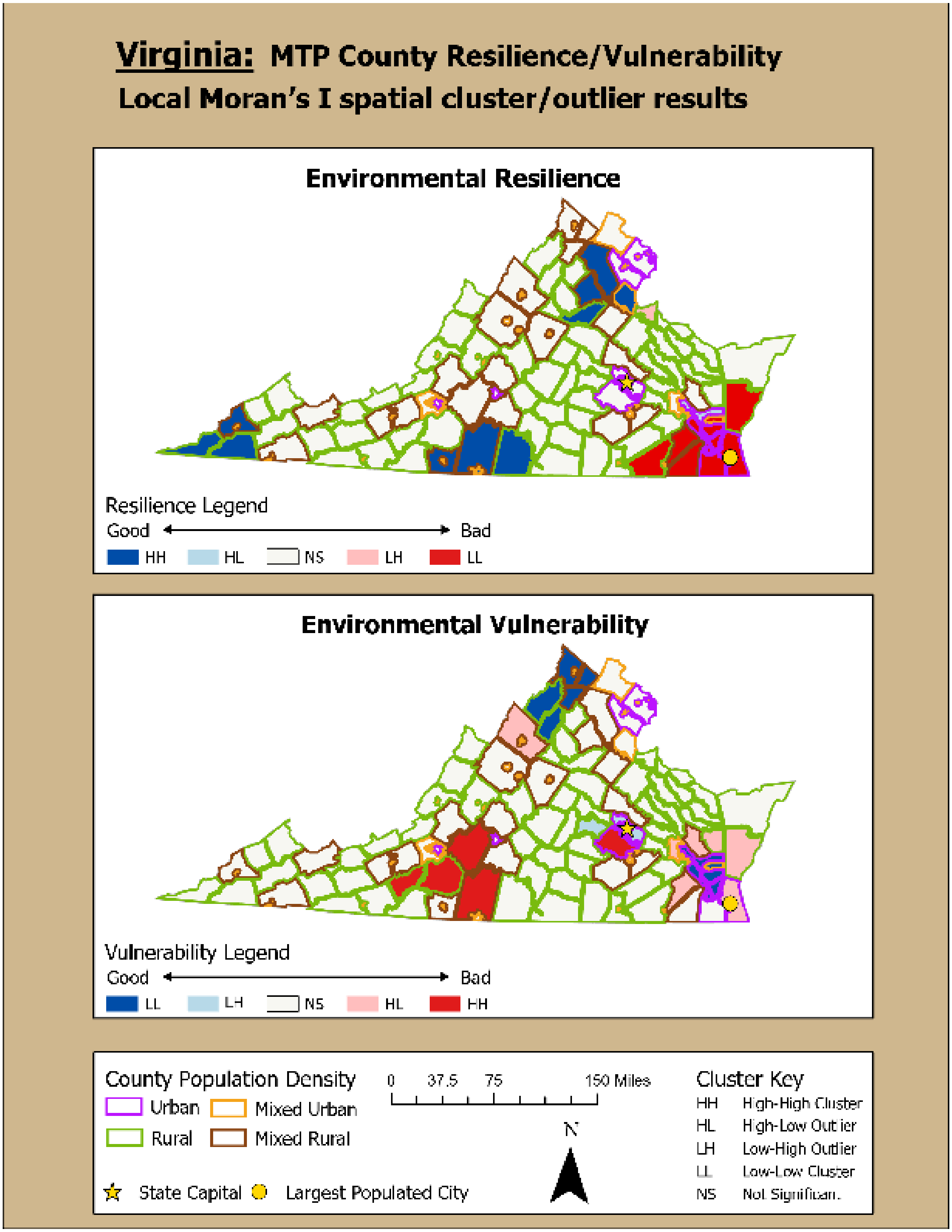
LL Low-Low Cluster
NS Not Significant


Virginia: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results
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Resilience Legend
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HL
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Environmental Vulnerability
Vulnerability Legend
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LH
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County Population Density
Urban
Mixed Urban
Rural
Mixed Rural
State Capital
Largest Populated City
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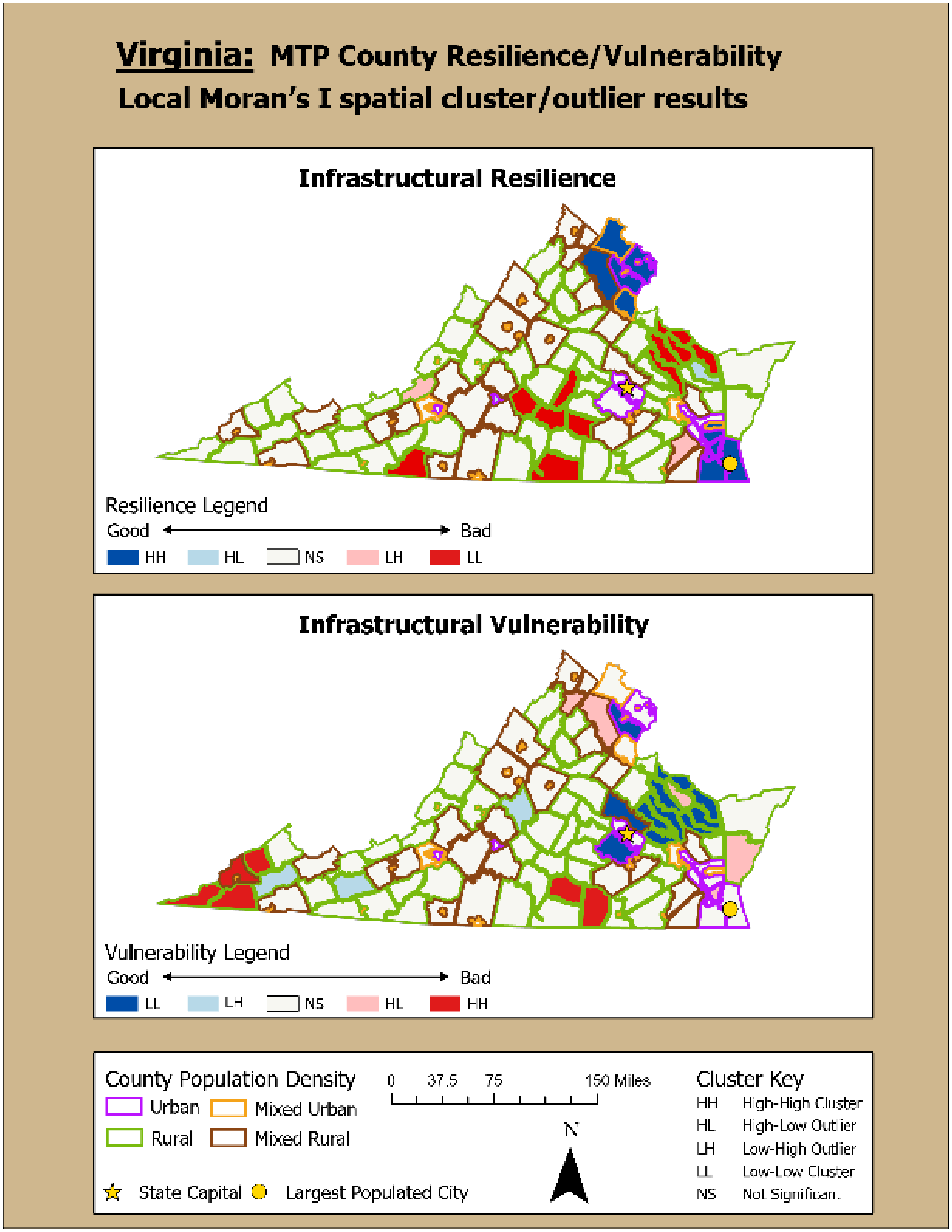
LH Low-High Outlier
LL Low-Low Cluster
NS Not Significant


Virginia: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results
Infrastructural Resilience
Resilience Legend
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Infrastructural Vulnerability
Vulnerability Legend
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LH
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HL
HH
County Population Density
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Mixed Rural
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37.5
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State Capital
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Cluster Key
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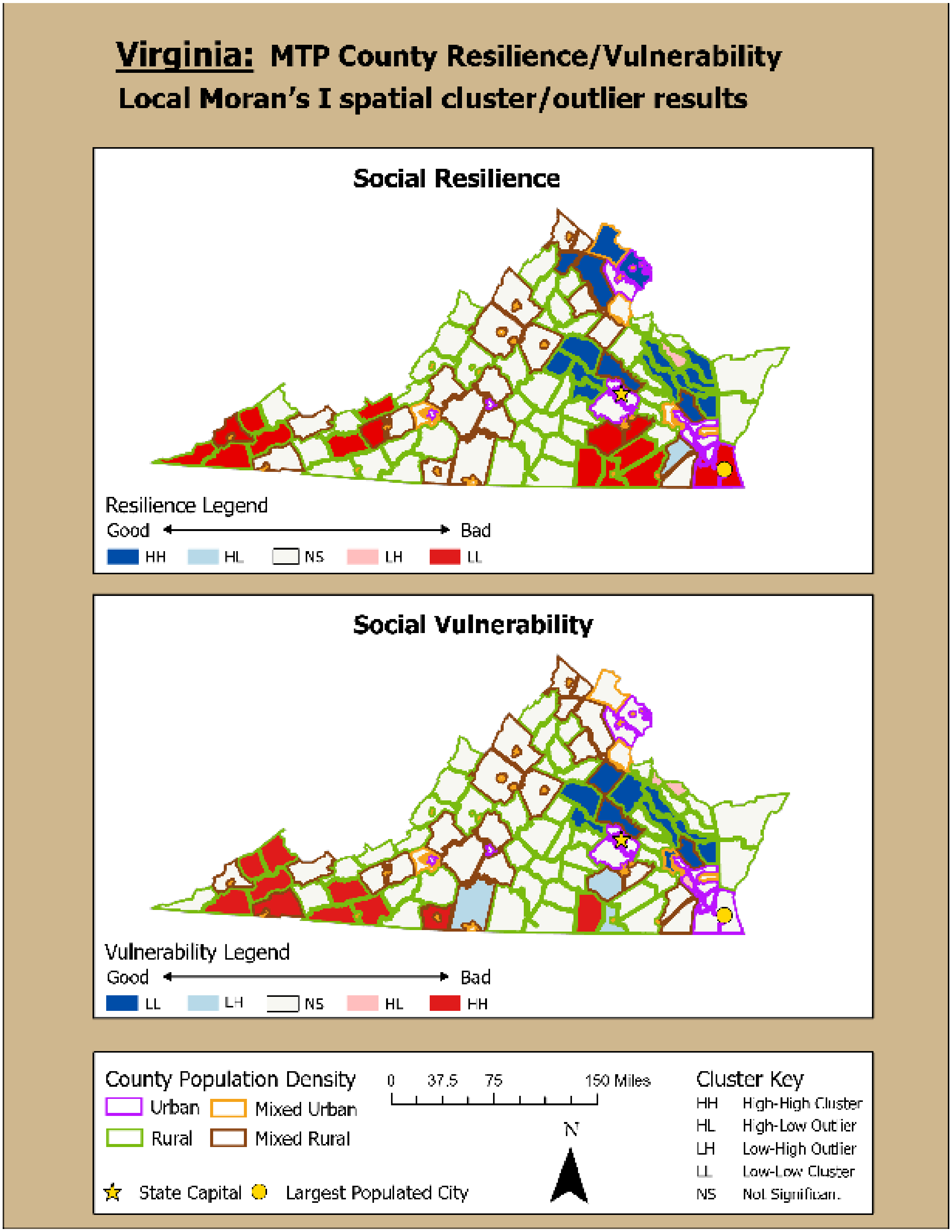
Virginia: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results
Social Resilience
Resilience Legend
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Social Vulnerability
Vulnerability Legend
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Bad
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LH
NS
HL
HH
County Population Density
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State Capital
Largest Populated City
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Cluster Key
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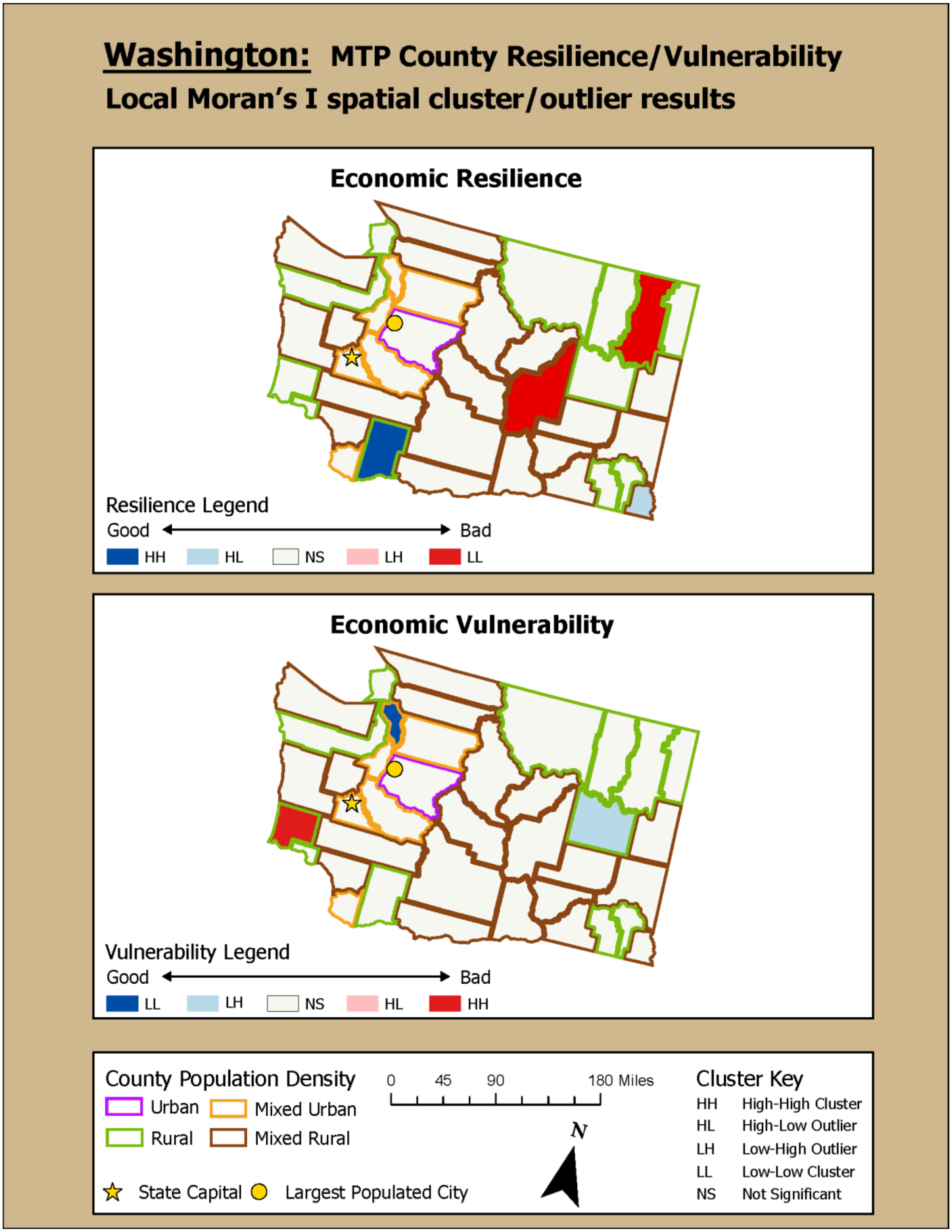
Washington: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results
Economic Resilience
Resilience Legend
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Bad
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HL
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LH
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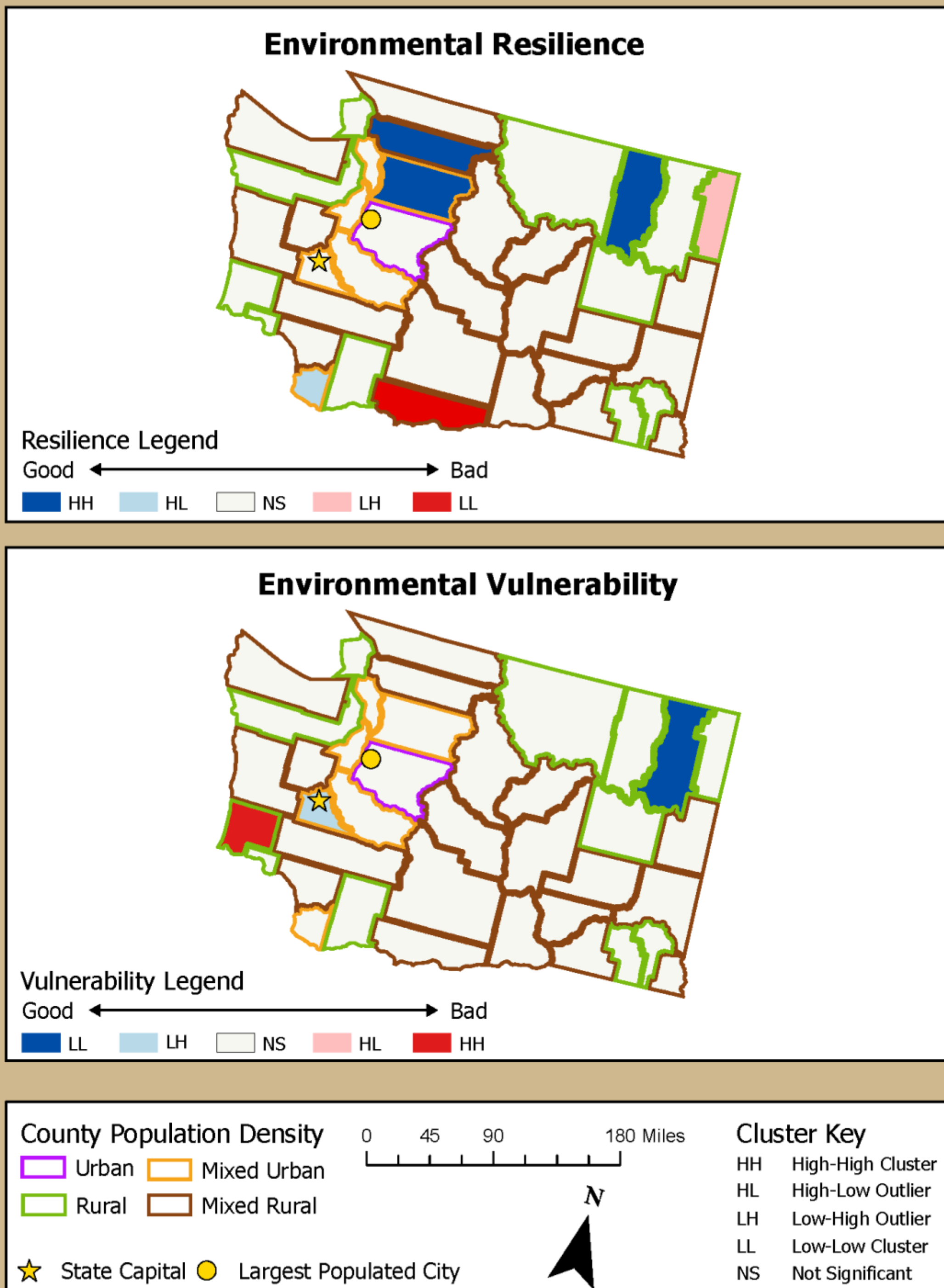
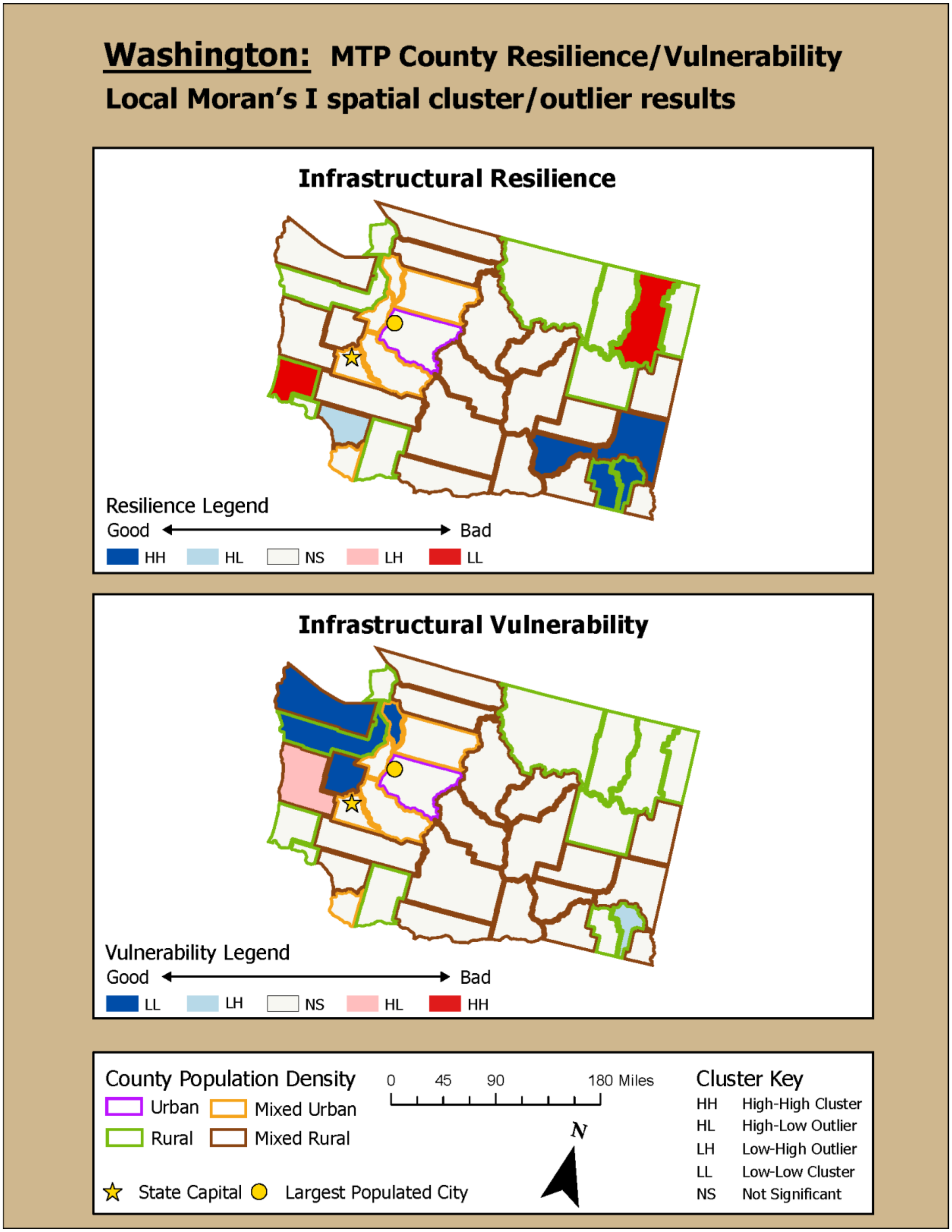
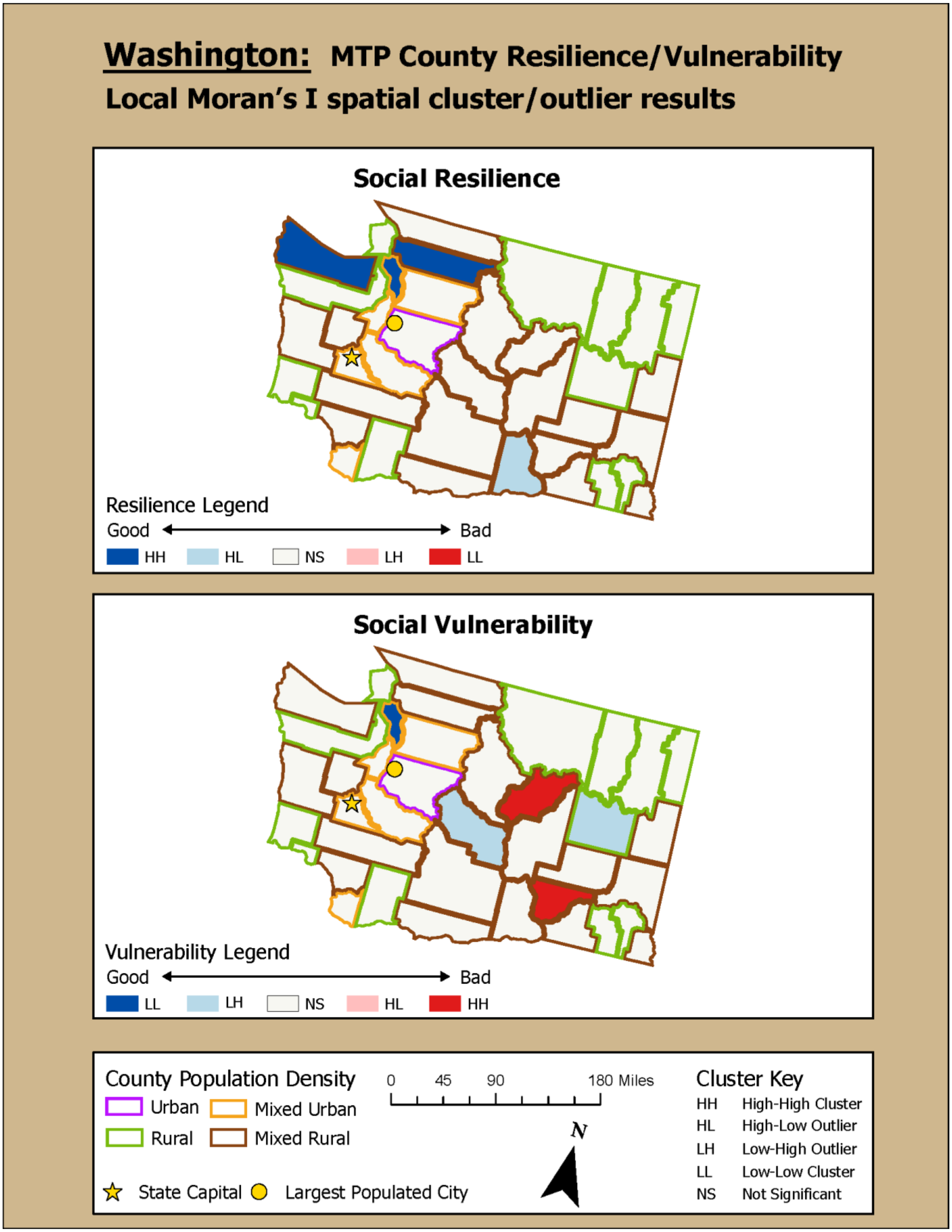
Economic Vulnerability
Vulnerability Legend
Good
Bad
LL
LH
NS
HL
HH
County Population Density
Urban
Mixed Urban
Rural
Mixed Rural
State Capital
Largest Populated City
0
45
90
180 Miles
N
Cluster Key
HH High-High Cluster
HL High-Low Outlier
LH Low-High Outlier
LL Low-Low Cluster
NS Not Significant

Washington: MTP County Resilience/Vulnerability

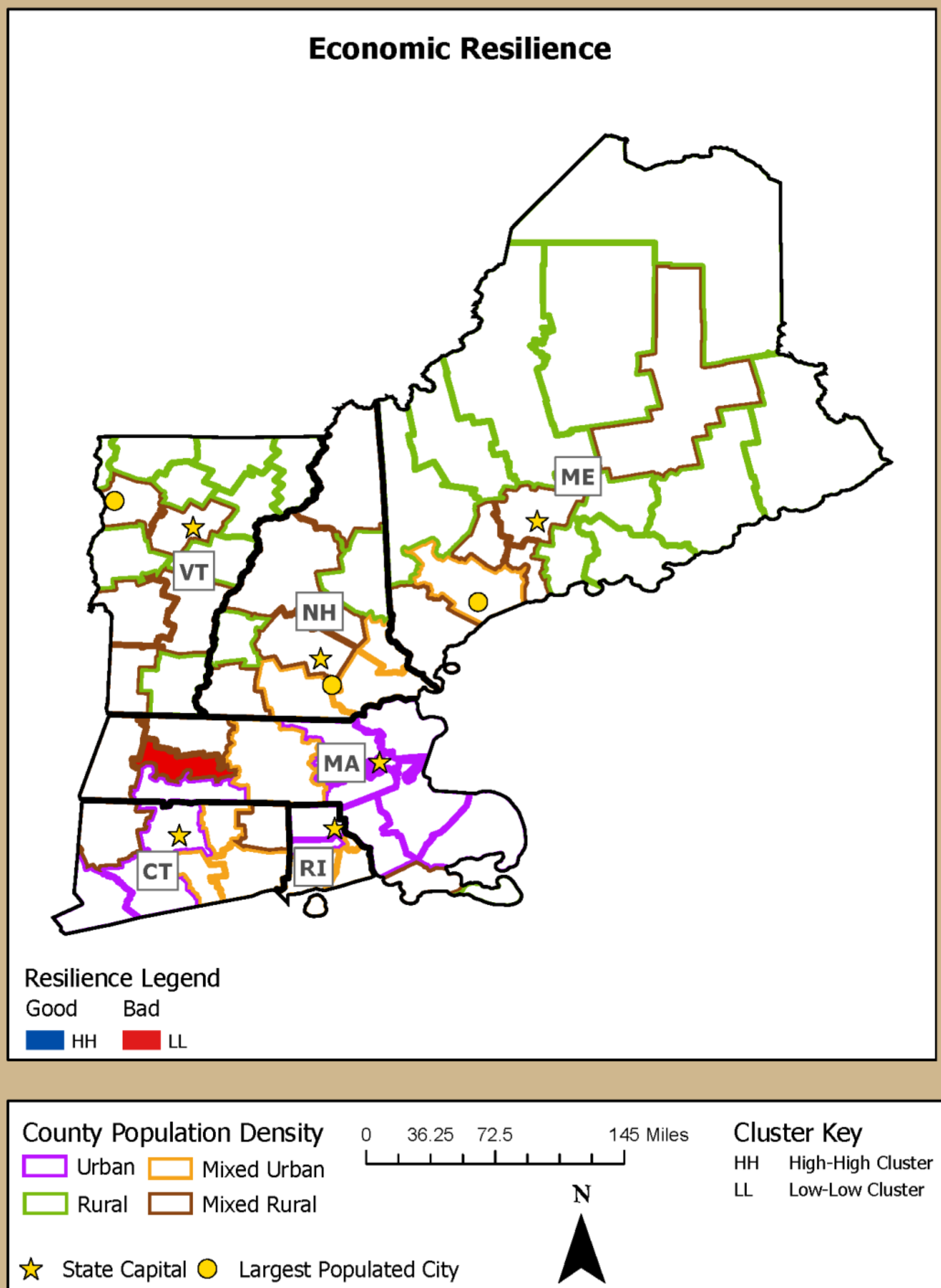
Local Moran's I spatial cluster/outlier results

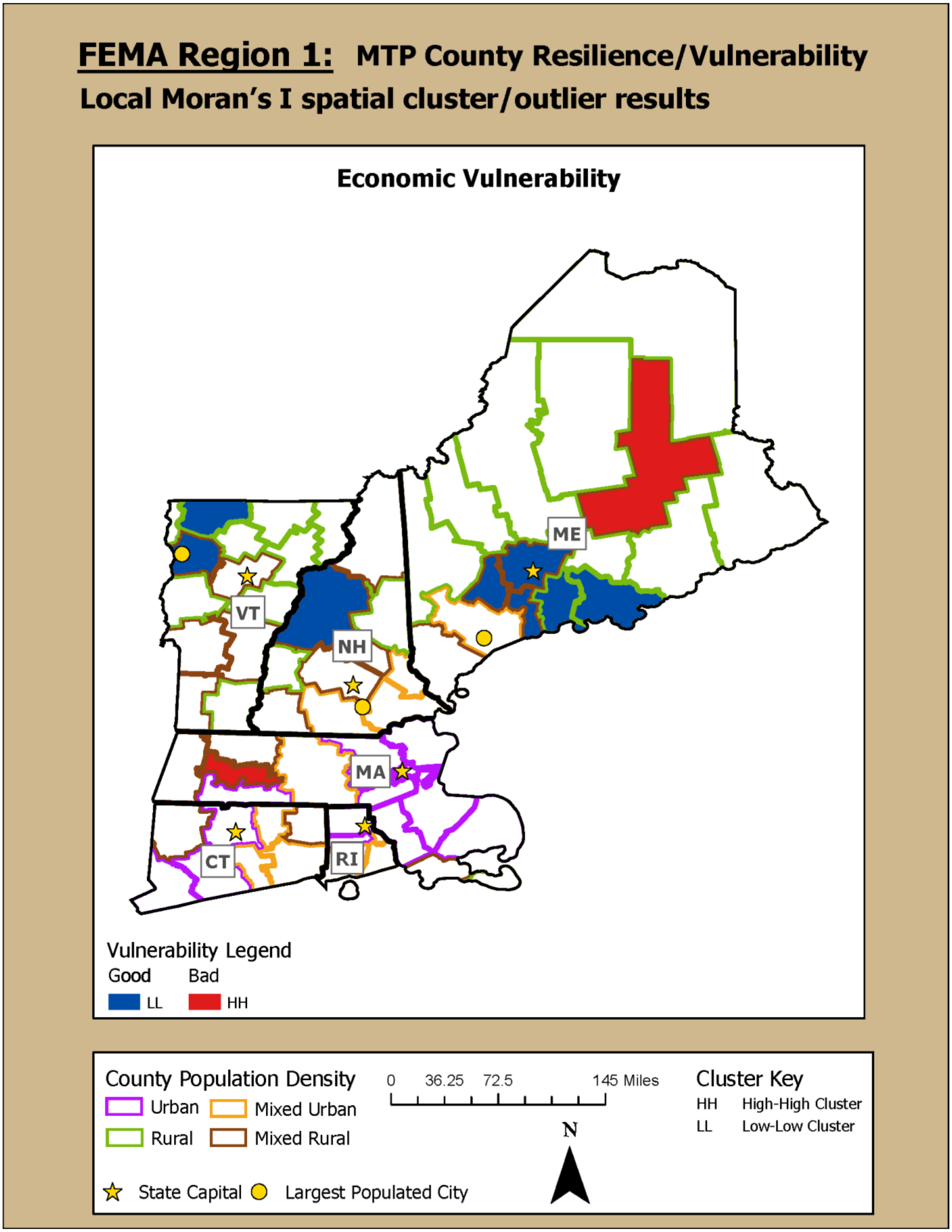


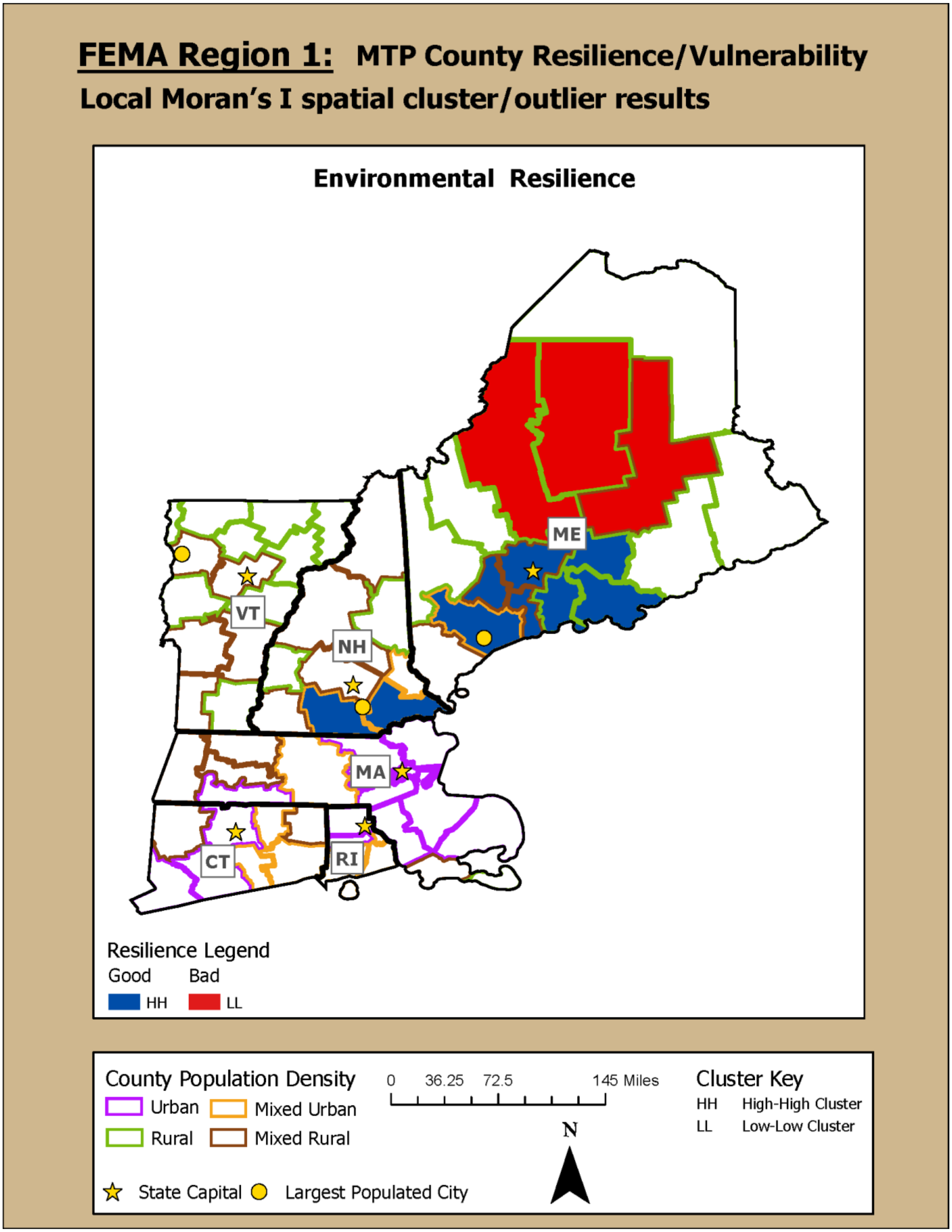

Washington: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results
Infrastructural Resilience
Resilience Legend
Good
Bad
HH
HL
NS
LH
LL
Infrastructural Vulnerability
Vulnerability Legend
Good
Bad
LL
LH
NS
HL
HH
County Population Density
Urban
Mixed Urban
Rural
Mixed Rural
0
45
90
180 Miles
N
Cluster Key
HH High-High Cluster
HL High-Low Outlier
LH Low-High Outlier
LL Low-Low Cluster
NS Not Significant
State Capital
Largest Populated City


Washington: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results
Social Resilience
Resilience Legend
Good
Bad
HH
HL
NS
LH
LL
Social Vulnerability
Vulnerability Legend
Good
Bad
LL
LH
NS
HL
HH
County Population Density
Urban
Mixed Urban
Rural
Mixed Rural
State Capital
Largest Populated City
0
45
90
180 Miles
N
Cluster Key
HH High-High Cluster
HL High-Low Outlier
LH Low-High Outlier
LL Low-Low Cluster
NS Not Significant

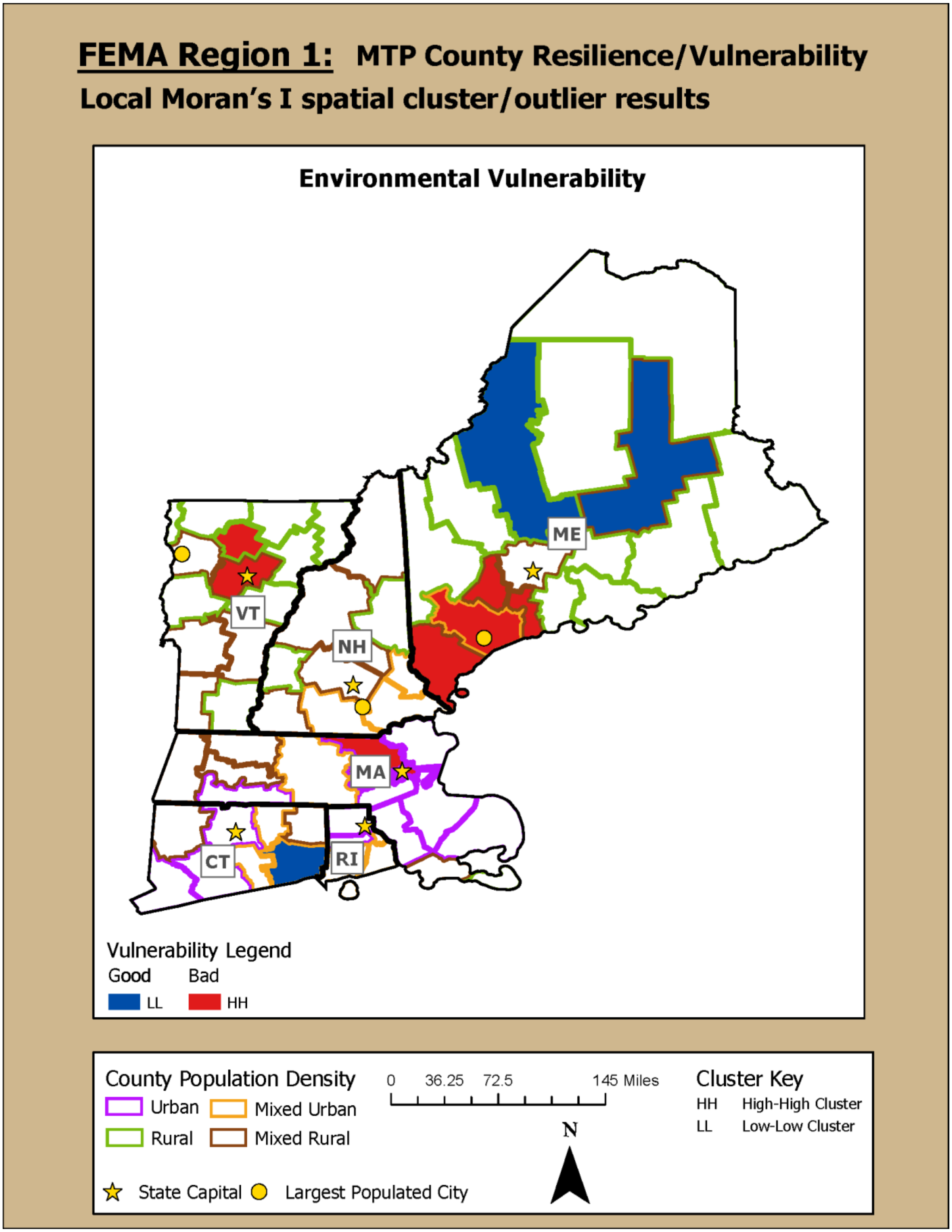
FEMA Region 1: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results

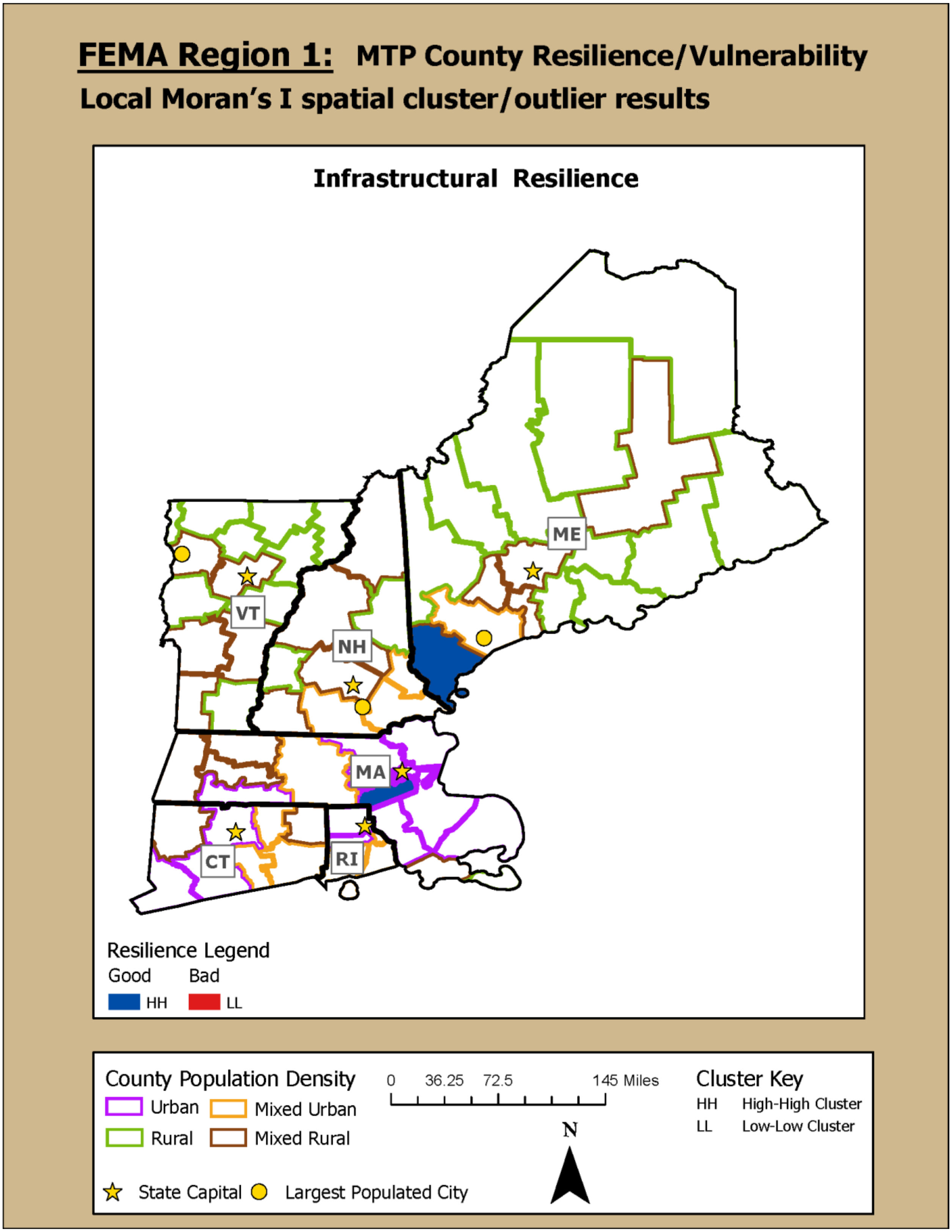


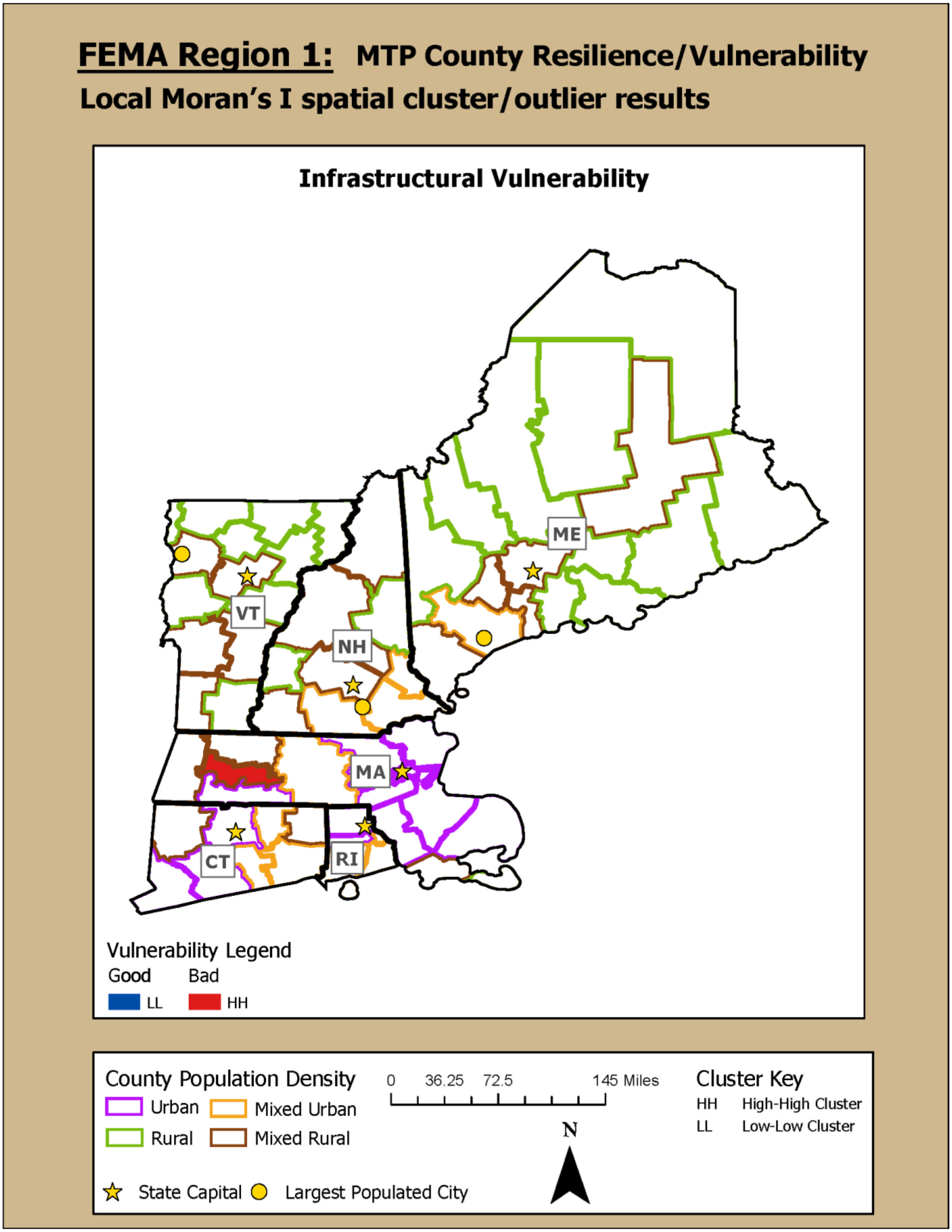

FEMA Region 1: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results
Economic Vulnerability
ME
VT
NH
MA
CT
RI
Vulnerability Legend
Good
Bad
LL
HH
County Population Density
Urban
Mixed Urban
Rural
Mixed Rural
State Capital
Largest Populated City
0
36.25
72.5
145 Miles
N
Cluster Key
HH High-High Cluster
LL Low-Low Cluster



FEMA Region 1: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results
Environmental Resilience
ME
VT
NH
MA
CT
RI
Resilience Legend
Good
Bad
HH
LL
County Population Density
Urban
Mixed Urban
Rural
Mixed Rural
0
36.25
72.5
145 Miles
N
Cluster Key
HH
High-High Cluster
LL
Low-Low Cluster
State Capital
Largest Populated City

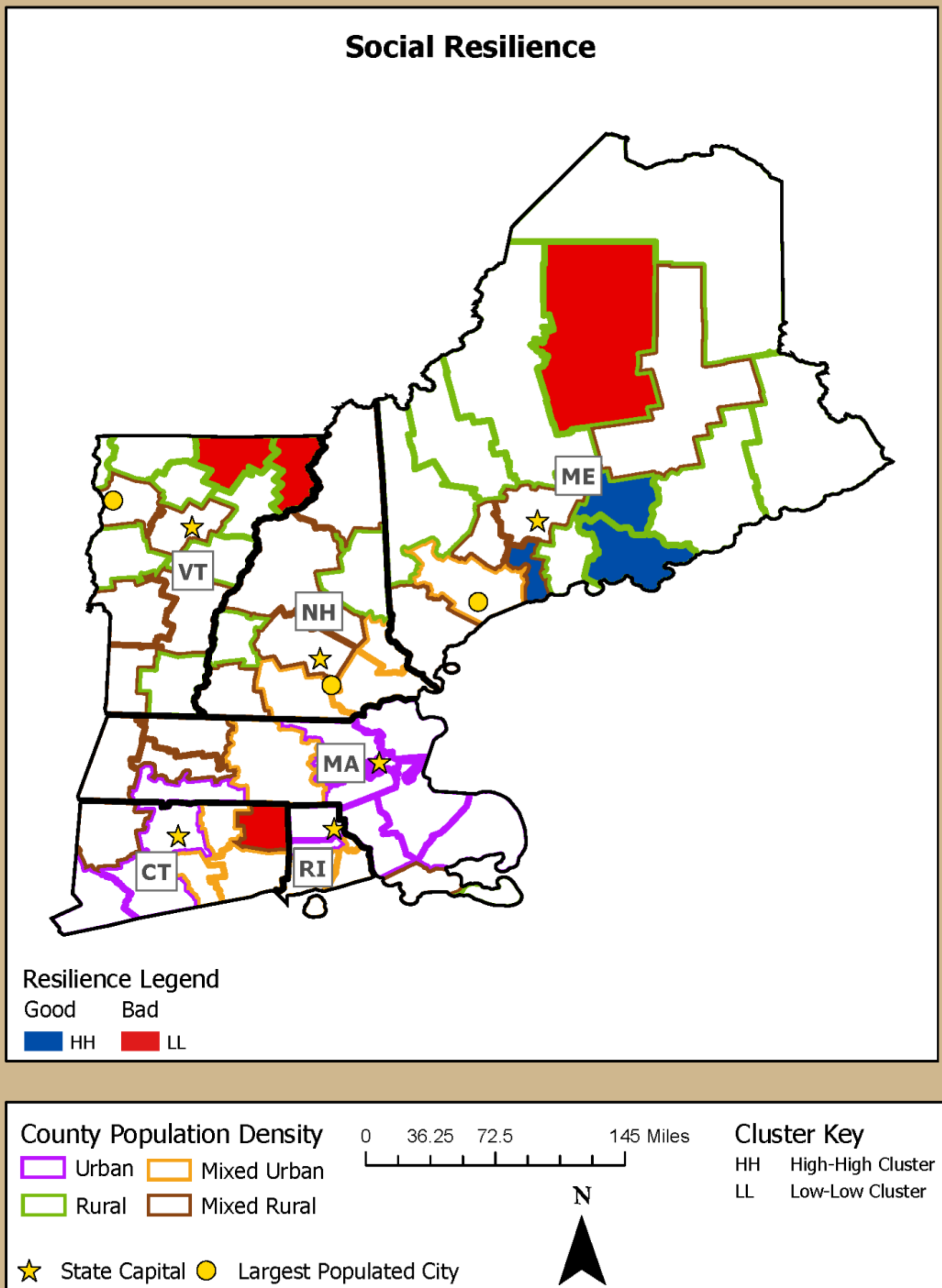

FEMA Region 1: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results
Environmental Vulnerability
ME
VT
NH
MA
CT
RI
Vulnerability Legend
Good
Bad
LL
HH
County Population Density
Urban
Mixed Urban
Rural
Mixed Rural
0
36.25
72.5
145 Miles
N
Cluster Key
HH
High-High Cluster
LL
Low-Low Cluster
State Capital
Largest Populated City

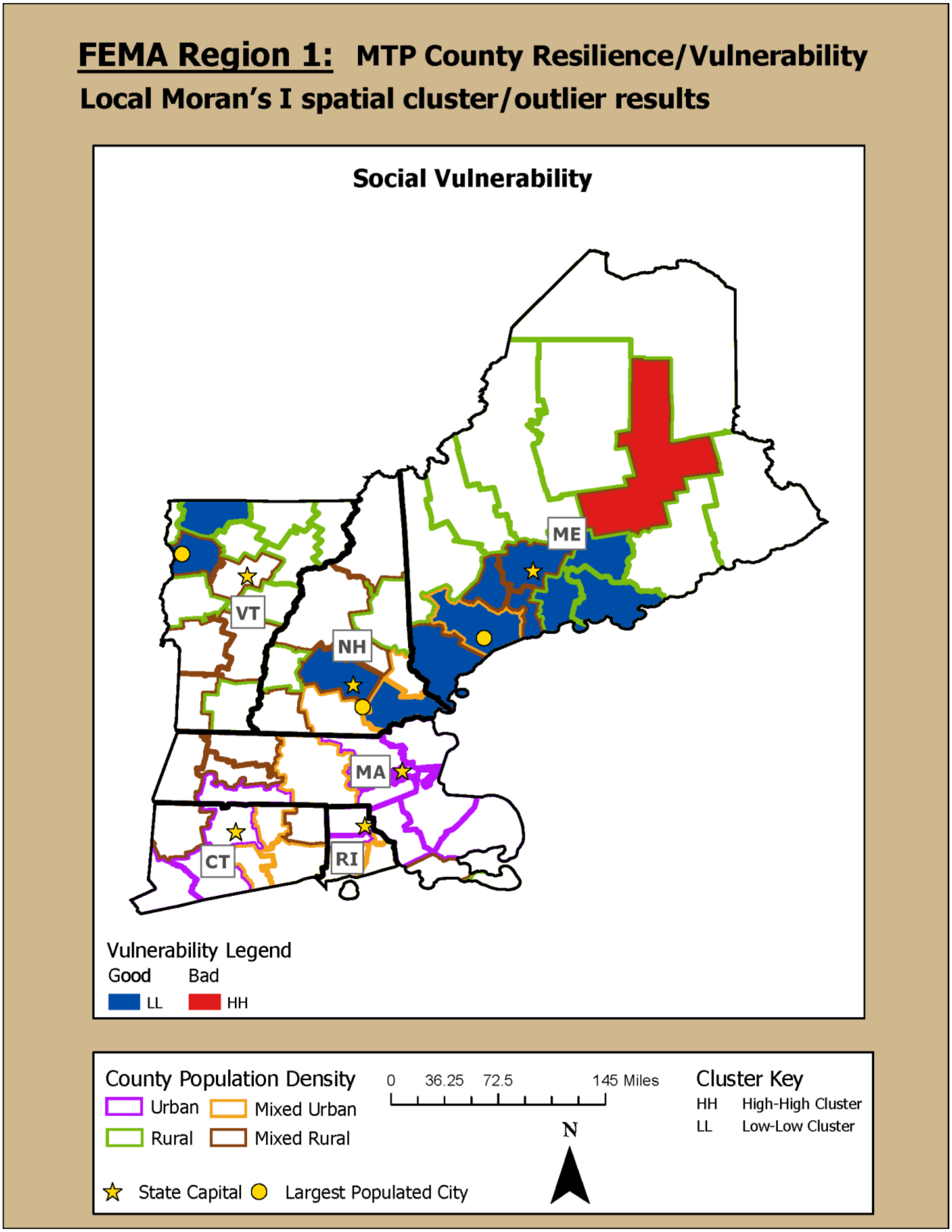

FEMA Region 1: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results
Infrastructural Resilience
ME
VT
NH
MA
CT
RI
Resilience Legend
Good
Bad
HH
LL
County Population Density
Urban
Mixed Urban
Rural
Mixed Rural
0
36.25
72.5
145 Miles
N
Cluster Key
HH High-High Cluster
LL Low-Low Cluster
State Capital
Largest Populated City

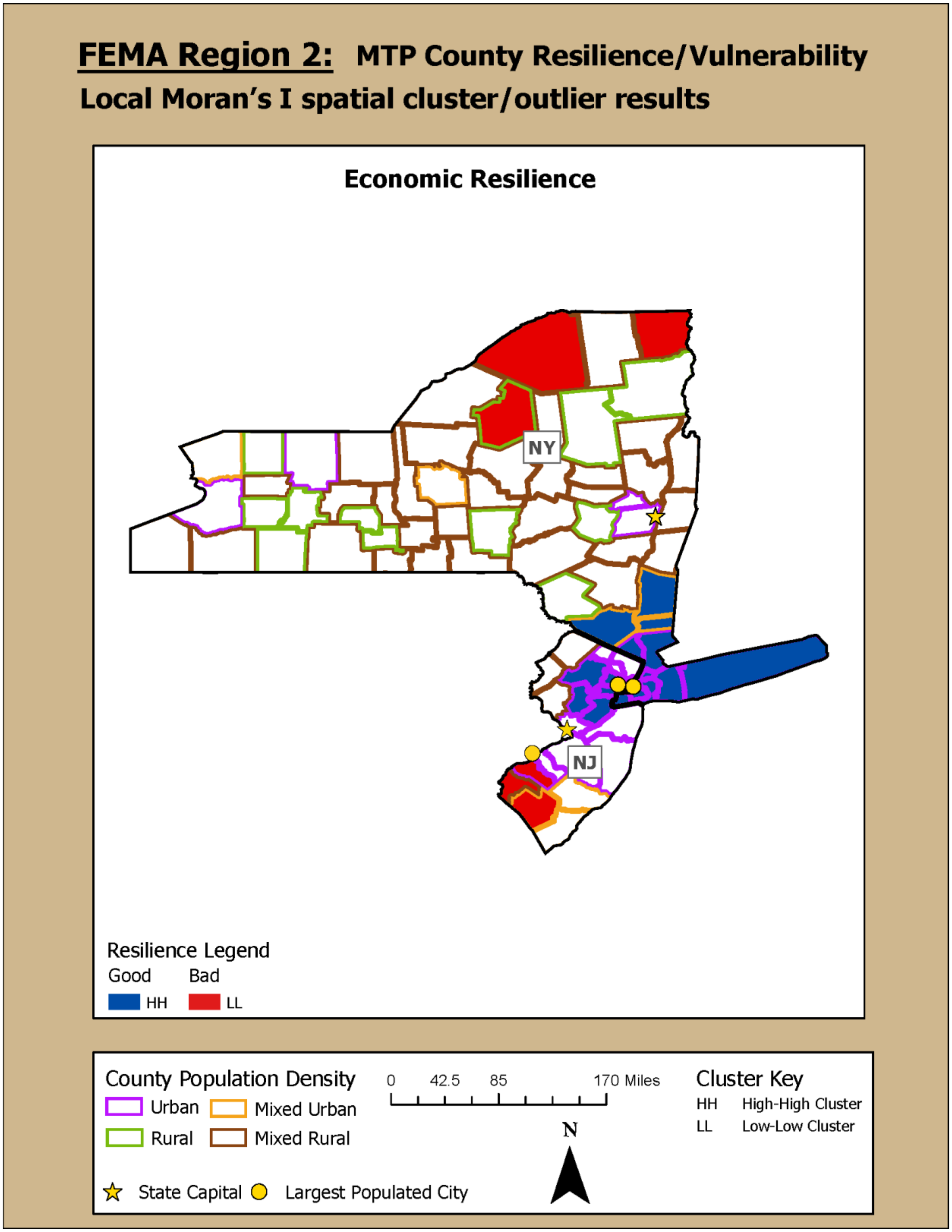

FEMA Region 1: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results
Infrastructural Vulnerability
ME
VT
NH
MA
CT
RI
Vulnerability Legend
Good
Bad
LL
HH
County Population Density
Urban
Mixed Urban
Rural
Mixed Rural
State Capital
Largest Populated City
0
36.25
72.5
145 Miles
N
Cluster Key
HH High-High Cluster
LL Low-Low Cluster

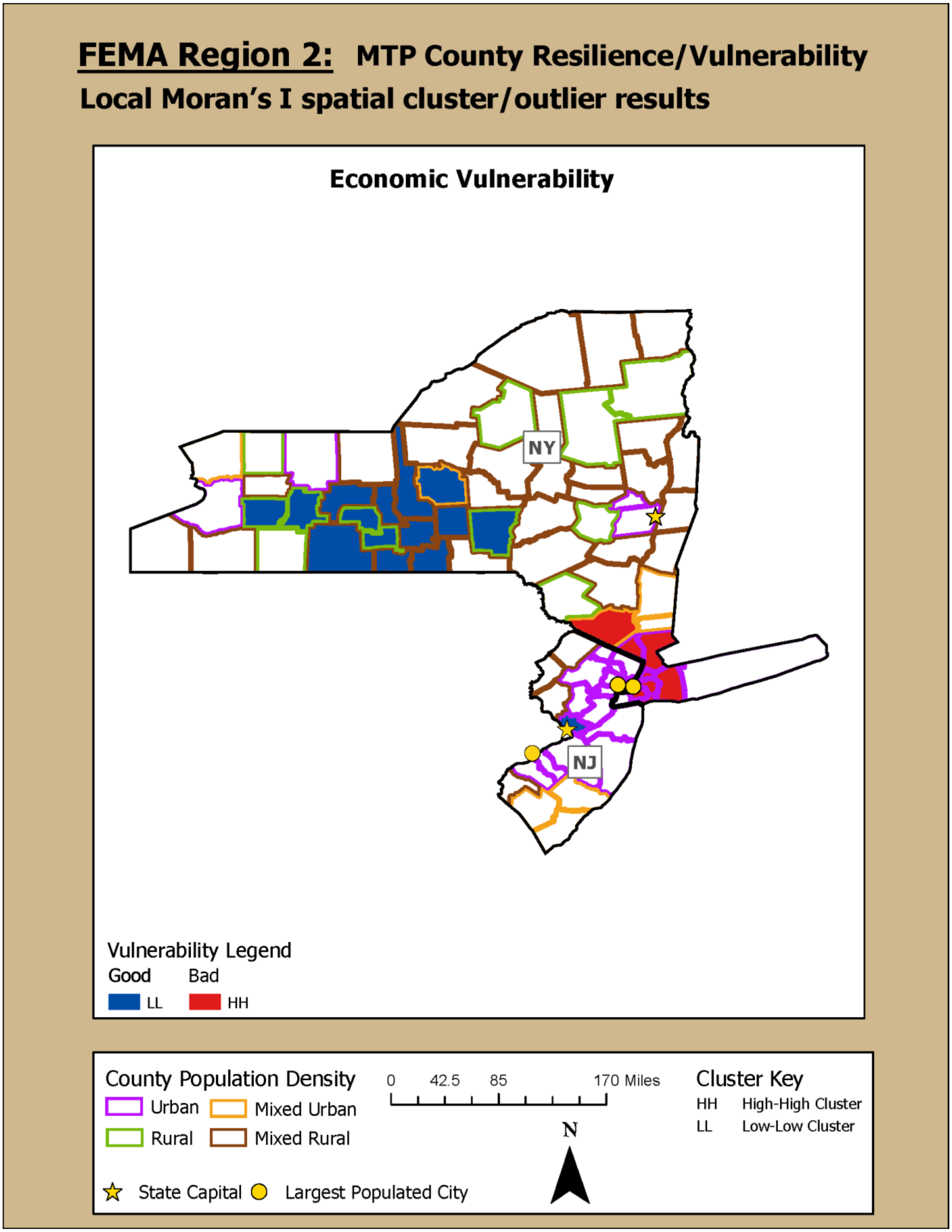
FEMA Region 1: MTP County Resilience/Vulnerability

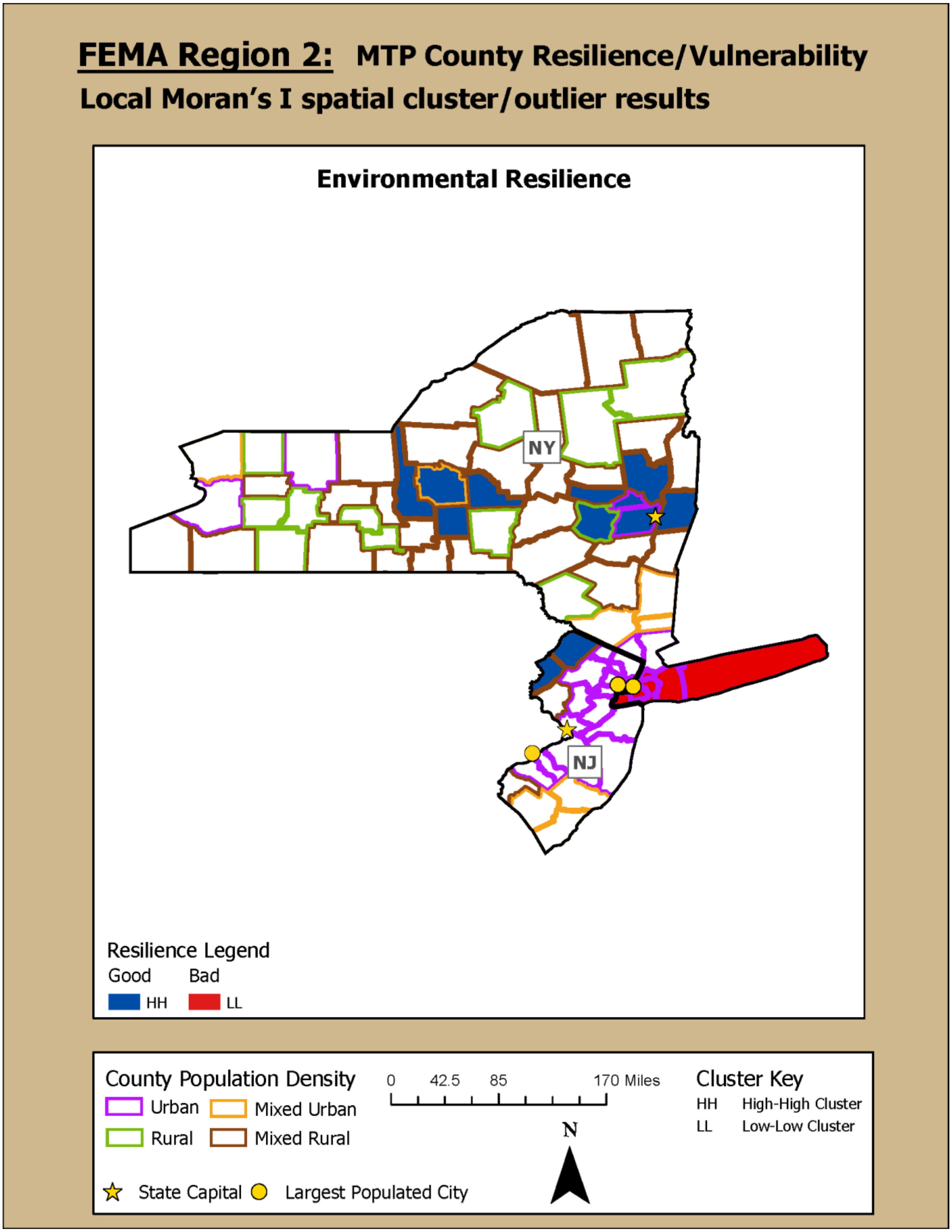
Local Moran's I spatial cluster/outlier results

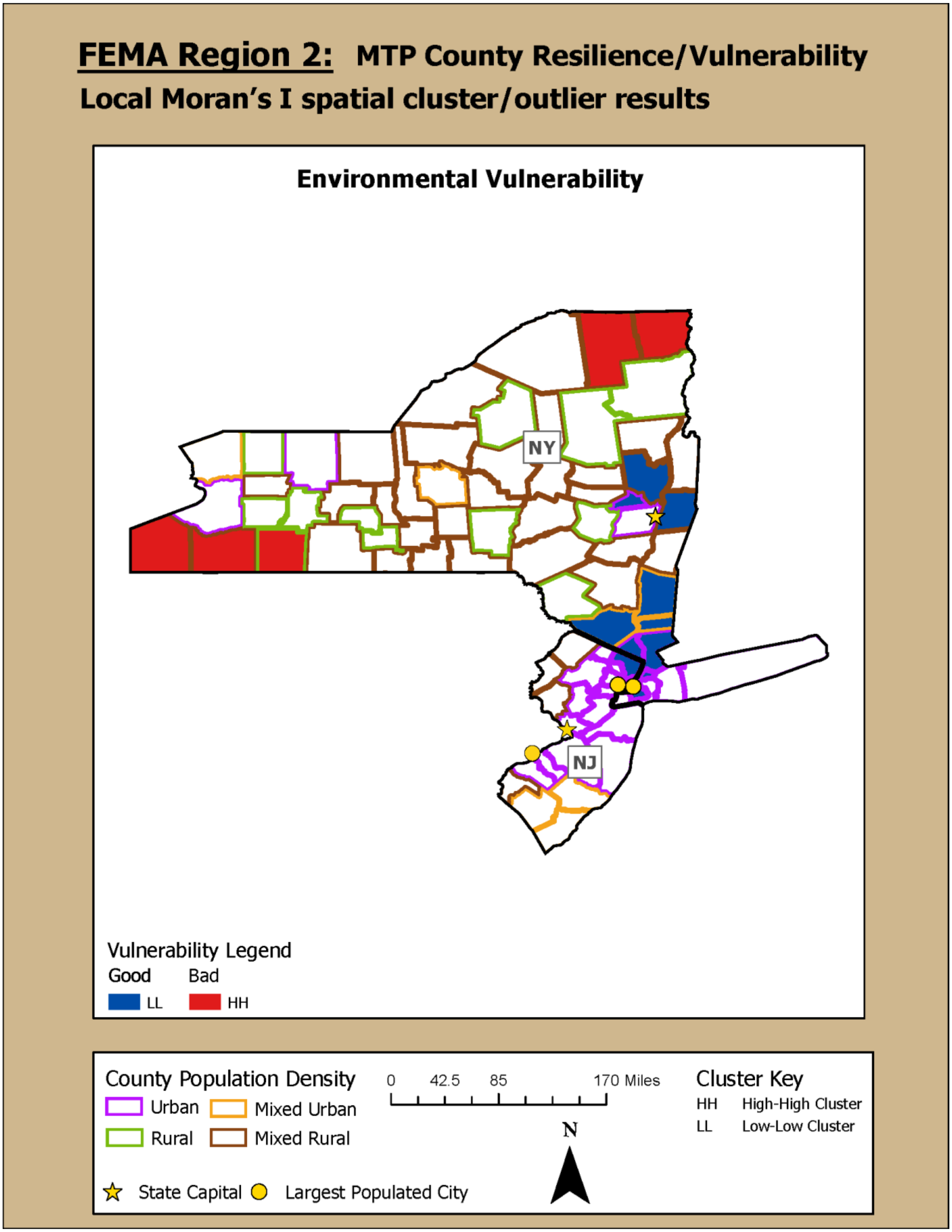



FEMA Region 1: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results
Social Vulnerability
ME
VT
NH
MA
CT
RI
Vulnerability Legend
Good
Bad
LL
HH
County Population Density
Urban
Mixed Urban
Rural
Mixed Rural
State Capital
Largest Populated City
0
36.25
72.5
145 Miles
N
Cluster Key
HH High-High Cluster
LL Low-Low Cluster


FEMA Region 2: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results
Economic Resilience
NY
NJ
Resilience Legend
Good
Bad
HH
LL
County Population Density
Urban
Mixed Urban
Rural
Mixed Rural
State Capital
Largest Populated City
0
42.5
85
170 Miles
N
Cluster Key
HH
High-High Cluster
LL
Low-Low Cluster

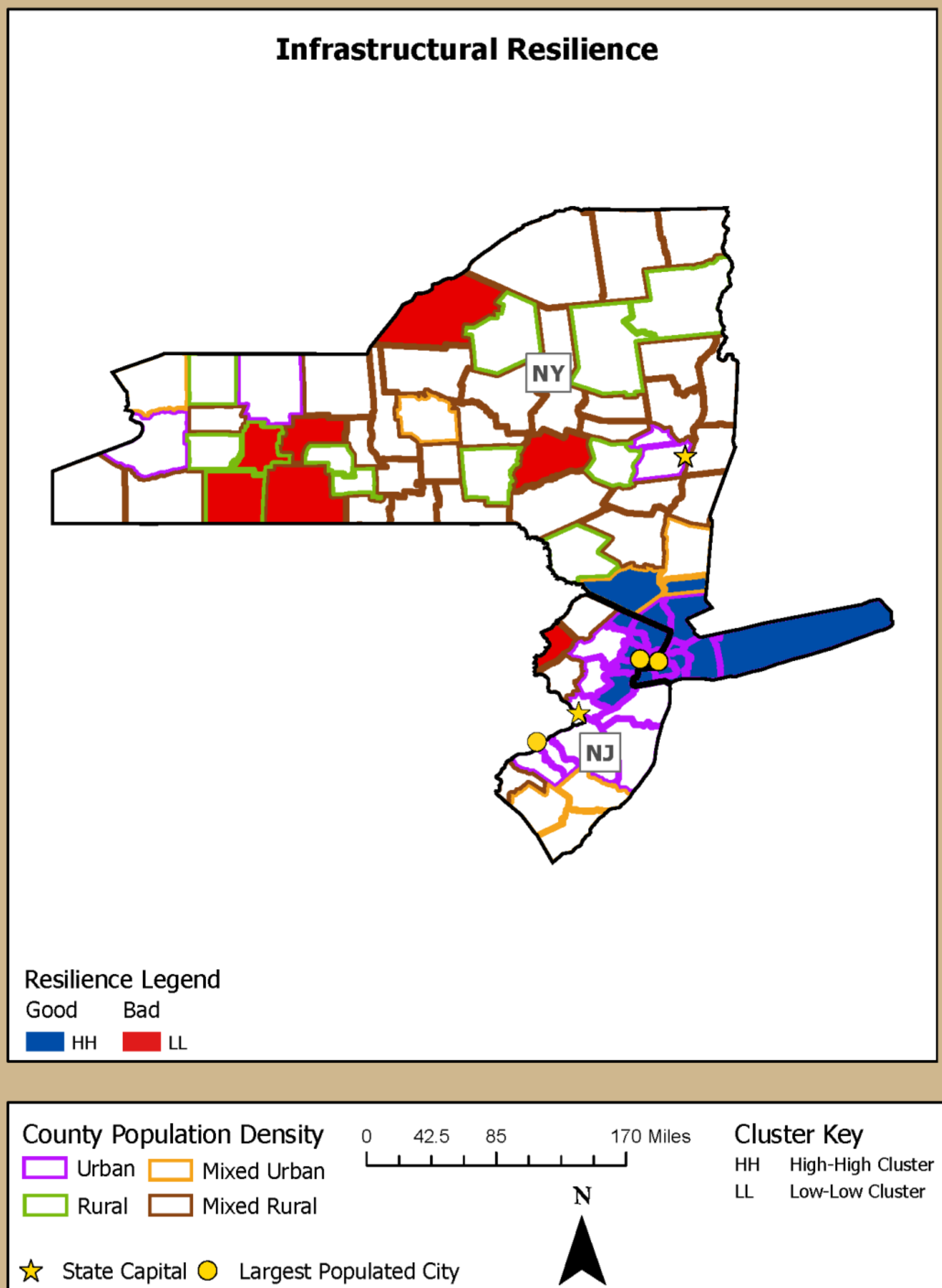

FEMA Region 2: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results
Economic Vulnerability
NY
NJ
Vulnerability Legend
Good
Bad
LL
HH
County Population Density
Urban
Mixed Urban
Rural
Mixed Rural
0
42.5
85
170 Miles
N
Cluster Key
HH
High-High Cluster
LL
Low-Low Cluster
State Capital
Largest Populated City


FEMA Region 2: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results
Environmental Resilience
NY
NJ
Resilience Legend
Good
Bad
HH
LL
County Population Density
Urban
Mixed Urban
Rural
Mixed Rural
0
42.5
85
170 Miles
N
Cluster Key
HH High-High Cluster
LL Low-Low Cluster
State Capital
Largest Populated City


FEMA Region 2: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results
Environmental Vulnerability
NY
NJ
Vulnerability Legend
Good
Bad
LL
HH
County Population Density
Urban
Mixed Urban
Rural
Mixed Rural
0
42.5
85
170 Miles
N
Cluster Key
HH High-High Cluster
LL Low-Low Cluster
State Capital
Largest Populated City

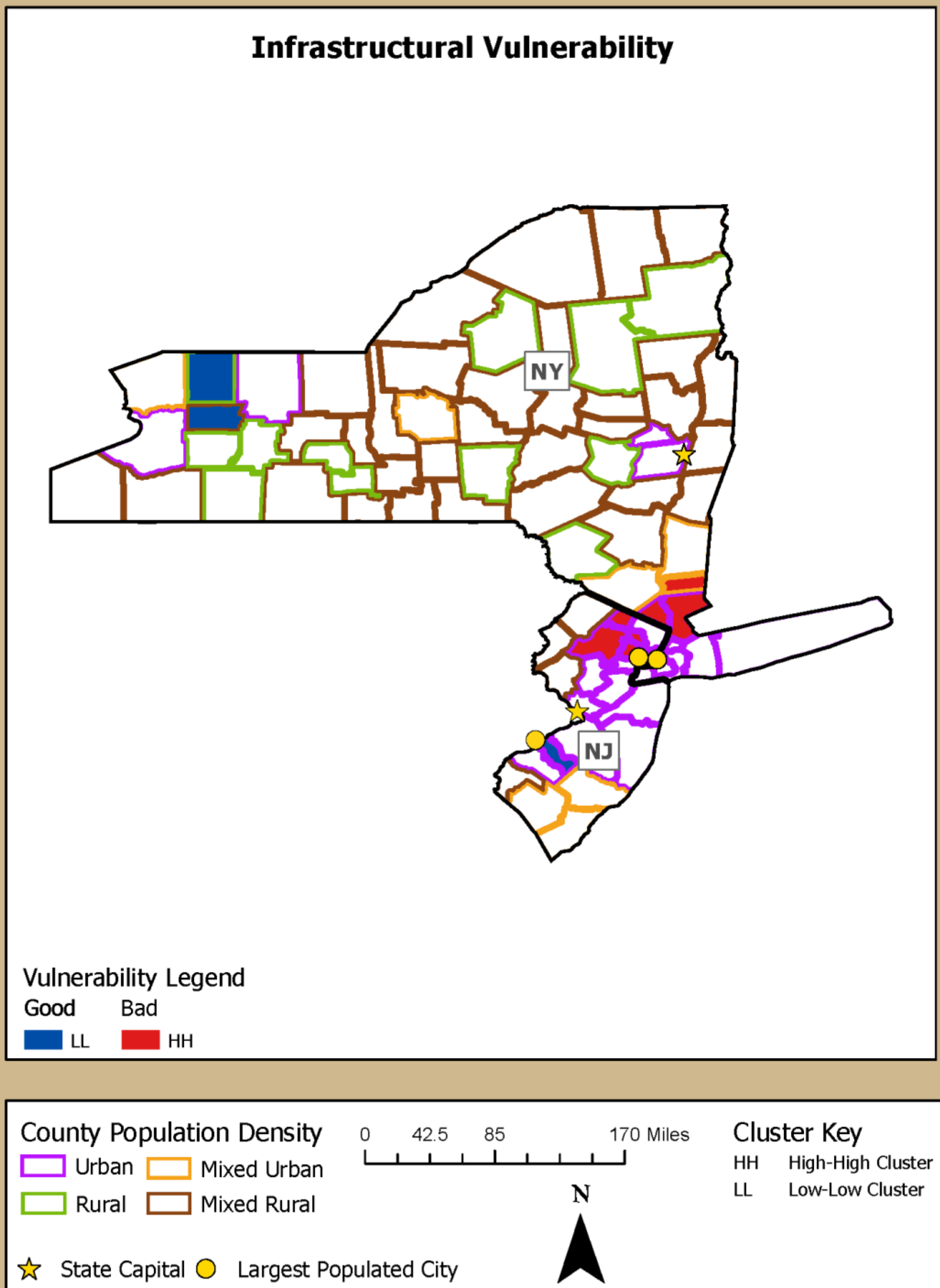
FEMA Region 2: MTP County Resilience/Vulnerability

Local Moran's I spatial cluster/outlier results



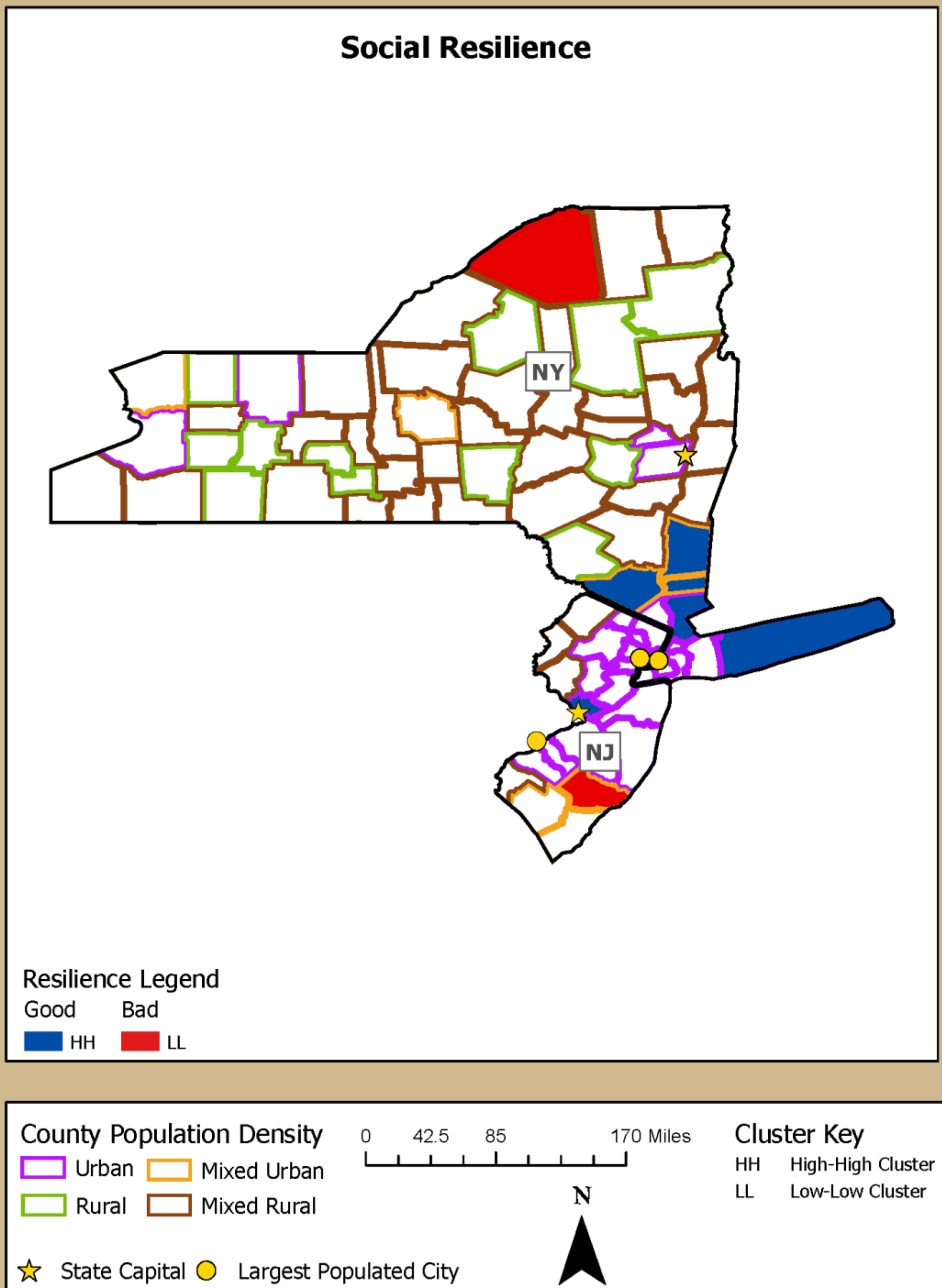
FEMA Region 2: MTP County Resilience/Vulnerability

Local Moran's I spatial cluster/outlier results



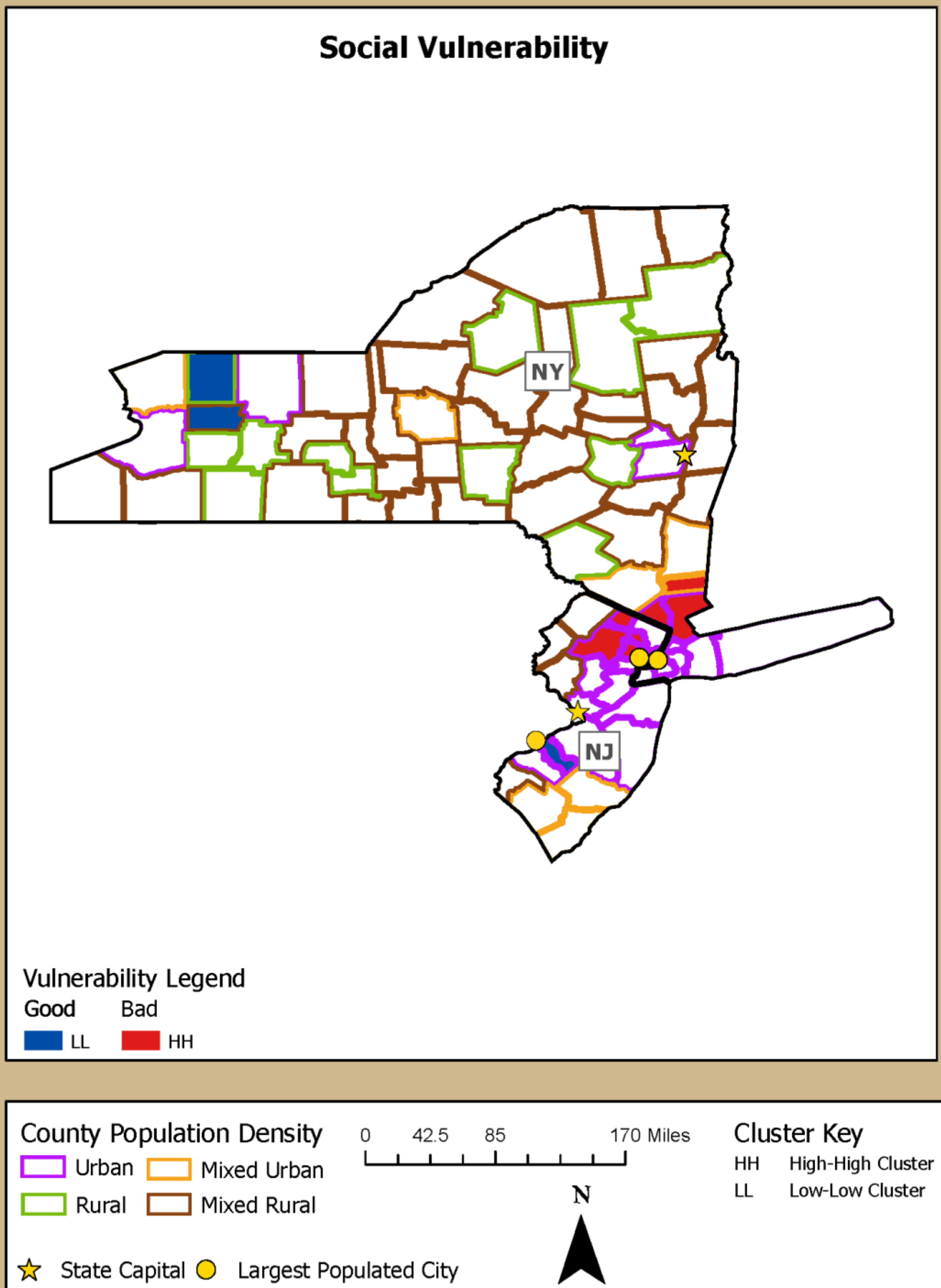
FEMA Region 2: MTP County Resilience/Vulnerability

Local Moran's I spatial cluster/outlier results



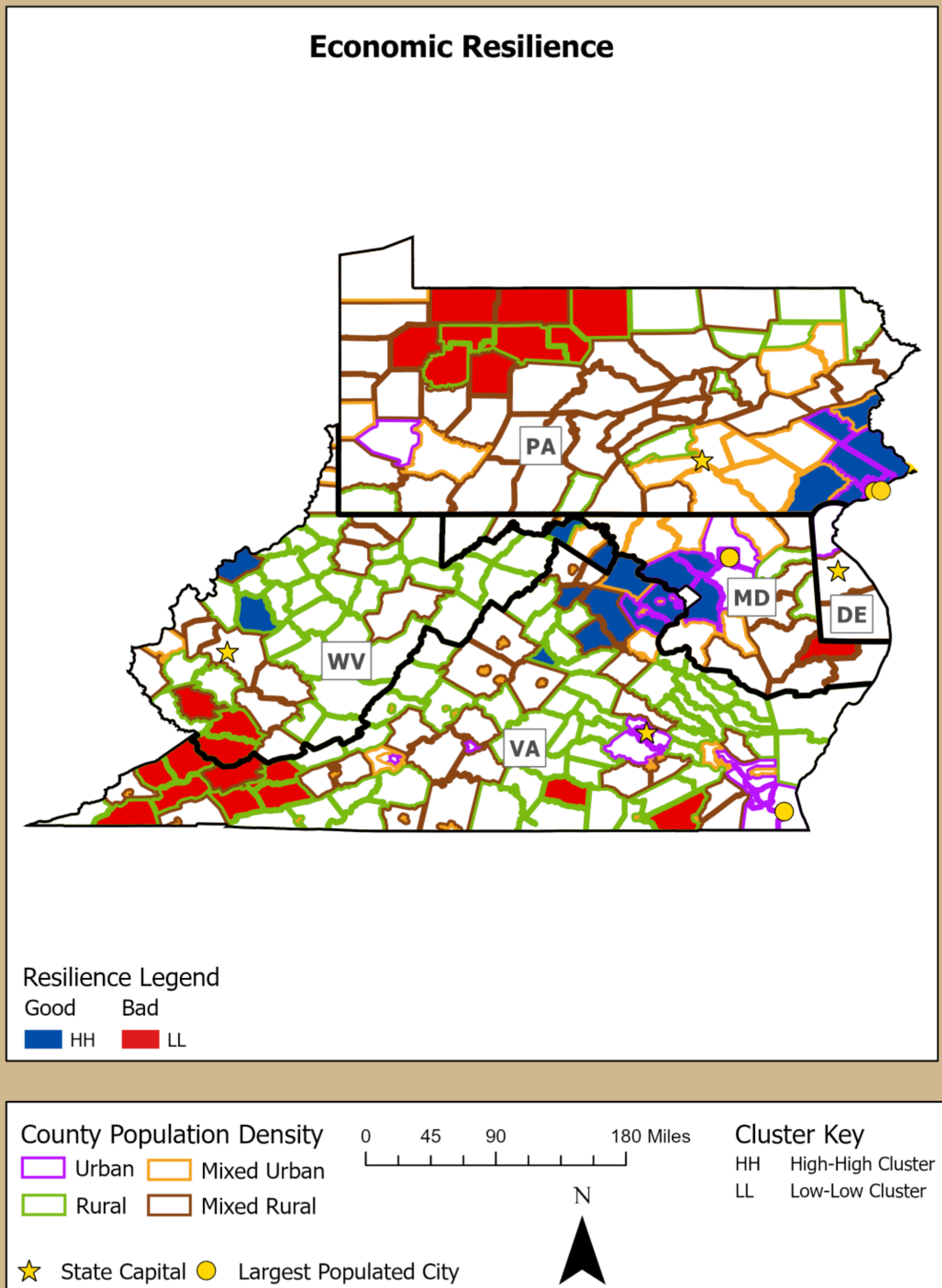
FEMA Region 2: MTP County Resilience/Vulnerability

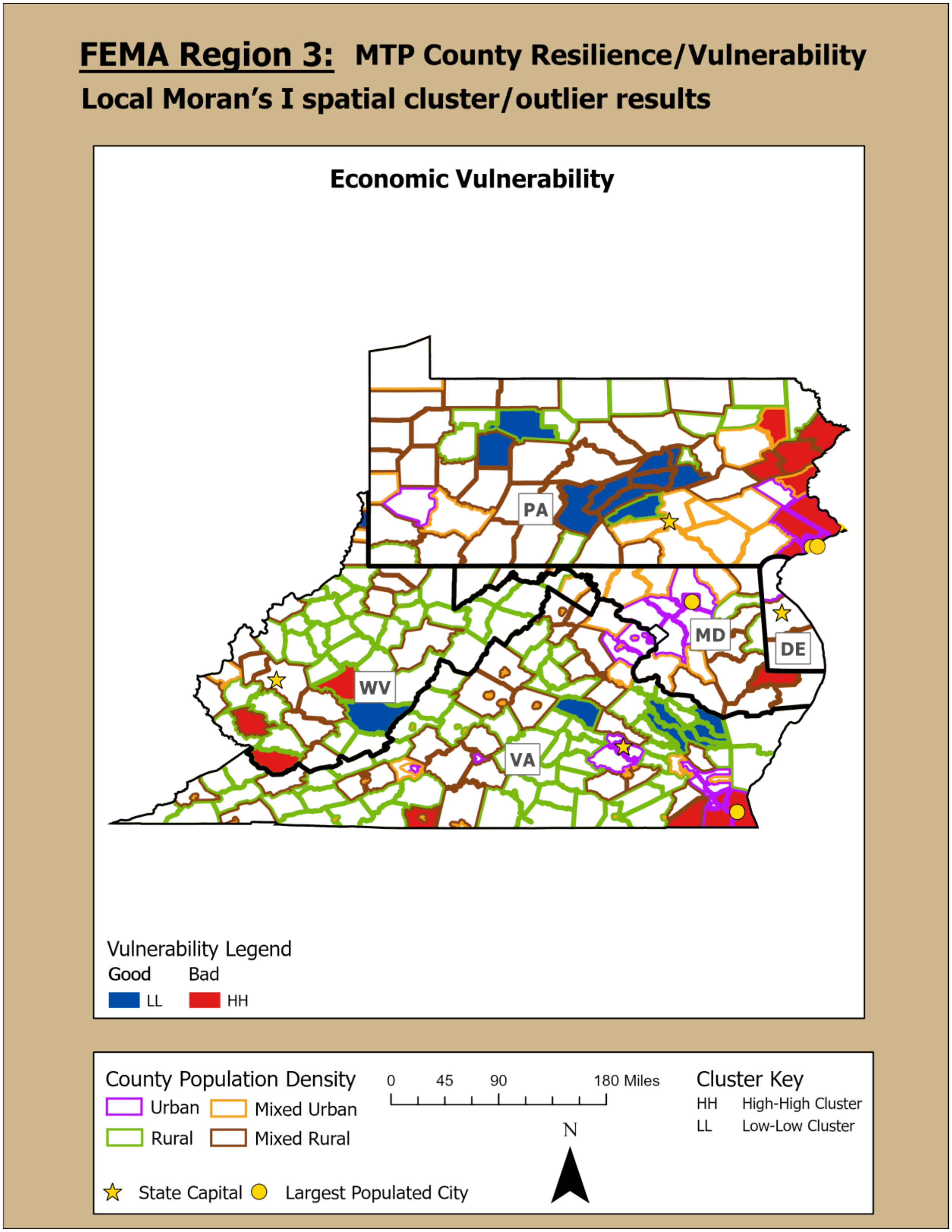
Local Moran's I spatial cluster/outlier results



FEMA Region 3: MTP County Resilience/Vulnerability

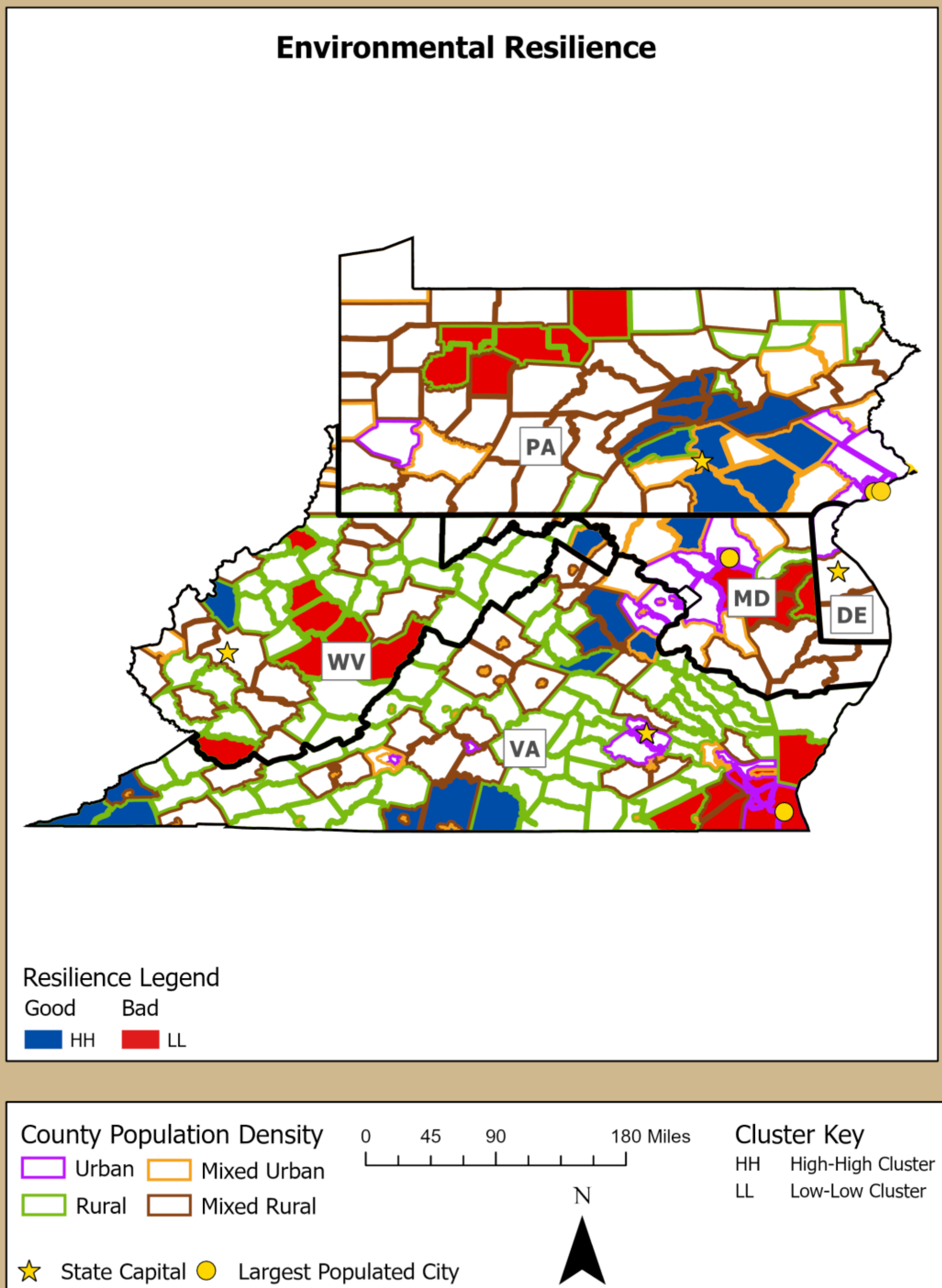
Local Moran's I spatial cluster/outlier results




FEMA Region 3: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results
Economic Vulnerability
PA
WV
MD
DE
VA
Vulnerability Legend
Good
Bad
LL
HH
County Population Density
Urban
Mixed Urban
Rural
Mixed Rural
0
45
90
180 Miles
N
Cluster Key
HH High-High Cluster
LL Low-Low Cluster
State Capital
Largest Populated City

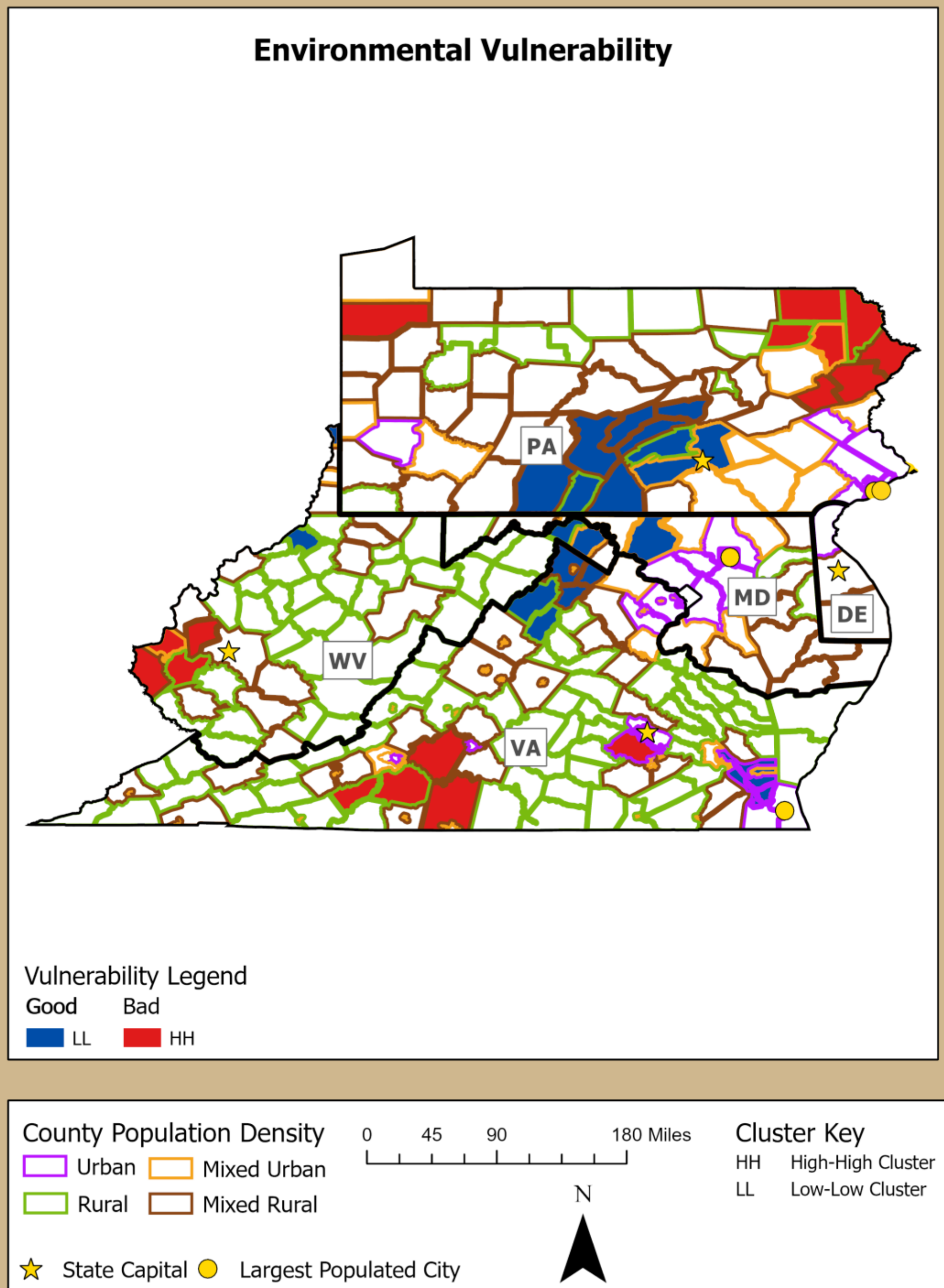
FEMA Region 3: MTP County Resilience/Vulnerability

Local Moran's I spatial cluster/outlier results



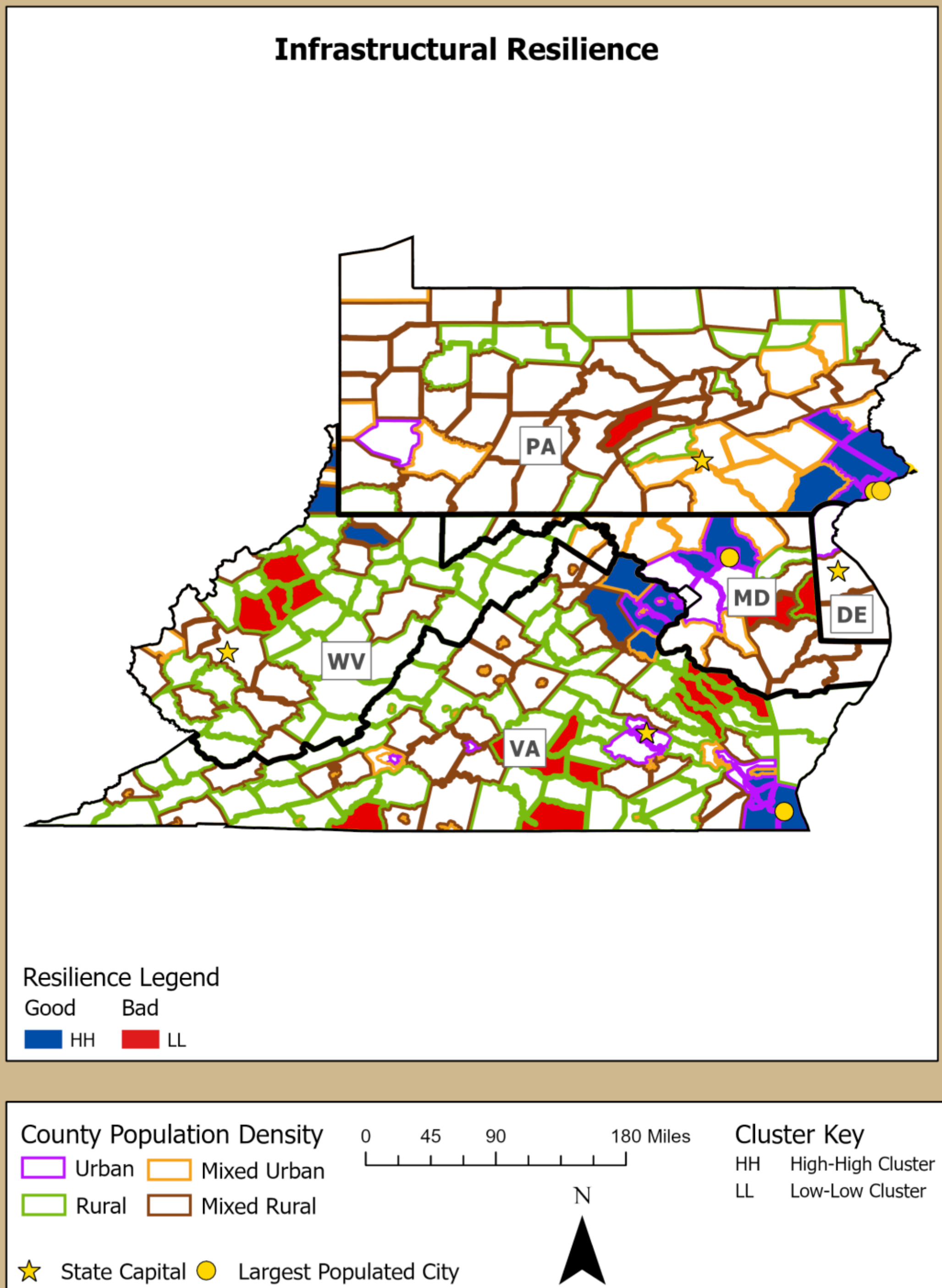
FEMA Region 3: MTP County Resilience/Vulnerability

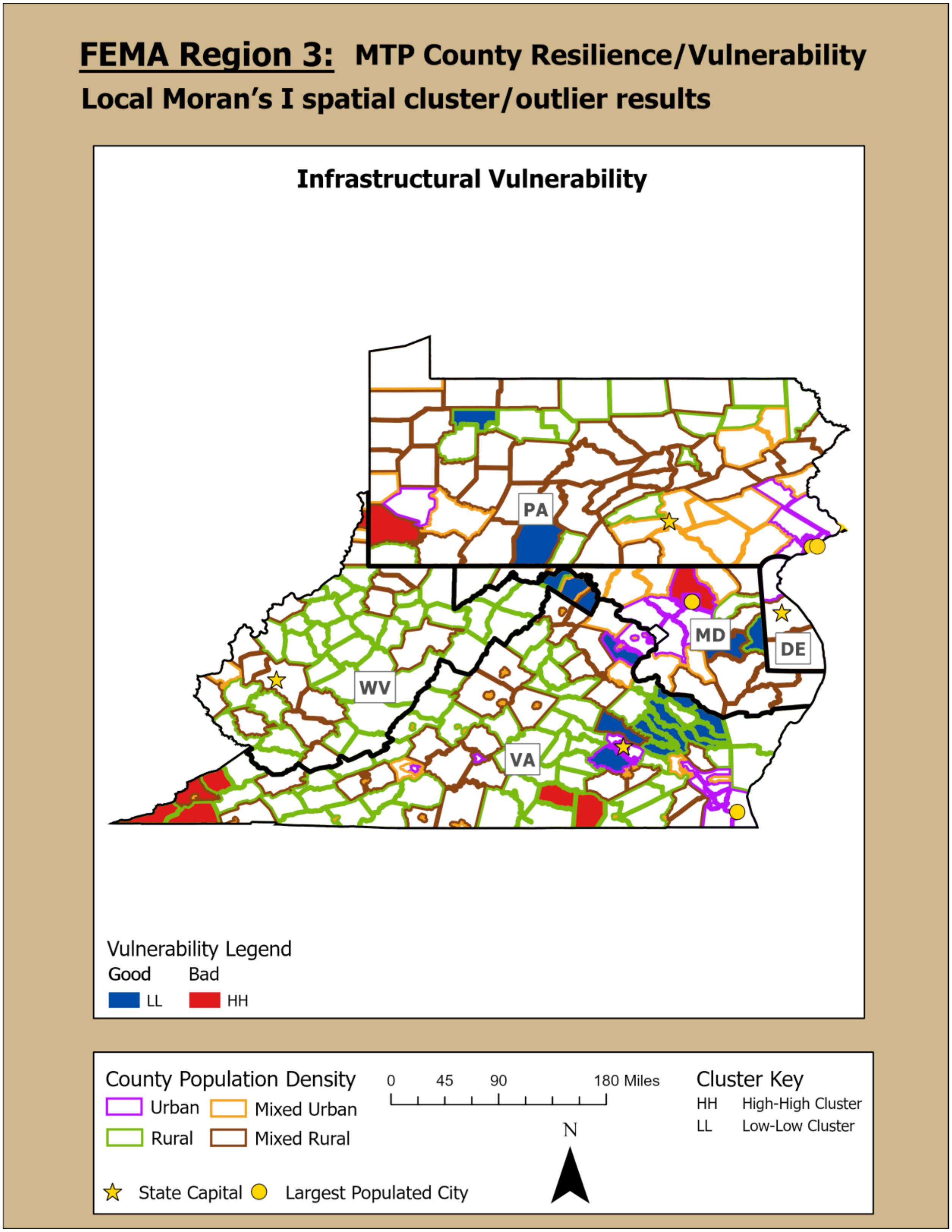
Local Moran's I spatial cluster/outlier results



FEMA Region 3: MTP County Resilience/Vulnerability

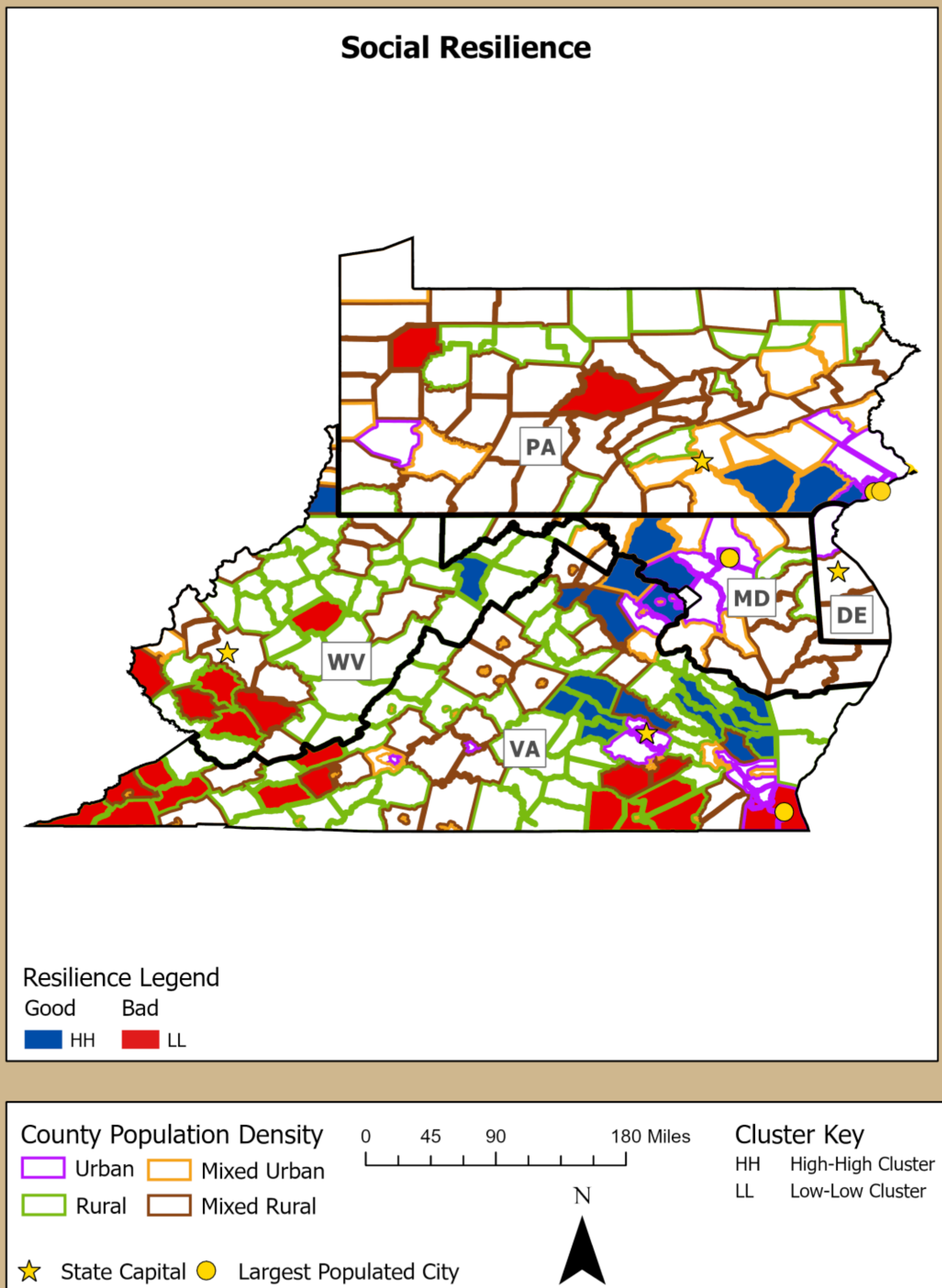
Local Moran's I spatial cluster/outlier results




FEMA Region 3: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results
Infrastructural Vulnerability
PA
MD
DE
WV
VA
Vulnerability Legend
Good
Bad
LL
HH
County Population Density
Urban
Mixed Urban
Rural
Mixed Rural
0
45
90
180 Miles
N
Cluster Key
HH High-High Cluster
LL Low-Low Cluster
State Capital
Largest Populated City

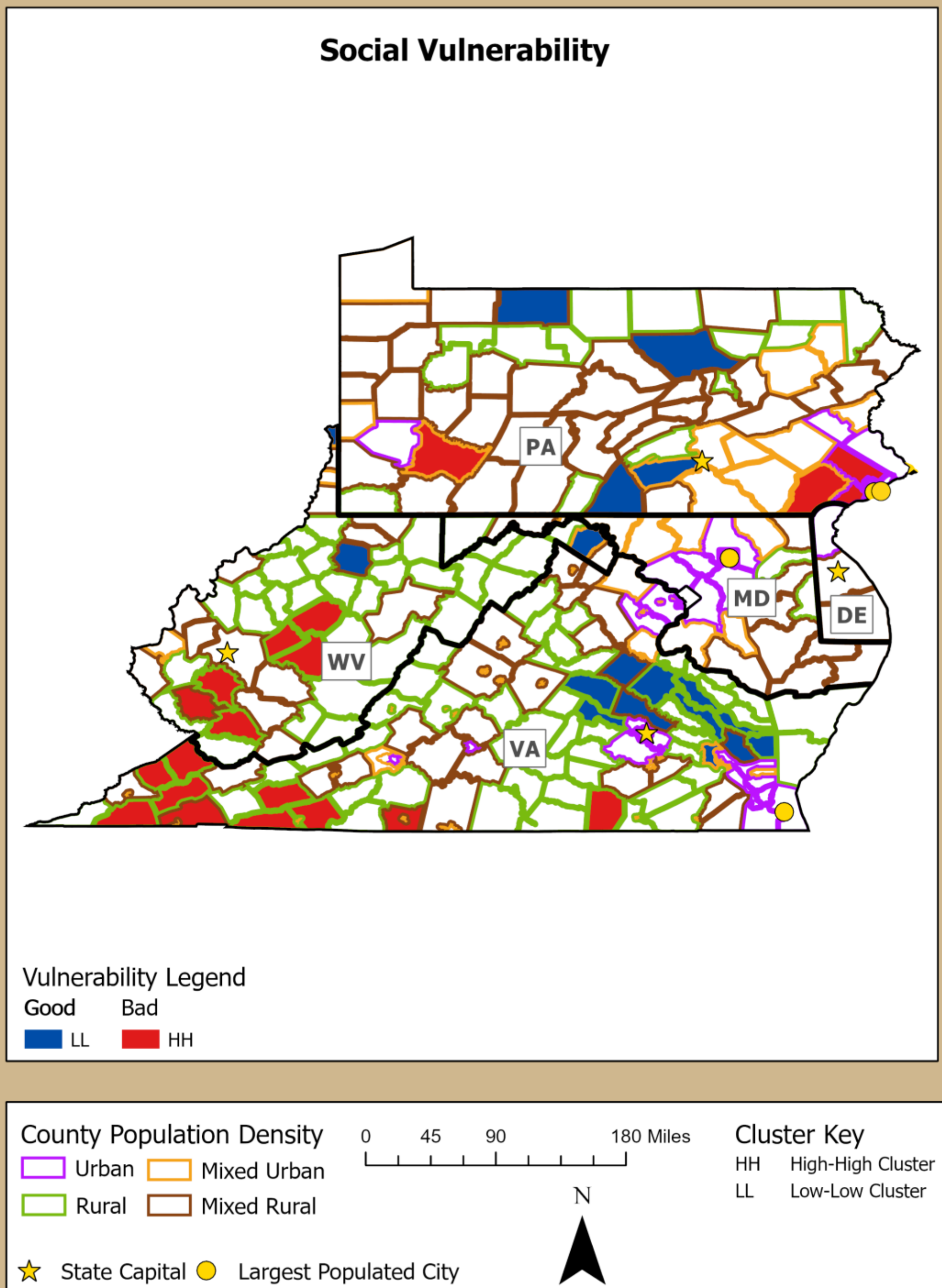
FEMA Region 3: MTP County Resilience/Vulnerability

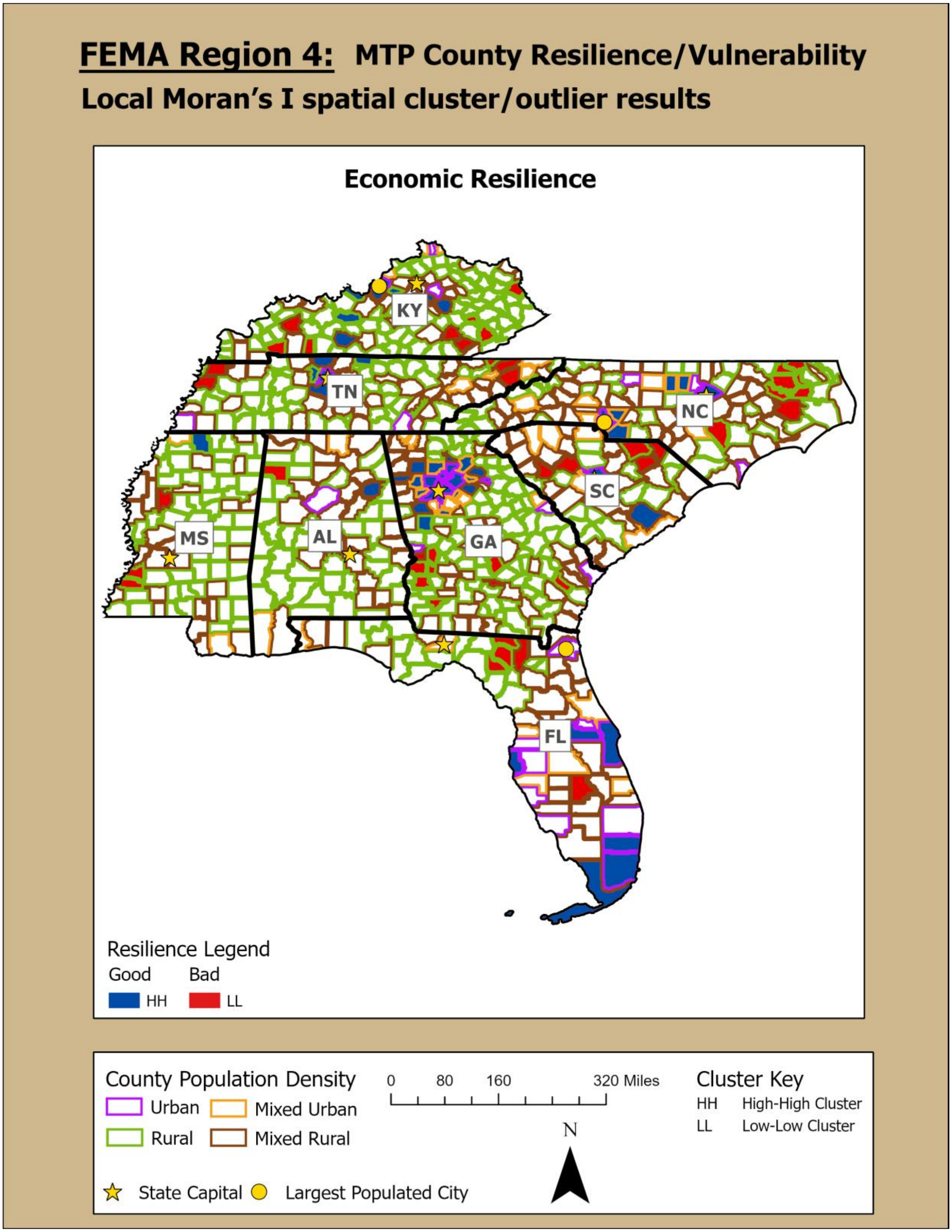
Local Moran's I spatial cluster/outlier results

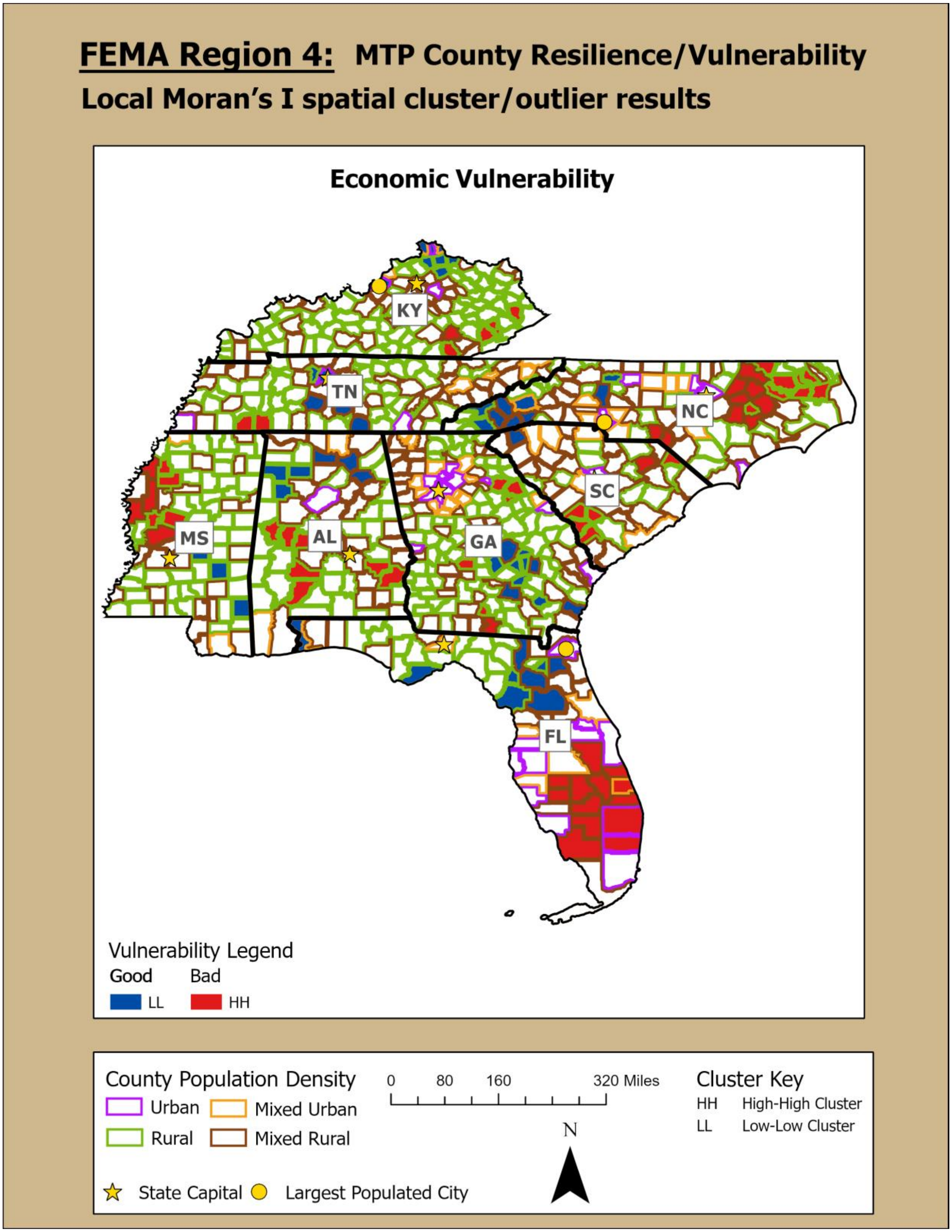


FEMA Region 3: MTP County Resilience/Vulnerability

Local Moran's I spatial cluster/outlier results

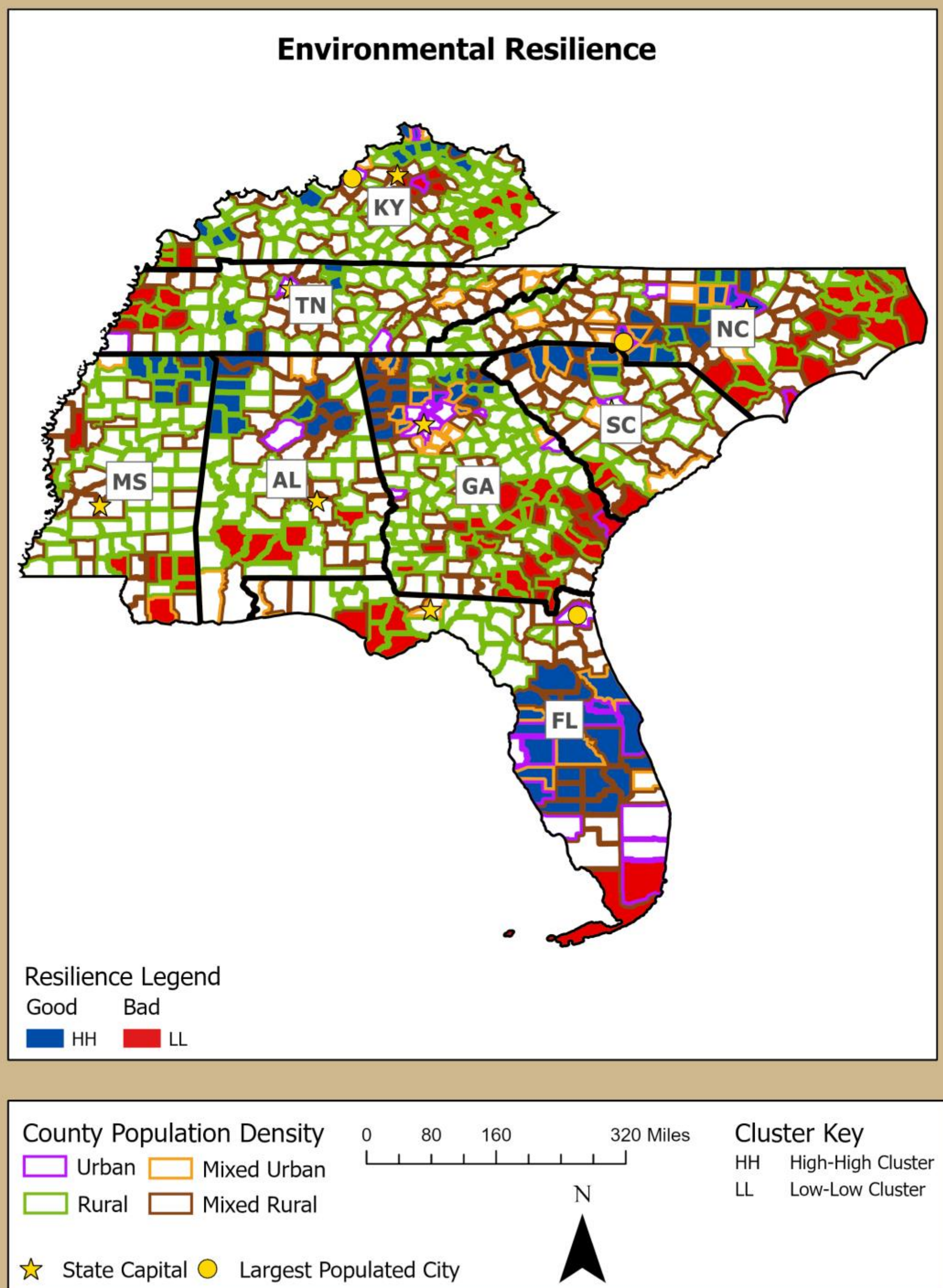


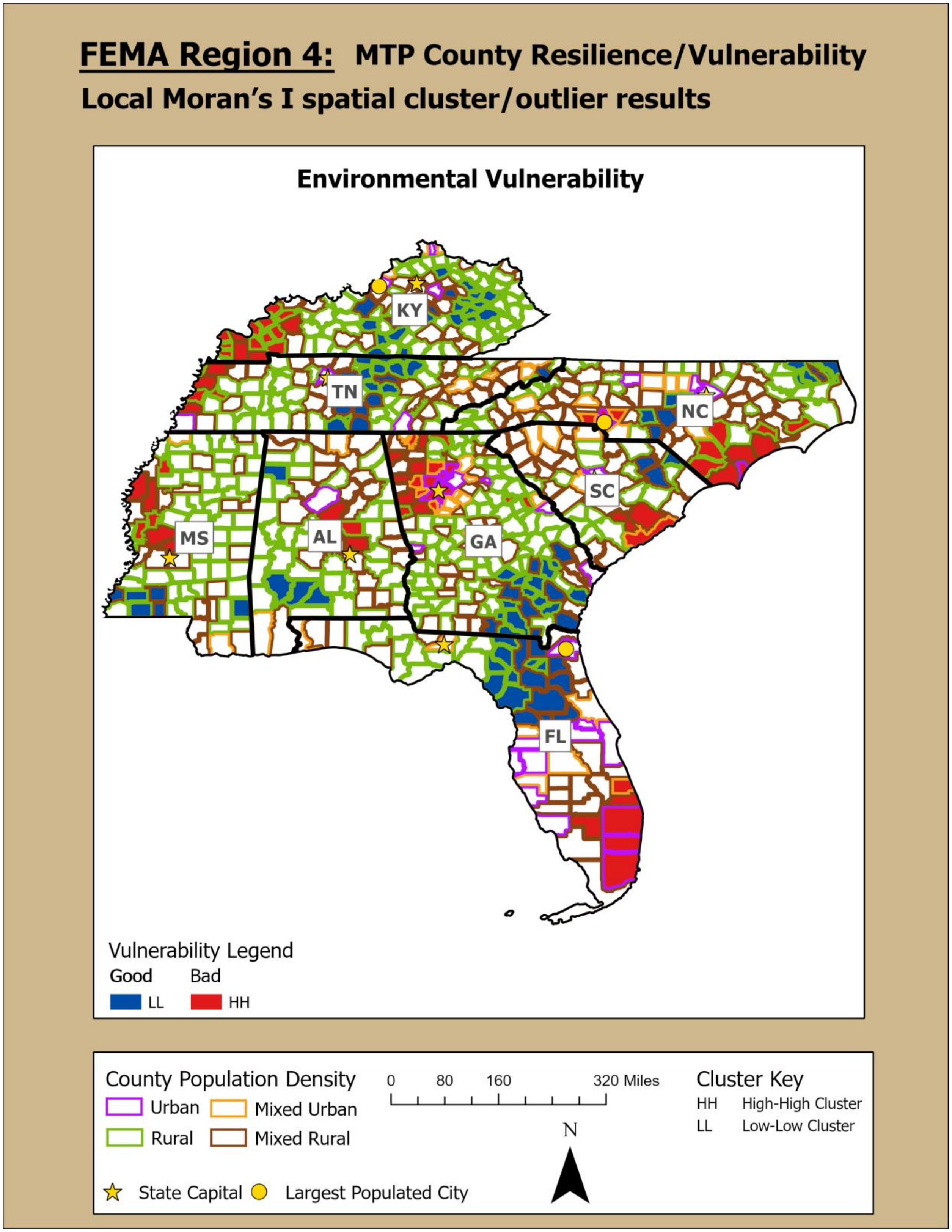

FEMA Region 4: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results
Economic Resilience
KY
TN
NC
SC
MS
AL
GA
FL
Resilience Legend
Good
Bad
HH
LL
County Population Density
Urban
Mixed Urban
Rural
Mixed Rural
0
80
160
320 Miles
Cluster Key
HH High-High Cluster
LL Low-Low Cluster
N
State Capital
Largest Populated City

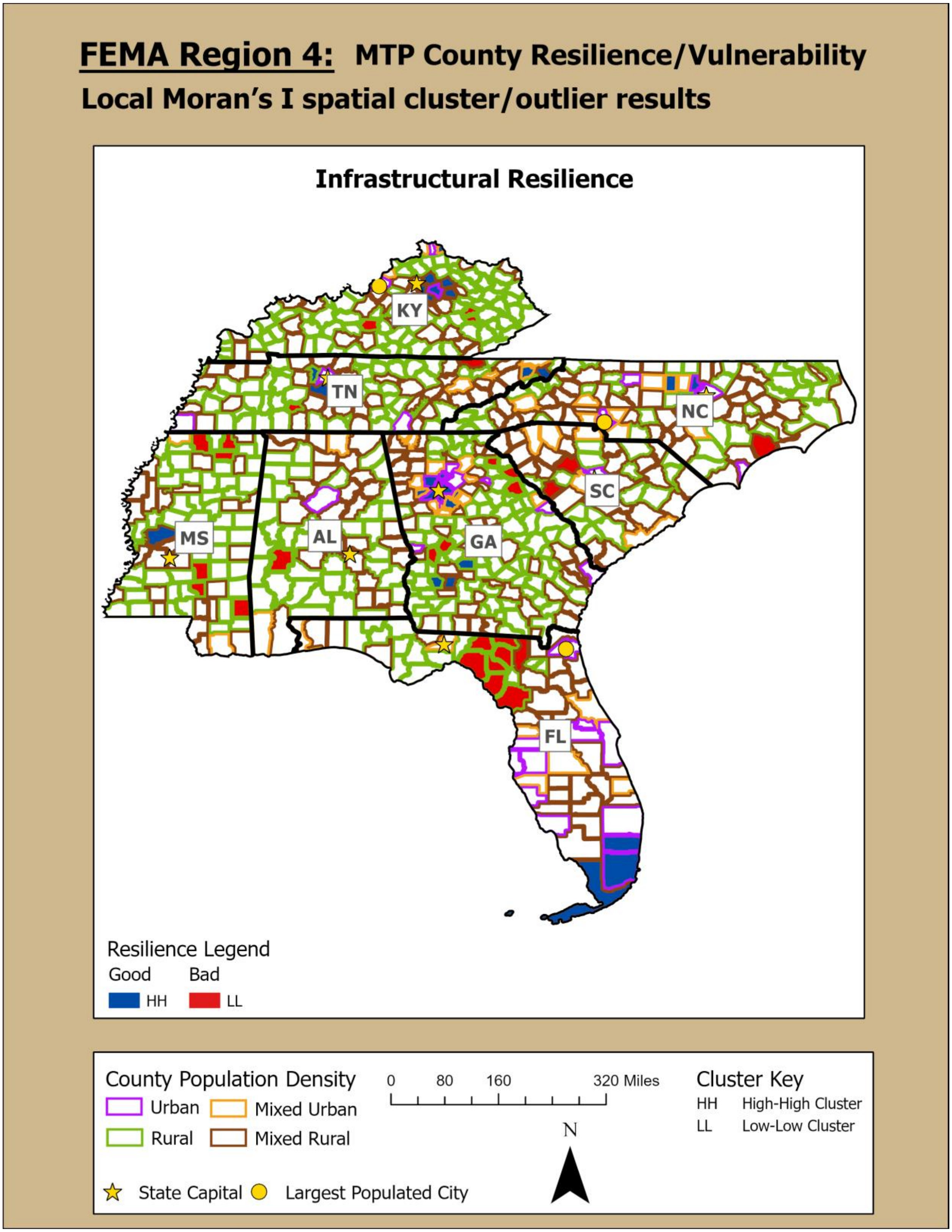

FEMA Region 4: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results
Economic Vulnerability
KY
TN
NC
SC
MS
AL
GA
FL
Vulnerability Legend
Good
Bad
LL
HH
County Population Density
Urban
Mixed Urban
Rural
Mixed Rural
0
80
160
320 Miles
N
Cluster Key
HH High-High Cluster
LL Low-Low Cluster
State Capital
Largest Populated City

FEMA Region 4: **MTP County Resilience/Vulnerability**

Local Moran's I spatial cluster/outlier results

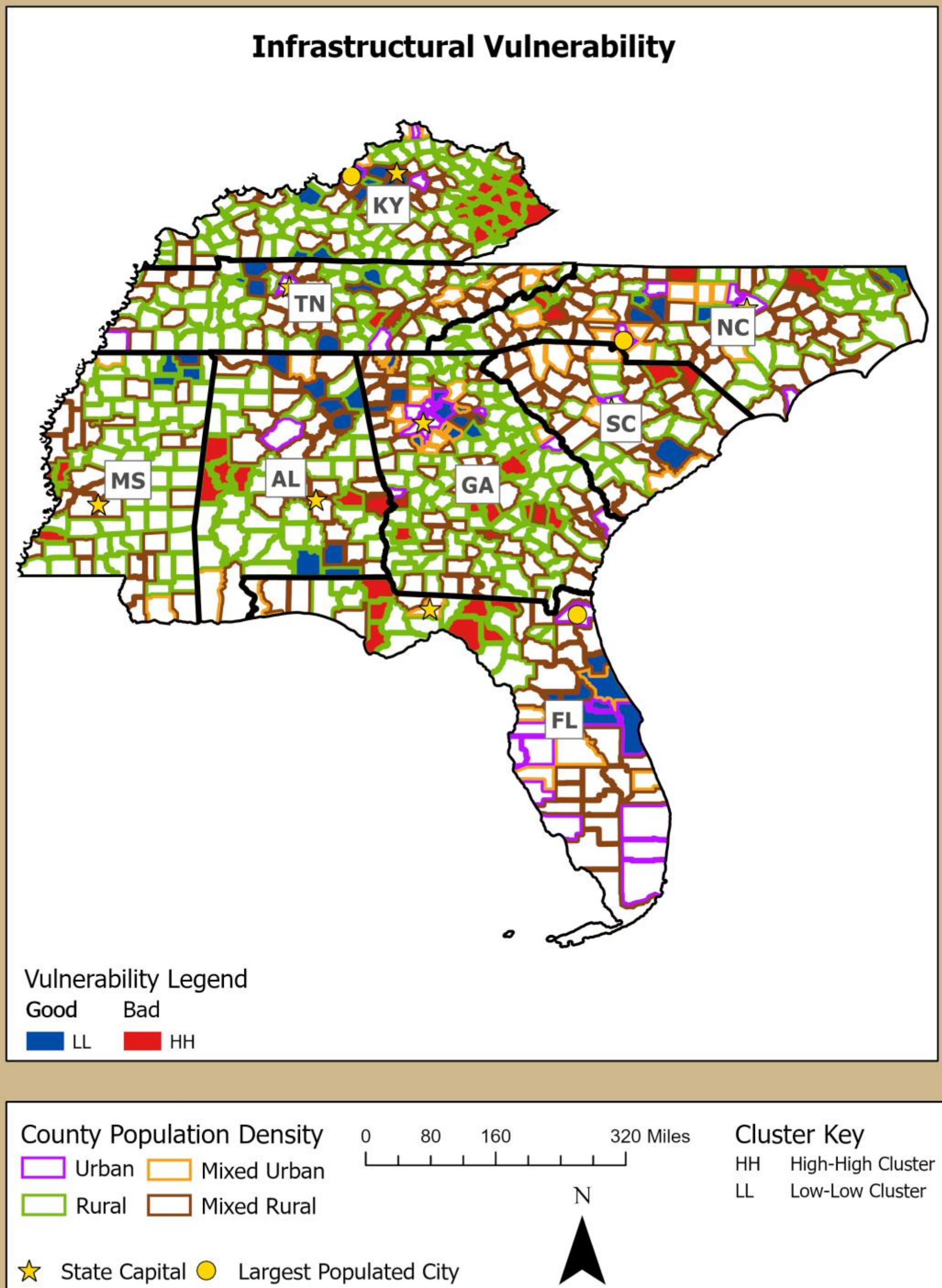


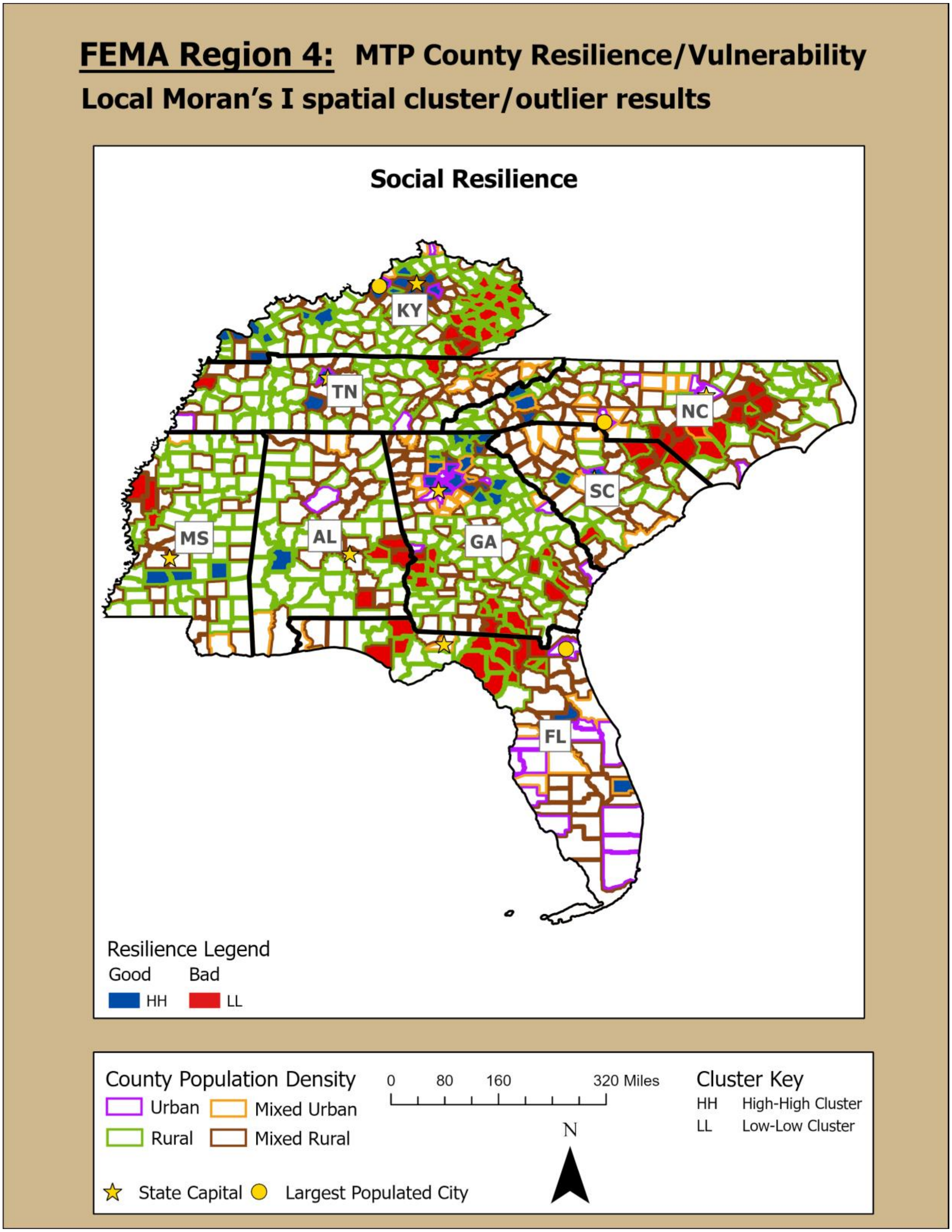

FEMA Region 4: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results
Environmental Vulnerability
KY
TN
NC
SC
MS
AL
GA
FL
Vulnerability Legend
Good
Bad
LL
HH
County Population Density
Urban
Mixed Urban
Rural
Mixed Rural
0
80
160
320 Miles
N
Cluster Key
HH High-High Cluster
LL Low-Low Cluster
State Capital
Largest Populated City


FEMA Region 4: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results
Infrastructural Resilience
KY
TN
NC
SC
MS
AL
GA
FL
Resilience Legend
Good
Bad
HH
LL
County Population Density
Urban
Mixed Urban
Rural
Mixed Rural
0
80
160
320 Miles
N
Cluster Key
HH High-High Cluster
LL Low-Low Cluster
State Capital
Largest Populated City

FEMA Region 4: MTP County Resilience/Vulnerability

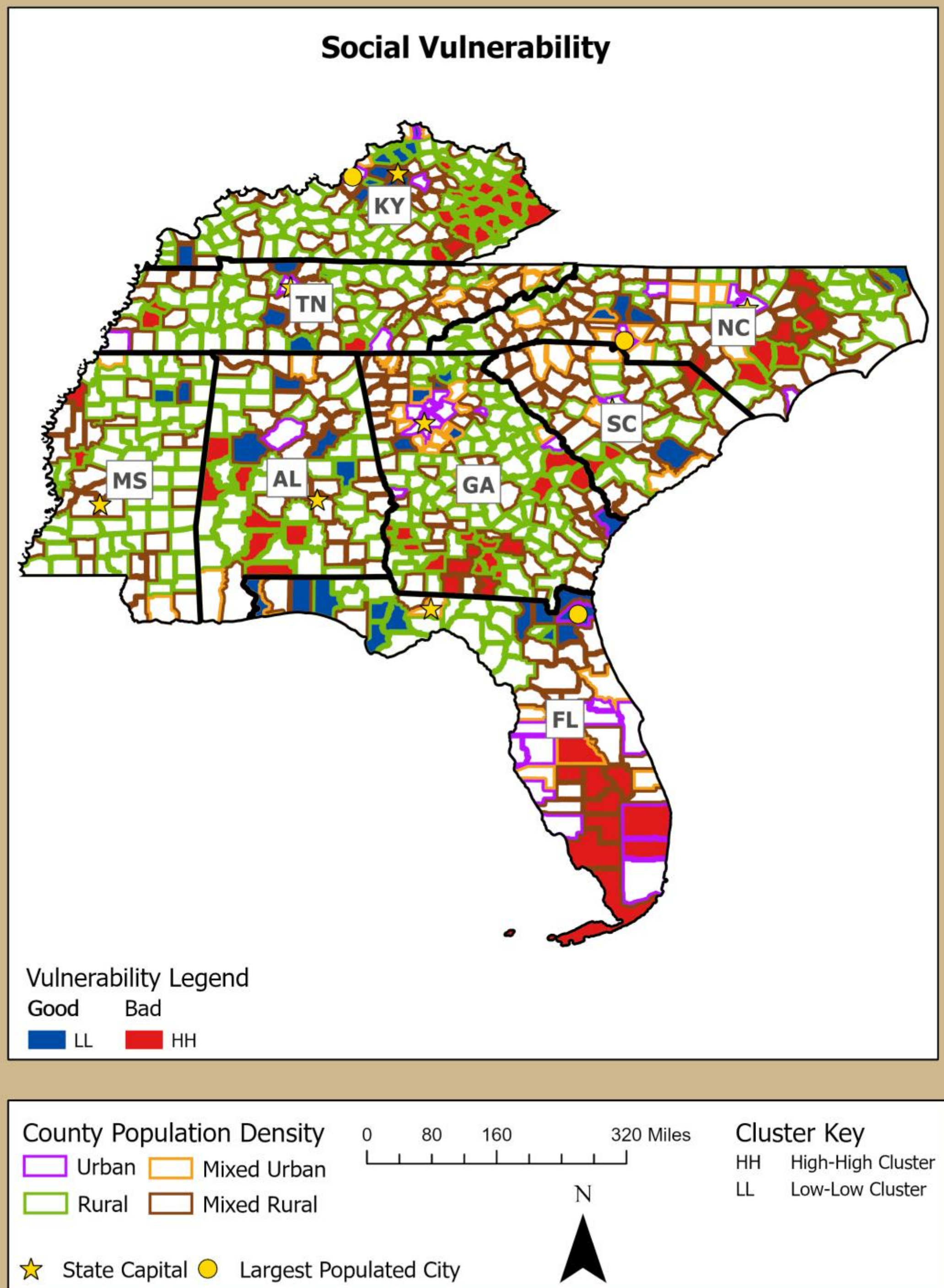
Local Moran's I spatial cluster/outlier results

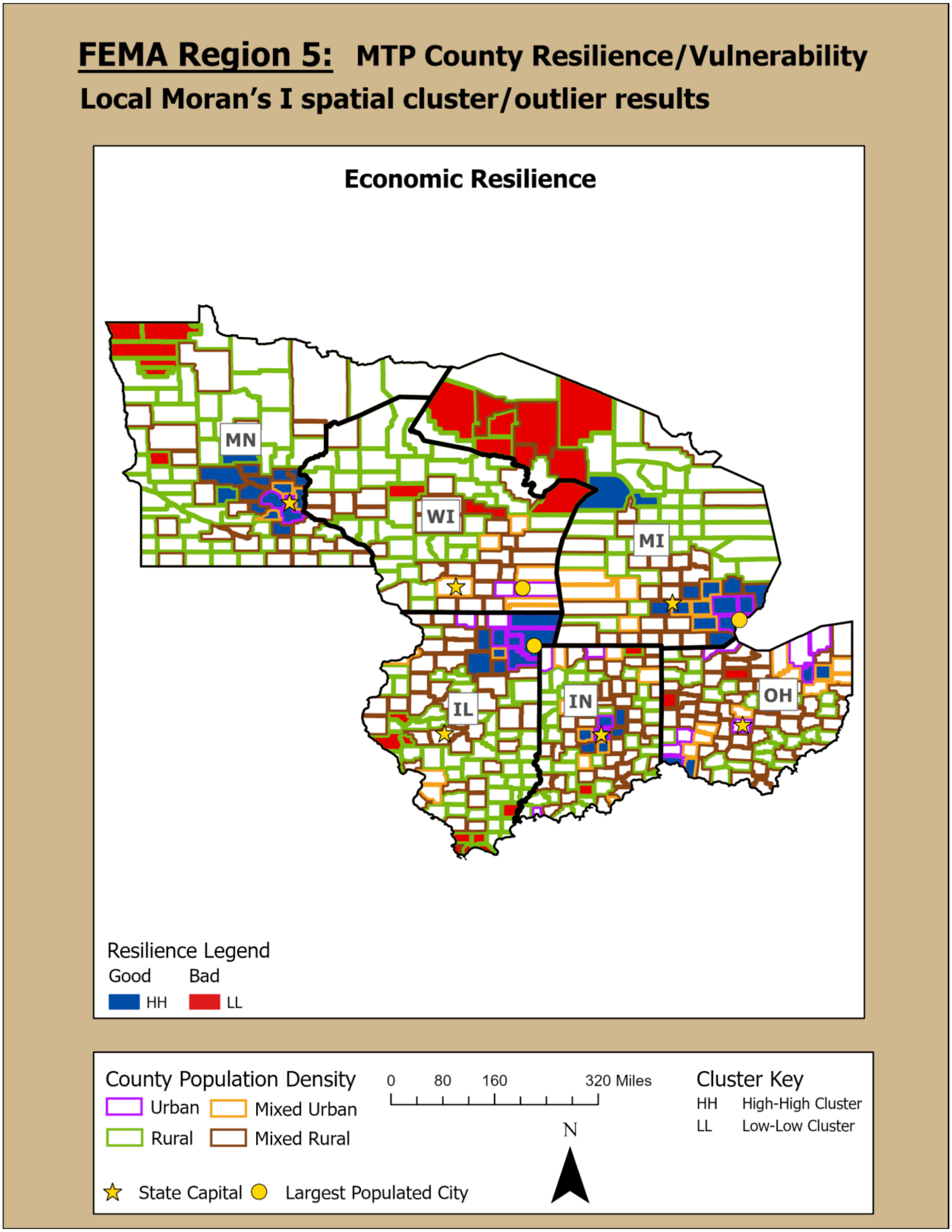



FEMA Region 4: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results
Social Resilience
KY
TN
NC
SC
MS
AL
GA
FL
Resilience Legend
Good
Bad
HH
LL
County Population Density
Urban
Mixed Urban
Rural
Mixed Rural
State Capital
Largest Populated City
0
80
160
320 Miles
N
Cluster Key
HH High-High Cluster
LL Low-Low Cluster

FEMA Region 4: MTP County Resilience/Vulnerability

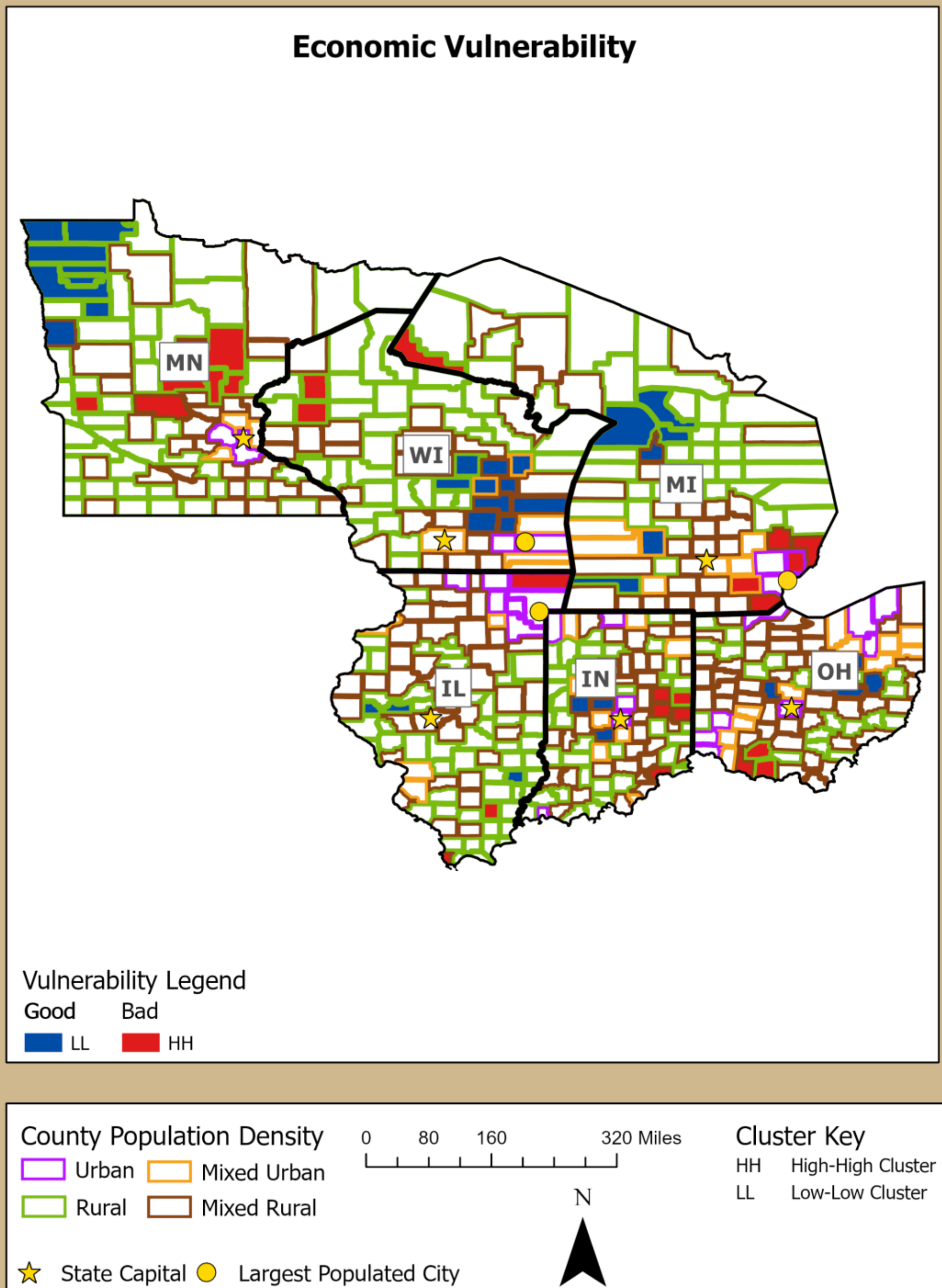
Local Moran's I spatial cluster/outlier results




FEMA Region 5: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results
Economic Resilience
MN
WI
MI
IL
IN
OH
Resilience Legend
Good
Bad
HH
LL
County Population Density
Urban
Mixed Urban
Rural
Mixed Rural
0
80
160
320 Miles
N
Cluster Key
HH High-High Cluster
LL Low-Low Cluster
State Capital
Largest Populated City

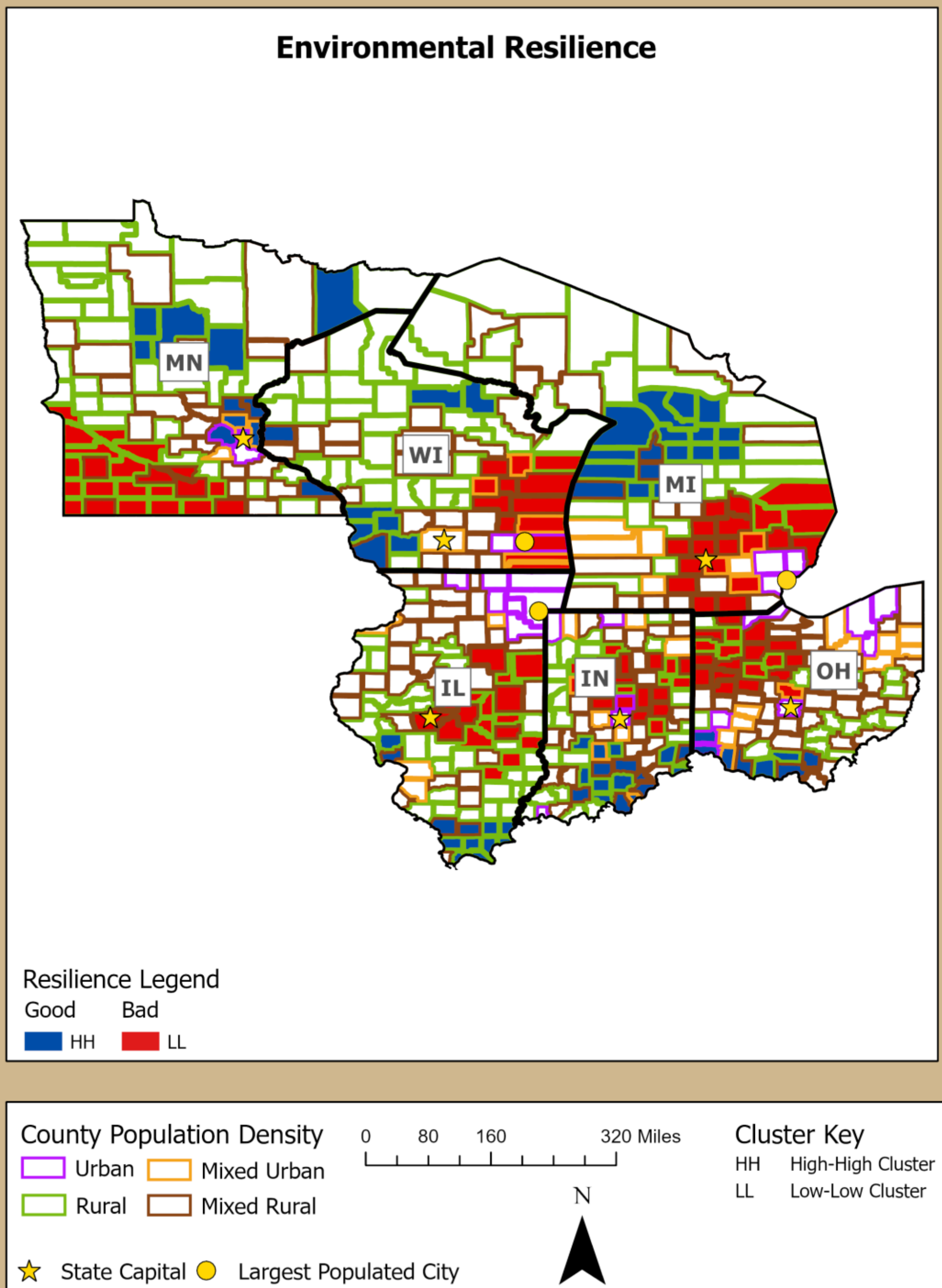
FEMA Region 5: MTP County Resilience/Vulnerability

Local Moran's I spatial cluster/outlier results

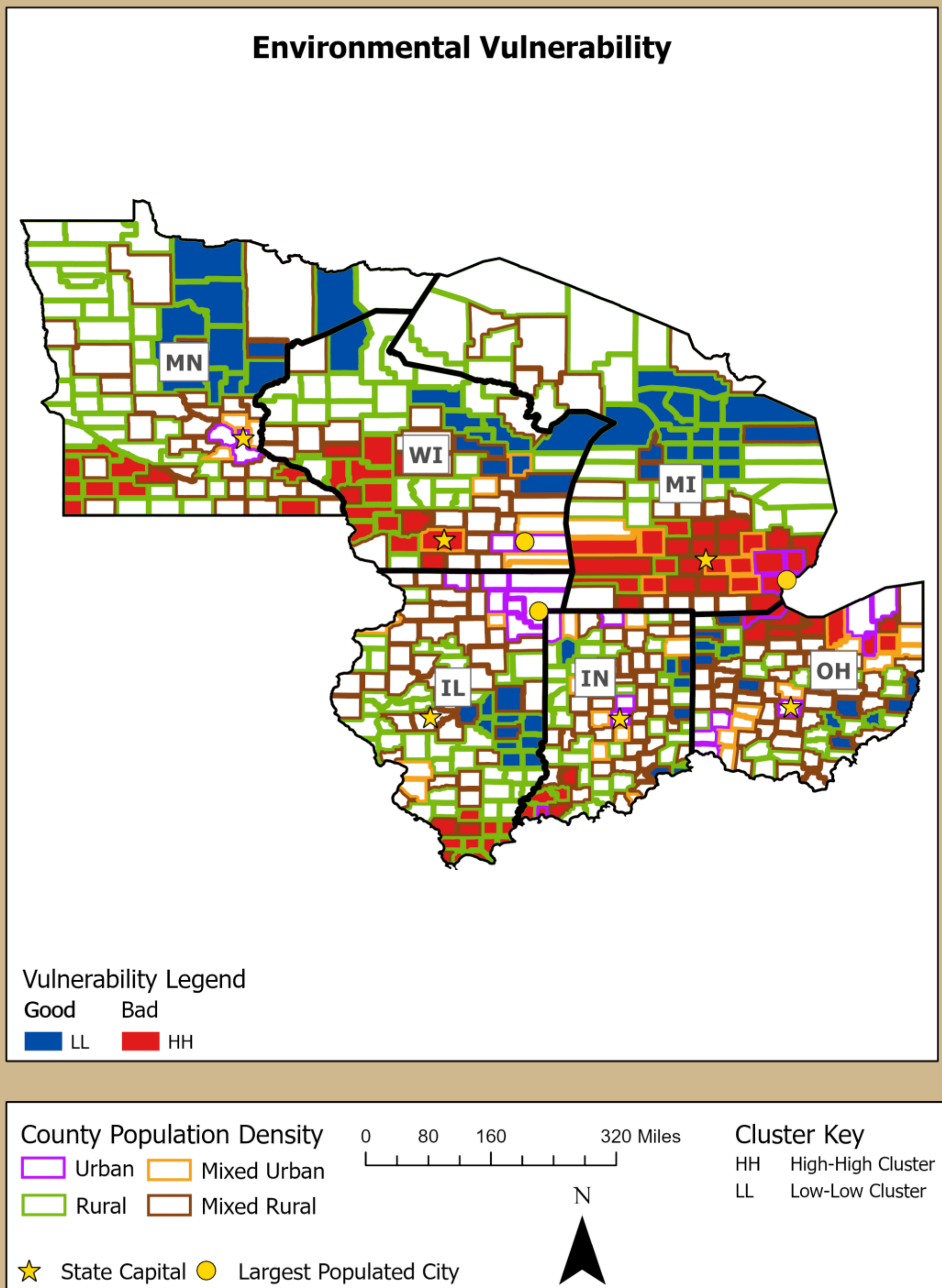


FEMA Region 5: MTP County Resilience/Vulnerability

Local Moran's I spatial cluster/outlier results

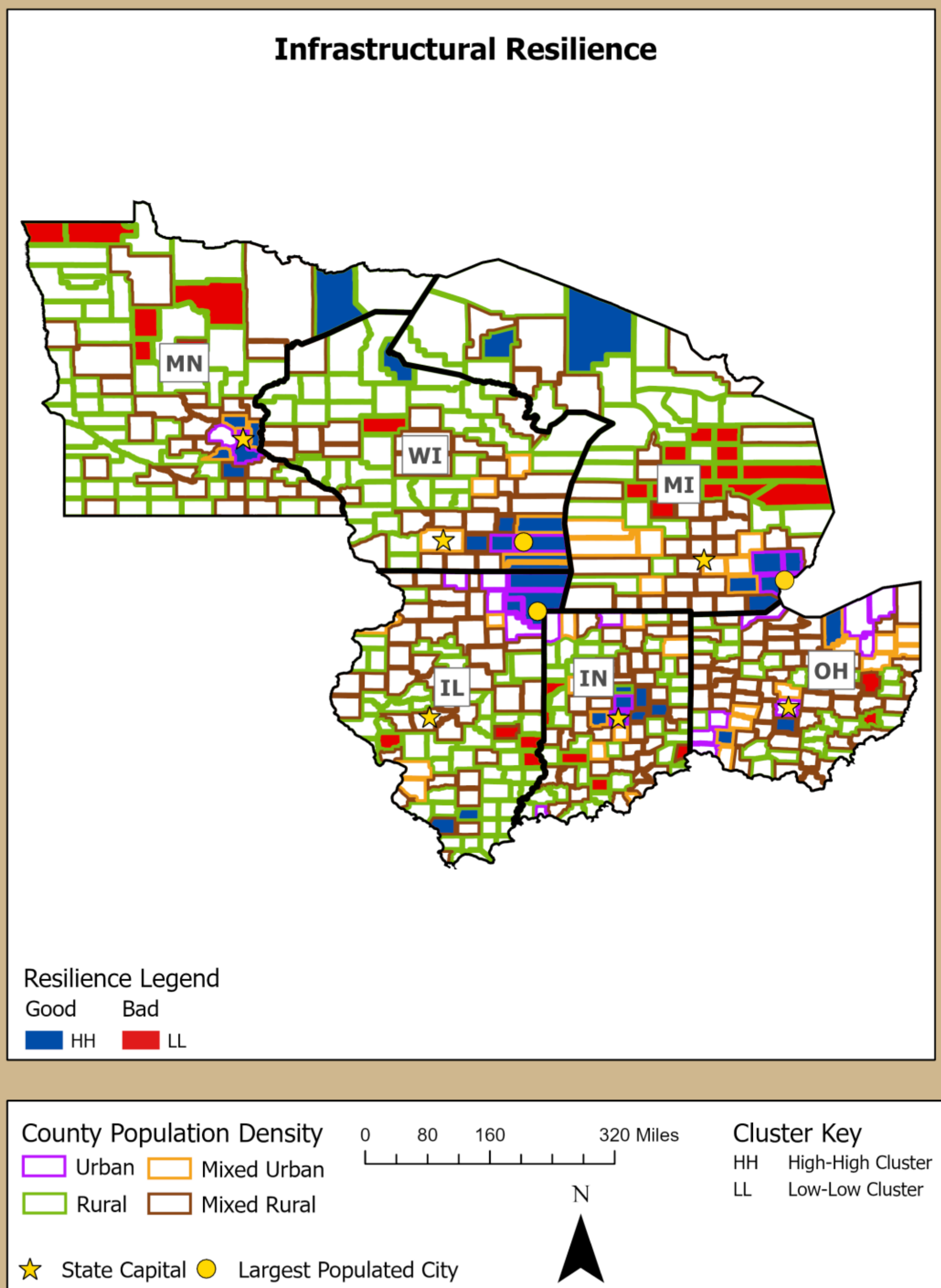


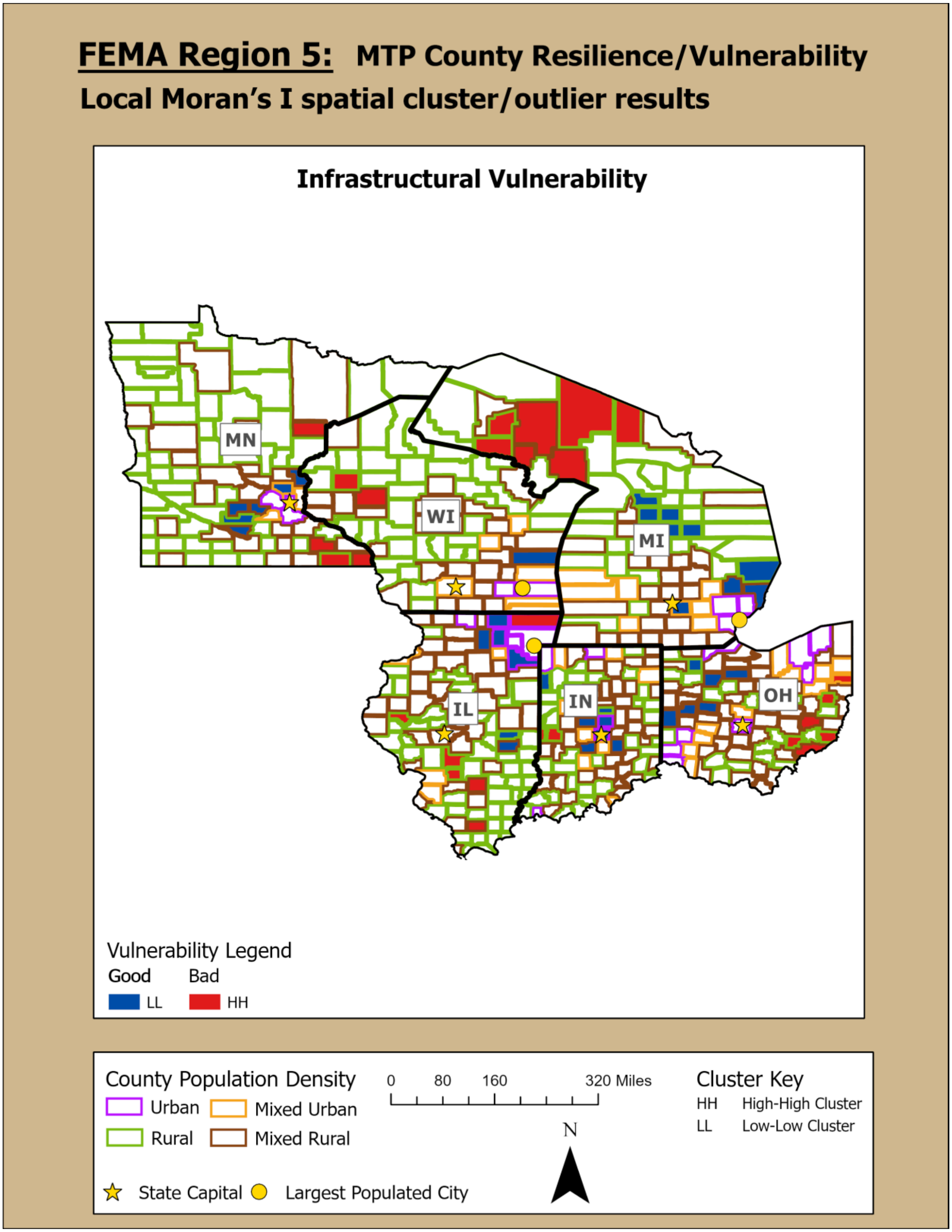
FEMA Region 5: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results

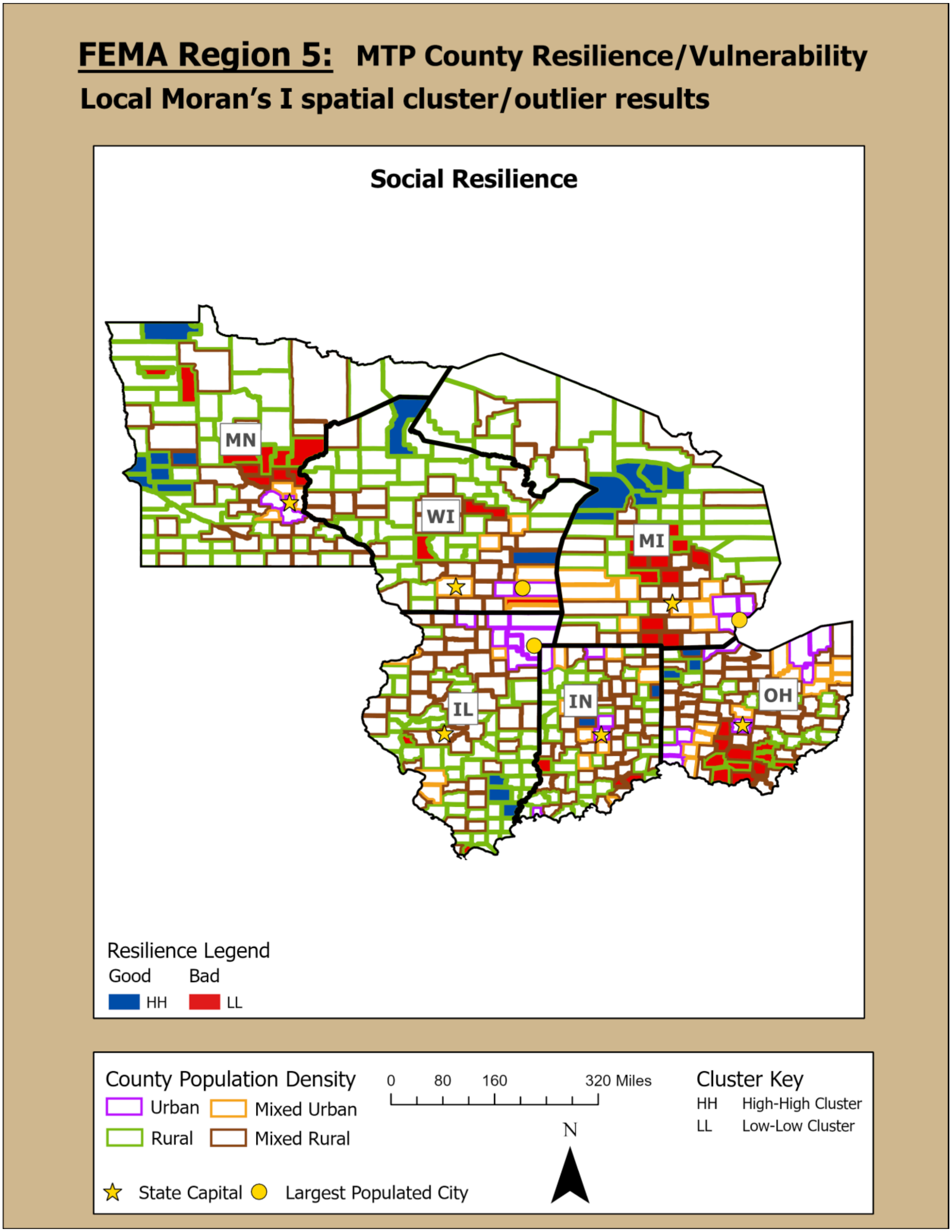


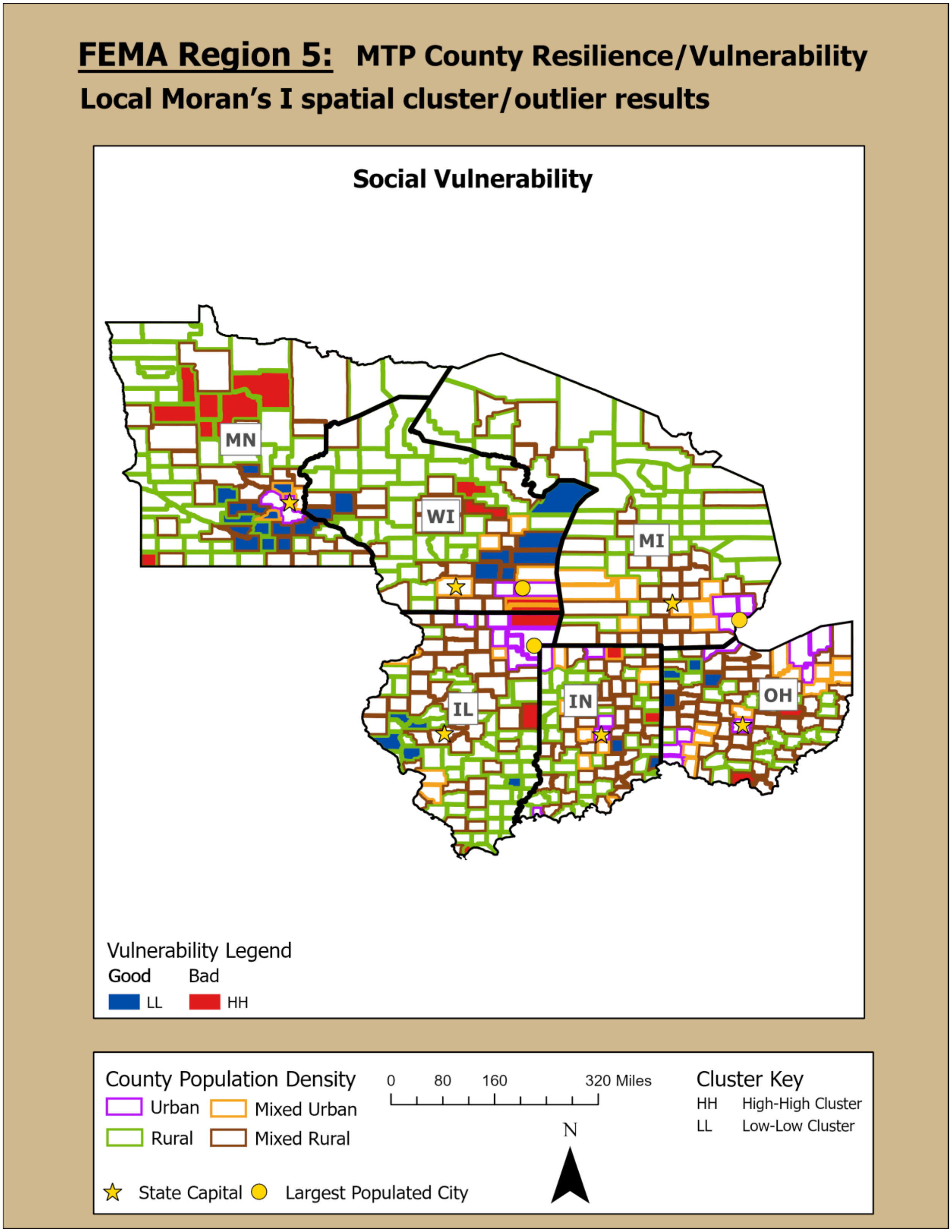
FEMA Region 5: MTP County Resilience/Vulnerability

Local Moran's I spatial cluster/outlier results



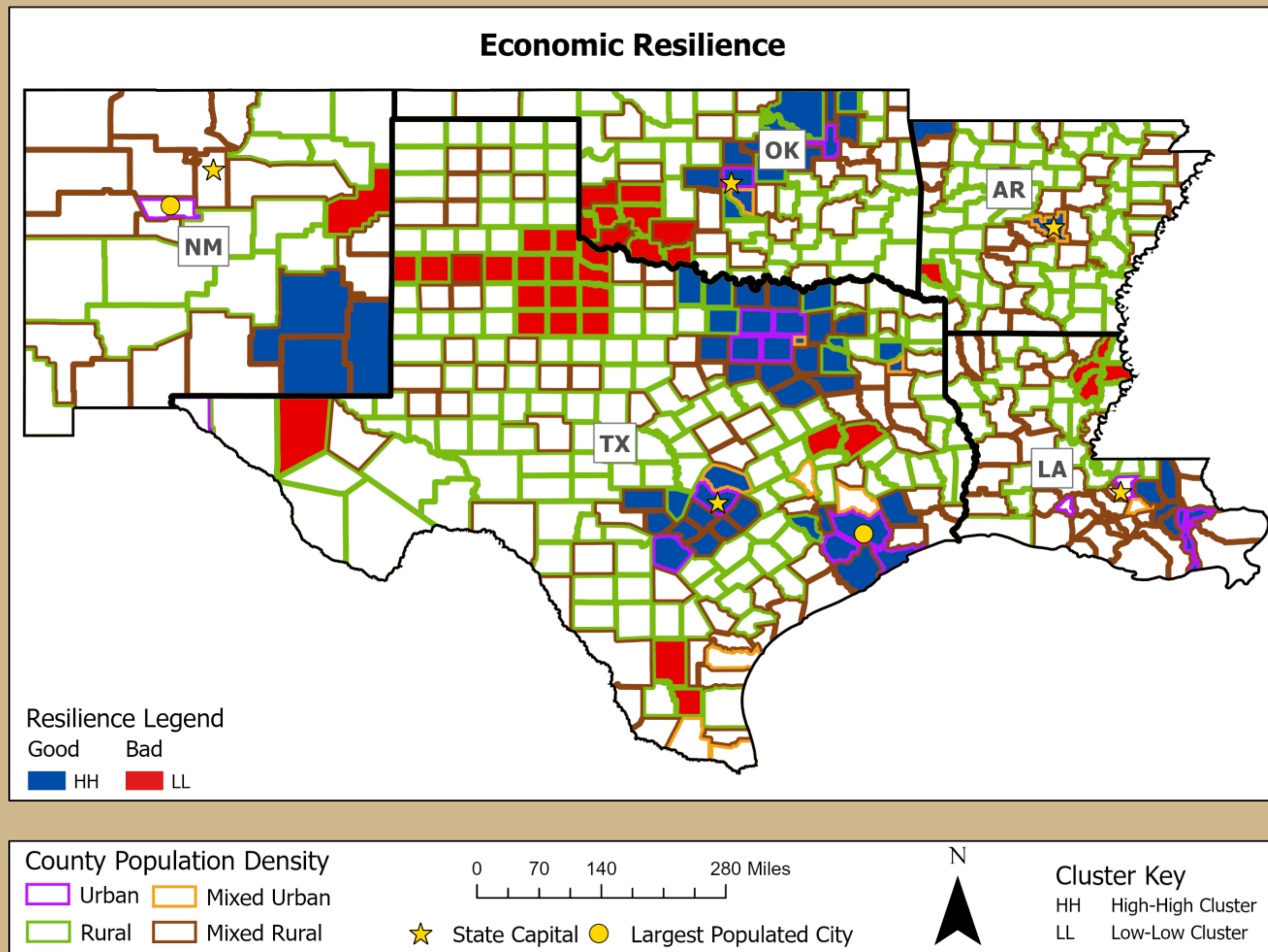

FEMA Region 5: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results
Infrastructural Vulnerability
MN
WI
MI
IL
IN
OH
Vulnerability Legend
Good
Bad
LL
HH
County Population Density
Urban
Mixed Urban
Rural
Mixed Rural
0
80
160
320 Miles
N
Cluster Key
HH High-High Cluster
LL Low-Low Cluster
State Capital
Largest Populated City


FEMA Region 5: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results
Social Resilience
MN
WI
MI
IL
IN
OH
Resilience Legend
Good
Bad
HH
LL
County Population Density
Urban
Mixed Urban
Rural
Mixed Rural
0
80
160
320 Miles
N
Cluster Key
HH High-High Cluster
LL Low-Low Cluster
State Capital
Largest Populated City


FEMA Region 5: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results
Social Vulnerability
MN
WI
MI
IL
IN
OH
Vulnerability Legend
Good
Bad
LL
HH
County Population Density
Urban
Mixed Urban
Rural
Mixed Rural
0
80
160
320 Miles
N
Cluster Key
HH High-High Cluster
LL Low-Low Cluster
State Capital
Largest Populated City

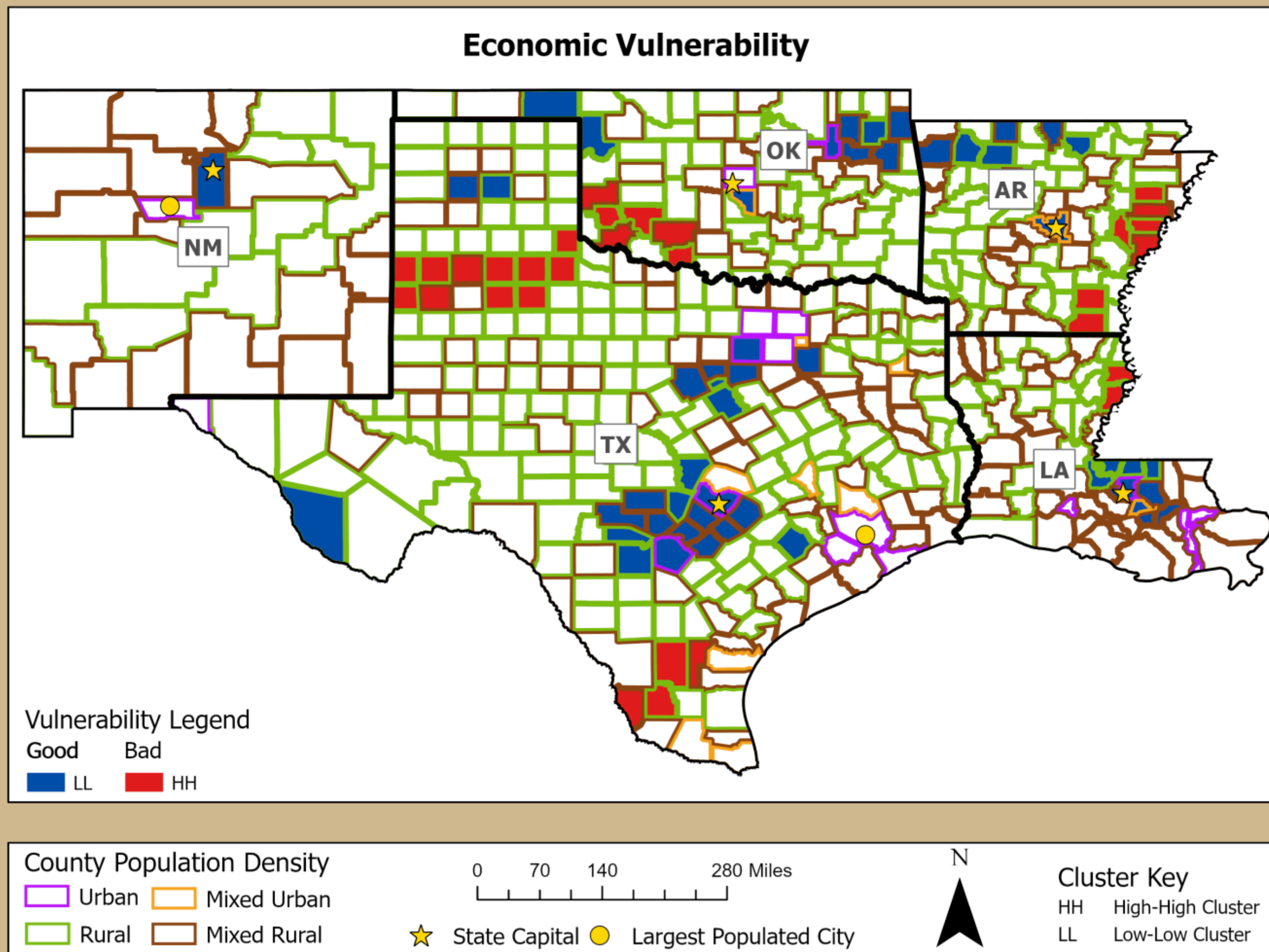
FEMA Region 6: MTP County Resilience/Vulnerability

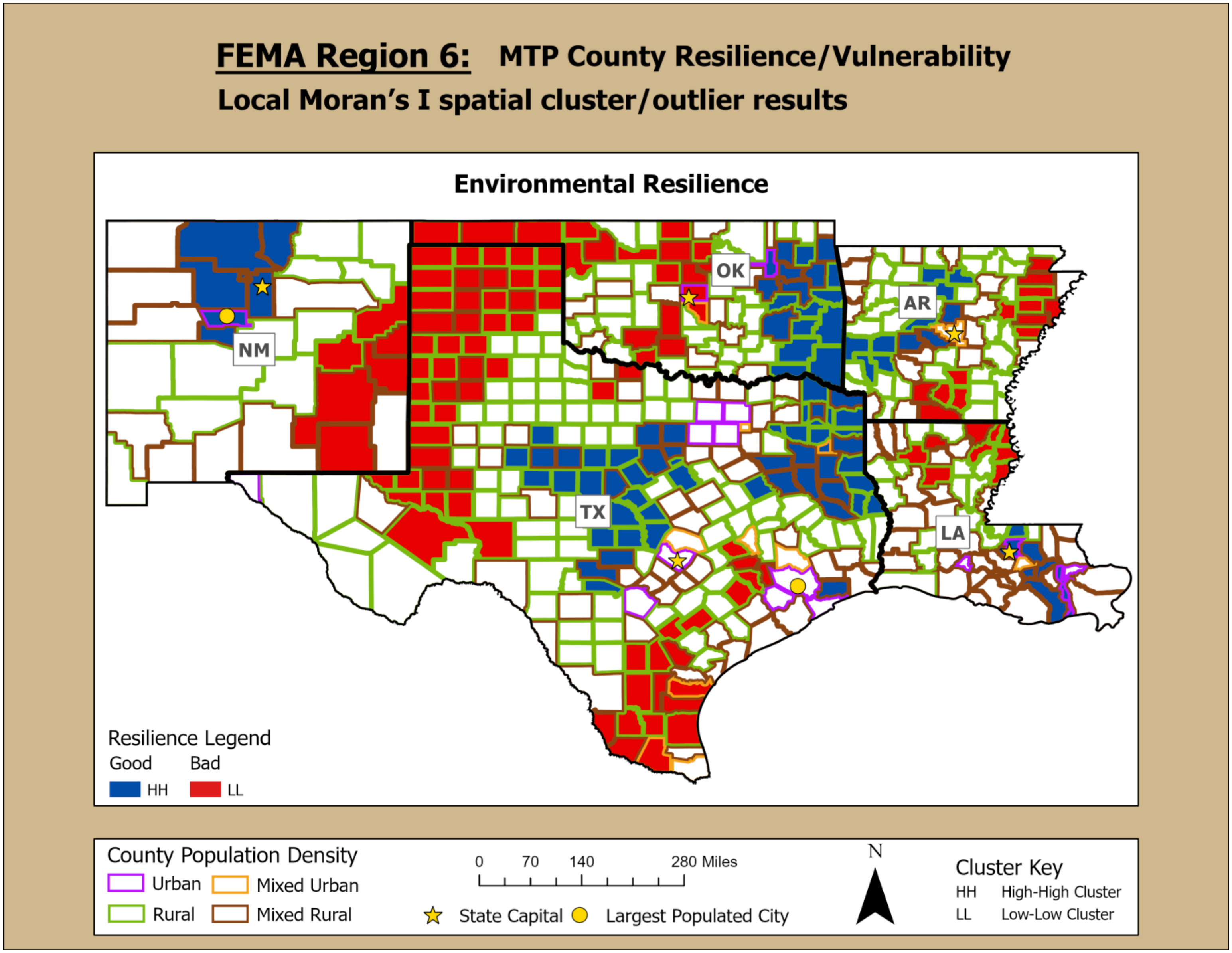
Local Moran's I spatial cluster/outlier results



FEMA Region 6: MTP County Resilience/Vulnerability

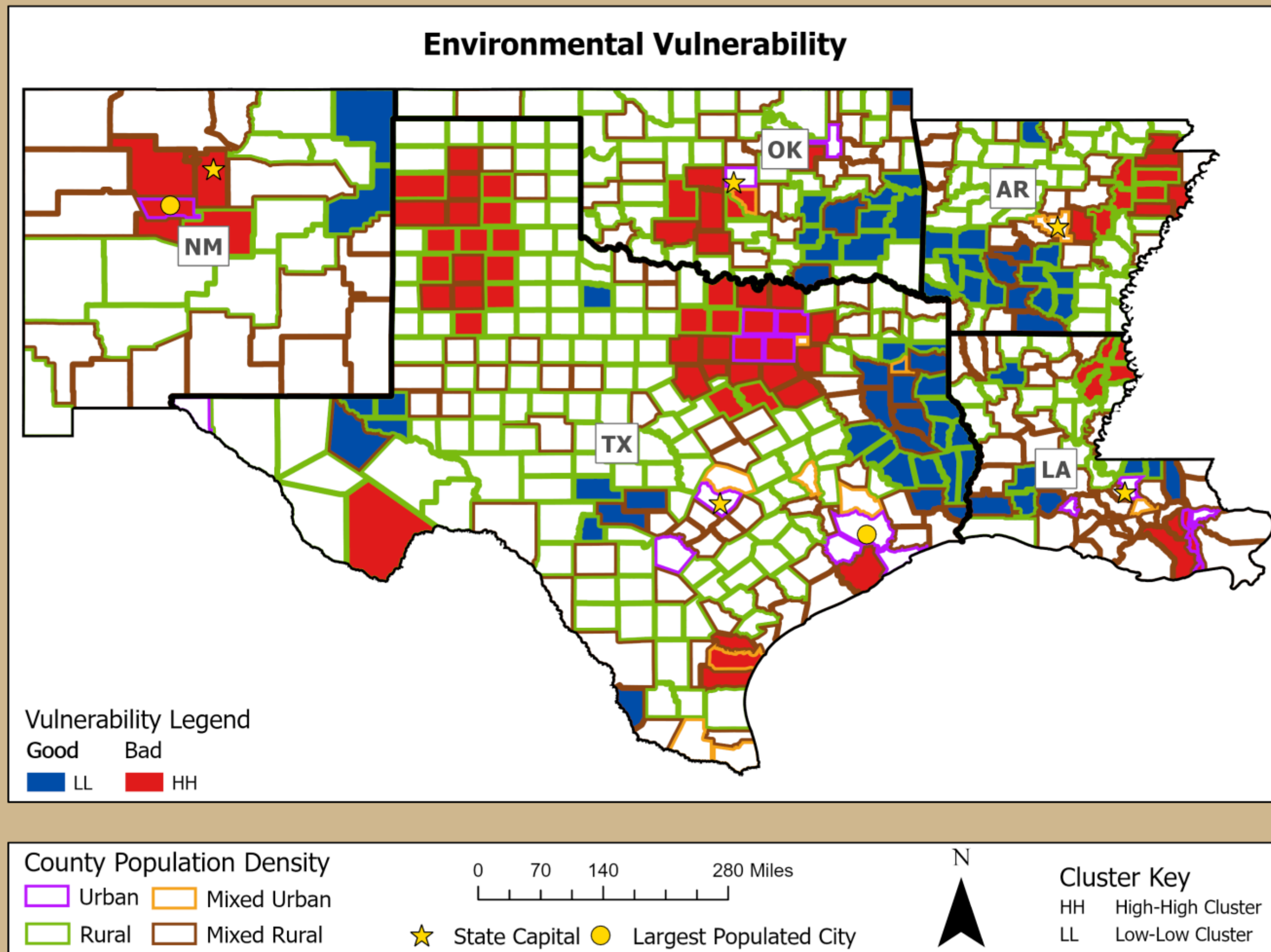
Local Moran's I spatial cluster/outlier results




FEMA Region 6: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results
Environmental Resilience
NM
OK
AR
TX
LA
Resilience Legend
Good
Bad
HH
LL
County Population Density
Urban
Mixed Urban
Rural
Mixed Rural
0
70
140
280 Miles
State Capital
Largest Populated City
N
Cluster Key
HH High-High Cluster
LL Low-Low Cluster

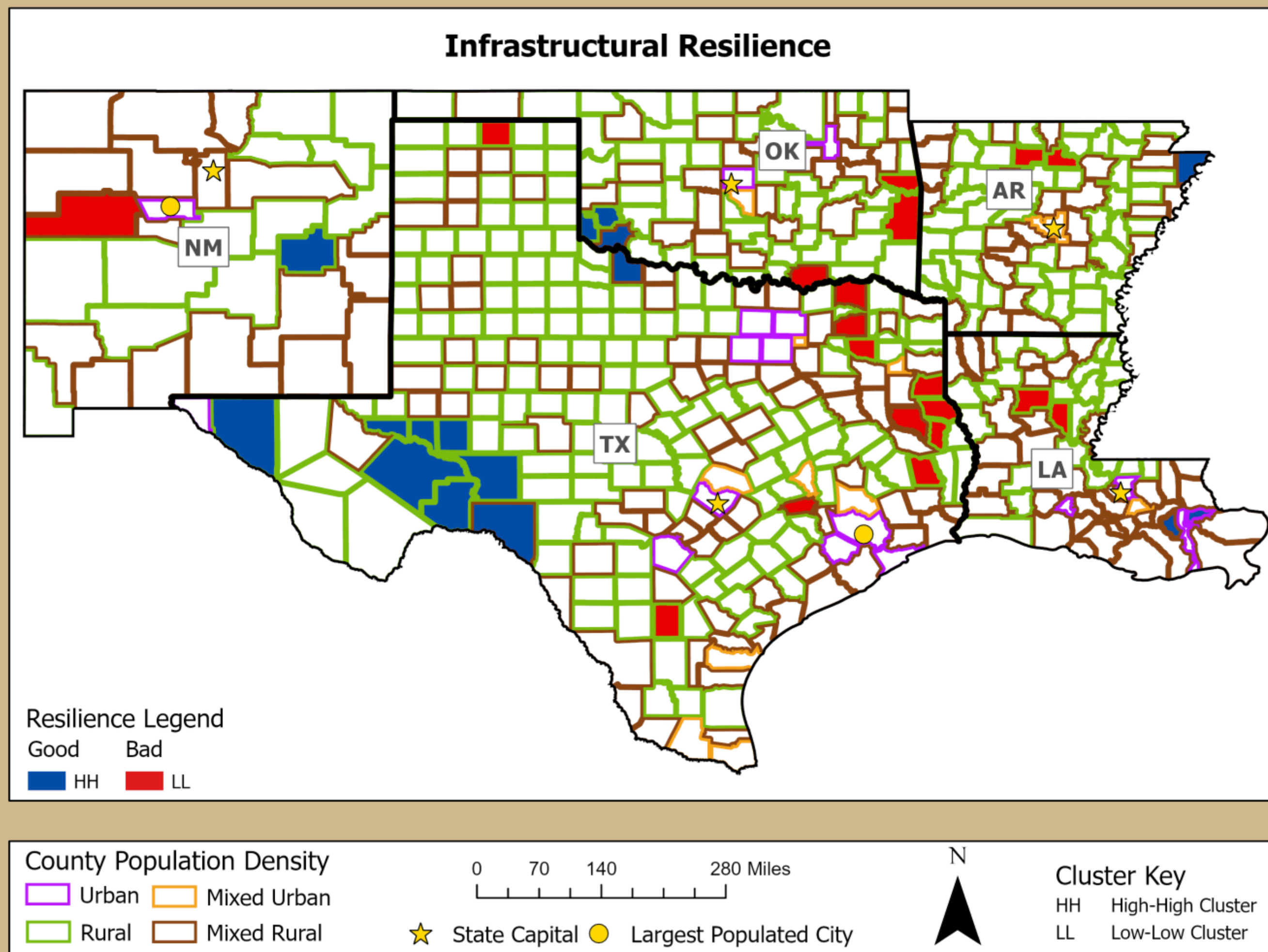
FEMA Region 6: MTP County Resilience/Vulnerability

Local Moran's I spatial cluster/outlier results



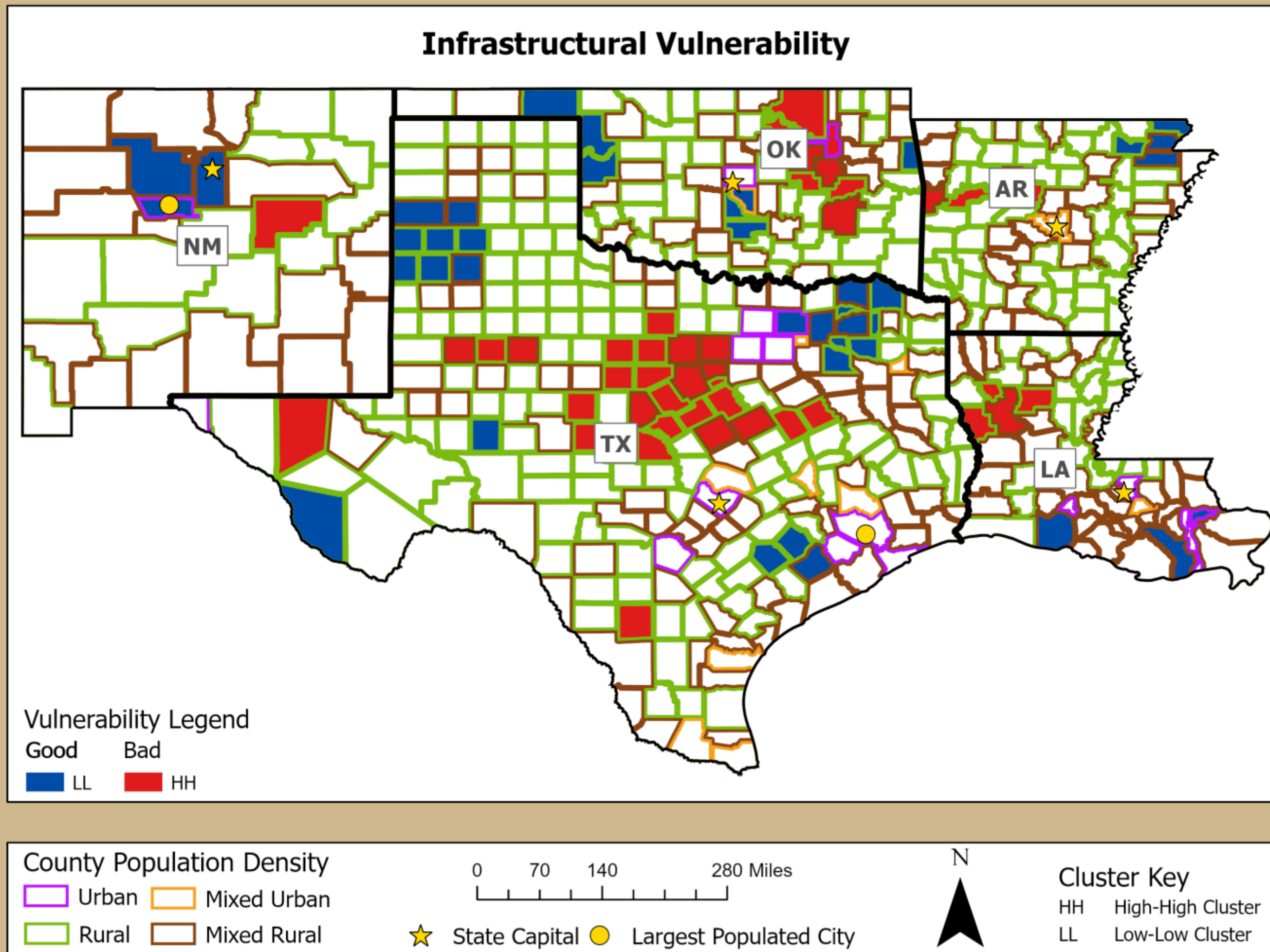
FEMA Region 6: MTP County Resilience/Vulnerability

Local Moran's I spatial cluster/outlier results



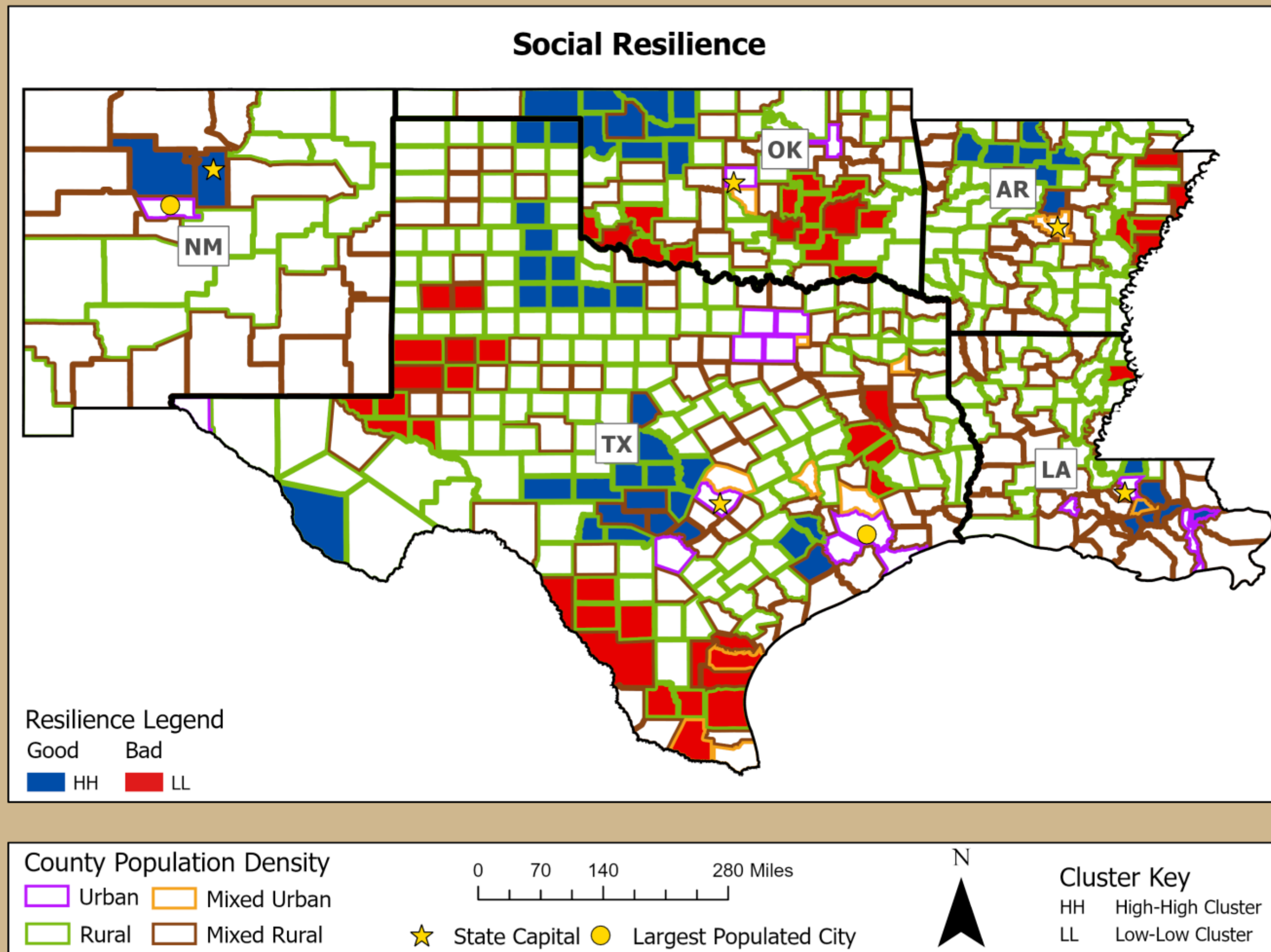
FEMA Region 6: MTP County Resilience/Vulnerability

Local Moran's I spatial cluster/outlier results



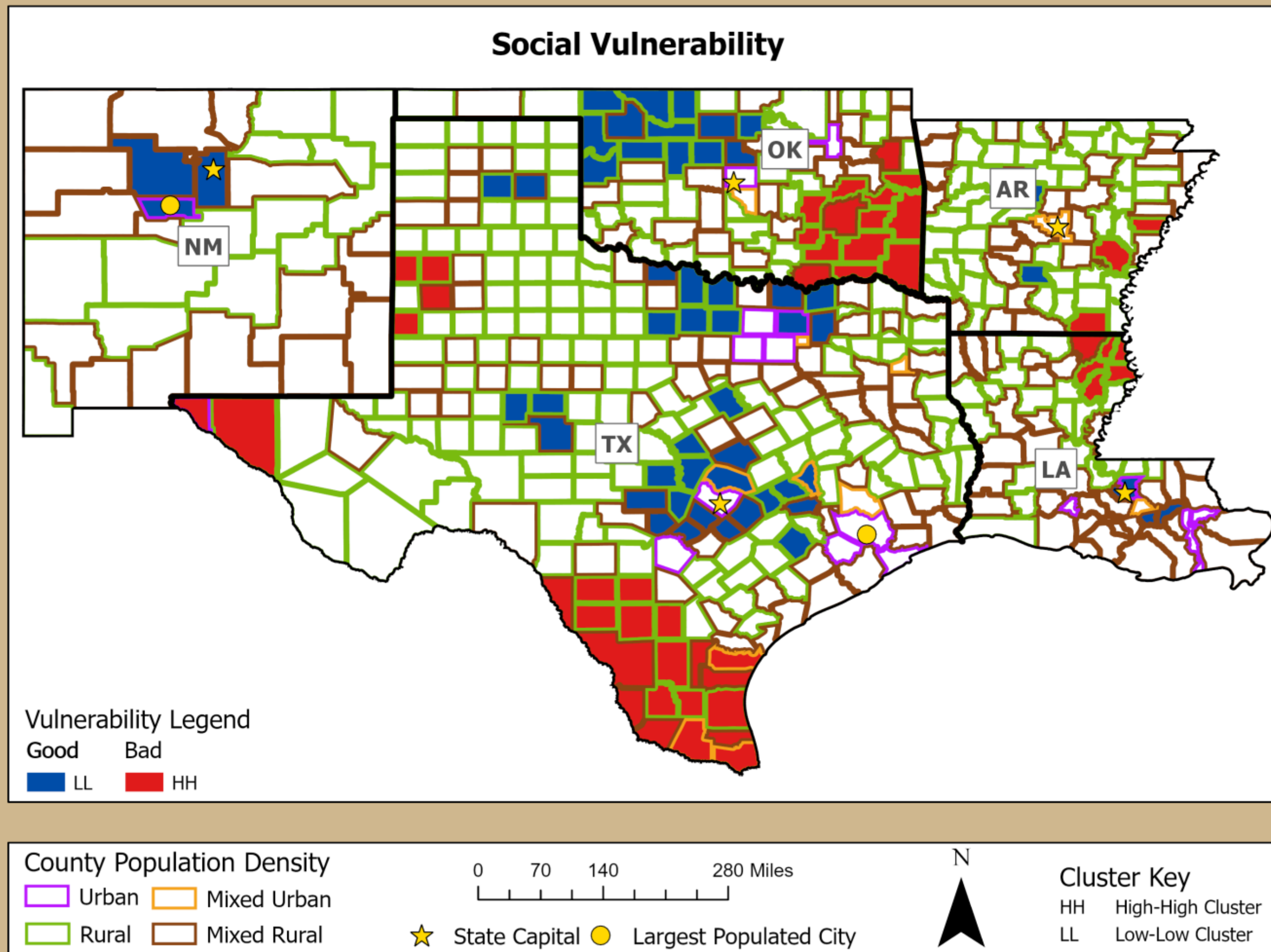
FEMA Region 6: MTP County Resilience/Vulnerability

Local Moran's I spatial cluster/outlier results



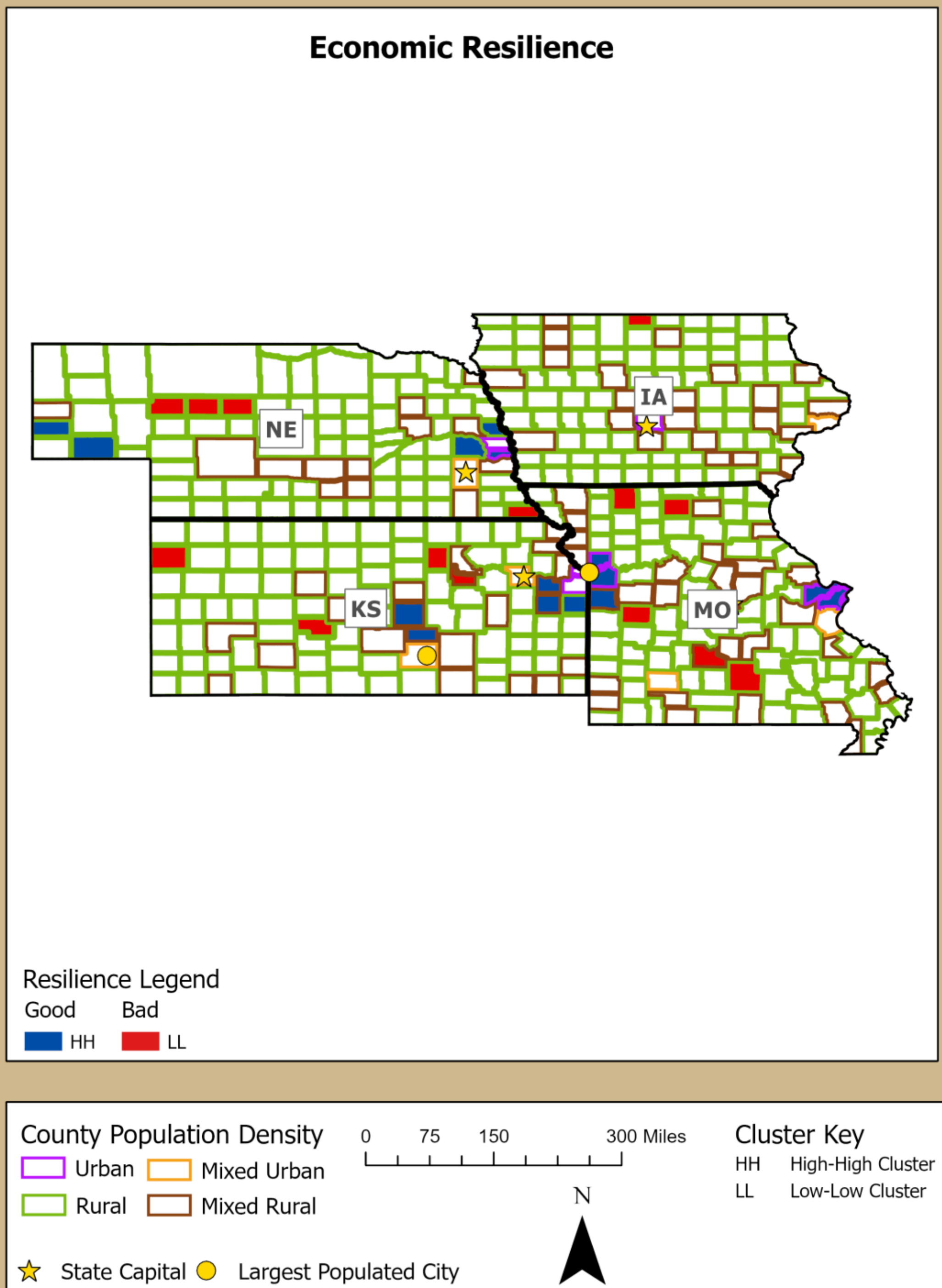
FEMA Region 6: MTP County Resilience/Vulnerability

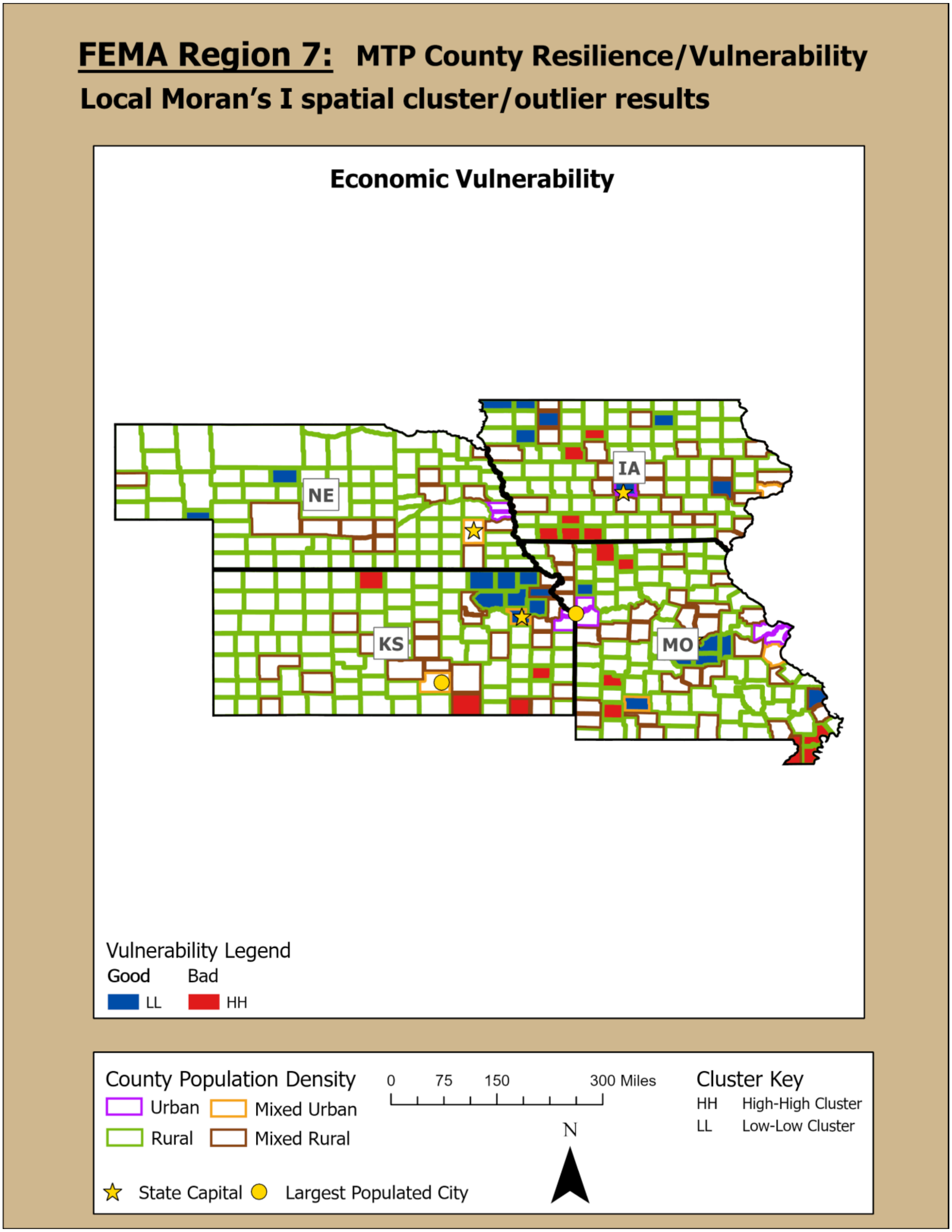
Local Moran's I spatial cluster/outlier results

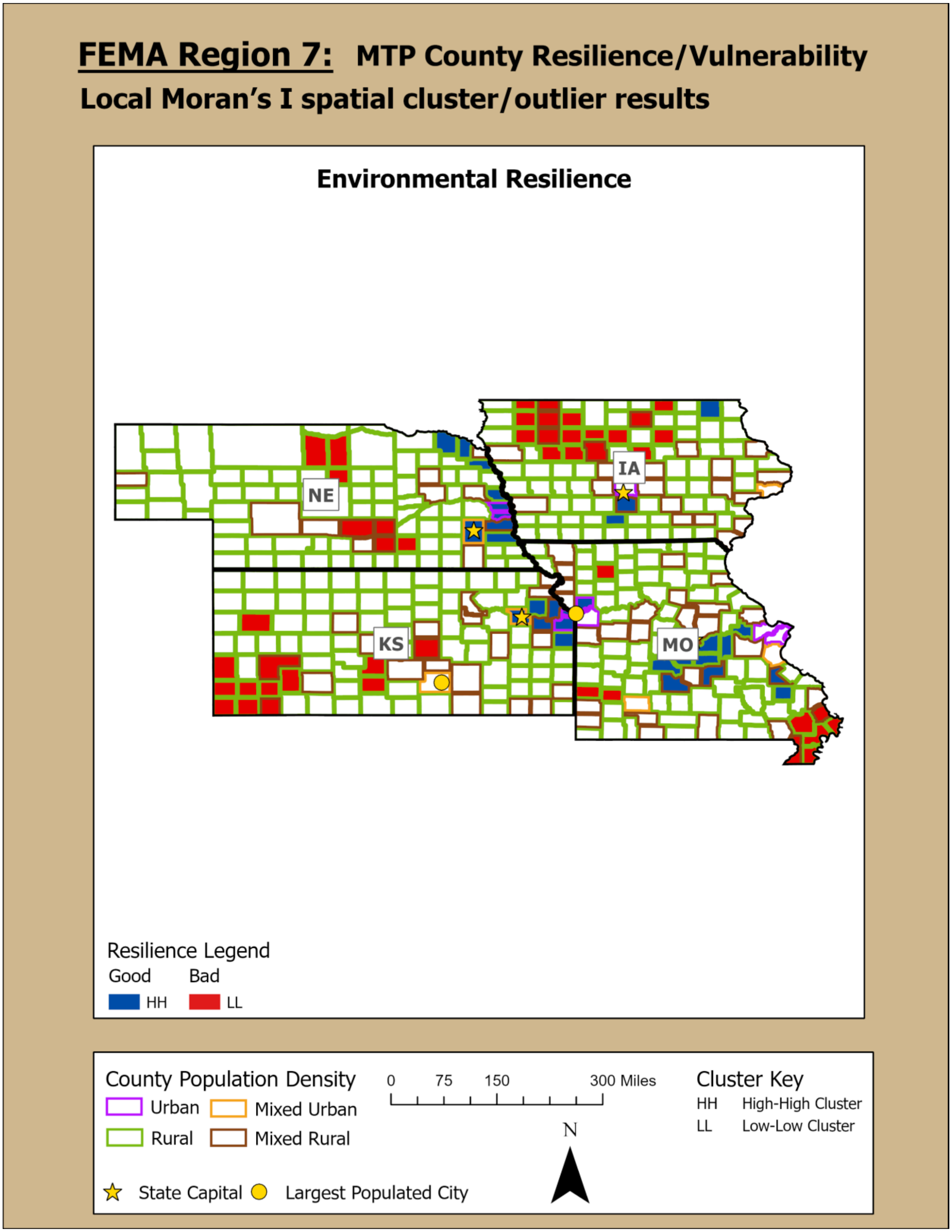


FEMA Region 7: MTP County Resilience/Vulnerability

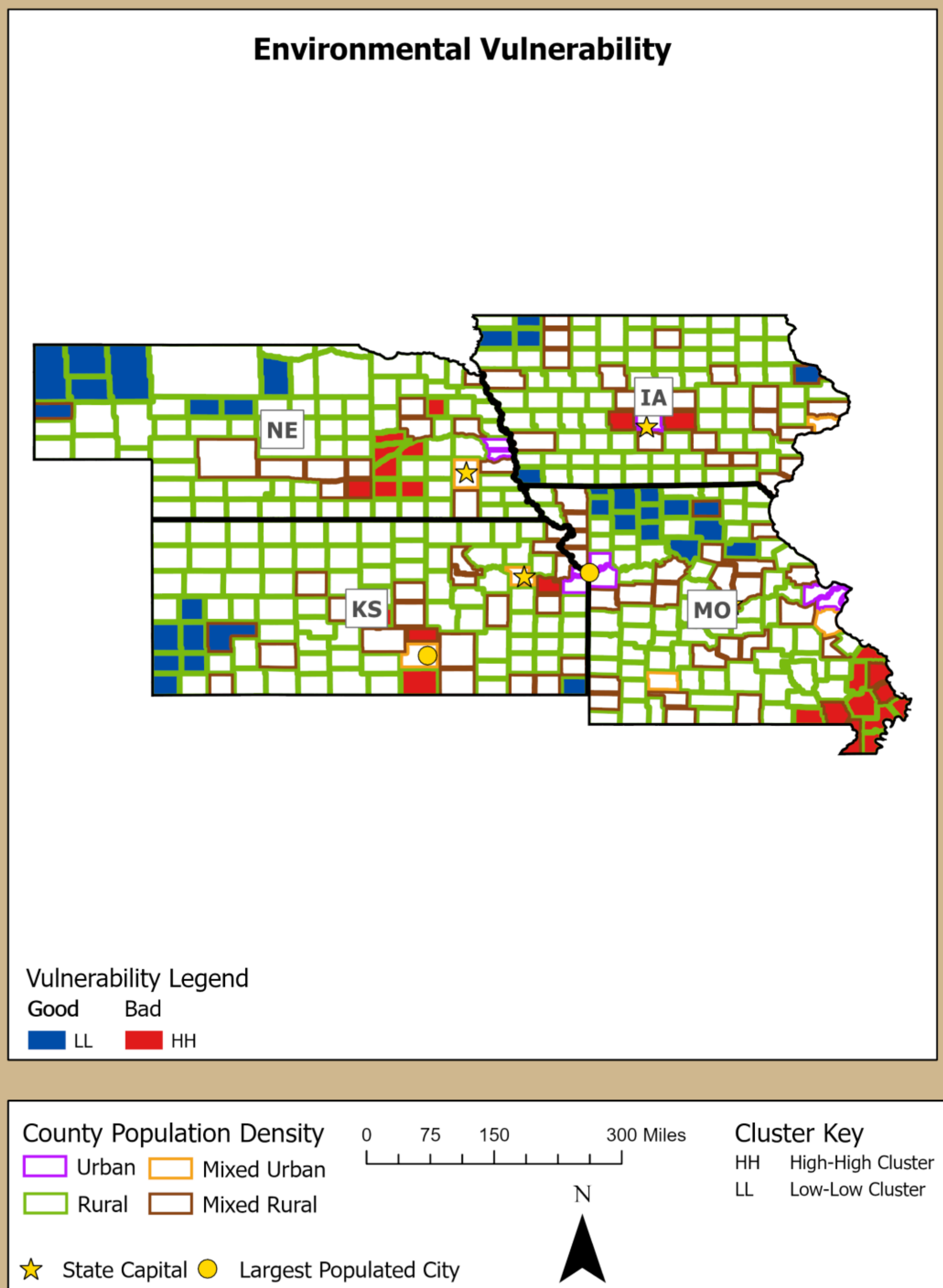
Local Moran's I spatial cluster/outlier results




FEMA Region 7: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results
Economic Vulnerability
NE
IA
KS
MO
Vulnerability Legend
Good
Bad
LL
HH
County Population Density
Urban
Mixed Urban
Rural
Mixed Rural
0
75
150
300 Miles
N
Cluster Key
HH High-High Cluster
LL Low-Low Cluster
State Capital
Largest Populated City

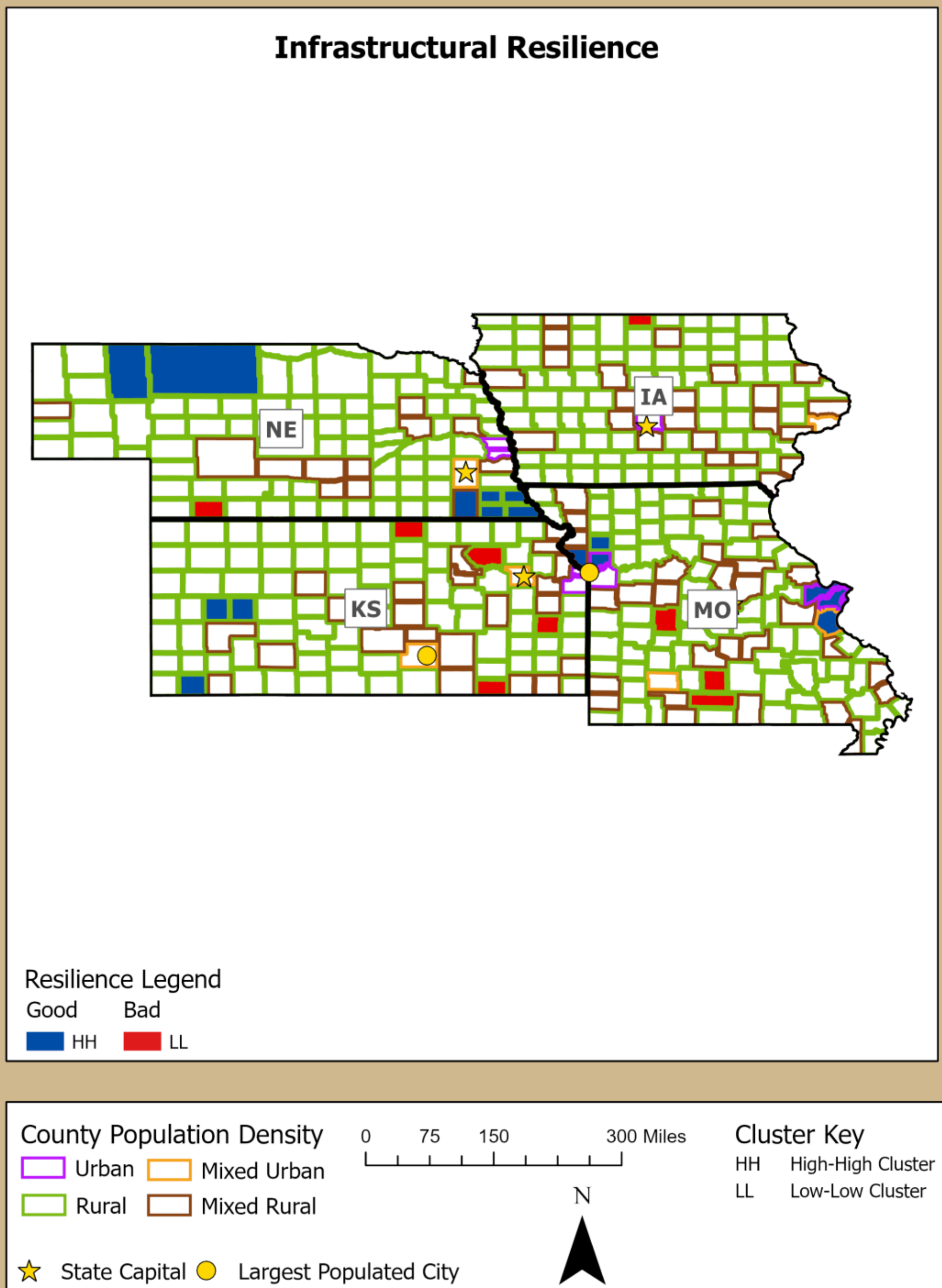

FEMA Region 7: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results
Environmental Resilience
NE
IA
KS
MO
Resilience Legend
Good
Bad
HH
LL
County Population Density
Urban
Mixed Urban
Rural
Mixed Rural
0
75
150
300 Miles
N
Cluster Key
HH High-High Cluster
LL Low-Low Cluster
State Capital
Largest Populated City

FEMA Region 7: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results



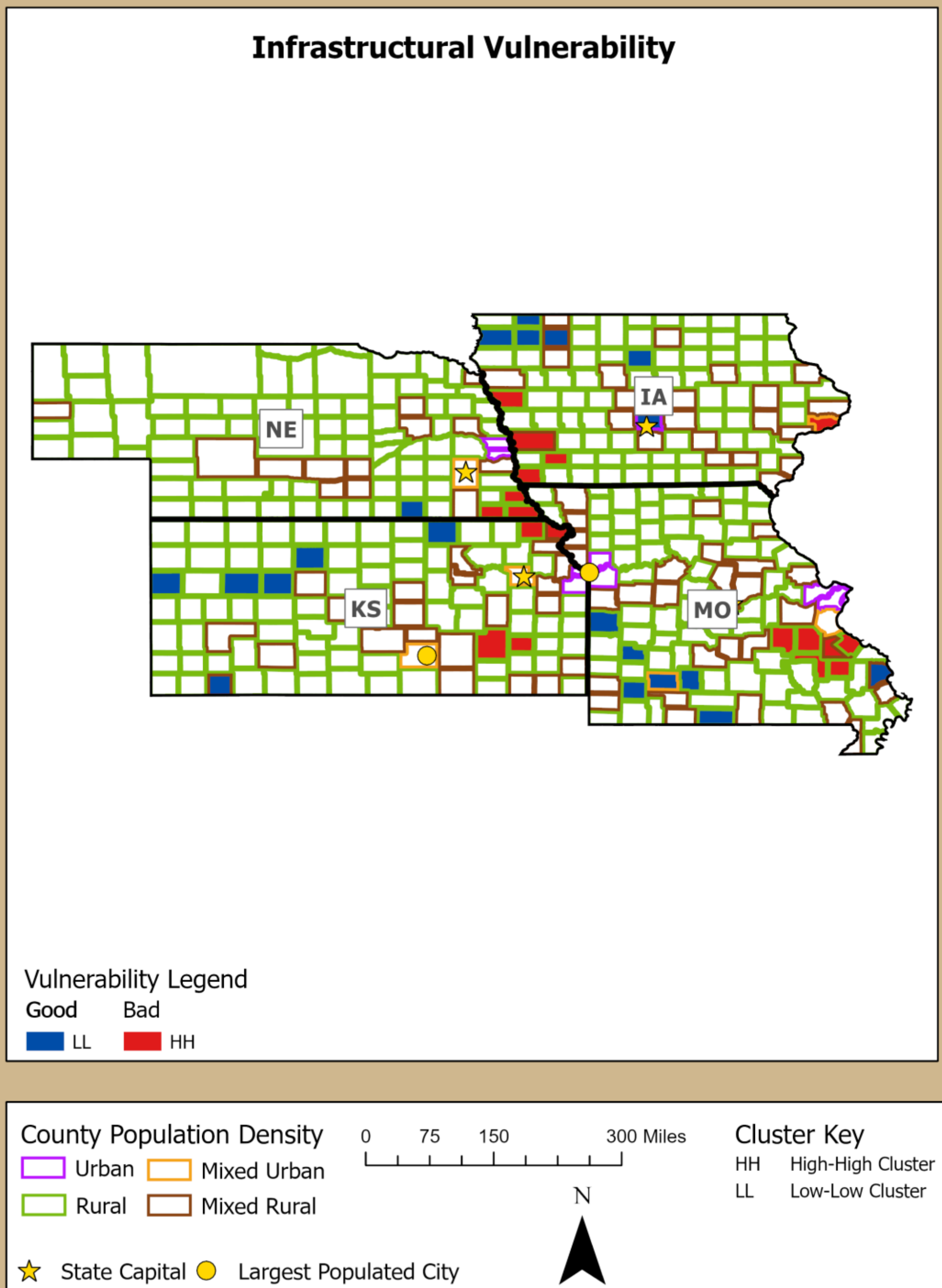
FEMA Region 7: MTP County Resilience/Vulnerability

Local Moran's I spatial cluster/outlier results



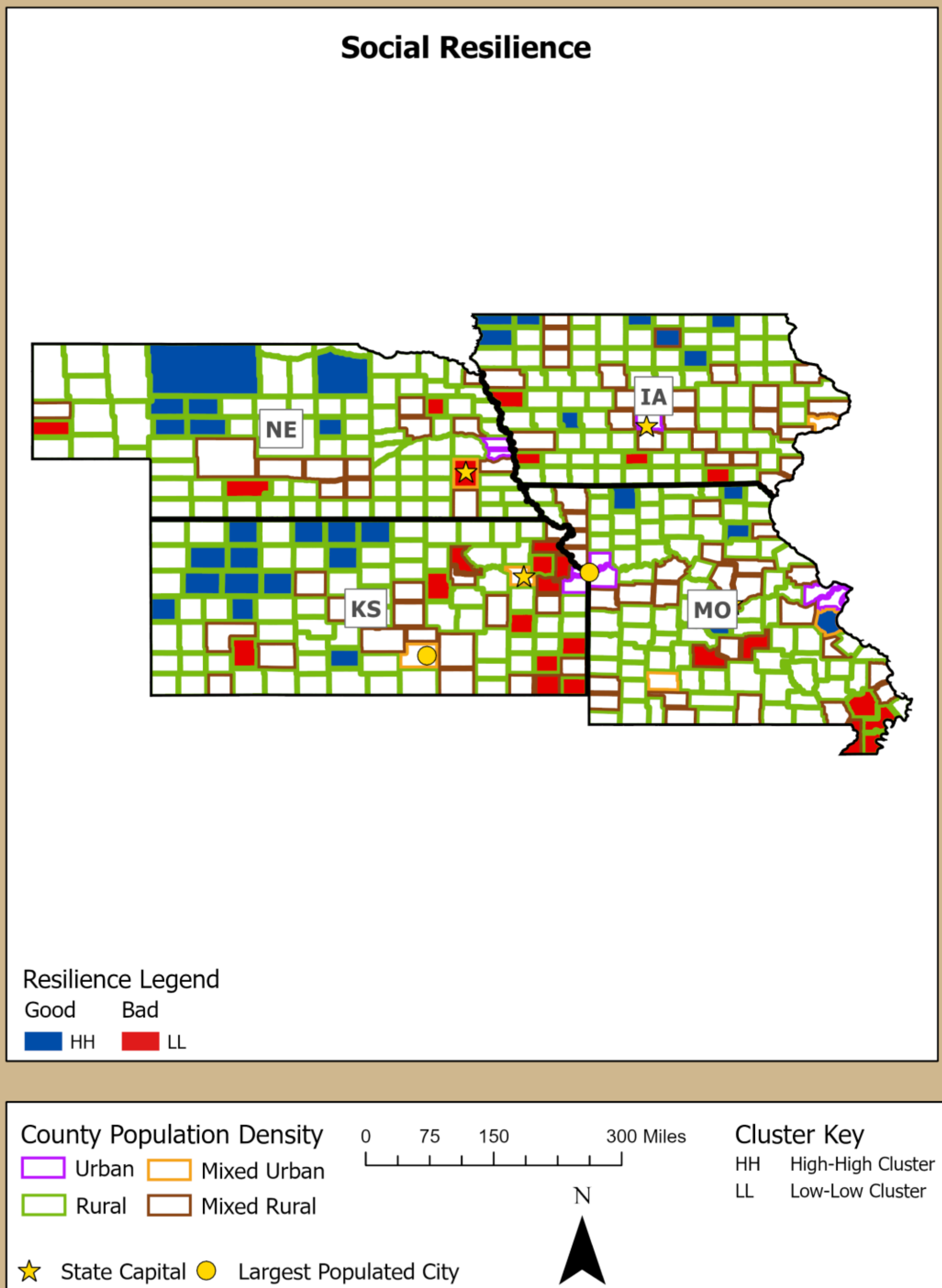
FEMA Region 7: MTP County Resilience/Vulnerability

Local Moran's I spatial cluster/outlier results



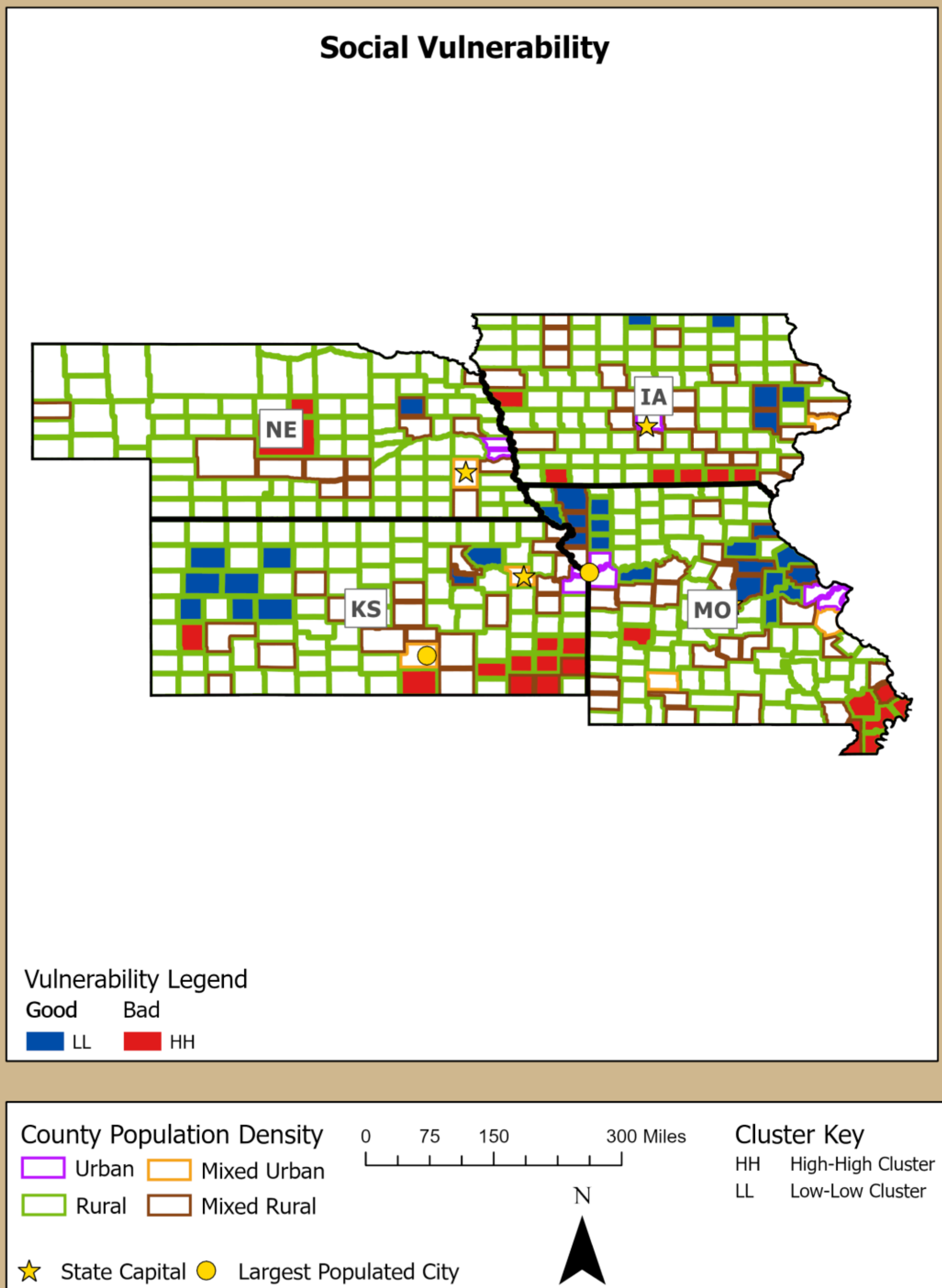
FEMA Region 7: MTP County Resilience/Vulnerability

Local Moran's I spatial cluster/outlier results



FEMA Region 7: MTP County Resilience/Vulnerability

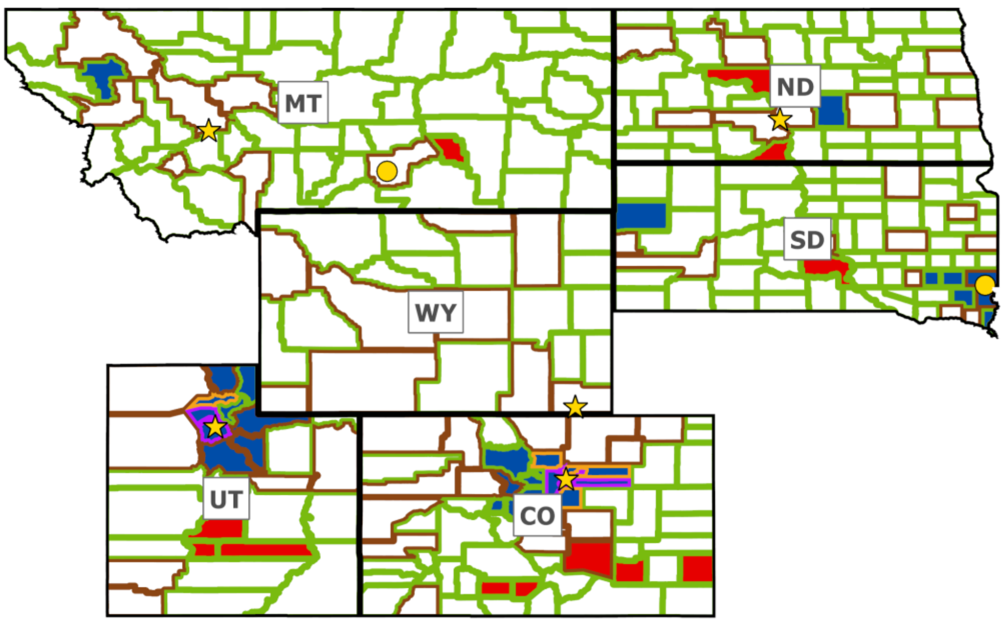
Local Moran's I spatial cluster/outlier results



FEMA Region 8: MTP County Resilience/Vulnerability

Local Moran's I spatial cluster/outlier results

Economic Resilience



Resilience Legend

Good Bad

HH LL

County Population Density

Urban Mixed Urban

Rural Mixed Rural

0 95 190 380 Miles

N

Cluster Key

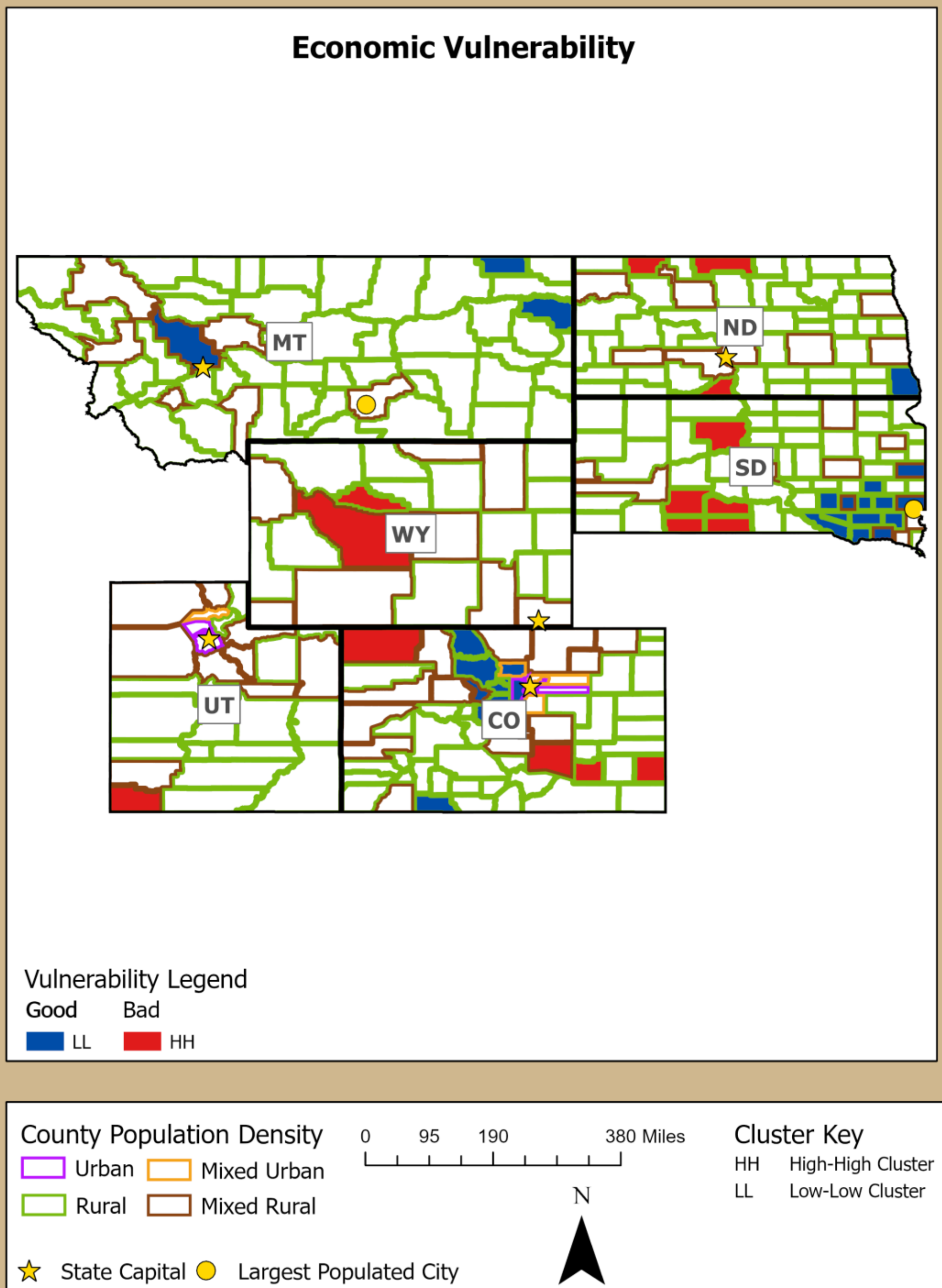
HH High-High Cluster

LL Low-Low Cluster

State Capital Largest Populated City

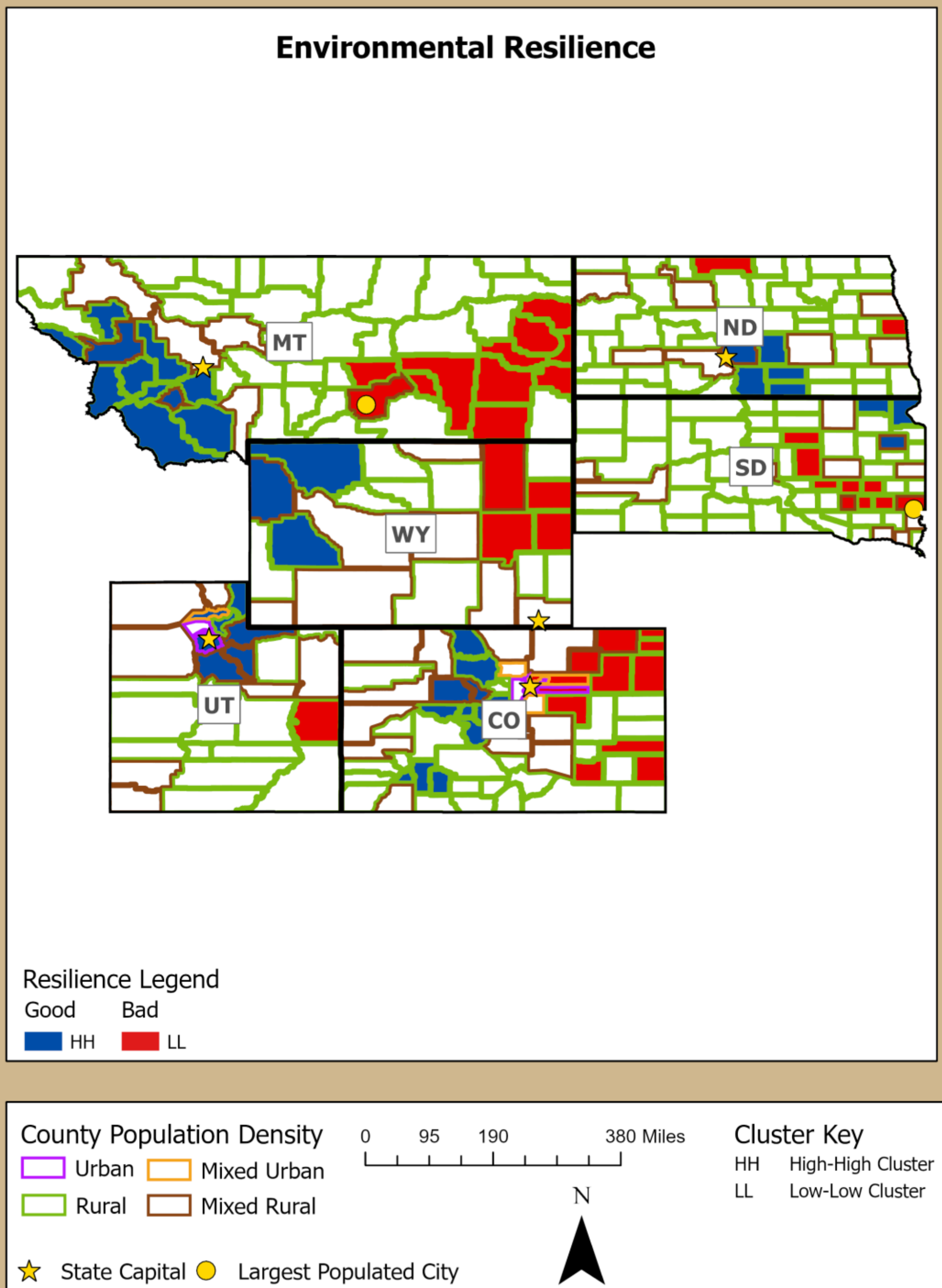
FEMA Region 8: MTP County Resilience/Vulnerability

Local Moran's I spatial cluster/outlier results



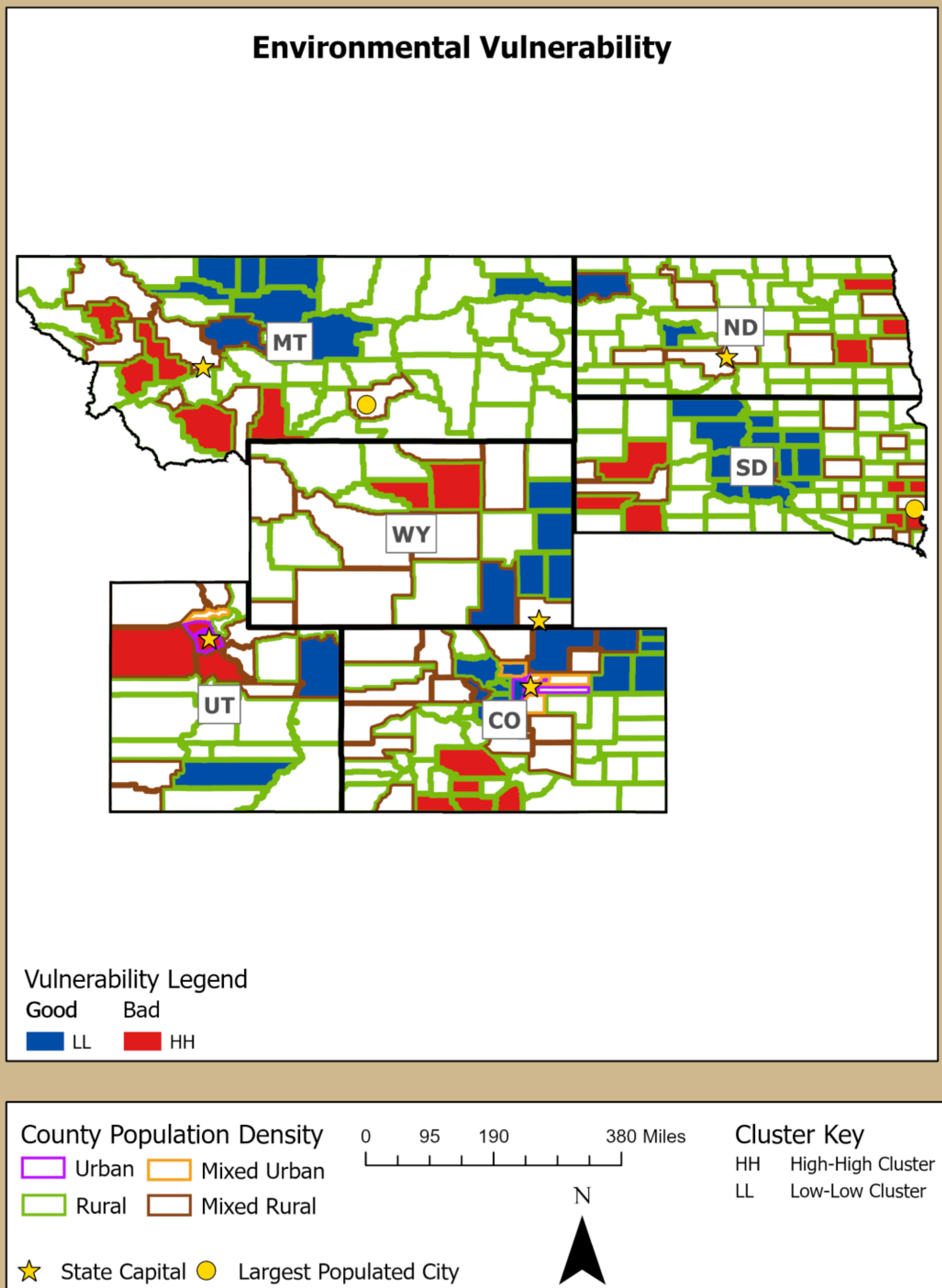
FEMA Region 8: MTP County Resilience/Vulnerability

Local Moran's I spatial cluster/outlier results



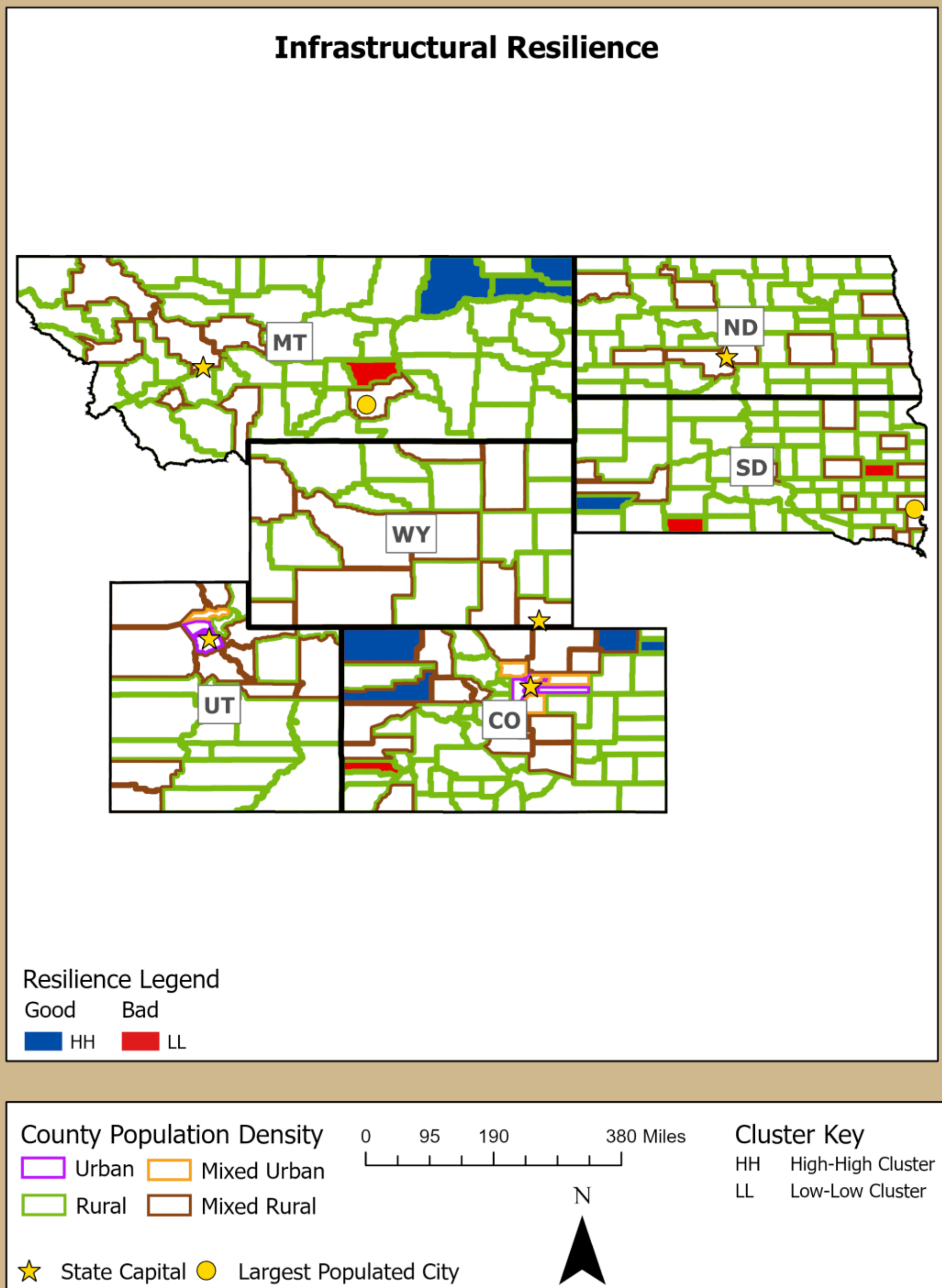
FEMA Region 8: MTP County Resilience/Vulnerability

Local Moran's I spatial cluster/outlier results



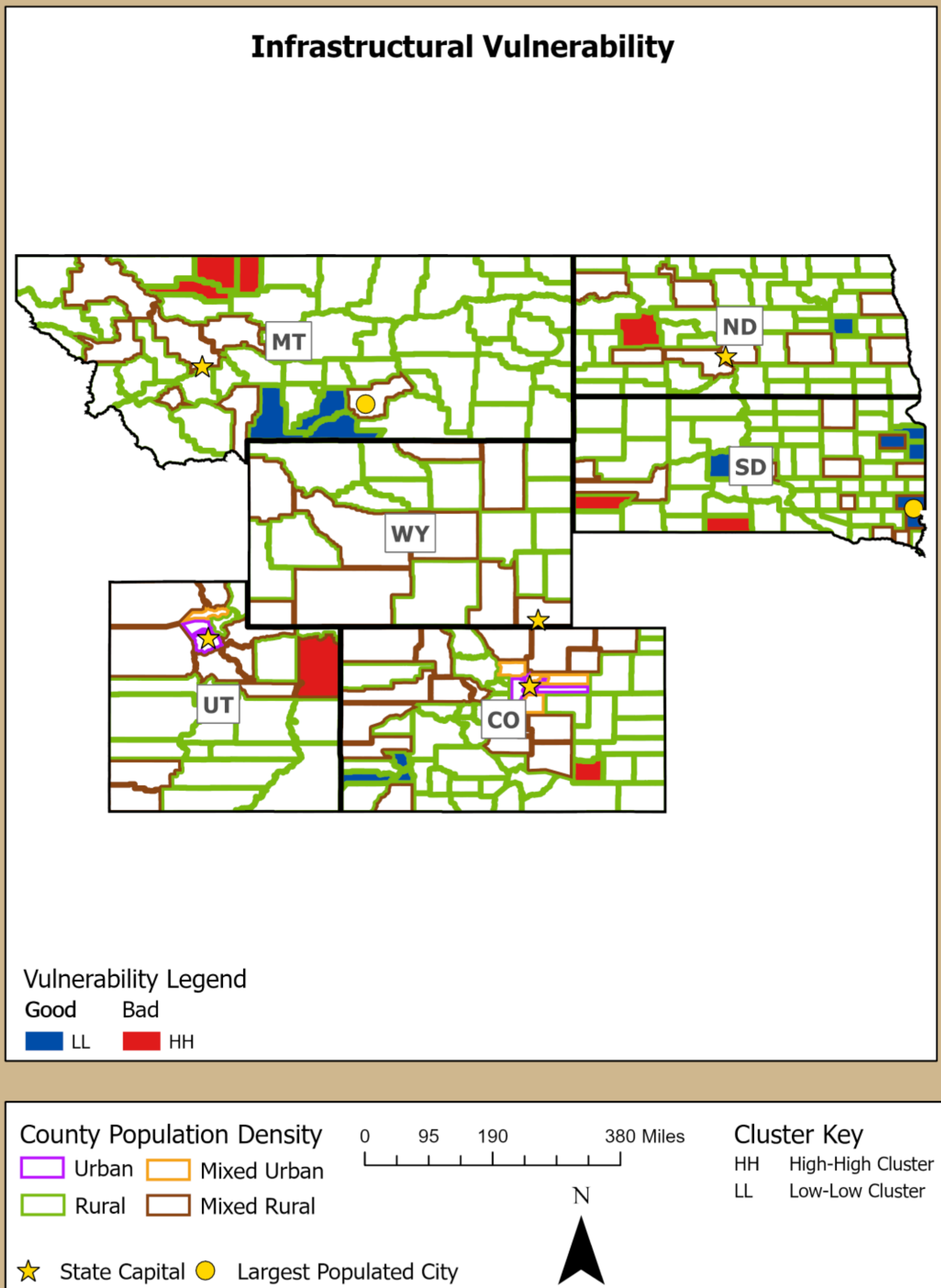
FEMA Region 8: MTP County Resilience/Vulnerability

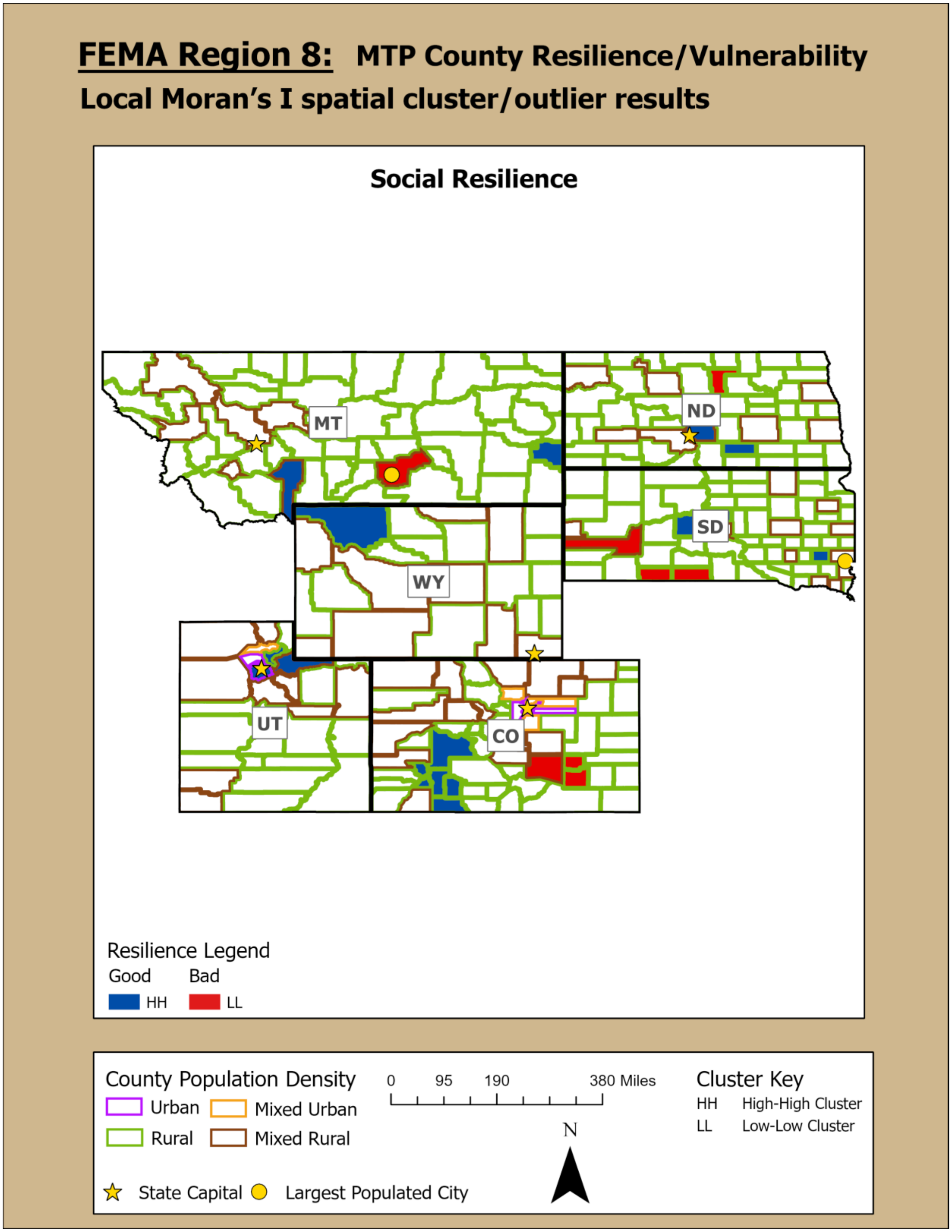
Local Moran's I spatial cluster/outlier results

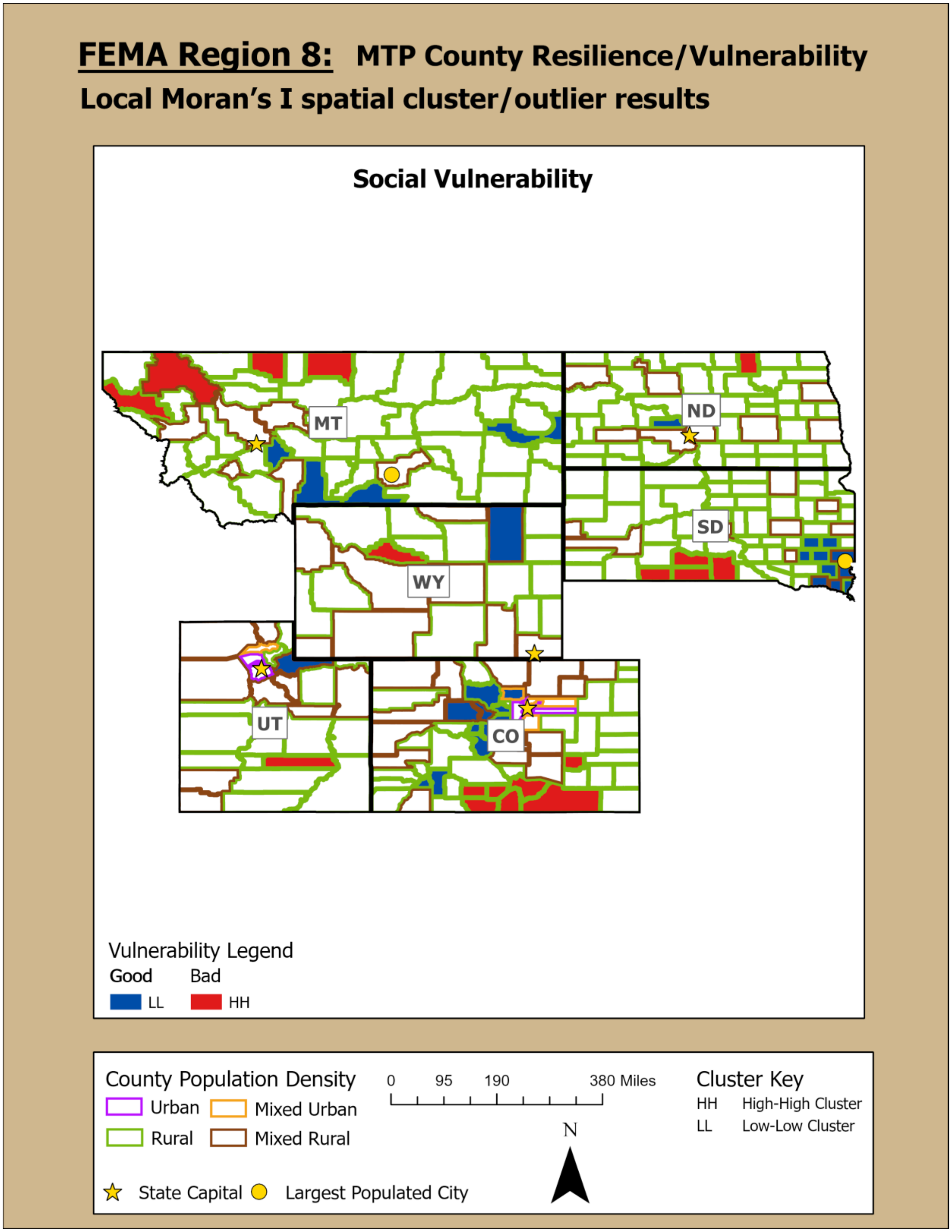


FEMA Region 8: MTP County Resilience/Vulnerability

Local Moran's I spatial cluster/outlier results



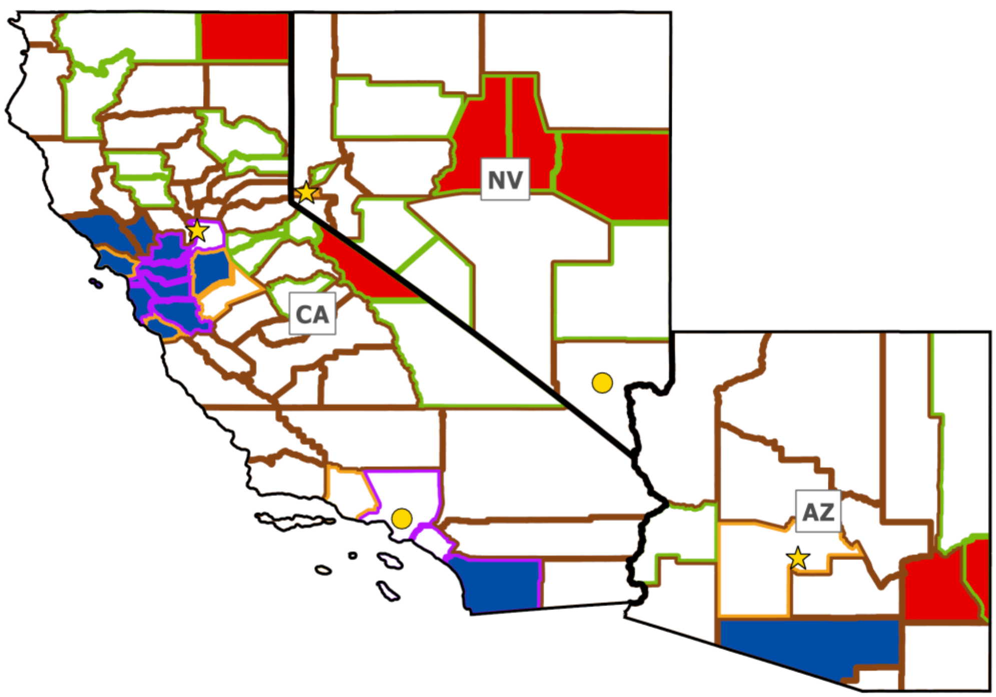

FEMA Region 8: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results
Social Resilience
MT
ND
SD
WY
UT
CO
Resilience Legend
Good
Bad
HH
LL
County Population Density
Urban
Mixed Urban
Rural
Mixed Rural
0
95
190
380 Miles
N
Cluster Key
HH High-High Cluster
LL Low-Low Cluster
State Capital
Largest Populated City


FEMA Region 8: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results
Social Vulnerability
MT
ND
SD
WY
UT
CO
Vulnerability Legend
Good
Bad
LL
HH
County Population Density
Urban
Mixed Urban
Rural
Mixed Rural
State Capital
Largest Populated City
0
95
190
380 Miles
N
Cluster Key
HH High-High Cluster
LL Low-Low Cluster

FEMA Region 9: MTP County Resilience/Vulnerability

Local Moran's I spatial cluster/outlier results

Economic Resilience



Resilience Legend

Good HH

Bad LL

County Population Density

Urban

Mixed Urban

Rural

Mixed Rural

0 75 150 300 Miles

N

Cluster Key

HH High-High Cluster

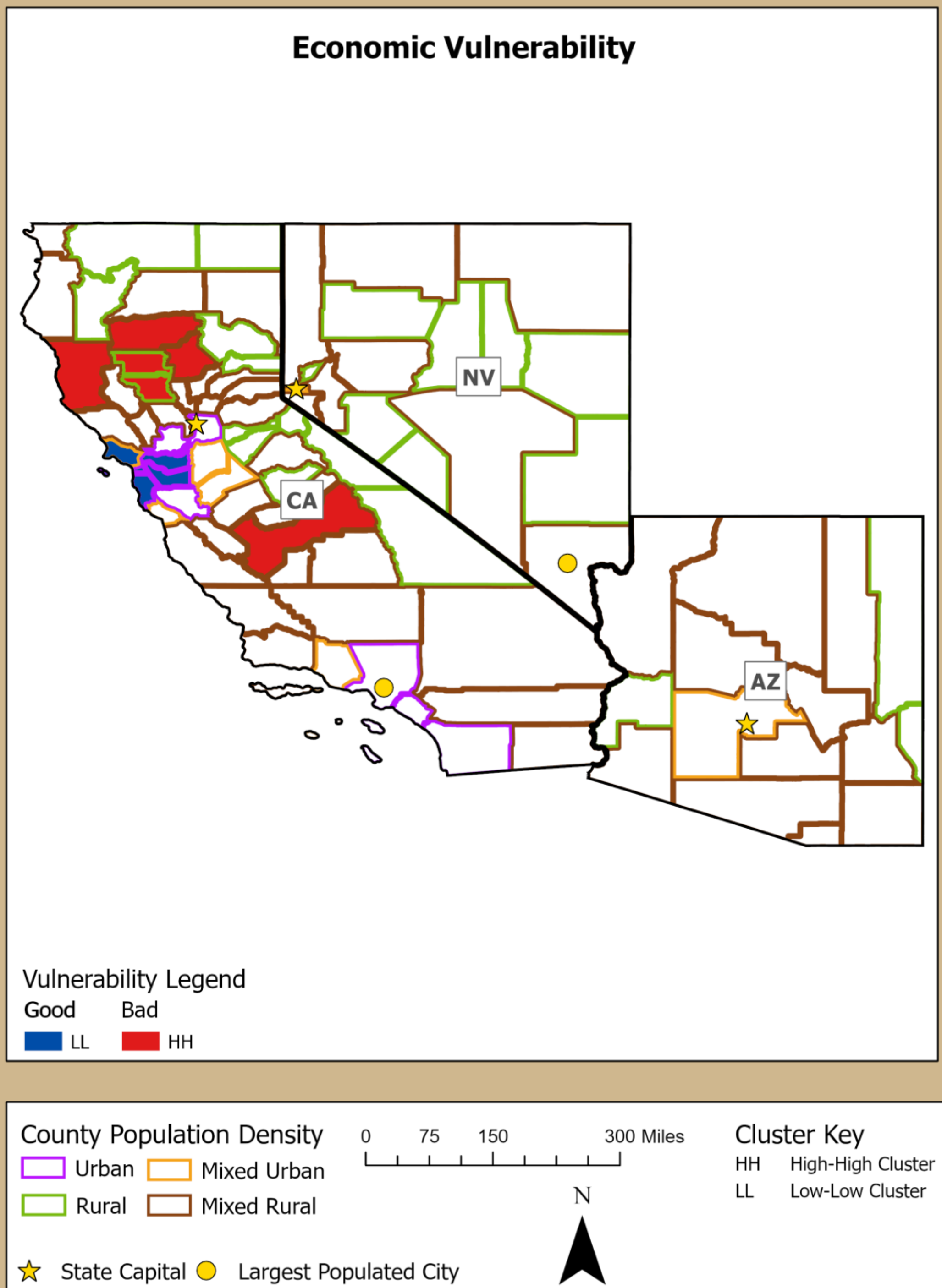
LL Low-Low Cluster

State Capital

Largest Populated City

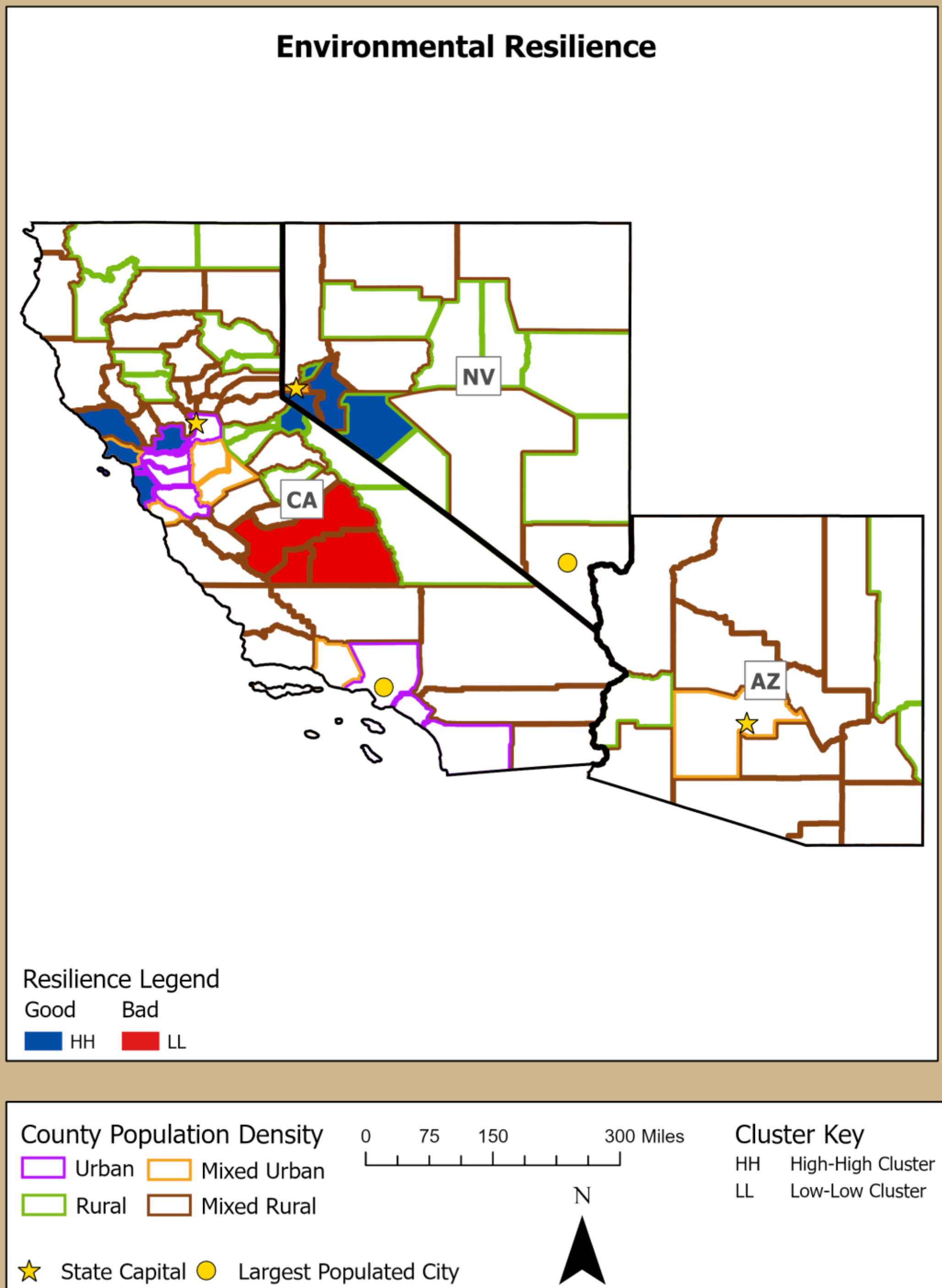
FEMA Region 9: MTP County Resilience/Vulnerability

Local Moran's I spatial cluster/outlier results



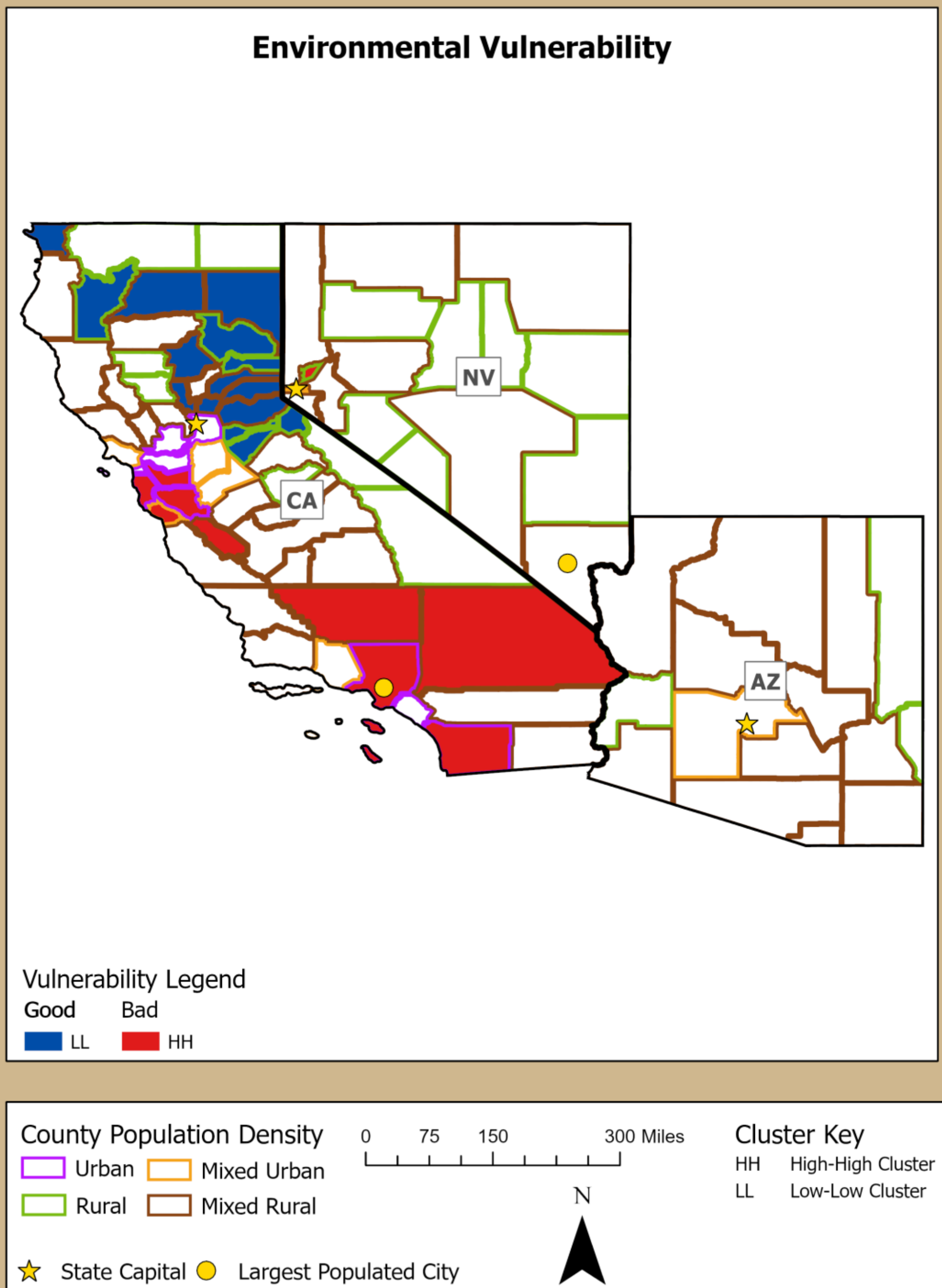
FEMA Region 9: MTP County Resilience/Vulnerability

Local Moran's I spatial cluster/outlier results



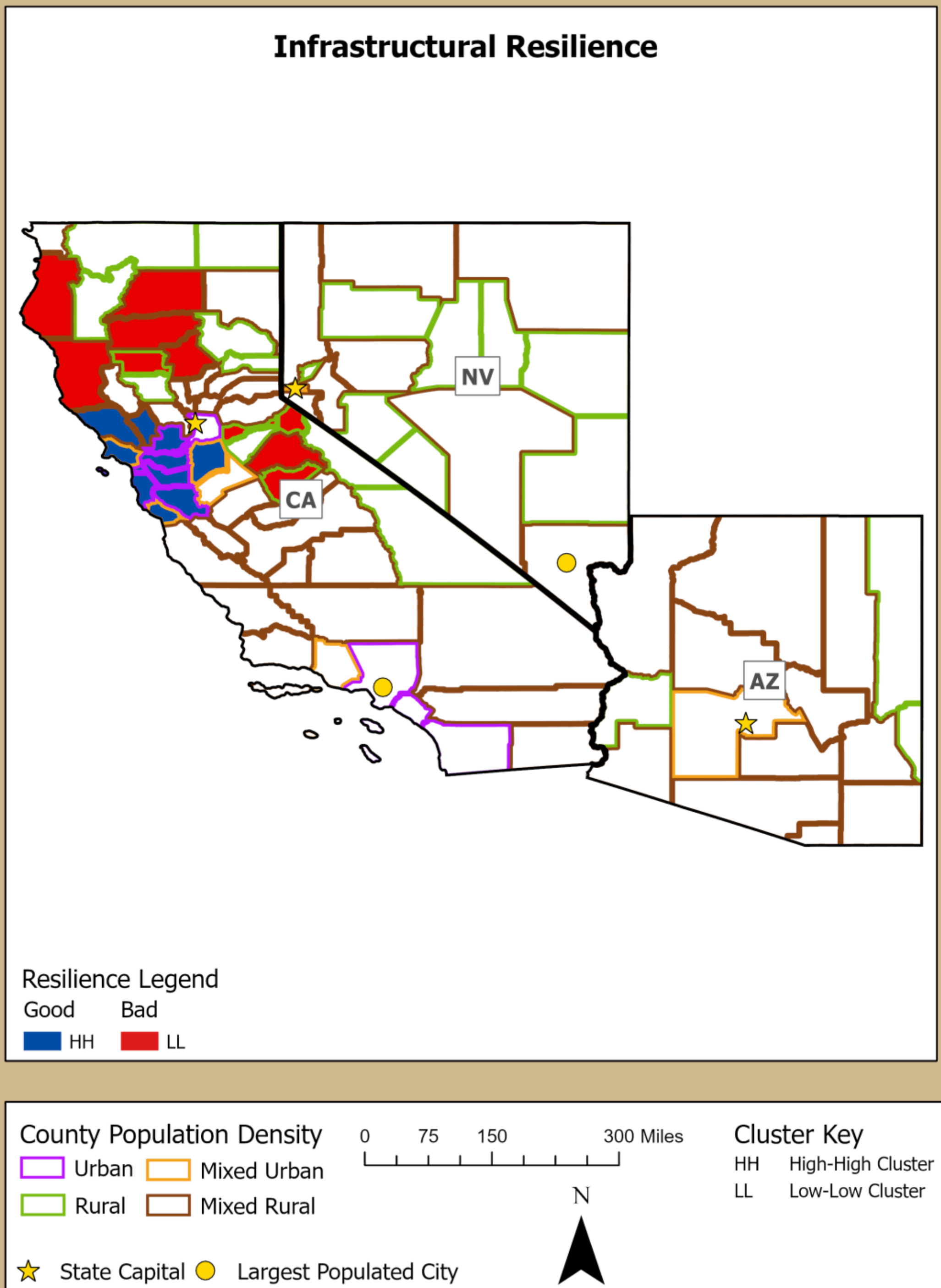
FEMA Region 9: MTP County Resilience/Vulnerability

Local Moran's I spatial cluster/outlier results



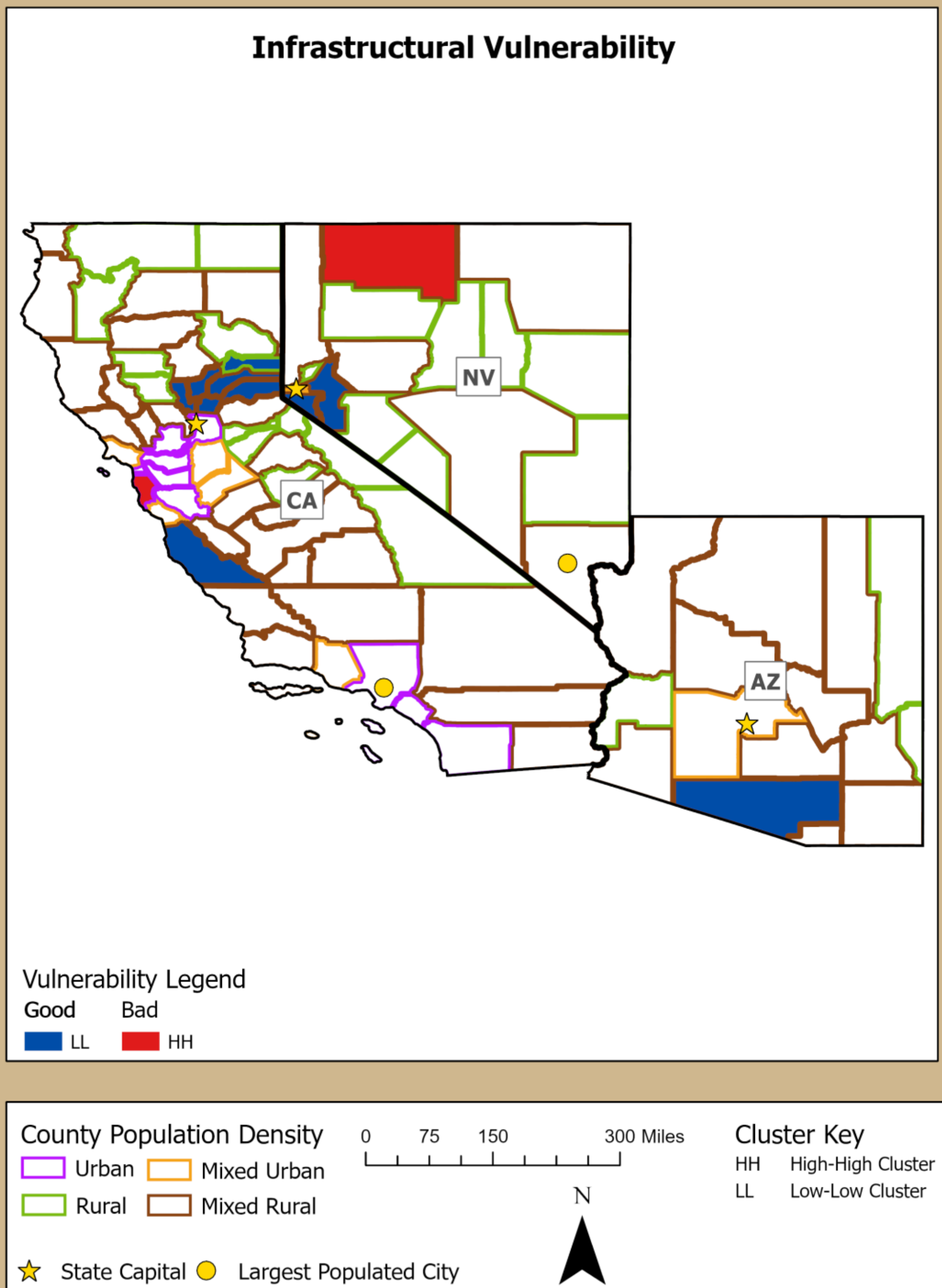
FEMA Region 9: MTP County Resilience/Vulnerability

Local Moran's I spatial cluster/outlier results

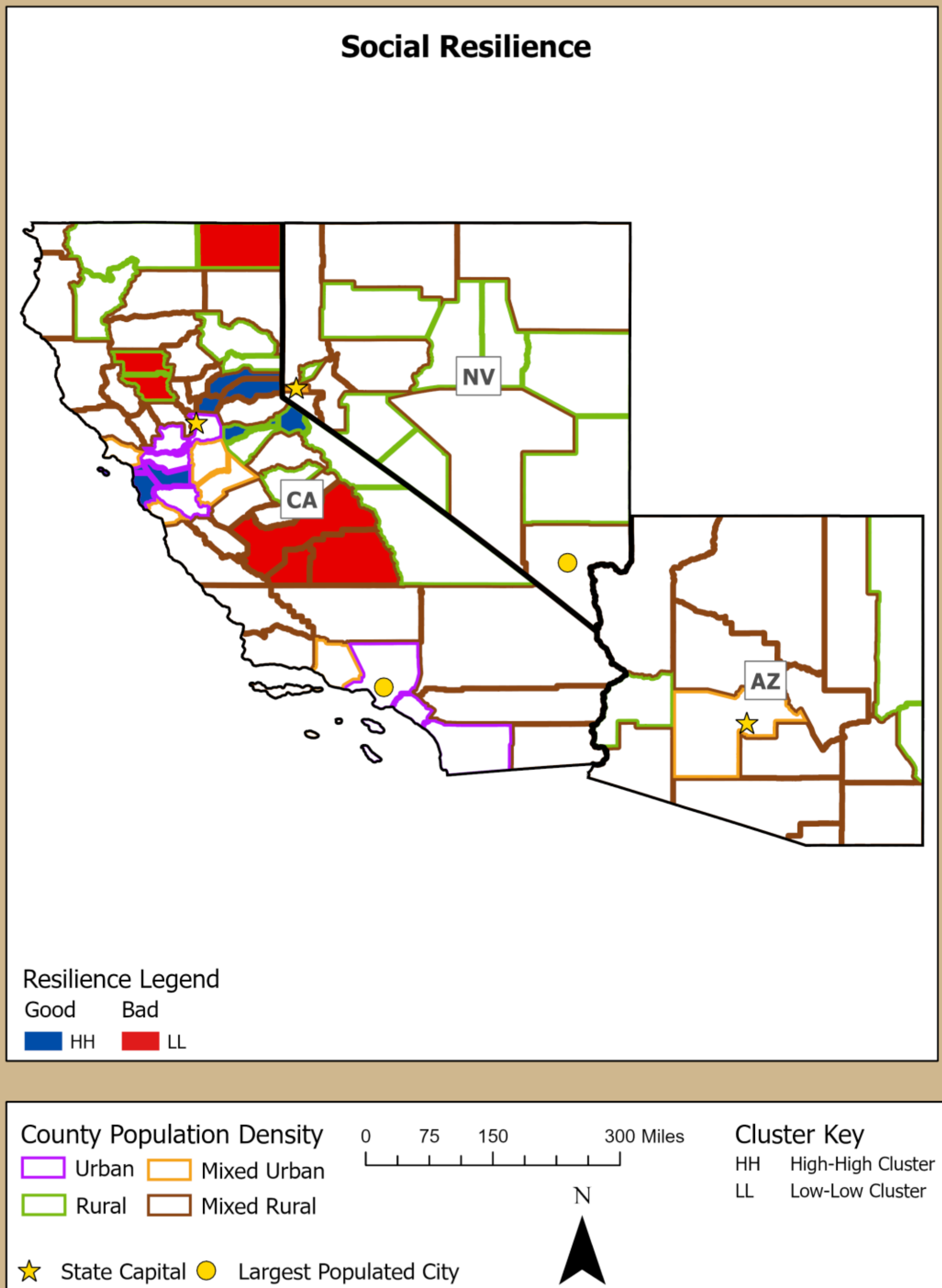


FEMA Region 9: MTP County Resilience/Vulnerability

Local Moran's I spatial cluster/outlier results

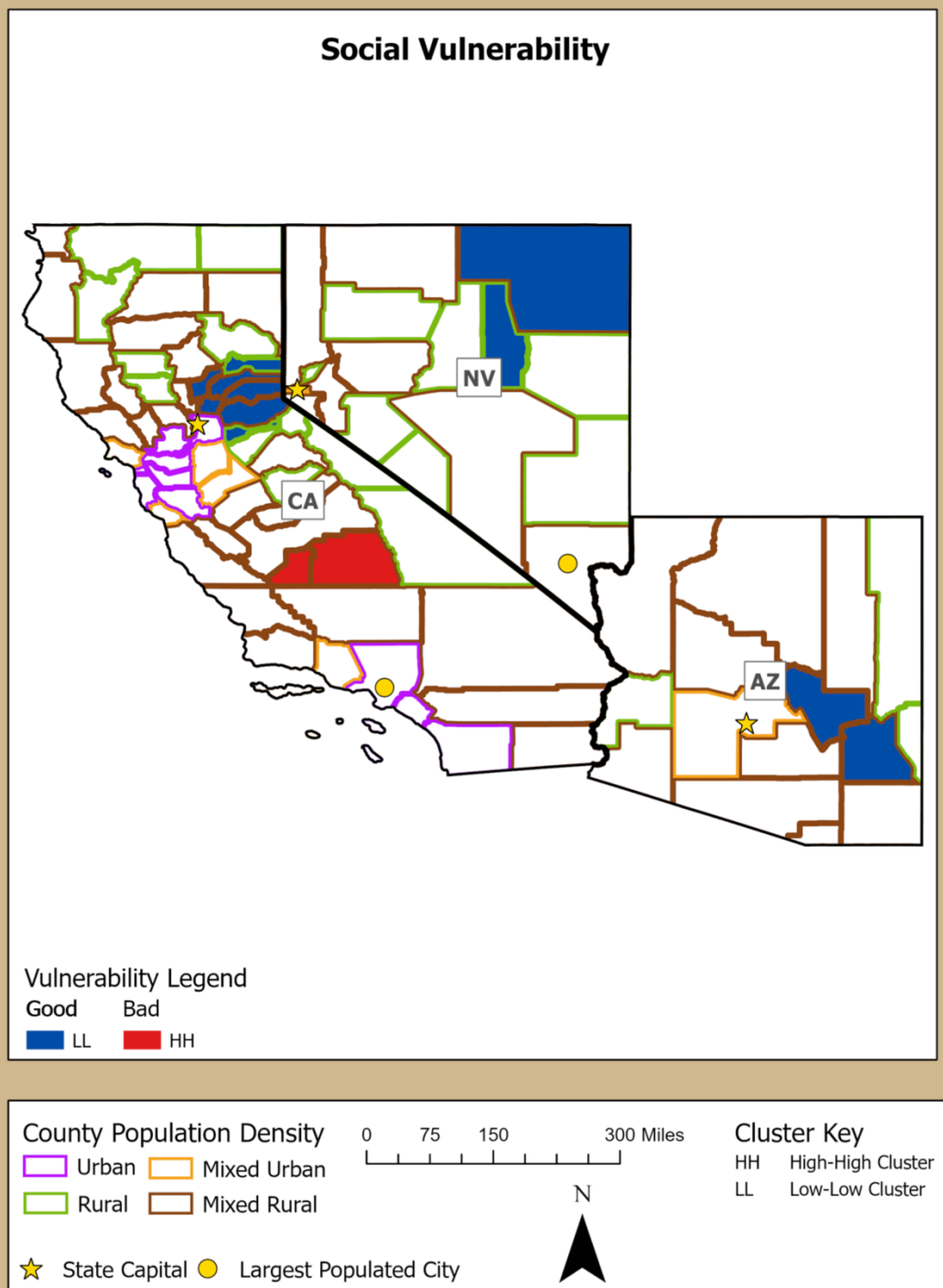


FEMA Region 9: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results



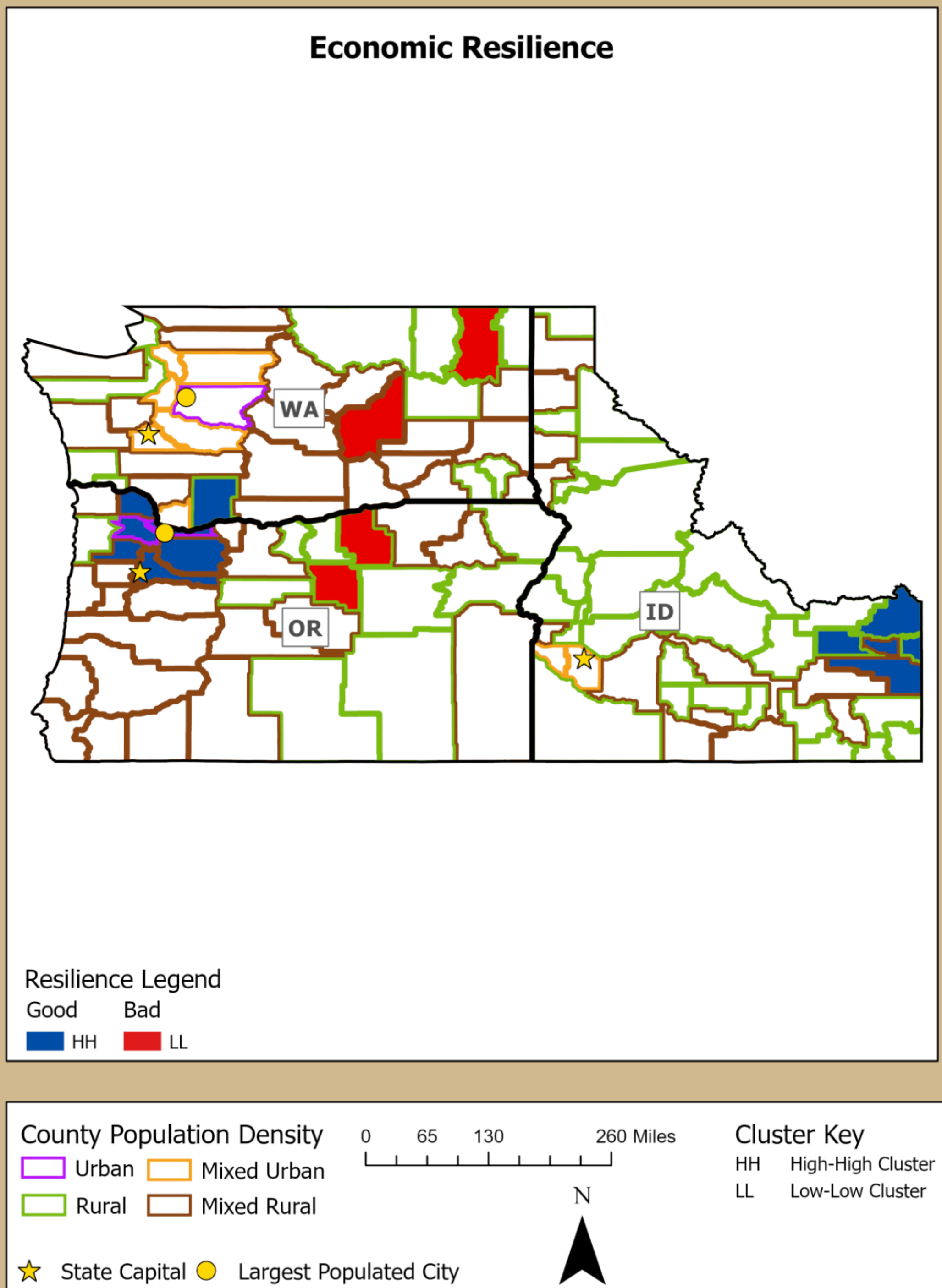
FEMA Region 9: MTP County Resilience/Vulnerability

Local Moran's I spatial cluster/outlier results



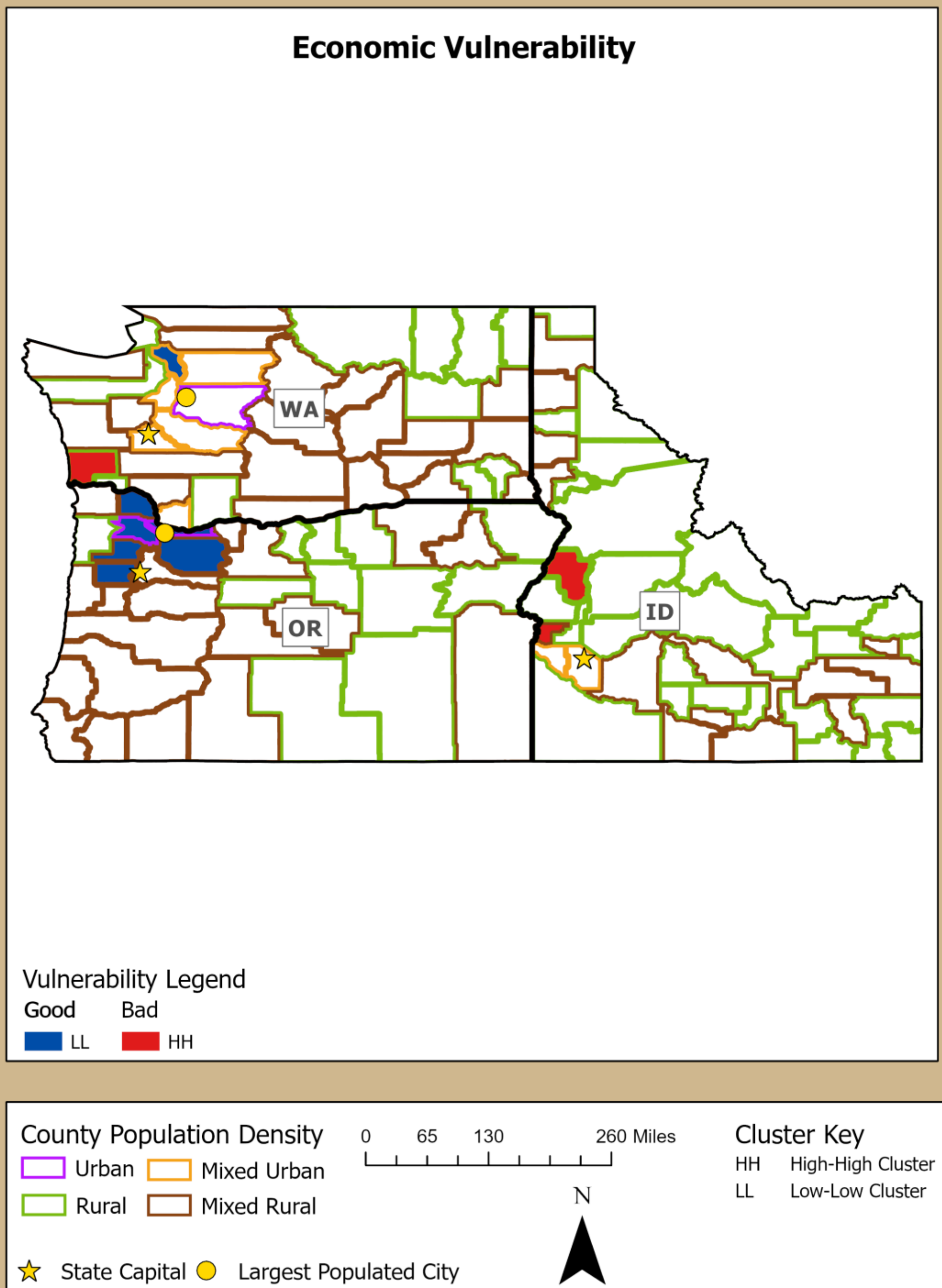
FEMA Region 10: MTP County Resilience/Vulnerability

Local Moran's I spatial cluster/outlier results



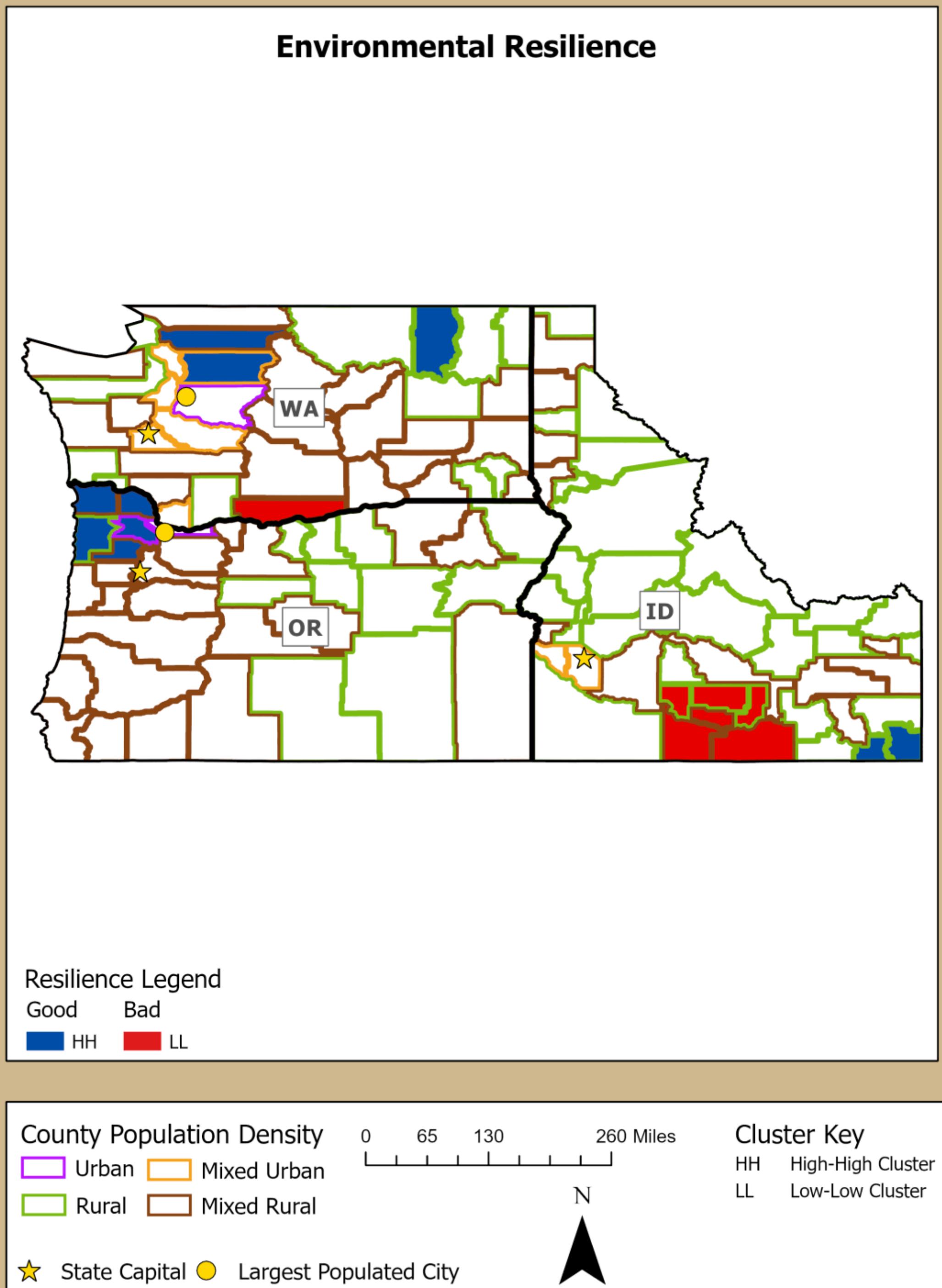
FEMA Region 10: MTP County Resilience/Vulnerability

Local Moran's I spatial cluster/outlier results



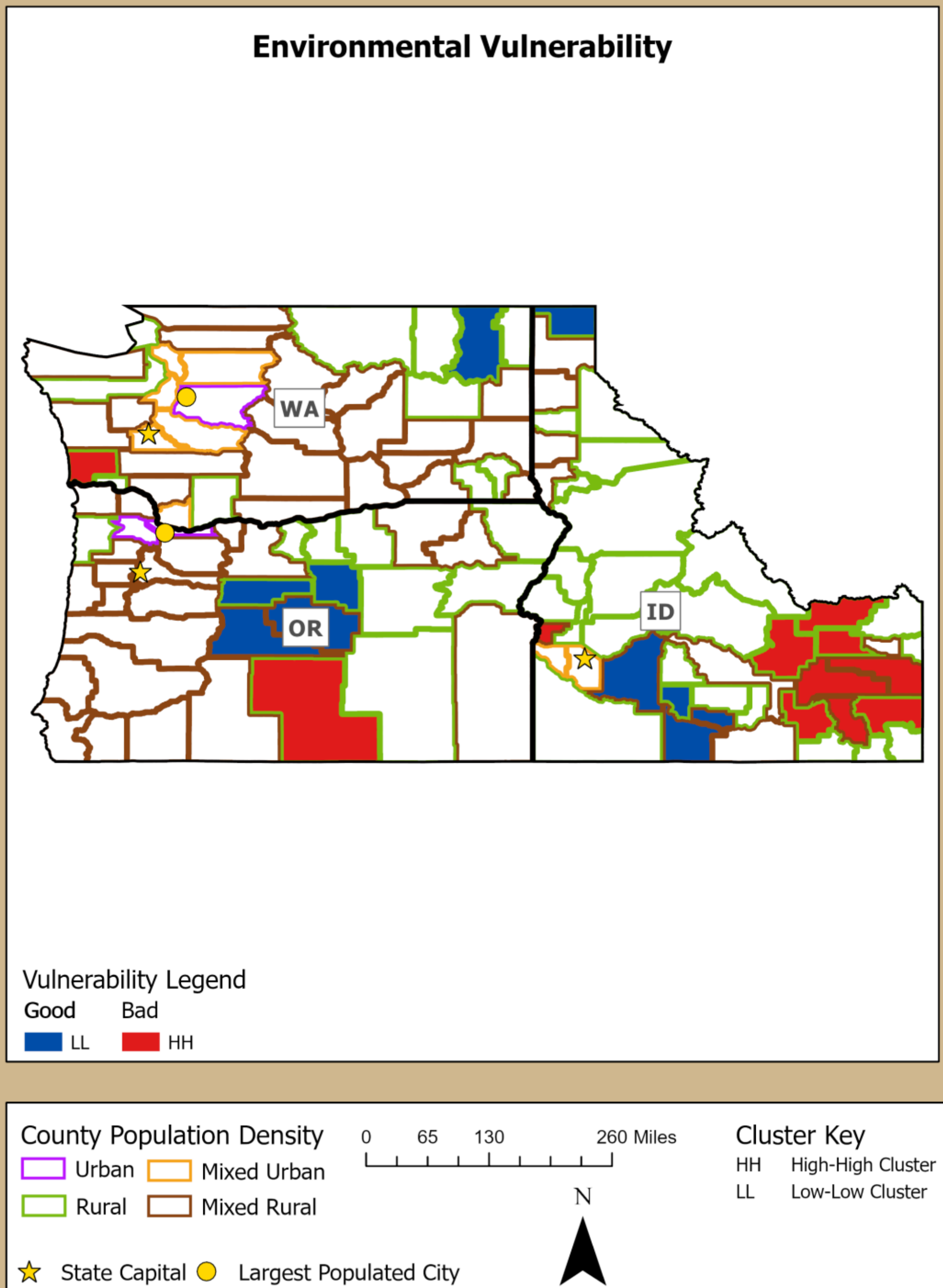
FEMA Region 10: MTP County Resilience/Vulnerability

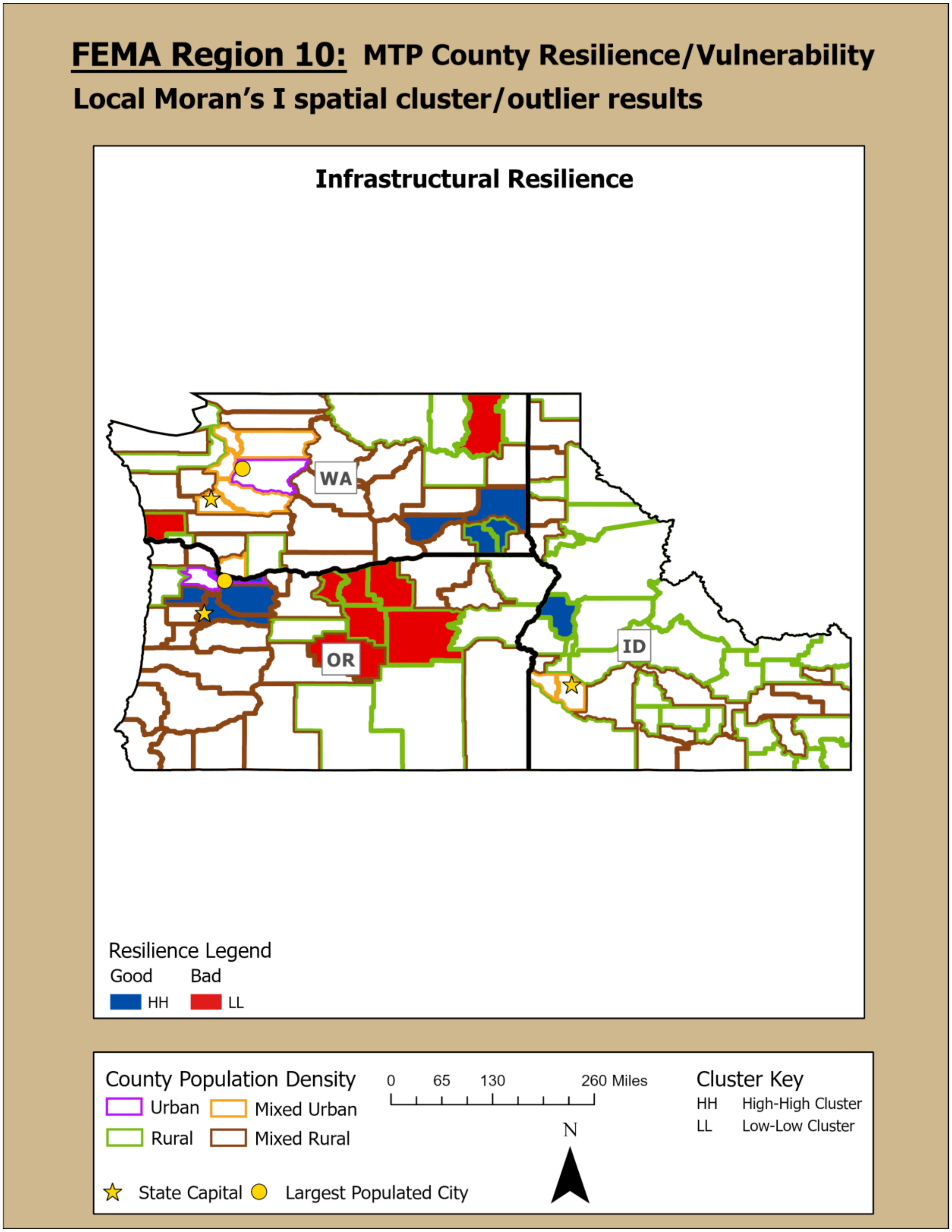
Local Moran's I spatial cluster/outlier results



FEMA Region 10: MTP County Resilience/Vulnerability

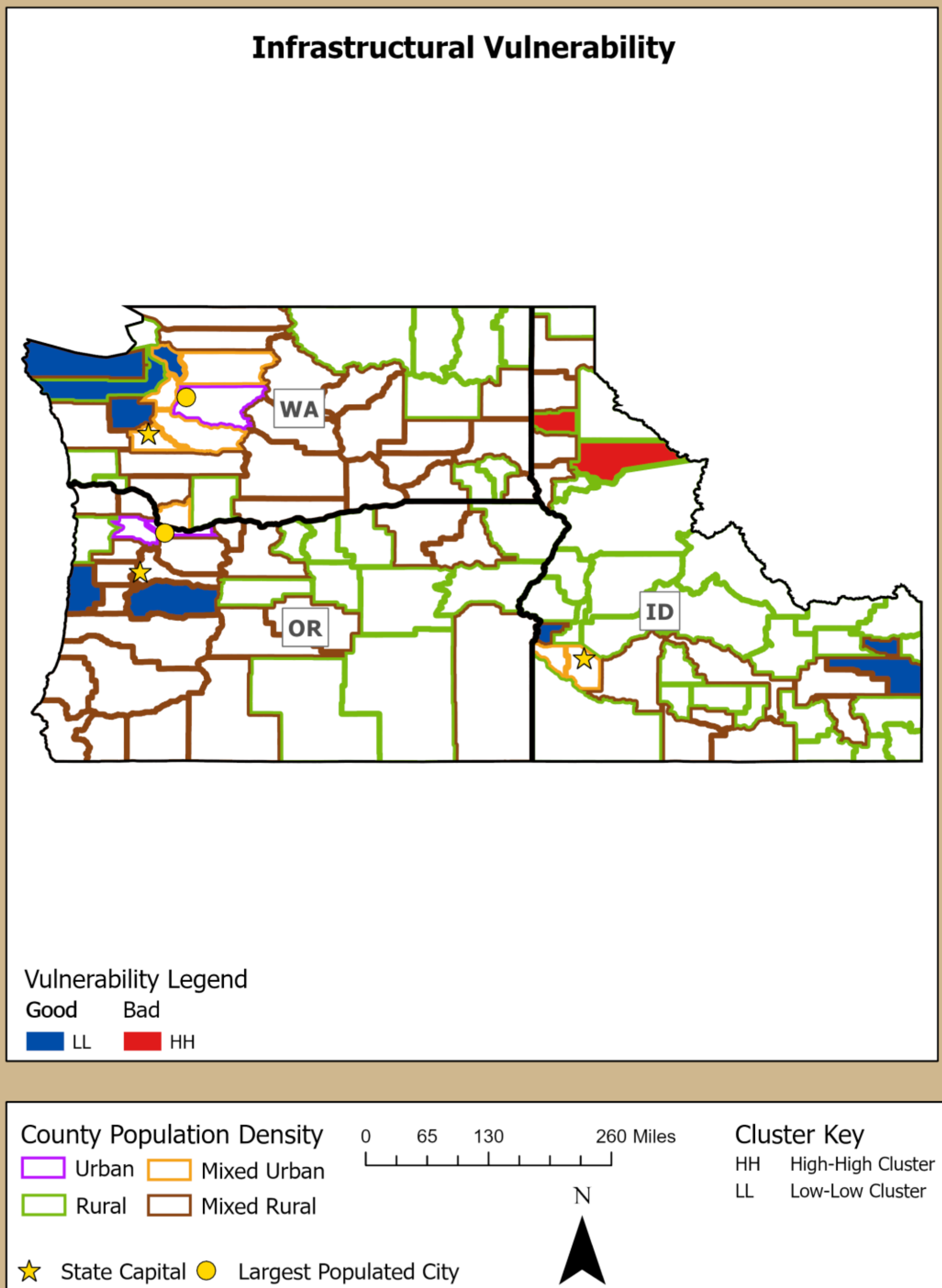
Local Moran's I spatial cluster/outlier results

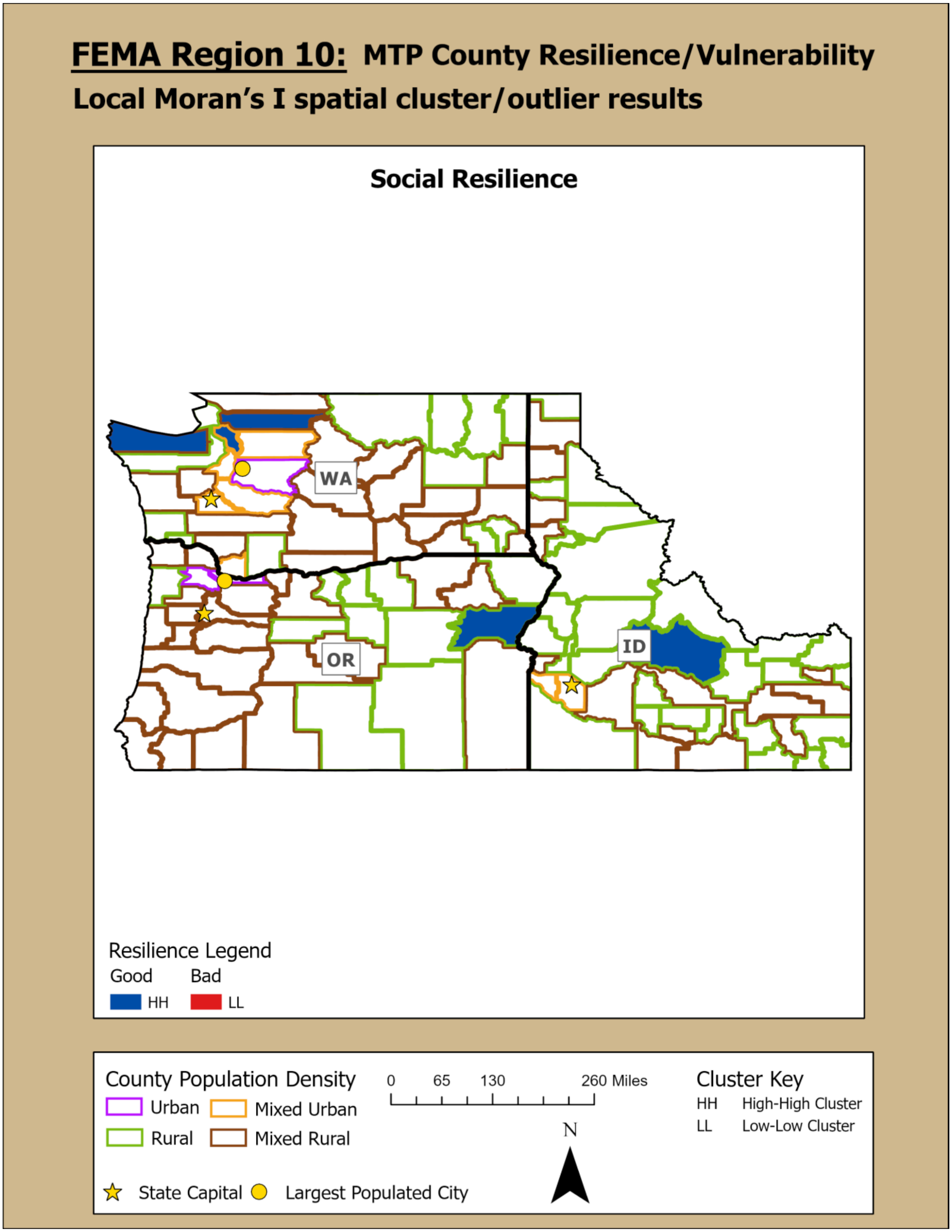


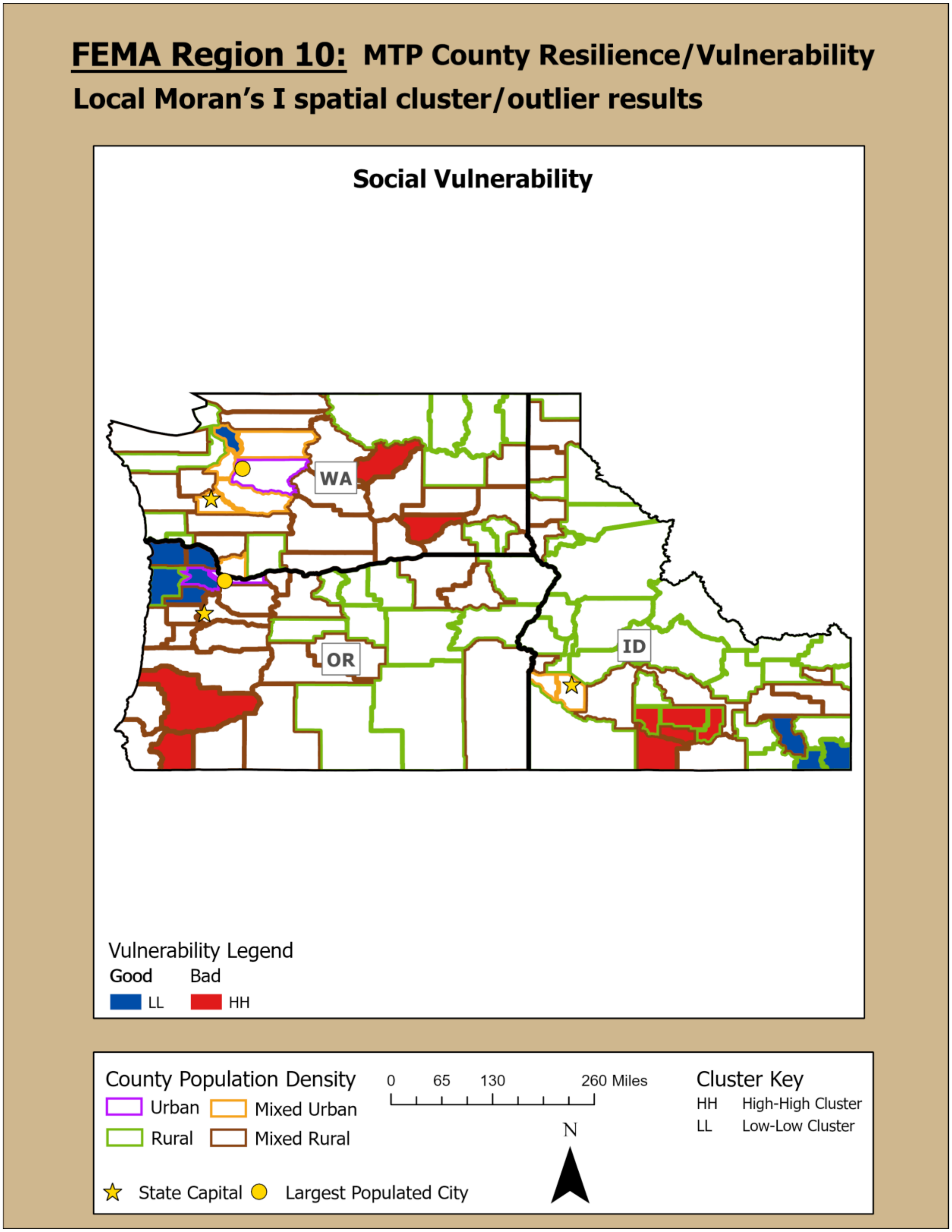

FEMA Region 10: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results
Infrastructural Resilience
WA
OR
ID
Resilience Legend
Good
Bad
HH
LL
County Population Density
Urban
Mixed Urban
Rural
Mixed Rural
State Capital
Largest Populated City
0
65
130
260 Miles
N
Cluster Key
HH High-High Cluster
LL Low-Low Cluster

FEMA Region 10: MTP County Resilience/Vulnerability

Local Moran's I spatial cluster/outlier results




FEMA Region 10: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results
Social Resilience
WA
OR
ID
Resilience Legend
Good
Bad
HH
LL
County Population Density
Urban
Mixed Urban
Rural
Mixed Rural
State Capital
Largest Populated City
0
65
130
260 Miles
N
Cluster Key
HH High-High Cluster
LL Low-Low Cluster


FEMA Region 10: MTP County Resilience/Vulnerability
Local Moran's I spatial cluster/outlier results
Social Vulnerability
WA
OR
ID
Vulnerability Legend
Good
Bad
LL
HH
County Population Density
Urban
Mixed Urban
Rural
Mixed Rural
State Capital
Largest Populated City
0
65
130
260 Miles
N
Cluster Key
HH High-High Cluster
LL Low-Low Cluster