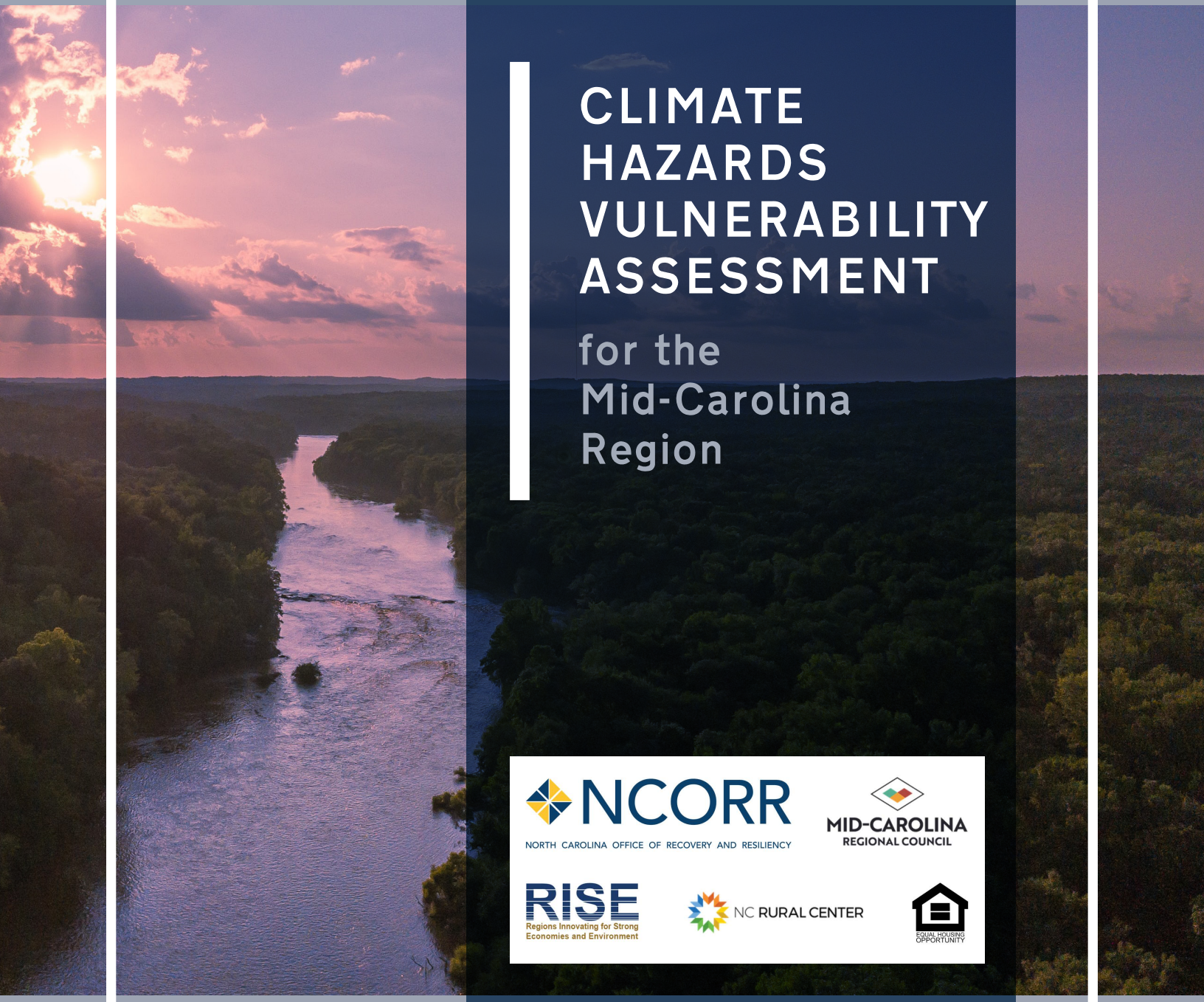

CLIMATE HAZARDS VULNERABILITY ASSESSMENT

for the Mid-Carolina Region

NCORR
NORTH CAROLINA OFFICE OF RECOVERY AND RESILIENCY

MID-CAROLINA
REGIONAL COUNCIL

RISE
Regions Innovating for Strong Economies and Environment

NC RURAL CENTER

EQUAL HOUSING OPPORTUNITY

Climate Change and Natural Hazards Vulnerability Assessment for the Mid-Carolina Region

December 2022

About NCORR

In the wake of Hurricane Florence in 2018, the State of North Carolina established the Office of Recovery and Resiliency (NCORR) to lead the state's efforts in rebuilding smarter and stronger. At that time, eastern North Carolina communities were still recovering from Hurricane Matthew, which had impacted the State in 2016. NCORR manages nearly a billion dollars in U.S. Department of Housing and Urban Development (HUD) funding in two grant types, Community Development Block Grant – Disaster Recovery (CDBG-DR) and Community Development Block Grant – Mitigation (CDBG-MIT). These are aimed at making North Carolina communities safer and more resilient from future storms. Additional funding is provided through the State Disaster Recovery Acts of 2017 and 2018, the Storm Recovery Act of 2019 and Economic Development Administration Disaster Supplemental Funds. NCORR manages programs statewide that include homeowner recovery, infrastructure, affordable housing, resilience and strategic buyouts. NCORR is a division of the North Carolina Department of Public Safety (DPS). To learn more about NCORR programs, visit ReBuild.NC.Gov. NCORR is a division of the Department of Public Safety.

Land Acknowledgement

We wish to acknowledge and honor the Indigenous communities native to this region and recognize that this vulnerability assessment covers communities and structures that are built on Indigenous homelands and resources. We recognize the Catawba, Cohaire, Lumbee, Skarureh/Tuscarora people and the Cumberland County Association of Indian People as past, present and future caretakers of this land. We also recognize the unnamed tribes that once oversaw these lands and have since relocated or been displaced.

Table of Contents

List of Figures

List of Tables

MID-CAROLINA
REGIONAL COUNCIL
Creative Regional Solutions

August 11, 2022

Dear Residents:

Our region, encompassing Cumberland, Harnett, and Sampson Counties, is the heart of North Carolina and has numerous positive attributes that make it a great community in which to live, work, and play. Yet, the region faces long-lasting impacts from Hurricanes Matthew and Florence, heat waves, an increasing number of high heat nights, droughts, and wildfires. However, there is good news in that many of these impacts can be avoided.

In light of these challenges, our goal for the Mid-Carolina Region is to take action to strengthen our resilience. This work includes reducing the immediate and long-lasting risks that natural and climate disasters pose for people, property, infrastructure, and natural resources. The Mid-Carolina Vulnerability Assessment uses rigorous technical analysis combined with local knowledge to outline the major gaps in our region's preparedness for future natural hazards, climate events, and their impacts. The report is the result of numerous meetings with residents, elected officials, local leaders, the North Carolina Office of Recovery and Resiliency, North Carolina Rural Center, and ESP Associates. These findings help us identify and prioritize efforts to become more resilient. In the coming months, we will use this Assessment to develop a suite up to 10 resilience projects for our three-county region. However, the Vulnerability Assessment is made available for use by the public, including the development of independent resilience efforts and grant applications.

As you read through this review of our region's susceptibility to climate impacts, I hope you will think about ways you can prepare neighborhoods, communities, and the region.

Sincerely,

Justin B. Hembree
Executive Director

6205 Raeford Road
Fayetteville, North Carolina 28304
910-323-4191

1. Executive Summary

The communities located within the Mid-Carolina region, like much of eastern and central North Carolina, are exposed and remain vulnerable to a variety of hazards, such as hurricanes, flooding, heat waves and other extreme weather events. The frequency and magnitude of natural hazards are expected to increase as the climate warms.[1]

This vulnerability assessment provides an in-depth analysis of persistent vulnerabilities within the Mid-Carolina region that are anticipated to increase in response to the changing climate conditions. The project team—including staff from the North Carolina Office of Recovery and Resiliency (NCORR), the Mid-Carolina Council of Governments, North Carolina Rural Center, and AECOM—developed this assessment using data from the state and local governments, academia, and previous planning documents; local knowledge and experiences; and information from previous natural disasters. After a brief introduction, this document begins with a review of how the region is prepared and preparing for worsening natural hazards, as well as a description of the challenges specific to the Mid-Carolina region. Next, this vulnerability assessment defines the current and future natural hazards relevant in North Carolina's Cumberland, Harnett and Sampson Counties. The report then gives a detailed description of how various sectors (e.g., housing, economy, public health) in Mid-Carolina will be impacted by the natural hazards that are becoming more intense and more frequent because of climate change. The assessment ends with a summary of the region's most worrisome vulnerabilities, referred to as "hot spots." The project team ground-truthed all findings with local stakeholders and residents.

Major Hazards

This document focuses on four hazards that significantly impact the Mid-Carolina region:

- Hurricanes and storms
- Flooding and heavy precipitation
- Extreme temperatures (including high heat indexes)
- Drought and wildfires

Summary of Vulnerabilities

This Vulnerability Assessment illustrates several primary issues that drive vulnerability in the region.

The Mid-Carolina region's **high rates of social vulnerability** create additional challenges for residents and emergency responders.

- The region has high rates of renters, mobile homes, poverty and challenging family situations.
- High proportions of people of color, elderly, and individuals who speak English less than well put many residents at a disadvantage, even before natural hazards occur.
- Energy burden is a serious concern across the region and will only get worse as climate change continues.

Flooding from hurricanes and storms surfaced as the most discussed hazard among stakeholders, who expressed concerns about emergency operations, delivery of utilities and economic impacts.

- The high proportion of mobile homes and renters in the region increases the exposure of families to impacts from high winds and flooding, which can lead to loss of homes, expensive repairs and unaddressed mold and corresponding health effects.
- Nearly all of the region's 15 most vulnerable tracts intersect the floodplain.
- Many of the water and wastewater pipes and pumps are in the most flood-prone areas, which complicates recovery and impacts residents who are unable to access normal water sources for drinking, sanitation, and other everyday uses.
- Cumberland and Harnett County offices are in the floodplain, as is Lillington's wastewater treatment plant. The Cumberland County

[1] North Carolina Institute for Climate Studies. 2020. *North Carolina Climate Science Report*. September 2020.

Emergency Operation Center nearly flooded during Hurricane Matthew.
- Some of the region's largest employers are in the 500-year floodplain, an area that is very likely to flood more frequently in the coming decades. Continued population growth and development can lead to an increase in flooding in future years.
- Fayetteville, Spring Lake, Hope Mills, unincorporated southern Harnett County, and Clinton have high population densities that intersect flood prone areas.
- Stakeholders extensively mentioned debris management issues in streams, dams with delinquent maintenance, undersized culverts on state-owned roads, and expanding development and as causes of flooding.
- There are three historical and cultural sites located in Cumberland County that fall within the 100-year floodplain that have already been damaged during past events.

Rising daytime and nighttime temperatures are a concern within the region because of their cascading impacts (drought and wildfires) and since heat relief strategies have not been a priority in previous planning efforts.

- Residents are particularly concerned about migrant farmworkers in Sampson County who often have trouble with English and are at increased risk because of their exposure from working long hours outdoors.
- Local stakeholders also emphasized the high proportion of elderly who are at risk of heat-related illnesses and death, especially since there are not enough case workers to provide the aging with necessary assistance.

Wildfires and droughts are becoming more prevalent across the region, in part due to the increasing proximity to the wildland-urban interface from expanding development.

- The wildfire risk in the Mid-Carolina region is most noticeable in Cumberland and portions of Harnett Counties. All developed areas in the region face some risk of wildfire.

Methodology

The team began with a literature and data review to outline what resources exists within the built and natural environments that could be exposed to the identified hazards. The team assessed how each asset has been impacted by past weather events, as well as how projected climate changes will impact those assets in the future. The team then determined how those impacts correlate to region-scale impacts, then presenting those findings to the stakeholders for their input.

The project team emphasized stakeholder engagement throughout the development of this vulnerability assessment. They began by establishing a Stakeholder Partnership made up of local leaders from all three Mid-Carolina Counties—Cumberland, Harnett, and Sampson—and from the public, private, and nonprofit sectors. A trained facilitator guides the monthly Stakeholder Partnership meetings with technical support provided by AECOM and NCORR. The project team used these meetings to identify natural hazards of concern; infrastructure, natural resources, and people repetitively impacted by these hazards; recurrent losses and damages; and anticipated impacts to the surrounding environments and to residents as the climate changes. The goal of the vulnerability assessment is to accurately depict the needs of the region to determine appropriate resilience strategies that will benefit the Mid-Carolina region in the face of climate change for years to come.

Next Steps

The Mid-Carolina region has created many plans that address hazards, but very few to-date have focused on the increasing challenges stemming from climate change. The few plans that address climate change, such as the Cumberland County Climate Resiliency Plan, are relatively new, but provide valuable insight on the beginning stages of resilience within the region. The next step in the RISE Regional Resilience Portfolio Program is for the project team and local stakeholders to use the information in this climate vulnerability assessment to identify five to 10 priority resilience strategies to address vulnerabilities that impact the Mid-Carolina region. The project team will place those priority projects in a published portfolio that outlines mechanisms for implementation, project leaders and partners, potential challenges, and relevant funding opportunities. NCORR has already identified funding to support some project implementation.

2. Introduction

North Carolina's residents, businesses, nonprofits, and governmental organizations are increasingly concerned by the growing frequency and intensity of heat waves, storms, precipitation patterns and their impacts. These weather events always hit an area larger than an individual town or county. To encourage regional coordination on identifying vulnerabilities and solutions, the North Carolina Office of Recovery and Resiliency (NCORR), with staff support from North Carolina Rural Center (NC Rural Center), created the Regions Innovating for Strong Economies and Environment (RISE) program. Each of the nine regions participating in this iteration of RISE are developing a vulnerability assessment (this document) and a portfolio of projects (forthcoming) to increase multi-county resilience to the impacts of climate change.

The primary objective of this vulnerability assessment is to analyze how natural hazards, paying particular attention to the changes in the area's climate happening now and by the 2050s, impact the Mid-Carolina region's residents, economy, infrastructure, resources, and landscapes. In doing so, each county and municipality within the region should better understand its unique risks to these hazards and be better prepared to evaluate and prioritize specific resilience actions for the final portfolio of projects.

About RISE

The RISE program supports resilience in North Carolina by:

- Facilitating the Regional Resilience Portfolio Program, which provides coaching and technical assistance for regional partners in the eastern half of North Carolina to build multi-county vulnerability assessments, identify priority actions that reduce risk and enhance resilience in the region and develop paths to implementation.
- Developing the North Carolina Resilient Communities Guide, a statewide resource that will provide tools, guidance and opportunities for building community resilience.
- Hosting the Homegrown Leaders program, an NC Rural Center leadership training workshop that operates in eastern North Carolina to emphasize resilience as a tool for community economic development.

The RISE Regional Resilience Portfolio Program covers nine areas that align with the North Carolina Council of Government regions seen in **Figure 1** below.

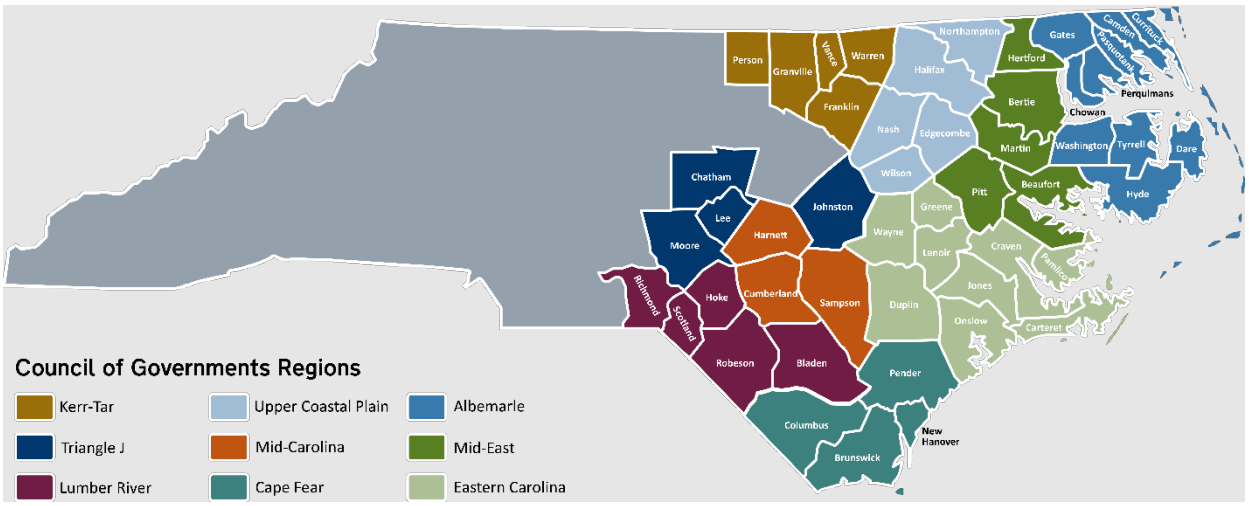

Figure 1: North Carolina's RISE Regions

This vulnerability assessment, which covers Cumberland, Harnett and Sampson Counties, fulfills the first deliverable of the Regional Resilience Portfolio Program for the Mid-Carolina region. The second and final deliverable of each region's RISE Regional Resilience Portfolio Program will be a compilation of five to 10 projects identified through community input and expert consultation. The portfolio document will outline funding opportunities and potential project partners to enable a clear path toward implementation for each project.

This report was generated with financial support from the U.S. Economic Development Administration under grant number 04-69-07472. RISE is also funded by the U.S. Department of Housing and Urban Development's CDBG-MIT program and in-kind support from NCORR and NC Rural Center. In addition, the Duke Energy Foundation committed $600,000 in grant funding to support the Regional Resilience Portfolio Program.

About the Mid-Carolina Region

For the purposes of this vulnerability assessment, the Mid-Carolina region is comprised of Cumberland, Harnett and Sampson Counties and the towns and cities within these counties, as shown below. Geographically, the region falls within the Coastal Plain of North Carolina, per the U.S. climate divisions defined by the National Oceanic and Atmospheric Administration's (NOAA) National Centers for Environmental Information. **Figure 2** and **Table 1** show the counties and municipal governments that comprise the Mid-Carolina region.

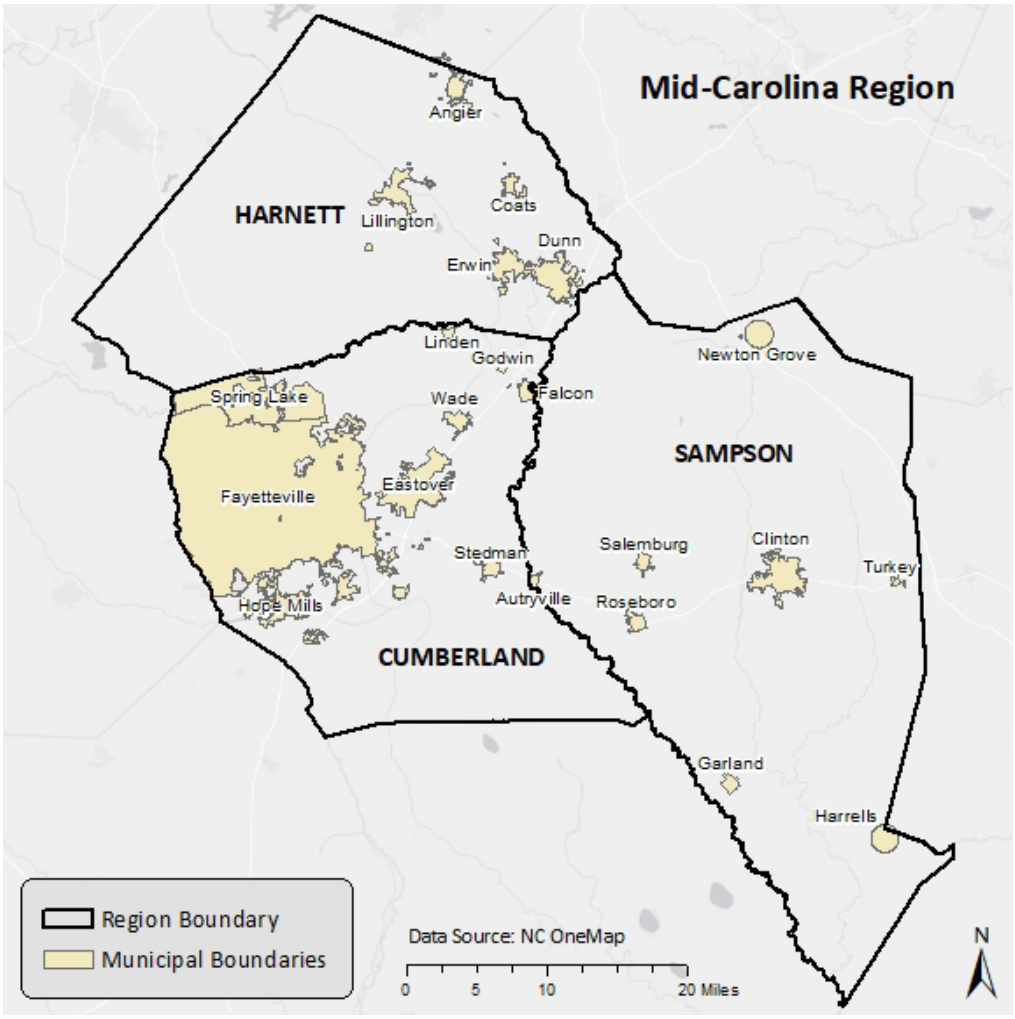

Figure 2: Map of the Mid-Carolina Region

Table 1: The Counties, Towns and Cities in the Mid-Carolina Region

Cumberland County
Eastover
Falcon
Fayetteville (County Seat)
Godwin
Hope Mills
Linden
Spring Lake
Stedman
Wade
Harnett County
Angier
Coats
Dunn
Erwin
Lillington (County Seat)
Sampson County
Autryville
Clinton (County Seat)
Garland
Harrells
Newton Grove
Roseboro
Salemburg
Turkey

Identified Hazards

This assessment focuses on four hazards that significantly impact the Mid-Carolina region at the local, county and regional scale, prioritizing the hazards that are most pervasive and disruptive to everyday life. The identified hazards are:

- Hurricanes and storms
- Flooding and heavy precipitation
- Extreme temperatures (including high heat indexes and wet bulb globe temperature)
- Drought and wildfires

The project team selected these hazards using information from the North Carolina Climate Science Report. These hazards are also identified in the state and regional hazard mitigation plans and have greatly impacted the region in the past, as reported by NOAA's National Centers for Environmental Information. The project team confirmed the validity of these hazards with stakeholders in the region. The intention of this vulnerability assessment is to help the region address today's natural hazards and to minimize the impacts and threats of hazards for future generations.

Vulnerability Assessment Methodology

To conduct this vulnerability assessment, the project team reviewed existing data and literature, discussed findings and gathered input from Mid-Carolina's residents and workers, and analyzed the results to provide guidance on the next phase of the RISE program—prioritizing projects to include in the regional portfolio.

Reports Included in the Literature Review

- Cape Fear Regional Hazard Mitigation Plan (2020)
- Cumberland Hoke Regional Hazard Mitigation Plan (December 2020)
- Sampson Duplin Regional Hazard Mitigation Plan (November 2020)
- Hurricane Matthew Resilient Redevelopment Plans for Cumberland, Harnett and Sampson Counties (May 2017)
- North Carolina Climate Science Report (September 2020)
- North Carolina Enhanced State Hazard Mitigation Plan (February 2018)
- North Carolina Emergency Management – Risk Management data and analyses
- Relevant County Plans (Economic Development, Comprehensive Plans, Land Use Plans, County Public Health Assessments, etc.)

Review of Literature and Data

The team began by using information from various datasets and reports to draft an inventory of the region's assets and challenges. The list of assets provides an overview of what already exists within the built environment that could be exposed to the identified hazards. The team assessed how each asset has been impacted by past weather events, as well as how projected climate changes will impact those assets in the future. The team then determined how those impacts correlate to region-scale impacts. The results of this review are included in *Chapter 4* and *Chapter 5*.

Stakeholder and Public Engagement

Next, the project team gathered local input and expertise from stakeholders to corroborate the findings of the data and literature review. To obtain this input, the project team held monthly Stakeholder Partnership meetings, described below, from January to May 2022; one public meeting in April 2022; launched a virtual public meeting space online that included a map where individuals could geographically note problem areas; and conducted an online public survey. The project team designed each of these opportunities to simultaneously educate participants and extract relevant information pertaining to vulnerable areas in the region. Due to the ongoing COVID-19 pandemic, all live meetings were held virtually using WebEx technology; the virtual meeting website, described below, was open to anyone at any time. Throughout the engagement process, the project team employed various strategies, including live presentation surveys, surveys done on one's own time and facilitated breakout discussion groups, to optimize participation.

Stakeholder Partnership Meetings

The project team established the Mid-Carolina region Stakeholder Partnership to support the development of this vulnerability assessment and the regional resilience portfolio (forthcoming). NCORR, the Mid-Carolina Council of Governments and a local representative identified by the NC Rural Center (see the "Facilitator" section below) recruited local leaders to serve as participants. See the call out box at right for a list of participating organizations. Throughout the process, the project team continues to add participants based on identified diversity gaps, stakeholder suggestions and inquiries.

Organizations Represented on the Mid-Carolina Stakeholder Partnership

- Carolina Wetlands Association
- Cities of Dunn and Fayetteville
- Cumberland County Government
- Episcopal Farmworker Ministry
- Fort Bragg
- Harnett County
- Harnett County Schools
- Harrells Community Center
- North Carolina Emergency Management
- North Carolina State University
- Sampson County Emergency Management
- Towns of Eastover, Hope Mills, Linden, Roseboro, and Spring Lake
- Wetland Solutions

Through monthly meetings beginning in January 2022 (lasting until the completion of the portfolio expected in December 2022), each Stakeholder Partnership member offered valuable insight on the region's strengths, weaknesses, opportunities and constraints that will influence the course of action taken to reduce the impacts of natural hazards exacerbated by climate change. This feedback is integrated with research findings throughout *Chapter 4* and *Chapter 5*.

The Stakeholder Partnership contributed significantly to the development of this document. During their monthly meetings held in the first part of 2022, participants covered all aspects of the vulnerability assessment, including discussions of natural hazards and how they impact individual streets, neighborhoods, and communities, as well as the region as a whole. The conversations initially focused on county-specific vulnerabilities before transitioning toward a regional perspective based on shared challenges and responsibilities. The Stakeholder Partnership also reviewed and provided feedback on a draft of this document. (The project team will integrate that feedback after the public comment period.)

Stakeholder Partnership meetings occurred alongside data gathering and analysis to ensure the project team had accurate sources of information and that community officials and other key stakeholders had ample opportunity to contribute to the ground-truthing component of the assessment.

Facilitator

The NC Rural Center hired a facilitator to work with each RISE region, including Mid-Carolina. This facilitator, who lives and works in the region, supported and often led outreach and engagements efforts. The facilitator:

- Helped recruit Stakeholder Partnership members
- Followed up with individual Stakeholder Partnership members to boost their engagement
- Provided facilitation services at each Stakeholder Partnership meeting
- Helped plan the Stakeholder Partnership meetings
- Served as a spokesperson for the region
- Offered their viewpoints based on their areas of expertise
- Helped identify strengths and vulnerabilities of the region
- Brainstormed projects to increase regional resilience
- Provided input to shape the two main deliverables of this project: a vulnerability assessment and a regional portfolio of projects ready for implementation

Public Meetings

The project team hosted a virtual public meeting on Tuesday, April 26, 2022, from 5:30 – 7:00 PM to continue ground-truthing data, literature, and analysis. During the meeting, the team gave a quick overview of the project scope and then broke attendees into small discussion groups, allowing for more substantial contributions. The facilitator and the rest of the project team collected input about areas of local vulnerability and challenges to climate resilience. Twenty-four individuals attended this public meeting.

Virtual Meeting Room

To facilitate greater input from the public and stakeholders, the project team created a virtual meeting room at risecentralnc.com to provide an online location for information and input opportunities relevant to the vulnerability assessment. This user-friendly website is open to anyone at any time, supplements the main public workshop described above and keeps participants comfortable, safe and healthy amidst the COVID-19 pandemic. This site will remain open through the end of the project, expected in December 2022. As of July 5, 2022, 240 people had visited this website.

Participants entered the virtual room through an online lobby, a screenshot of which can be seen in **Figure 3**, where they were prompted to select their region of interest (Mid-Carolina: Cumberland. Harnett or Sampson Counties or Triangle J: Chatham, Lee, Moore or Johnston Counties). Each region's virtual room offered ample information for each participant to explore, such as a project overview, funding opportunities and key challenges faced by the region. The virtual room also shared links to subscribe to RISE updates,

submit additional comments or questions, identify problem areas on the NCORR Action Map, described below, and complete the public survey, also described below. Some content on the website was offered in Spanish.

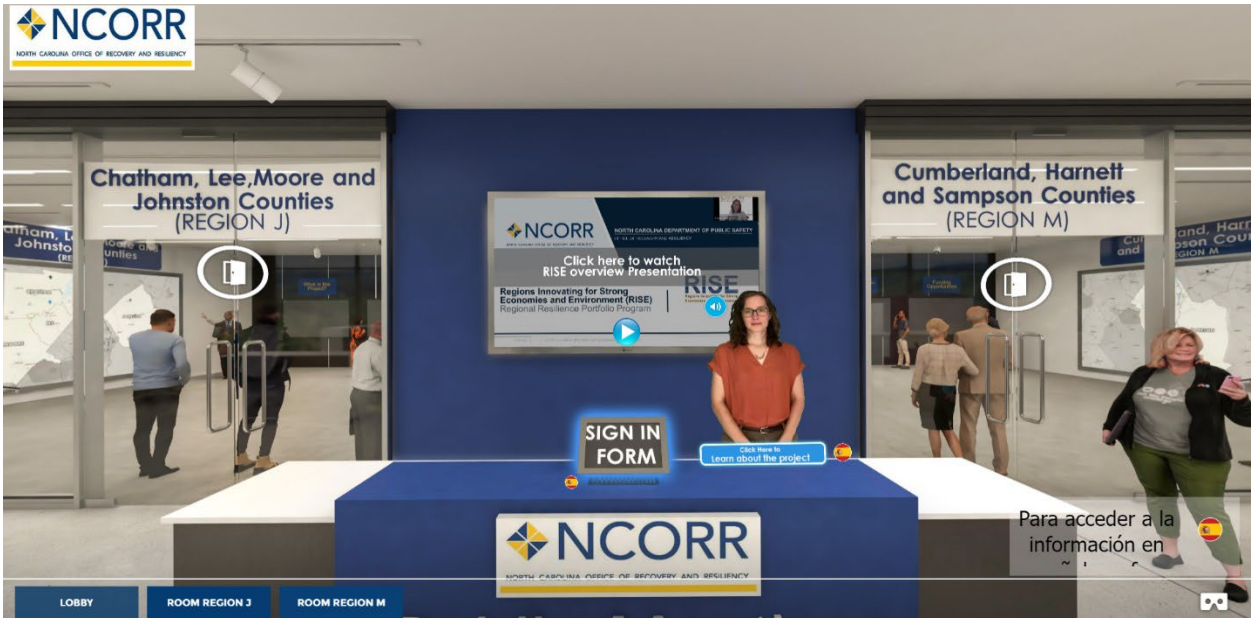

Figure 3: A Screenshot of the Virtual Room at risecentralnc.com

NCORR Action Map

The project team created the NCORR Action Map to increase ground-truthing data collection through visual engagement. Accessible to participants through the virtual meeting room and during Stakeholder Partnership and public meetings, the map enabled individuals to demarcate areas of vulnerability across the region.

The tool itself outlined county boundaries for the Mid-Carolina region encompassing Cumberland, Harnett and Sampson Counties. Users had the ability to input information based on areas of potential impact. Once an area was selected via point, line or polygon, the tool promoted the user to identify the hazard of concern, any specific occurrence(s) worth noting, name and organization of submitter and any issue(s) caused by the identified hazard. The project team received information provided through the map and reviewed it with members of the Stakeholder Partnership. Information collected through this tool is integrated throughout *Chapter 4* and *Chapter 5* and is listed in full in **Appendix A**.

Public Survey

As a final measure, the project team created and offered a public survey to increase opportunities to submit comments about the region's hazards and vulnerabilities. Created in Survey Planet, the survey distributed by the facilitator via several platforms, NCORR press releases and social media posts, the Mid-Carolina Council of Government's social media and email lists, and on county and municipal social media outlets. The questionnaire was available for approximately two months and consisted of eight questions, six of which were open-ended. Survey respondents ranked hazards, identified hazard-prone areas, considered vulnerable or disadvantaged populations and submitted potential strategies to build resilience. The project team included survey results throughout *Chapter 4* and *Chapter 5* of this vulnerability assessment. Nineteen individuals responded to the survey. A copy of the survey can be found in **Appendix B**.

3. Mid-Carolina's Overall Strengths and Challenges Related to Resilience

Strengths Related to Resilience

Community leaders and stakeholders in the Mid-Carolina region have a framework of plans and past investments upon which they can build additional strengths and capacities to increase resilience to the impacts of climate change. Residents, stakeholders and community leaders have a strong history of responding to disasters. Those experiences have taught many lessons. Past storms have led community members to take steps to reduce vulnerability and increase resilience. This section reviews those steps by describing current and recently completed projects as well as past planning efforts. These efforts will serve as a foundation for identifying new projects and programs to fill the gaps.

Strong Planning Capacity and Previous Planning Efforts

Throughout the years, programs and policies have been put into place at federal, state and local levels to foster local planning efforts aimed at confronting the most prevalent hazards. As a result, the region and the state are better equipped to address weather events that turn disastrous. Existing resources serve as a strong foundation to support future projects and plans. This assessment takes into consideration existing planning documents, local government capabilities and projects underway to build a comprehensive approach to heightening regional resilience as climate change accelerates.

Table 2 provides a summary of the planning and regulatory capabilities of the Mid-Carolina counties. The table list plans, ordinances and programs as examples of the region's planning and regulatory capabilities. The table marks a "Y" where that capability exists, and a "N" where it does not exist. These listed items demonstrate a jurisdiction's commitment to guiding and managing growth, development and redevelopment, and emergency response. The examples below include transportation plans, hazard mitigation plans, comprehensive land use plans, open space management plans and others. The table also includes the zoning, subdivision ordinances and building codes that regulate land development and structure requirements. The local governments of the Mid-Carolina region implement these plans, programs, policies and ordinances to help protect residents as well as environmental, economic, historic and cultural resources.

Table 2: Capability Assessment Summary for the Mid-Carolina Region

Capabilities	Cumberland	Harnett	Sampson
Hazard Mitigation Plan	Y	Y	Y
Resilient Redevelopment Plan	Y	Y	Y
Comprehensive Plan/Master Plan	Y	Y	Y
Open Space Management Plan	Y	Y	N
Local Emergency Operations Plan	Y	Y	Y
Economic Development Plan	Y	Y	Y
Capital Improvement Plan	Y	Y	Y
Continuity of Operations Plan	N	Y	Y
Disaster Recovery Plan	N	N	Y
Zoning Ordinance	Y	Y	Y

Capabilities	Cumberland	Harnett	Sampson
Subdivision Ordinance	Y	Y	Y
Floodplain Ordinance	Y	N	N
Flood Damage Prevention Ordinance	N	Y	Y
Stormwater Management Plan/Ordinance	Y	Y	N
Unified Development Ordinance	N	Y	N
Building Code	Y	Y	Y
Fire Code	Y	Y	Y
Site Plan Review Requirements	Y	Y	Y
National Flood Insurance Program (NFIP)	Y	Y	Y

Note: Data were obtained from Regional Hazard Mitigation Plans

The project team reviewed each of these capabilities to better understand the region's capacity for dealing with weather-related disasters.

But even if these plans, ordinances, codes, and programs exist, current policies and practices may be inadequate to address future changing conditions. Local governments may need to shift toward a risk-based approach for certain planning processes and plans. This shift would place climate change at the forefront of planning efforts, encouraging local leaders to increase adaptive capacity and prioritize sustainable and innovative measures.

Local Hazard Mitigation Plans

The hazard mitigation plans for Cumberland, Harnett and Sampson Counties serve as a strong foundation for the portfolio of projects. They provide relevant information on existing vulnerabilities, natural hazard occurrence and proposed mitigation actions. These types of plans, which increased in number across the country following the Disaster Mitigation Act of 2000[2], are intended to strengthen preparedness, reduce risk and minimize negative impacts from hazards. The project team reviewed the status and relevance of the actions within these plans and will consider unimplemented actions for inclusion within the portfolio of projects.

The Disaster Mitigation Act of 2000 provides technical and financial assistance to state and local governments, often contingent upon whether these entities developed a hazard mitigation plan that was approved by the Federal Emergency Management Agency (FEMA). These plans must be updated and re-submitted for FEMA approval every five years to maintain eligibility. Cumberland, Harnett and Sampson Counties regularly update their local hazard mitigation plans to secure federal funding opportunities. All three counties last updated their plan in 2020.

Counties must adopt and update their local hazard mitigation plans to remain eligible for the following funding opportunities: Hazard Mitigation Grant Program, Building Resilient Infrastructure and Communities (BRIC) grant, Flooding Mitigation Assistance and Rehabilitation of High Hazard Potential Dam Grant Program. Funding obtained through these programs could be used to help address vulnerabilities identified for the Mid-Carolina region.

[2] The Disaster Mitigation Act of 2000, Public Law 106-930, also called DMA2K, is a U.S. federal legislation passed in 2000 that amended provisions of the Unites States Code related to disaster relief. The amended provisions are named after Robert Stafford, who led the passage of the Stafford Disaster Relief and Emergency Assistance Act of 1988.

In addition to providing funding, FEMA-approved hazard mitigation plans help state, local and tribal governments to do the following:

- Increase education and awareness of natural hazards and community vulnerabilities;
- Build partnerships with government, organizations, businesses and the public to reduce risk;
- Identify long-term strategies for risk reduction with input from stakeholders and the public;
- Identify cost-effective mitigation actions that focus resources on the greatest risk areas;
- Integrate planning efforts and risk reduction with other community planning efforts;
- Align risk reduction with other state, tribal or community objectives; and
- Communicate priorities to potential funders.[3]

Hurricane Matthew Resilient Redevelopment Plan

Cumberland, Harnett and Sampson Counties, in partnership with the state government and local governments, developed Resilient Redevelopment Plans in 2017 in response to Hurricane Matthew. These plans aimed to identify redevelopment strategies, innovative construction projects and other actions that allow each county to adequately respond to natural hazards as they continue to increase in frequency and intensity. This planning effort highlights the region's capacity to proactively respond to devastation and reduce future impacts. The collaborative development displayed the region's ability to leverage intragovernmental partnerships to achieve an outcome. The implementation of these plans is still underway.

Comprehensive and Master Plans

Across the region, local and county governments have developed, implemented, and updated comprehensive plans to guide future development and land use. Land use regulations serve as a powerful tool to improve an area's resilience through floodplain and wetland restrictions, tree protection, water conservation, design standards and zoning. A comprehensive plan impacts land use and development through official controls and implementation actions. Official controls include zoning ordinances, subdivision ordinances and capital improvement plans, while implementation actions include small areas studies, feasibility studies, new programs and updated ordinances.

The communities in the Mid-Carolina region are increasingly using their regulatory authority to address the growing impacts of climate change, including through their Comprehensive and Master Plans, to integrate strategies that combat the increasing frequency and intensity of natural hazards. For example, the Cumberland County 2030 Growth Vision plan identifies the following priority actions: well managed growth and development, preserved open space, quality housing and residential development, sustainable environments, enhanced public safety services and intergovernmental cooperation and efficiency.

Economic Development Plans

Cumberland, Harnett and Sampson Counties have developed economic development plans to strengthen the economy and increase economic resilience. According to the U.S. Economic Development Administration, it is becoming increasingly apparent that regional economic prosperity is linked to an area's ability to prevent, withstand and quickly recover from major disruptions to its economic base. Weather events, especially as they become stronger and more frequent, can impact (and have impacted) the local economy. The Harnett County Comprehensive Growth Plan states that economic development is a policy endeavor with aims of economic and social well-being of people involving areas of human capital, critical infrastructure, regional competitiveness, environmental sustainability, social inclusion, health, safety, literacy and other initiatives. Economic resilience depends on a community's ability to recover quickly from a shock, withstand a shock and avoid the shock altogether. At the regional level, economic development is instrumental in building the capacity for economic resilience.

[3] FEMA. 2021. *Mitigation Planning and Grants*.

Capital Improvement Plans

Current county capital improvement plans incorporate resilience strategies such as emergency radio replacement, relocation of critical facilities, radio tower replacement and broadband expansion. Counties should continue to consider innovative techniques to integrate resilience into capital improvement projects to combat climate change and natural disasters.

Capital improvements allow local officials to explicitly incorporate anticipated climate risk into budgeting and investment processes. As climate change persists, the region will experience more frequent and intense natural disasters, and its infrastructure facilities and systems will be at higher risk. Current practices for considering natural hazards in infrastructure planning and decision making uses static snapshots based on historical models. However, use of historical models provides a limited view of the negative impacts of future changes in climate on local infrastructure.

There is tremendous opportunity to increase resilience by informing capital improvement planning through techniques that incorporate information from extreme weather and climate hazards. As new data, tools and techniques continue to develop, planning practitioners at the local and regional scale should review climate data to account for worsening climate impacts in their capital infrastructure plans[4] . Making connections between regional, comprehensive or functional plans and the local capital improvements plan can empower communities to ensure that infrastructure is meeting long-term resilience goals.

Cumberland County Climate Resiliency Plan

The Cumberland County Climate Resiliency Plan outlines the priority climate impacts the county faces, observed and projected climate trends, and a Strategic Action Plan. The report presents existing climate and non-climate related conditions of concern including the follow four climate risks that are currently serious threats to the county: heat waves, severe weather events, heavy precipitation and prolonged drought. This plan was drafted in 2015 through collaborative efforts by the Model Forest Policy Program, the Cumberland River Compact and Sustainable Sandhills. This plan is the first of its kind within the Mid-Carolina region and can be replicated using appropriate measures by other neighboring counties to support regional resilience.

High-Capacity Local Emergency Management Programs

In addition to the planning and regulatory capabilities discussed above, the Emergency Management Departments in the region play a crucial role in resilience building. One of the goals of these departments is to prevent and protect the community from natural hazards. Emergency Management is a coordinated effort involving local, state and federal government agencies as well as volunteer organizations; and within an integrated emergency management framework, these entities assist residents and their communities to prepare for, respond to, recover from and eliminate or reduce the impacts of natural disasters. Important responsibilities that are carried out by Emergency Management that increase regional resilience include alerting residents via public notification systems, calling out cooling stations throughout the region, maintaining Emergency Operations Plans and performing routine maintenance.

Federal and State Funding Through Local Efforts

The towns and counties that comprise the Mid-Carolina region are continuously applying for grant funding to enhance resilience both locally and regionally. Although some applications are unsuccessful due to lack of technical resources, others are awarded for their efforts and received or anticipate funding in upcoming years. The following projects, with various sources of funding, are either underway or complete in the Mid-Carolina region:

- Cumberland County received BRIC funding to install additional stream gauges for forecasting and notification.

[4] Flood Science Center. 2020. *Building Coastal Resilience through Capital Improvements Planning*.

- The City of Fayetteville is updating flood mapping for accurate data and representation using funding from the Stormwater Operating Funds.
- The North Carolina Land and Water Fund awarded a planning grant to the Carolina Wetlands Association to study the Stony Run corridor along the eastern side of Dunn, NC, running from US 301 to I-95. This project is in partnership with Harnett County through the Soil and Water Conservation office.
- The Town of Linden applied for a Streamflow Rehabilitation Assistance Program grant from the North Carolina Department of Agriculture and Consumer Services to clear out a drainage ditch.
- Harnett County received funding from the USDA Natural Resources Conservation Service Emergency Watershed Protection Program and from the North Carolina Department of Agriculture and Consumer Services Division of Soil and Water Conservation Streamflow Rehabilitation Assistance Program to clear river debris where the Cape Fear and Upper Little Rivers merge.

Challenges Related to Resilience

The project team identified several non-climate stressors that have the potential to reduce the overall impact of natural hazards if appropriately addressed. The U.S. Climate Resilience Toolkit defines a non-climate stressor as "a change or trend unrelated to climate that can exacerbate hazards."[5] These stressors affect aspects of everyday life and heighten vulnerability in the region as the climate continues to warm. It is important to establish the relationship between non-climate stressors and natural hazard impacts in order to better understand the long-term strategies necessary to build resilience.

Increased Development

The Mid-Carolina region has experienced growth and increased development, which presents challenges to community resilience-building efforts. As seen in **Table 3**, the Mid-Carolina region overall has seen a significant population increase between 2010 and 2020—approximately 30,000 people—according to census data. Likewise, the total number of housing units within the region has increased by approximately 38,000 between 2010 and 2020.[6] This additional infrastructure reinforces the idea that development is based on need, and if the population continues to increase, so will development in order to accommodate the region's population. Although growth is generally desired, especially when considering the local economy, it places increased pressure on the region's resources, contributing to climate change and challenging environmental sustainability.[7]

Growth can strain local planners and challenge the plans and ordinances currently in place. Local officials and planners are tasked with implementing policy, creating programs and updating land use regulations (zoning, subdivision regulation and floodplain management regulations) to address the changing climate and promote more resilient communities. For example, comprehensive plans and capital improvement plans are long-term visions that guide future land use and infrastructure improvements. However, adjustments and new approaches are necessary to account for increasing natural hazards and to ensure that growth does not increase vulnerability to hazards. Even when growth is well-managed through plans, ordinances and policies, more homes, businesses and infrastructure lead to more exposure to hazards, especially those that uniformly impact a community or do not occur in spatially defined areas such as drought and extreme temperatures. These additional considerations will create new and pressing challenges, relying heavily on innovative thinking and technology.

According to the North Carolina Climate Science Report, as urban expansion continues and housing developments extend farther into previously undeveloped areas, the opportunity to use fire as a prescribed

[5] US Climate Resilience Toolkit. 2021. *Glossary.*
[6] PolicyMap. 2022. 2010 and 2020 Census Data.
[7] United Nations Population Fund. 2013. *Sustainable Development and Population Dynamics*: Placing People at the Centre.

means of mitigating wildfire damage may be reduced. In turn, this could lead to an increase in the occurrence of wildfire with health and economic impacts. When structures are built close to forests or other types of natural vegetation, they pose two problems related to wildfires. First, more wildfires can result from human ignitions during yard cleanup. Second, wildfires will pose a greater risk to lives and homes as approximately one in three houses and one in ten hectares are now in the wildland urban interface (WUI).[8] Cumberland, Harnett and Sampson Counties confirmed this increase in frequency of wildfires during the Stakeholder Partnership meetings.

Increased development in the region has exacerbated flood impacts, as well, and stakeholders recognize it. Hurricanes are already increasing freshwater flooding, and flooding will get worse as impervious surfaces and development increases in low-lying areas[9]. For example, "removing vegetation and soil, grading the land and constructing drainage networks increase runoff to streams from rainfall and snowmelt. As a result, the peak discharge, volume and frequency of floods increase in nearby streams. Changes to stream channels during urban development can limit their capacity to convey floodwater. Roads and buildings constructed in flood prone-areas are expected to increase flood hazards, including inundation and erosion, as new development continues"[10]. Stakeholders identified many roadways and major highways, which, when flooded, create barriers for evacuation routes and emergency services during the time of a disaster. As population increases, these blocked roads will cause more and more impacts on the community.

Table 3: Mid-Carolina Region County Growth Rates 2010-2020

County	Growth Rate (2010-2020)
Cumberland County	4.8%
Harnett County	16.7%
Sampson County	-7.3%
Mid-Carolina Region	**14.2%**

Note: Data were obtained from the North Carolina Office of State Budget and Management

Just as increased development poses issues for communities in the Mid-Carolina region, upstream and adjacent development impacts all three counties, as well. For example, structures that encroach on a floodplain, such as a bridge, can increase upstream or downstream flooding by narrowing the width of the channel and increasing the channel's resistance to flow.[11] **Figure 4** below provides a graphic representation of the scale of the Cape Fear River Basin in which most of the Mid-Carolina region is located. It is important to note that land use choices and development that occurs in places like Greensboro and Durham, NC, can have impacts in Cumberland, Harnett and Sampson Counties. These impacts have not been given much, if any, consideration in past planning efforts.

[8] Radeloff, Volker C., David P. Helmers, H. Anu Kramer, and Susan I. Stewart. 2018. "Rapid growth of the US wildland-urban interface raises wildfire risk." *Proceedings of the National Academy of Sciences*. March 12, 2018.

[9] North Carolina Institute for Climate Studies. 2020. *North Carolina Climate Science Report*. September 2020. p. 86

[10] Konrad, Christopher. 2016. *Effects of Urban Development on Floods.*

[11] Konrad, Christopher. 2016. *Effects of Urban Development on Floods.*

Figure 4: The Cape Fear River Basin and the Mid-Carolina Region

Aging and Undersized Infrastructure

The region's infrastructure, especially that which is inadequately sized and in poor condition, is at risk from the effects of climate change; the state of this infrastructure amplifies the region's vulnerability to natural hazards. Stakeholders marked dams, levees, culverts and bridges as problem areas on the Action Map throughout the region. This infrastructure has deteriorated over the years due to lack of rehabilitation, repairs and costly upgrades. This disrepair increases the region's susceptibility to disastrous events and any associated impacts. Residents of all three counties mentioned undersized culverts and levees as a concern. Similarly, local stakeholders discussed how rural portions of the region lack sufficient infrastructure to power heating, ventilation and air conditioning (HVAC) systems, which limits cooling center and shelter capacities. This deficiency coincides with the notion that smaller communities lack the technical and financial resources to build resilience on their own, highlighting the importance of regional collaboration.

Physical infrastructure, including roads, bridges, buildings and utility systems, are intended to have a lifespan of several decades. Such infrastructure will experience the effects of global warming over its lifetime. There have been no systematic quantitative studies of the impacts of climate warming and associated conditions on infrastructure design standards for North Carolina[12]; however, infrastructure in the Mid-Carolina region remains extremely vulnerable to natural hazards. Both the integrity and function of infrastructure is threatened as a result of changing climate conditions.

The Department of Homeland Security explains that age is one of many factors that affect the performance of infrastructure and its robustness against threats posed by common environmental conditions and extreme natural hazards. Infrastructure age often acts together with other factors such as design, maintenance, and operation in increasing the vulnerability of infrastructure to these threats. Department of Homeland Security emphasizes the relationship between infrastructure and resilience, stating, "Infrastructure robustness and resiliency represent interdependent qualities of systems. Robust systems are inherently more resilient. A probabilistic approach to robustness and resiliency encompasses all threats. As such, robust and resilient design represents a true independence from threat."[13]

Access to Resources and Funding Opportunities

Access to resources and funding opportunities, especially within smaller communities in the region, was a challenge following recent disaster events. In fact, during the outreach component of this assessment, several stakeholders noted that they had applied for a specific grant but were not selected. Lack of time, resources and personnel can place limitations on success rates. For example, individuals working in Cumberland County noted that both the Towns of Linden and Spring Lake had applied for grant opportunities for disaster recovery assistance, but neither were awarded, and it is likely that this scenario is common in other parts of the region and state. The opportunity for funding and financial assistance exists, but many local governments have had limited success.

Collaboration and Communication Between Local Governments

Limited communication and collaboration throughout the region threaten resilience planning and recovery. During the public engagement components of the vulnerability assessment, attendees noted that it is unclear who is responsible for certain roads, streams and structures in the county when response is necessary (particularly in the unincorporated areas). Similarly, inter-county communication is important as adjacent counties do impact one another. Rivers and dams located in the Mid-Carolina region impact neighboring counties and must be considered by each nearby county. Collaboration could even allow municipalities, especially the smaller communities within the region, to leverage their existing resources and services at no additional cost. Collaboration and consistent communication between all scales of local governments is essential to properly address climate change and the impacts felt at the local and regional level.

Education and Outreach to Heighten Awareness

Overall, the region has taken a reactive approach to education, outreach and planning initiatives. For example, all counties within the region developed a resilience redevelopment plan following Hurricane Matthew. Had a plan been established prior to Matthew, impacts may have been reduced. Although catastrophic, recent disasters have emphasized the importance of heightening education and awareness at the regional level before a disaster occurs. With proper notice and instruction, property and structural damage may be reduced, public safety increased and recovery accelerated. This outreach should take place regularly based on the season and the hazard most probable. Enhancing education will increase awareness before and during disaster events.

[12] North Carolina Institute for Climate Studies. 2020. *North Carolina Climate Science Report*. September 2020. p. 202

[13] DHS. 2010. Aging Infrastructure: Issues, Research, and Technology. p. 2-2

Complex Disaster Recovery Programs

The complexity of state and federal disaster recovery programs often deters local governments and individuals from receiving assistance. Some residents and local leaders are unaware these programs exist, and others struggle to under the issues the programs are intended to address or how to apply. The Stakeholder Partnership identified this issue as a concern in the Mid-Carolina region, and it is likely a concern statewide and beyond, as well.

Outdated Flood Insurance Maps

The flood maps used for the region are outdated and offer a limited perspective. Flood insurance maps are useful tools for understanding flood risk' however, in many cases, they may not depict the full picture of risk for a community. The mapping process helps communities comprehend flood risk and make more informed decisions. Unfortunately, the process of updating a flood map can take months and, more often, years to complete. By the time the maps are ready, the data and processes used to update a flood map are often outdated. **Table 4** shows the effective date for the counties in the Mid-Carolina region. These dates may look recent, but a lot of development and land use changes have taken place since 2018 and 2019, rendering the current datasets out of date.

Table 4: Flood Maps Effective Dates for Mid-Carolina Counties

County	Effective Date of Current Flood Maps
Cumberland	6/20/2018
Harnett	6/20/2018
Sampson	12/6/2019

If a flood map is inaccurately depicted, community flood risk may also be inaccurately communicated, and new development may be allowed in areas that are at risk; however, ground-truthing can help. The input submitted by the Stakeholder Partnership and members of the public allowed the project team to better understand flood exposure throughout the region. For example, the Stakeholder Partnership identified Locks Creek in Cumberland County as an extreme case of repetitive flooding that does not fall within a mapped FEMA floodplain, and many of the residents in the area do not have flood insurance.

This initial understanding of regional strengths and challenges helps regional stakeholders pinpoint vulnerabilities and sets the stage for the identification of resilience strategies.

4. Hazards

This section reviews the four major natural hazards and related impacts that climate scientists project will get worse by the 2050s. These hazards include:

- Hurricanes and Storms
- Flooding and Heavy Precipitation
- Extreme Temperatures (including High Heat Indexes)
- Drought and Wildfires

Throughout this section, there are several references to the coastal plain of North Carolina and how the hazards listed above are changing for that region of the state. The Mid-Carolina region falls completely within this climate division, as shown in **Figure 5**. Therefore, references to the coastal plain also apply to the Mid-Carolina region.

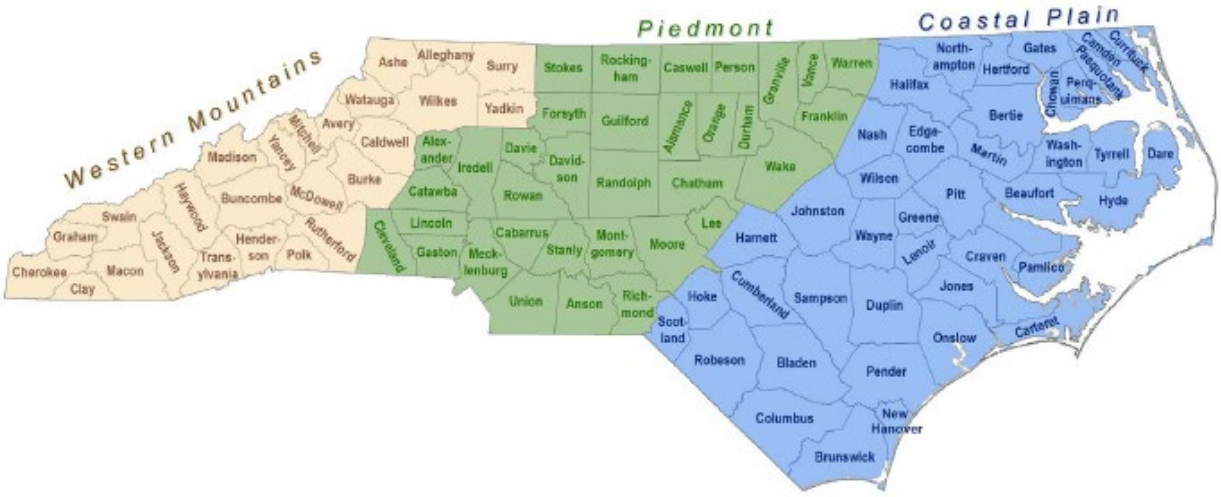

Figure 5: North Carolina Climate Divisions (Source: North Carolina Climate Science Report

Presidential Disaster Declarations

Disaster declarations provide initial insight into the hazards that will likely continue to impact the Mid-Carolina region. Since 1968, sixteen presidential disaster declarations have been reported in the Mid-Carolina region, as seen in **Table 5** below. This number includes 10 declarations related to hurricanes and tropical storms and four declarations related to winter storms. The others were related to severe storms, tornadoes and flooding.

Table 5: Presidential Disaster Declarations in the Mid-Carolina Region

Year	Disaster Number	Description	Cumberland County	Harnett County	Sampson County
1968	234	Severe Ice Storm		X	
1984	699	Severe Storms and Tornadoes	X		X
1984	724	Hurricane Diana			X

Year	Disaster Number	Description	Cumberland County	Harnett County	Sampson County
1996	1087	Blizzard of 96		X	
1996	1134	Hurricane Fran	X	X	X
1999	1292	Hurricane Floyd	X	X	X
2000	1312	Severe Winter Storm		X	
2003	1448	Severe Ice Storm		X	
2003	1490	Hurricane Isabel	X	X	X
2004	1546	Tropical Storm Frances	X		
2011	1969	Severe Storms, Tornadoes and Flooding	X	X	X
2011	4019	Hurricane Irene			X
2016	4285	Hurricane Matthew	X	X	X
2018	4393	Hurricane Florence	X	X	X
2019	4465	Hurricane Dorian			X
TOTALS		**Mid-Carolina Region Total: 16**	**8**	**10**	**10**

Note: Data were obtained from FEMA.

Drought events do not typically reach the level of presidential declaration, but there has been one Emergency Declaration for drought in the Mid-Carolina region (in 1977 for Harnett County). Emergency Declarations provide federal assistance for responding to the event, but do not provide long-term recovery assistance that comes with a presidential declaration. In 2007, the State of North Carolina was plagued by warm temperatures and drought. Based on the statistical drought measures, the 2007 drought rivaled or exceeded the drought of 1925, which had long been viewed as the worst drought in North Carolina. August 2007 finished as the second warmest and second direst on record. By the beginning of September, more than 60% of the state was classified in Extreme Drought conditions. Conditions worsened into early October where 37% of North Carolina was classified in Exceptional Drought. Similarly, wildfires in North Carolina rarely grow to the level of presidential declaration, but there has been one Fire Management Assistance declaration in the region (the 2011 Simmons Road Fire in Cumberland County).

Hurricanes and Storms

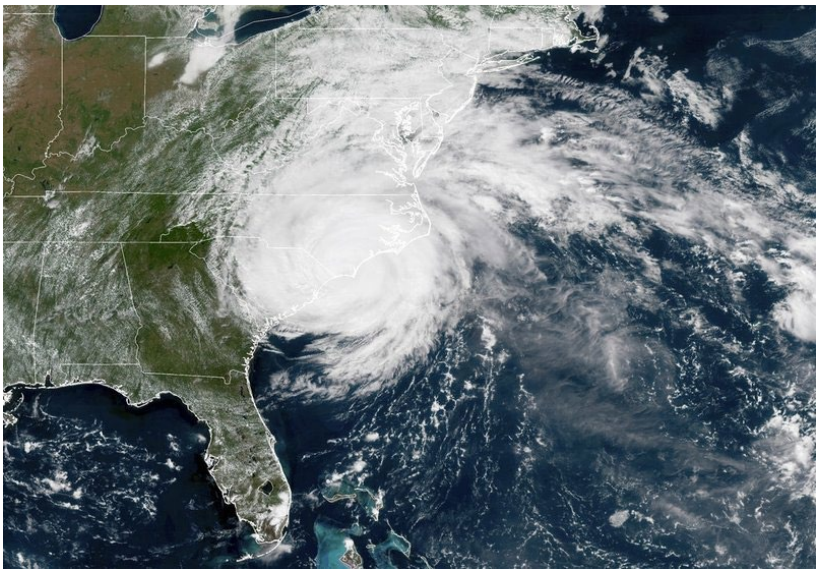

Figure 6: Hurricane Florence (NOAA)

Within the Mid-Carolina region, hurricanes and hurricane season are a focal point in hazard planning and preparedness. Results from the public survey reinforce the large concern for hurricanes. Respondents rated hurricanes as a 4.38 out of 5.00 in terms of impact and level of disruption (5.00 being the largest). Climate change is anticipated to affect hurricanes by increasing sea surface temperatures, a key factor that influences cyclone formation and behavior. The U.S. Global Change Research Programs and the Intergovernmental Panel on Climate Change project that hurricanes will become more intense in the 21st century, resulting in higher wind speeds and heavier rains. Scientists have already noticed this increase in intensity for Hurricane Florence, an image of which is shown in **Figure 6**.[14]

Hurricane intensity, duration and frequency have increased in the region over the last four decades. This upward trend is expected to continue as the Atlantic Ocean warms and the atmosphere holds higher levels of moisture. In return, the Mid-Carolina region can expect increases in rainfall and over the next thirty years and beyond. It is virtually certain that the increasing intensity of hurricanes will lead to increases in storm surge flooding in the coastal plain where Cumberland, Harnett and Sampson Counties are located. The exact number of hurricanes the region can anticipate is unclear due to several meteorological factors but is anticipated to increase through the 2050s, especially if the emissions of greenhouse gas are not significantly reduced.

Like much of North Carolina, the Mid-Carolina region has experienced an average of slightly more than one tropical storm or hurricane every year since 1990. More recent activity (since 1985) suggests that statewide activity has been above the 20th-century average with approximately eight events annually. Consistent findings reveal that the strongest storms will become stronger as the climate continues to warm. Heavy precipitation amounts accompanying hurricanes is very likely to escalate, increasing freshwater flood potential in the region.

Notable hurricanes to impact the region in recent years include Hurricane Fran (1996), Hurricane Floyd (1999), Hurricane Isabel (2003), Hurricane Matthew (2016) and Hurricane Florence (2018). Hurricane Fran impacted all three counties across the region.

Wind Damage

Strong winds are always a concern during hurricanes and other storms. The U.S. has recently experienced several significant thunderstorm wind events, and more scientific studies are needed to offer insights into how climate change is affecting these weather events.[15] Mid-Carolina stakeholders stated that wind

[14] Reed, Kevin. 2018. Estimating the Potential Impact of Climate Change on Hurricane Florence.

[15] North Carolina Institute for Climate Studies. 2020. *North Carolina Climate Science Report*. September 2020. p. 140

patterns influence the likelihood and extent of wildfires that occur in the region. In addition, wind affects daily weather patterns, but does not receive as much in-depth attention when compared to other indicators such as temperature or precipitation. Wind is too local and intermittent to make informed projections about how wind strength and frequency will change by the 2050s.

Flooding and Heavy Precipitation

Most large-scale flooding in the Mid-Carolina region results from the heavy precipitation coming from hurricanes, tropical storms and other coastal storms. Scientists project that these storms will produce more extreme precipitation and flooding through the 2050s. These findings are supported by recent trends. Eastern North Carolina experienced three extreme flood-producing hurricanes in the last twenty-five years: Floyd, Matthew and Florence.

Flooding

Floodplains—or areas near waterbodies most likely to flood during heavy precipitation events—and all the structures and residents who reside in the floodplain are increasingly at risk. Below, **Figure 7** indicates the location of FEMA flood zones as determined by maps developed through the National Flood Insurance Program. Flood maps for each county and municipality can be found in **Appendix C**. These maps show the 100- and 500-year flood zones within the Mid-Carolina region and were obtained from the North Carolina Floodplain Mapping Program. Flood zones for all municipalities and counties in the region are included within Appendix C to help depict a comprehensive picture of both local and regional flooding. Similarly, local flooding can have regional impacts depending on location and severity.

Looking at the 100 and 500-year flood zones, Cumberland County's populations and buildings are at the greatest risk of flooding. The 500-year flood zone runs the entire length of the county through Eastover, Wade and Linden. Portions of the flood zone extend into Spring Lake, Hope Mills and the eastern part of Fayetteville. In Harnett County, the 500-year flood zone is in the southeastern portion of the county through parts of Erwin, Dunn, and Lillington. The 500-year flood zone is in the southern, central, and northern portions of Sampson County and is most prevalent in the southeast. Impacted areas in Sampson County include Autryville, Clinton and Newton Grove. Stakeholders mentioned several of these areas, such as Spring Lake, Fayetteville, and Newton Grove, because they experience repetitive flooding. It is important to note that these flood-zone maps provide *estimates* of where flooding could occur in the Mid-Carolina region, but flooding can, and does, occur outside of these areas as well.

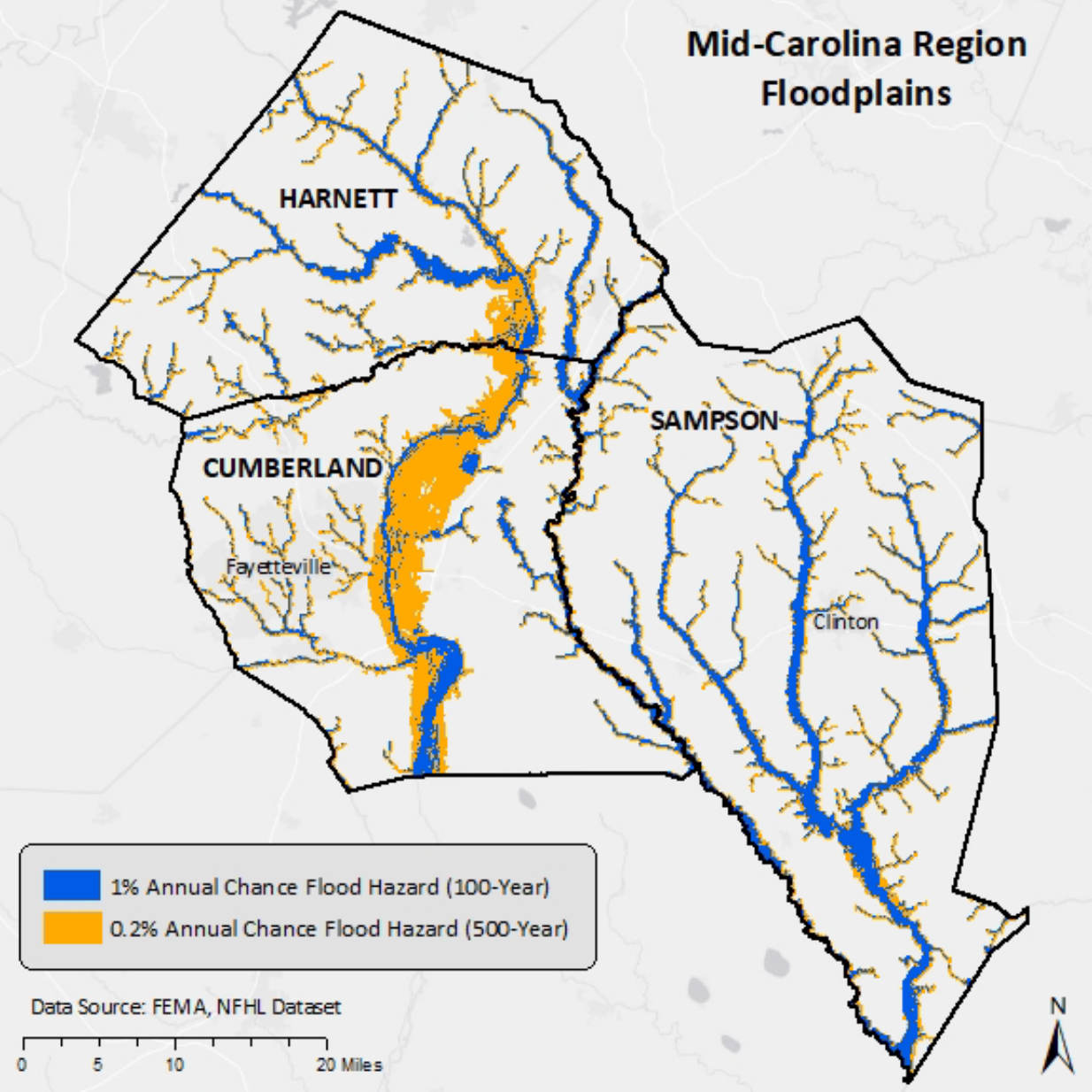

Figure 7: FEMA Floodplains in the Mid-Carolina Region

In addition to areas near water bodies being at increased risk of inundation, flash flooding, localized flooding and compound flooding are also expected to happen more frequently by the 2050s in the Mid-Carolina region. Flash flooding occurs within a few hours of excessive rainfall, a dam or levee failure, or a mudslide.[16] In June 2020, Sampson County received over 11 inches of rain in 24 hours, leading to boat crews conducting water rescues. In November 2020, flash flooding in Cumberland County caused impassable roads, internet outages, and school and meeting cancelations. Localized flooding happens when underground stormwater systems or rural ditches are not large enough to handle the amount of rainwater coming from the storm. This type of flooding often causes basements and roads to take on water. Hard surfaces collect rainwater and send it to nearby ditches or stormwater pipes, and as development increases

[16] National Weather Service. Floods.

the number of hard surfaces, the region's stormwater management systems are becoming overwhelmed. This problem is exacerbated by the increasing number of heavy precipitation events (see "Heavy Precipitation" below). Compound flooding takes place when more than one of these flood types happen in one area.

Annual Precipitation

Precipitation and precipitation patterns can affect flood levels, as well as the amount of surface water and groundwater available for consumption, irrigation, industry and many species and habitats. Although there are no distinguishable trends in annual precipitation totals in the Mid-Carolina region, the North Carolina Climate Science Report states that the "2015-2018 period was the wettest on record in the Coastal Plain, averaging about 10 inches above the long-term average of 49 inches."[17] Hurricanes, thunderstorms and winter coastal storms are the main causes of precipitation within the region. Hurricanes impact annual precipitation levels. For example, 2018 was the wettest year on record at 67 inches. Hurricane Florence contributed 12 inches to the annual total that year.[18] Based on projections, annual precipitation is likely to increase in the Mid-Carolina region based on the likelihood of increased hurricanes and storms. The average climate model projections predict an overall small increase in total precipitation by the 2050s.

Heavy Precipitation

Based on an overall upward trend in the coastal plain, it is likely the Mid-Carolina region will experience an increase in heavy precipitation—or storms with three inches of water or more within a 24-hour period—in the coming decades. This upward trend is demonstrated by the average number of days with at least three inches of precipitation has been about 35% above the long-term average. Compared to the 1996–2015 average, by the end of the century, the annual number of days with precipitation of three inches or more is projected to increase by 78-130%, depending on the world's total release of greenhouse gas emissions.[19] Climate change is increasing the intensity of precipitation events in Mid-Carolina.

Extreme Temperatures, Including High Heat Indexes

Unusually hot temperatures are becoming more common in Cumberland, Harnett and Sampson Counties. As shown in **Figure 8**, extreme heat—a combination of high temperatures and high humidity[20]—is the leading cause of weather-related deaths.[21] Temperatures are increasing in the Mid-Carolina region and the 30-year average is indicative of the ongoing challenge of extreme heat. Heat exhaustion and heat stroke are common causes of death during a heat wave. High temperatures also contribute to deaths from heart attack, strokes and other cardiovascular diseases.[22]

[17] North Carolina Institute for Climate Studies. 2020. *North Carolina Climate Science Report*. September 2020. p. 110
[18] North Carolina Institute for Climate Studies. 2020. *North Carolina Climate Science Report*. September 2020. p. 110
[19] North Carolina Institute for Climate Studies. 2020. *North Carolina Climate Science Report*. September 2020. p. 112
[20] NOAA. Glossary.
[21] NOAA. 2021. *Weather Related Fatality and Injury Statistics*.
[22] EPA. 2021. *Excessive Heat Events Guidebook.*

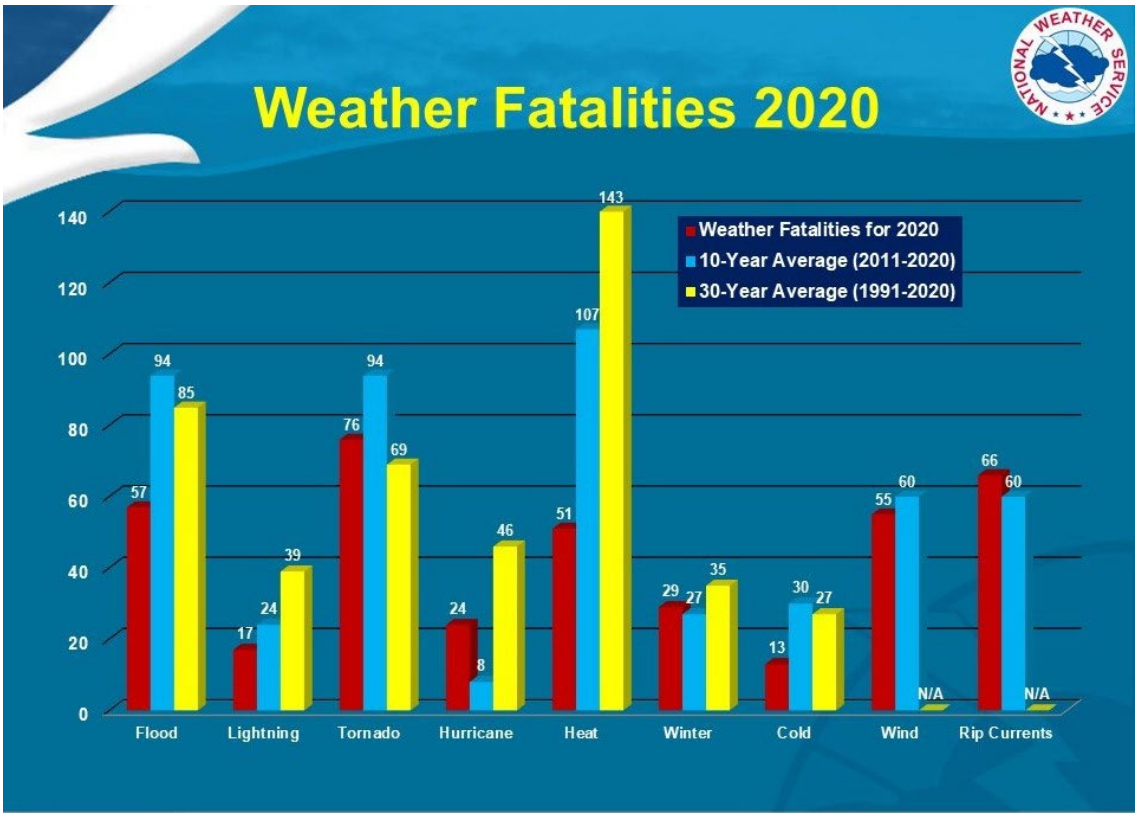

Figure 8: U.S. Weather Fatalities: 2020 and 10-year and 30-year Averages (National Weather Service)

Average Temperatures

Trends in annual average temperatures in the Mid-Carolina region have been increasing since the 1960s and temperatures have remained consistently above average since the 1990s. Half of the warmest years recorded to date within North Carolina have taken place within the past decade, and 16 of the last 18 years have ranked higher than the long-term average of about 61°F for the coastal plain. By the end of this century, average temperatures in the coastal plain are projected to increase by 2-10°F compared to the average temperatures for 1996-2015.[23] Given these trends, average temperatures in the Mid-Carolina region are expected to rise over the next thirty years at a similar rate.

Frequency of Very Hot Days, Very Warm Nights and Heat Waves

Although the Mid-Carolina region is not yet experiencing an overall increase in frequency of very hot days—characterized as having a maximum temperature of 95°F or higher, the number of very warm nights—characterized as having a minimum temperature of 75°F or higher—have been on an upward trajectory since the 1970s. On average, the region sees about 13 very hot days annually. There were more instances of very hot days in the earlier half of the 20th century when compared to more recent years. The highest annual average of very hot days in the coastal plain occurred in 1930-1934, with an average of 23 days per year. Despite a lack of a recent trend, by the end of the century, the number of very hot days—maximum temperature of 95°F or higher—is likely to increase by 11–94 days, compared to the 1996–2015 average.[24]

[23] North Carolina Institute for Climate Studies. 2020. *North Carolina Climate Science Report*. September 2020. p. 95-97

[24] North Carolina Institute for Climate Studies. 2020. *North Carolina Climate Science Report*. September 2020. p. 97-99

The region sees a long-term average of about six warm nights per year. Changes over time have been similar to the pattern in annual average temperatures. Most years since 1985 have been at or above the long-term average, while 2014-2018 all saw more than double the long-term average number of very warm nights[25].The number of very warm nights is concerning because hospital visits increase when our bodies do not have a chance to cool down at night because nighttime temperatures are not falling below 75°F for several nights in a row, which can happen during or outside of a heat wave.

Heat waves can lead to illness and death, particularly among older adults, the very young and other vulnerable populations. As the Earth's climate warms overall, heat waves are expected to become more frequent and intense, increasing the need to heighten resilience against heat-related natural hazards According to climate model projections, the annual hottest maximum temperature in the coastal plain is expected to increase by 2-12°F by the end of the century, compared to the 1996-2015 average.[26]

Heat Indexes

The heat index—a measure of the combination of heat and humidity—is expected to increase across the Mid-Carolina region, yet another concern for human health. In fact, local scientists project that "it is very likely that the summer heat index values will increase because of increases in absolute humidity."[27] The heat index is often referred to as the "feels like" temperature, because meteorologists often report temperatures as, for example, "94°F but it will feel like 102°F." The combination of high temperatures and humidity, a common occurrence in North Carolina, makes health impacts occur at much lower actual temperatures. The wet bulb globe temperature is a relatively new tool that takes into account temperature, humidity, wind speed, sun angle and cloud cover. It is a way to measure the heat stress on a body. This differs from the heat index, which takes into consideration temperature and humidity and is calculated for shady areas.

Urban Heat Islands

An additional complication of increasing temperatures is urban heat islands. Despite its name, urban heat islands affect urban and rural areas. No matter how big or how small, a greater concentration of man-made surfaces (concrete, asphalt, etc.) absorb, hold and release heat throughout the day and well into the evening hours. These urban heat islands, which can be up to 22°F warmer than nearby green spaces,[28] can lead to higher energy costs, increased air pollution and additional challenges for more socially vulnerable populations. As hard surfaces hold on to heat and slowly release it into the evening, urban heat islands also cause night-time temperatures to be higher than they would be otherwise, leading to more individuals visiting emergency rooms. The City of Fayetteville (2019 population estimate 211,657[29]) represents the largest urban area within the region and likely experiences the greatest urban heat island effect.

Drought and Wildfires

Drought

Within the coastal plain, the highest number of months with an official drought status of at least moderate severity occurred between the years 1930 and 1934, with an average of six months per year. More recently, drought events between the years 2007 and 2009 were identified as the most severe since the 1930s, when the conversion of prairie to farmland caused the Dust Bowl. Local scientists project that, in the Mid-Carolina region, it is likely that droughts will become more frequent and more severe in the next thirty years, greatly

[25] North Carolina Institute for Climate Studies. 2020. *North Carolina Climate Science Report*. September 2020. p. 98

[26] North Carolina Institute for Climate Studies. 2020. *North Carolina Climate Science Report*. September 2020. p. 104

[27] Davis, C. & Dello K. 2020. *Inside the Greenhouse: North Carolina's Hottest Year on Record.*

[28] Brady, Jennifer. 2018. *The High Cost of Hot.*

[29] US Census Bureau. 2019 Estimates.

impacting soil moisture deficits, rainfed agriculture and natural vegetation. Although droughts are a natural occurrence in North Carolina, future droughts in the Mid-Carolina region are anticipated to be warmer in comparison to historical events with a high level of confidence. The warmer conditions will increase evapotranspiration, resulting in more rapid drying.[30]

Drought conditions change frequently and can be tracked at the U.S. Drought Monitor (USDM) website which is updated weekly.[31] More localized, state-specific information for drought can be found from the North Carolina Drought Management Advisory Council.[32]

Wildfire

The State of North Carolina has experienced a long-term upward trend in the number of wildfires, but a downward trend in the acreage burned; that finding is expected to be similar in the Mid-Carolina region. Year-to-year variability is influenced by climate factors such as drought events. The increasing air temperatures will likely increase regional drying via evapotranspiration. The coastal plain is anticipating an increase of more than 300% in the number of weeks with conditions conducive to very large fires by mid-21st century.[33]

Like much of the coastal plain and state at-large, the Mid-Carolina region has recently experienced a notable increase in wildfires. Stakeholders noted that smaller burns caused by wildfires are already occurring, at minimum, three to four times a week in the 2022 season. The wildfire season itself has grown in length as a result of warmer springs, longer summer dry seasons and drier soils and vegetation. Similarly, the frequency, extent and severity of fires is a concern heightened by increased temperatures and drought.

The expansion of residential development and population from urban centers out into rural landscapes increases the potential for wildland fire to threaten public safety and damage to forest resources and dependent industries. Population growth within the wildland-urban interface substantially increases the risk of wildfire, as seen in **Figure 9**, which shows the highest risk areas in and around the most populous Mid-Carolina area—the city of Fayetteville. Wildfire hazard maps for each county and municipality can be found in **Appendix D**. These maps show the wildland urban interface risk index within the Mid-Carolina region and were obtained using the Southern Group of State Foresters Wildfire Risk Assessment Portal. The risk index for all municipalities and counties in the region is included within Appendix D to help depict a comprehensive picture of both local and regional wildfire concerns.

Based on the maps provided in Appendix D, the western half of Cumberland County is at a higher risk of wildfire than the eastern half. In accordance with development trends and growth, Fayetteville appears most at risk in Cumberland County when compared to other municipalities. Risk in Harnett County is moderate with clustered areas at greater risk than non-clustered areas. These clusters form around municipalities including Lillington, Erwin, Coats and the southwest portion of the county. Based on wildland urban interface mapping, Sampson County is at the lowest risk of wildfire within the region. Similar to Harnett County, the risk is greater near local municipalities when compared to the unincorporated portions of the county. Additional information about wildfire risk in North Carolina can be obtained from the North Carolina Forest Service.[34]

[30] North Carolina Institute for Climate Studies. 2020. *North Carolina Climate Science Report*. September 2020. p. 113-114
[31] National Drought Mitigation Center. 2022. *US Drought Monitor*.
[32] North Carolina Drought Management Advisory Council. 2022. *US Drought Monitor of North Carolina*.
[33] North Carolina Institute for Climate Studies. 2020. *North Carolina Climate Science Report*. September 2020. p. 188 - 190
[34] North Carolina Forest Service. 2017. *The Wildland/Urban Interface*.

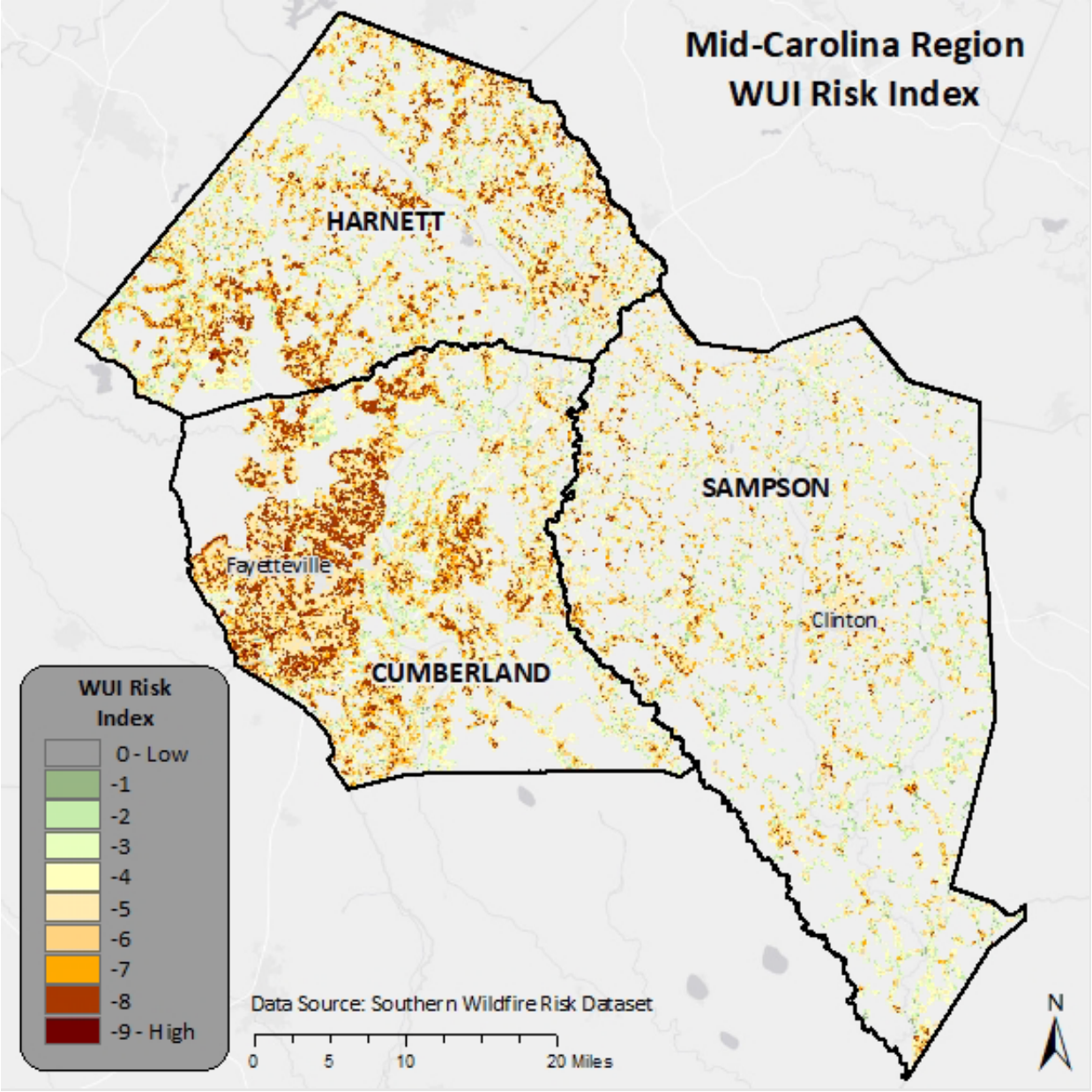

Figure 9: Wildland Urban Interface (WUI) Areas in the Mid-Carolina Region

5. Impacts

This section describes the potential impacts of present and future hazards on the following sectors:

- Housing
- Critical Infrastructure
- Major Economic Development
- Public Health
- Historical and Cultural Resources

This section also reviews planned and underway projects that aim to address vulnerabilities.

A first step to understanding the region's vulnerability is to assess the inventory of assets across Cumberland, Harnett and Sampson Counties. By understanding the total type and number of assets that exist, we can conduct additional analyses to better understand where they are located in relation to known hazard areas. This helps to quantify the vulnerability for such assets. **Table 6** provides a summary of all buildings (residential, commercial, and government) that currently exist in the Mid-Carolina region. The estimated building values are taken from County tax assessor data. Based on the information provided, the City of Fayetteville, the City of Clinton and the unincorporated areas of each county make up a large portion of the region's buildings with Fayetteville having the highest number of buildings.

Table 6: Asset Data for the Mid-Carolina Region

Location	Number of Buildings	Estimated Total Building Values
Eastover	1,872	$215,200,739
Falcon	173	$31,424,573
Fayetteville	77,133	$29,367,005,454
Godwin	56	$4,673,017
Hope Mills	5,625	$1,241,564,925
Linden	107	$12,380,563
Spring Lake	3,667	$813,806,220
Stedman	475	$65,460,451
Wade	308	$26,052,793
Cumberland County Unincorporated Areas	43,093	$7,060,039,084
Cumberland County Total	**132,509**	**$38,837,607,819**
Angier	1,831	$310,687,521
Coats	1,019	$161,732,688
Dunn	4,363	$960,911,429
Erwin	2,174	$387,730,262
Lillington	1,102	$361,474,164
Harnett County Unincorporated Areas	47,063	$6,103,585,663
Harnett County Total	**57,552**	**$8,286,121,727**
Autryville	145	$25,302,775
Clinton	3,984	$1,681,918,658
Harrells	197	$39,211,171
Garland	409	$88,012,554
Newton Grove	440	$128,173,747

Location	Number of Buildings	Estimated Total Building Values
Roseboro	760	$283,039,294
Salemburg	352	$117,991,969
Turkey	165	$29,441,736
Sampson County Unincorporated Areas	40,548	$5,823,325,732
Sampson County Total	**47,000**	**$8,216,417,636**
Mid-Carolina Region Total	**237,061**	**$55,340,147,182**

Notes: Data were obtained from the State of North Carolina Department of Emergency Management's Risk Management Building-Level Database

Hazard Impacts on Housing

This section provides information about the impacts of present-day and future hazards on housing in the Mid-Carolina region. Many homes across the area are vulnerable to flooding under multiple scenarios, including current 100- and 500-year floodplains and historic flood extents. The climate projections reviewed in Chapter 4 will also make many non-climate issues, such as energy-cost burden, standards to which manufactured or other housing was built, issues with new development and availability of affordable alternatives to vulnerable housing, worse.

Table 7 provides an overview of census data on the number of housing units, the median home value and the estimated number of housing units built in or before 1979 for the Mid-Carolina region. The table shows that new homes are continuing to be built in Cumberland, Harnett and Sampson County. These new structures typically require additional infrastructure and amenities, such as roads, sewer systems and water lines. New development, even in rural areas, can contribute to an increase in wildfires and flooding: the presence of humans increases the likelihood of ignitions; and the impermeable surfaces that come with new houses increases stormwater runoff, leading to more water in stormwater systems and waterways.

Table 7: Housing Characteristics of Mid-Carolina Region Counties

County	Housing Units (2000)	Housing Units (2010)	Housing Units (2020)*	Median home value of an owner-occupied home (2019)**	Estimated number (percent) of housing units built in 1979 or before**
Cumberland	118,425	135,524	142,175	$135,300	59,354 (40.56%)
Harnett	38,605	46,731	52,876	$154,000	15,840 (30.56%)
Sampson	25,142	27,234	25,481	$89,300	12,631 (45.56%)
TOTAL:	182,172	209,489	220,532	-	87,825

*Notes: *Data were obtained from the American Community Survey 2016-2020; **Data were obtained from the American Community Survey 2015-2019; All other data were obtained from 2000 and 2010 US Census Data.*

Housing built prior to 1980 also tends to be more vulnerable to hazard impacts. According to the latest American Community Survey, the median age of U.S. homes is 39 years. Nearly one-half of Sampson County's housing stock was built prior to 1980 (**Table 6**), indicating a higher level of vulnerability for residents in these houses. Interestingly, Sampson is the only county in the region that experienced a

decrease in housing units between 2010 and 2020, which could potentially correlate with the aging housing stock or the population decline. Harnett County has the newest housing stock within the Mid-Carolina region, which is a strength when withstanding natural hazards.

Table 8: Housing Vulnerability Data

County	Estimated number (percent) of renters	Estimated number (percent) of homeowners that are cost-burdened	Estimated number (percent) of renters that are cost-burdened	Estimated number (percent) of housing units that are mobile homes
Cumberland	61,803 (49.27%)	15,698 (24.67%)	29,912 (48.40%)	13,085 (8.94%)
Harnett	15,728 (34.63%)	6,101 (20.55%)	6,611 (42.03%)	10,883 (21.00%)
Sampson	7,188 (30.70%)	3,159 (19.47%)	2,932 (40.79%)	10,167 (37.67%)
TOTAL:	84,719	24,958	39,455	34,135

Notes: Data were obtained from the American Community Survey 5-year estimates 2015-2019 via Policy Map (https://www.policymap.com/newmaps#/)

Table 8 shows typical housing statistics used as indicators of vulnerability. The most concerning results from Table 8 are the percent of mobile homes. The national average is 5.40%.[35] All three counties are above average, and Harnett and Sampson Counties are substantially above average. Mobile homes are at higher flood risk than other housing types. According to Headwaters Economics, previous research demonstrates that mobile homes tend to be located in floodplains and are over-represented in National Flood Insurance Policy claims.[36]

Manufactured and mobile homes provide housing to some of the most vulnerable populations. In general, in comparison to other housing types, mobile home residents have higher rates of poverty, are more likely to have a disability, are more likely to be senior or families with small children and are more likely to be immigrants.[37]

[35] Headwaters Economics. *Neighborhoods at Risk Tool.*
[36] Headwaters Economics. 2022. Mobile Home Residents Face Higher Flood Risk.
[37] Headwaters Economic. 2022. Mobile Home Residents Facing Higher Flood Risk.

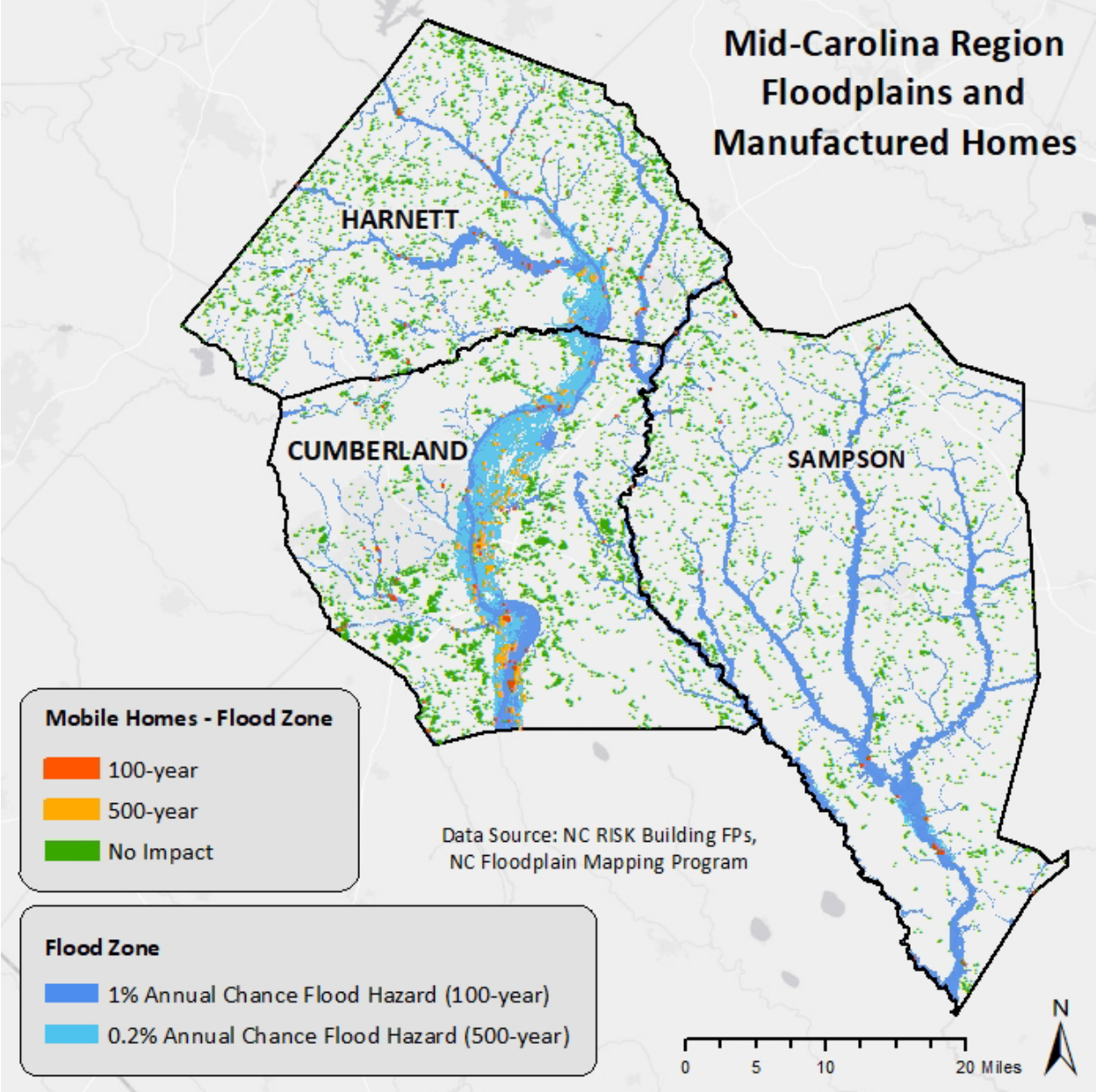

Figure 10: Mid-Carolina Region Floodplains and Manufactured Homes

Manufactured and mobile homes are concentrated in the unincorporated sections of Cumberland, Harnett and Sampson Counties with a considerable number also in Fayetteville, Eastover, Erwin and Newton Grove. There are considerable numbers of manufactured homes located in the 100 and 500-year floodplain in Cumberland County. More specifically, there are a total of 116 manufactured homes in the 100-year floodplain and 454 manufactured homes in the 500-year floodplain in Cumberland County. There are clusters of manufactured homes located in the 100-year and 500-year floodplain in southeastern Harnett County, and clusters of manufactured in the 100-year floodplain in Sampson County. Climate change will only exacerbate mobile home vulnerability to flooding. Hazard mitigation plans and disaster recovery efforts typically overlook mobile homes limiting funding and assistance opportunities.

Likewise, the national average percent of renters 35.60%[38], which puts Cumberland County above average. Based on census tract level mapping, a large majority of renters in Cumberland County are located in Fayetteville and Spring Lake with some tracts in Spring Lake showing 100% renter occupancy. Headwaters Economics' Neighborhoods at Risk identifies fourteen neighborhoods in Cumberland County where vulnerabilities to climate change exceed the county median. Within these neighborhoods, 71.7% of units are rentals, 10% of the properties are at flood risk with 13.1% located in the 500-year floodplain, 67.3% of the area lacking tree canopy and 27.7% of these neighborhoods is made up of impervious surface.[39]

North Carolina is one of several states identified by the Joint Center for Housing Studies of Harvard University as having large numbers of rental units at risk of substantial annual losses from increasingly common hazards like flooding, wildfires and hurricanes. As shown in **Figure 10**, the Mid-Carolina region, like much of the coastal plain, has a significant number of rental units deemed "high risk;" as noted by the orange or yellow covering the entire region. Nationally, single-family and manufactured homes are most likely to be exposed, many of which are rented or owned by low-income or "cost-burdened" families who face serious financial strain when the value of lost or damaged property does not meet the high threshold required to receive disaster relief aid. These national findings are likely applicable to the Mid-Carolina region.

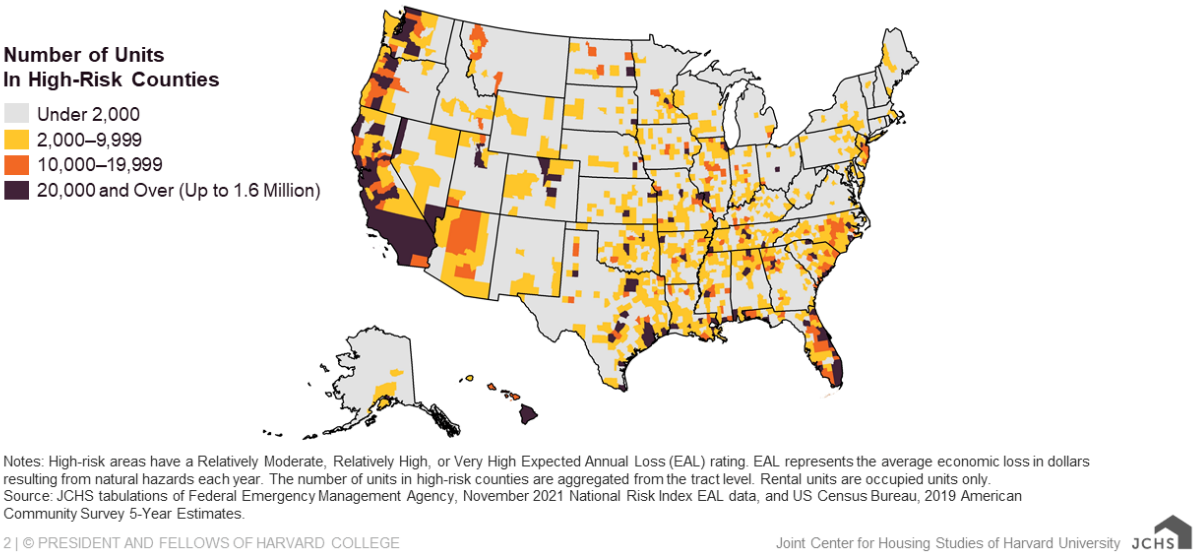

Figure 11: More Than 17 Million U.S. Rental Units Are Under Threat from Environmental Hazards

Another non-climate issue that will be made worse by climate change is energy burden, or "the percentage of gross household income spent on energy costs"[40]. As shown in **Table 9**, extremely low-income households—0-30% of the area median income—within the Mid-Carolina region experience the highest energy-cost burden, while those at 30-60% and 60-80% area median income remain considerably cost-burdened. While the average energy burden for the State of North Carolina is 9%, the average energy burden for low-income households at the 0-30% average median income threshold within the Mid-Carolina region is more than double and roughly four times higher than average county levels. As daytime and

[38] Headwaters Economics. *Neighborhoods at Risk Tool.*
[39] Headwaters Economics. *Neighborhoods at Risk Tool.*
[40] DOE. 2020. *Low-Income Energy Affordability Data (LEAD) Tool.* Fact Sheet.

nighttime temperatures increase with climate change, low-income households will experience an even larger energy burden. In other words, this inequality will get worse.

Table 9: Average Energy Burden of Low-Income and All Households

County	Average energy burden (% income) for low-income households at 0-30% AMI*	Average energy burden (% income) for low-income households at 30-60% AMI	Average energy burden (% income) for low-income households at 60-80% AMI	Average energy burden (% income) for all households
Cumberland	19%	9%	6%	3%
Harnett	19%	10%	6%	4%
Sampson	21%	12%	8%	5%

*Notes: *AMI - average median income; Data were obtained from the DOE LEAD Tool, American Community Survey 5-Year Average 2012-2015 (https://www.energy.gov/eere/slsc/maps/lead-tool)*

Hurricane and Storm Impacts on Housing

When hurricanes come ashore in North Carolina and work their way into, or near, the Mid-Carolina region, homes can be torn apart by the powerful winds, and inland flooding can cause catastrophic damage, both in and outside of mapped flood hazard areas. The location, age and type of housing unit are determinants of the structure's ability to withstand a hurricane event. For example, residential structures built according to outdated design standards and building codes will be more vulnerable to damage or destruction from hurricane-force winds and flooding. Mobile homes, of which there are a high proportion in Mid-Carolina, are especially vulnerable to hurricanes and storms.

Although climate scientists are unable to discern the expected occurrence of future wind events, the risk remains and should be understood. Wind events can have short-term and long-term impacts on residential structures, including missing shingles and siding, uprooted trees, disrupted powerlines and even total destruction of the structure. Downed trees are a typical consequence of wind events, which can cause significant damage to a home and result in power outages. Long-term outages can lead to spoiled food and electrical damage within homes.

Because of the proximity of the Mid-Carolina region to the North Carolina coastline, as well as the projected increase in intensity of these events, hurricane impacts on housing are expected to continue.

Flooding and Heavy Precipitation Impacts on Housing

Housing located both within and outside of mapped flood hazard areas can be impacted by flooding from heavy precipitation. FEMA flood maps provide an understanding of residential structures that may be at a greater risk of exposure; however, these maps do not always capture the complete picture of risk due to the technological limitations of flood modeling. Generally speaking, FEMA flood maps underestimate flood risk, which leaves property owners unaware and unprepared. It is both costly and labor intensive to keep flood maps updated and is further complicated by climate change.[41]

FEMA's maps are not designed to account for flooding caused by intense rainfall, which is anticipated to increase in intensity and frequency as the climate warms.[42] As such, homes located in the 500-year floodplain will experience increased flooding from heavy precipitation. Homes located outside of the 500-year floodplain will likely experience increased flooding as a result of increased heavy precipitation events. As shown in Table 10, there are 1,968 residential structures in the 100-year floodplain and 6,796 residential structures in the 500-year floodplain. Many of these structures are located in the unincorporated portions

[41] Flavelle et al., 2020. *New Data Reveals Hidden Flood Risk Across America.*
[42] Flavelle et al., 2020. *New Data Reveals Hidden Flood Risk Across America.*

of the region, as well as in Fayetteville, Eastover, Hope Mills, Spring Lake, Dunn, Erwin, Clinton and Newton Grove.

Ground-truthing information collected during the public engagement component of this planning process indicated that these maps do not fully depict the risk of flooding within the Mid-Carolina region, as many of the homes impacted by flooding during Hurricanes Matthew and Florence were located outside of any mapped flood hazard area.

Table 10: Residential Structures in the 100 and 500-Year Floodplain

Location	Number of Residential Buildings	
	1% Annual Chance (100-year)	0.2% Annual Chance (500-year)
Eastover	29	303
Falcon	0	0
Fayetteville	915	2,931
Godwin	0	0
Hope Mills	11	33
Linden	0	3
Spring Lake	22	29
Stedman	3	3
Wade	0	0
Cumberland County Unincorporated Areas	387	2,409
Cumberland County Total	**1,367**	**5,711**
Angier	1	2
Coats	0	0
Dunn	79	92
Erwin	16	65
Lillington	1	7
Harnett County Unincorporated Areas	265	627
Harnett County Total	**362**	**793**
Autryville	0	5
Clinton	39	57
Harrells	0	0
Garland	0	0
Newton Grove	18	33
Roseboro	0	0
Salemburg	0	0
Turkey	0	0
Sampson County Unincorporated Areas	182	197
Sampson County Total	**239**	**292**
Mid-Carolina Region Total	**1,968**	**6,796**

Flood waters inside a home can cause devastating damage to carpets, flooring, walls, furniture, electrical wiring and plumbing. The deeper the flood waters, the greater the devastation. Since FEMA flood maps are

used to help homeowners understand the relationship between their property and the highest risk of flooding, inaccurate and outdated mapping can have significant implications when a disaster strikes. A better-informed community can take precautionary measures to reduce vulnerability and increase resilience, including the purchase of flood insurance. Following Hurricane Florence, many residents located in Spring Lake opted to relocate instead of rebuild due to inadequate flood insurance. Overall, there is a concern that residents will relocate outside of the region as flood events continue or increase.

The Stakeholder Partnership identified several ongoing and planned projects to address impacts of flooding on housing and other sectors. For example, Cumberland County has recently applied for FEMA funding through the Building Resilient Infrastructure and Communities (BRIC) program to install additional gauges for accurate flood warning. The City of Fayetteville is working to install stream sensors that assist with flood forecasting and evaluating the use of previous dam sites as "dry storage" areas.

The risk of flooding is heightened in developed areas where impervious pavements force water to quickly run off into sewer systems.[43] Therefore, residential structures located in or nearby urban centers may be at an increased risk of flooding as extreme precipitation events become more frequent. Major urban centers, such as the City of Fayetteville located in Cumberland County, should receive additional consideration.

The North Carolina Climate Science Report explains that wind events are too local and intermittent to predict future patterns or forecast projections. Although unable to discern the expected occurrence of future wind events, the risk remains and should be assessed. Wind events can have short-term and long-term impacts on residential structures, including missing shingles and siding, uprooted trees, disrupted powerlines and even complete destruction of the structure. Downed trees are a typical consequence of wind events, which can cause significant damage to a home and result in power outages. Long-term outages can lead to spoiled food and electrical damage within homes. The Stakeholder Partnership identified several ongoing and planned projects to address impacts of flooding on housing and other sectors. For example, Cumberland County has recently applied for FEMA funding through the BRIC program to install additional gauges for accurate flood warning.

Extreme Temperature Impacts on Housing

Extreme temperatures cause physical damage to residential and commercial buildings and increase energy costs. Extreme hot temperatures cause roofs to degrade faster. Cooling equipment, especially as it ages, may struggle to keep up during heat waves, especially if it must run all day and all night. In addition, residents' energy costs will increase with more frequent hot days and nights. These increased costs can be a particularly heavy burden for economically distressed populations as discussed previously. Additional considerations should be given to homes within developed areas of the region, where air temperatures are higher due to the heat island effect.

Drought and Wildfire Impacts on Housing

Whereas wildfires clearly threaten housing, the impacts of drought on housing are less obvious. Drought can cause the ground underneath homes to physically crack and shift, leading to compound issues with the structure's frame, roof, doors, windows and basement. These repairs can be severe and costly, placing a financial burden on homeowners. Additionally, water shortages caused by drought can impose limitations on housing development that exacerbate ongoing housing shortages, particularly within the affordable housing market.

Drought conditions also heighten the risk of wildfire, which can have devastating impacts on housing as a single fire event can destroy a home or entire neighborhood. Approximately one in three houses and one in 10 hectares are located in the wildland-urban interface—the area where structures and other human

[43] Center for Climate and Energy Solutions. *Extreme Precipitation and Climate Change.*

improvements meet and intermingle with undeveloped wildland or vegetative fuels.[44] Residential structures located within these areas have a higher risk of wildfire exposure. When homes are built in close proximity to forests and other types of natural vegetation, this poses several significant problems related to wildfires. First, the risk of wildfire increases as a result of human ignitions from yard cleanup. Additionally, allowing a natural fire to clean the forest floor becomes impossible due to the risk of fire spreading to nearby homes. Wildfire vulnerability in the region is discussed earlier in this document.

Hazard Impacts on Critical Infrastructure and Facilities

Although necessary for a properly functioning society, critical infrastructure and facilities remain vulnerable to the exposure and impact of natural hazards like much of the built environment. It is imperative that these facilities continue operation during and following a disaster to reduce the severity of impacts and to accelerate recovery.

When considering the ability of critical infrastructure and facilities to withstand present-day and projected climate impacts, local leaders should think about the structural integrity of those locations and the potential effects on services if they do become operational. Poor or aging infrastructure can turn natural hazards into natural disasters. Starting with regular infrastructure maintenance, repair and upgrades can go a long way toward ensuring optimal performance and function, especially as hurricanes, flooding and other hazards become stronger and more frequent.

Critical infrastructure

Typical critical facilities include hospitals, fire stations, police stations, storage of critical records, and similar facilities. Critical infrastructure "includes the vast networks of highways, connecting bridges and tunnels, railways, utilities and buildings necessary to maintain normalcy in daily life. Transportation, commerce, clean water and electricity all rely on these vital systems."

- *U.S Department of Homeland Security*

This section discusses how climate change is impacting the Mid-Carolina region's critical infrastructure and facilities currently, and how those impacts will get worse without proper preparation. **Table 11** provides a current inventory of all facilities in the region. Recent funding programs, including the American Rescue Plan Act, the Bipartisan Infrastructure Law (also called the Infrastructure Investment and Jobs Act) and others, could provide an opportunity for jurisdictions within the Mid-Carolina region to fund projects that can decrease vulnerability to infrastructure, increasing community resilience.

Table 11: Critical Facilities in the Mid-Carolina Region

Location	School	Law Enforcement	Fire/EMS	Hospital	Emergency Operations Center
Eastover	2	0	1	0	0
Falcon	0	0	1	0	0
Fayetteville	63	8	23	3	1
Godwin	0	0	0	0	0
Hope Mills	7	1	1	0	0
Linden	0	0	1	0	0
Spring Lake	5	1	2	0	0
Stedman	2	1	1	0	0

[44]Radeloff, Volker C., David P. Helmers, H. Anu Kramer, and Susan I. Stewart. 2018. "Rapid growth of the US wildland-urban interface raises wildfire risk." *Proceedings of the National Academy of Sciences*.

Location	School	Law Enforcement	Fire/EMS	Hospital	Emergency Operations Center
Wade	0	0	1	0	0
Cumberland County Unincorporated Areas	20	1	11	0	0
Cumberland County Total	**99**	**12**	**42**	**3**	**1**
Angier	1	1	2	0	0
Coats	1	1	1	0	0
Dunn	3	1	2	1	0
Erwin	3	1	2	1	0
Lillington	1	3	2	0	1
Harnett County Unincorporated Areas	18	2	17	0	0
Harnett County Total	**27**	**9**	**26**	**2**	**1**
Autryville	0	0	1	0	0
Clinton	6	3	0	1	1
Garland	0	1	2	0	0
Harrells	0	0	2	0	0
Newton Grove	0	1	2	0	0
Roseboro	2	1	2	0	0
Salemburg	1	1	1	0	0
Turkey	0	0	1	0	0
Sampson County Unincorporated Areas	14	0	11	0	0
Sampson County Total	**23**	**7**	**22**	**1**	**1**
Mid-Carolina Region Total	**149**	**28**	**90**	**6**	**3**

Note: Data were obtained from the NC Risk Building-Level Database.

Transportation corridors are of critical importance to the economy; movement of goods, services and emergency personnel; and evacuation during regional emergencies. Cumberland County serves as a regional transit hub for the southeastern coastal plain. Interstate 95 traverses north to south through the entirety of the county. Other major thoroughfares include Highways 401, 210, 87 and 24. There is a regional airport in Fayetteville and major rail lines traverse the county, as well. Cumberland County is also home to Fort Bragg and Pope Airforce Base, both of which play a major role in the regional economy. **Figure 12** shows Cumberland County's major infrastructure and critical facilities. Most of these locations fall on the western side of the jurisdiction, which aligns with the county's heavily developed areas. The county contains two hospitals, both in Fayetteville and its vicinity.

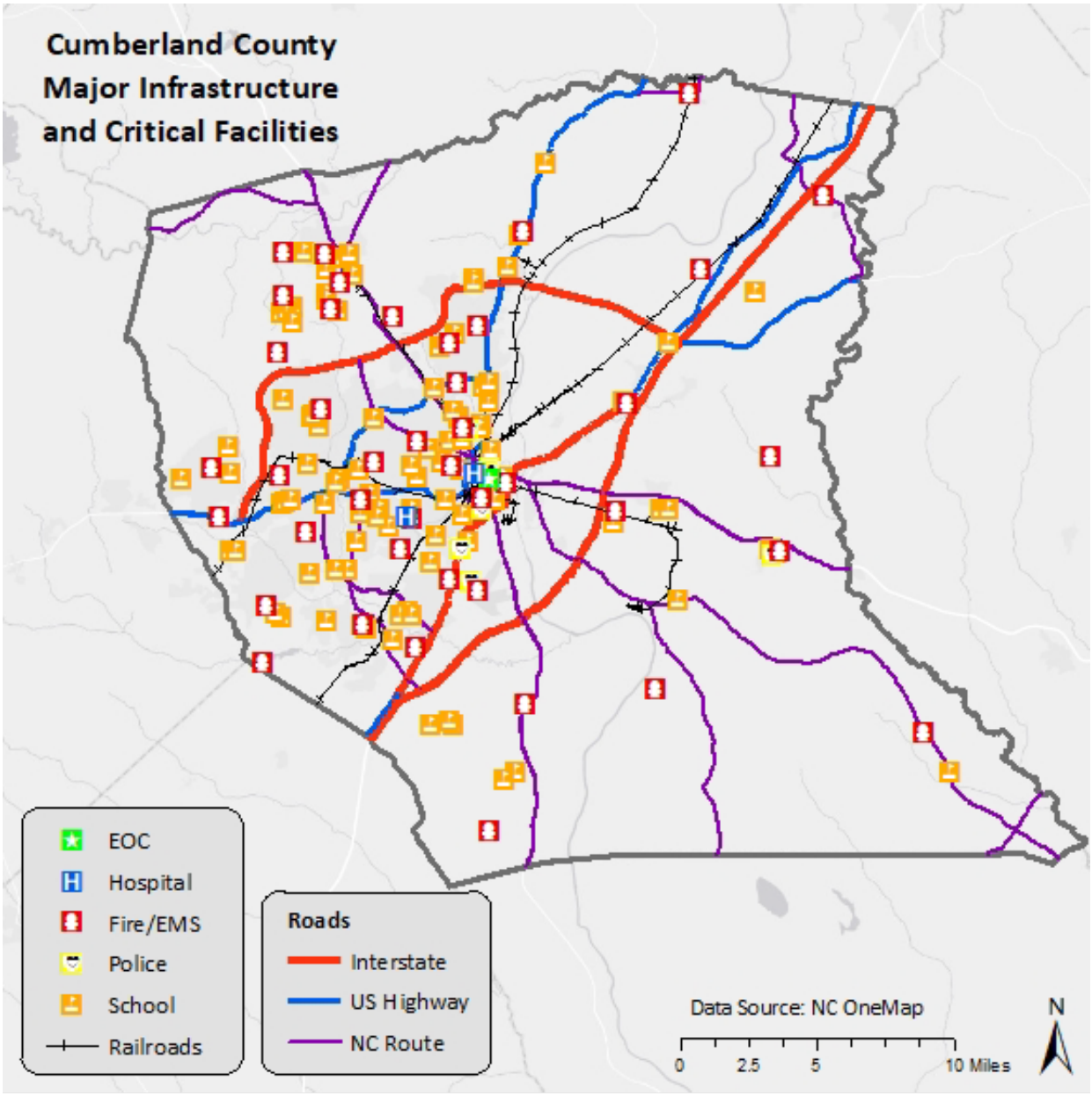

Figure 12: Cumberland County Major Infrastructure and Critical Facilities
(Note: EOC stands for Emergency Operations Center)

Harnett County also hosts several major roads. More specifically, I-95 and U.S. Highway 301 pass through the City of Dunn in the eastern portion of the county. U.S. Highway 401 runs north to south through the middle of the county, passing through Lillington. U.S. Highway 421 also goes through Lillington, Buies Creek, Erwin and Dunn. It runs relatively perpendicular to US 401. NC Highway 24 and NC Highway 87 service the southwestern portion of the county, providing access to nearby Fort Bragg. **Figure 13** shows the major infrastructure and critical facilities located in Harnett County. Fire stations, EMS facilities and schools are distributed across the county, but the two hospitals are in the southeastern part of the county in Dunn and Lillington.

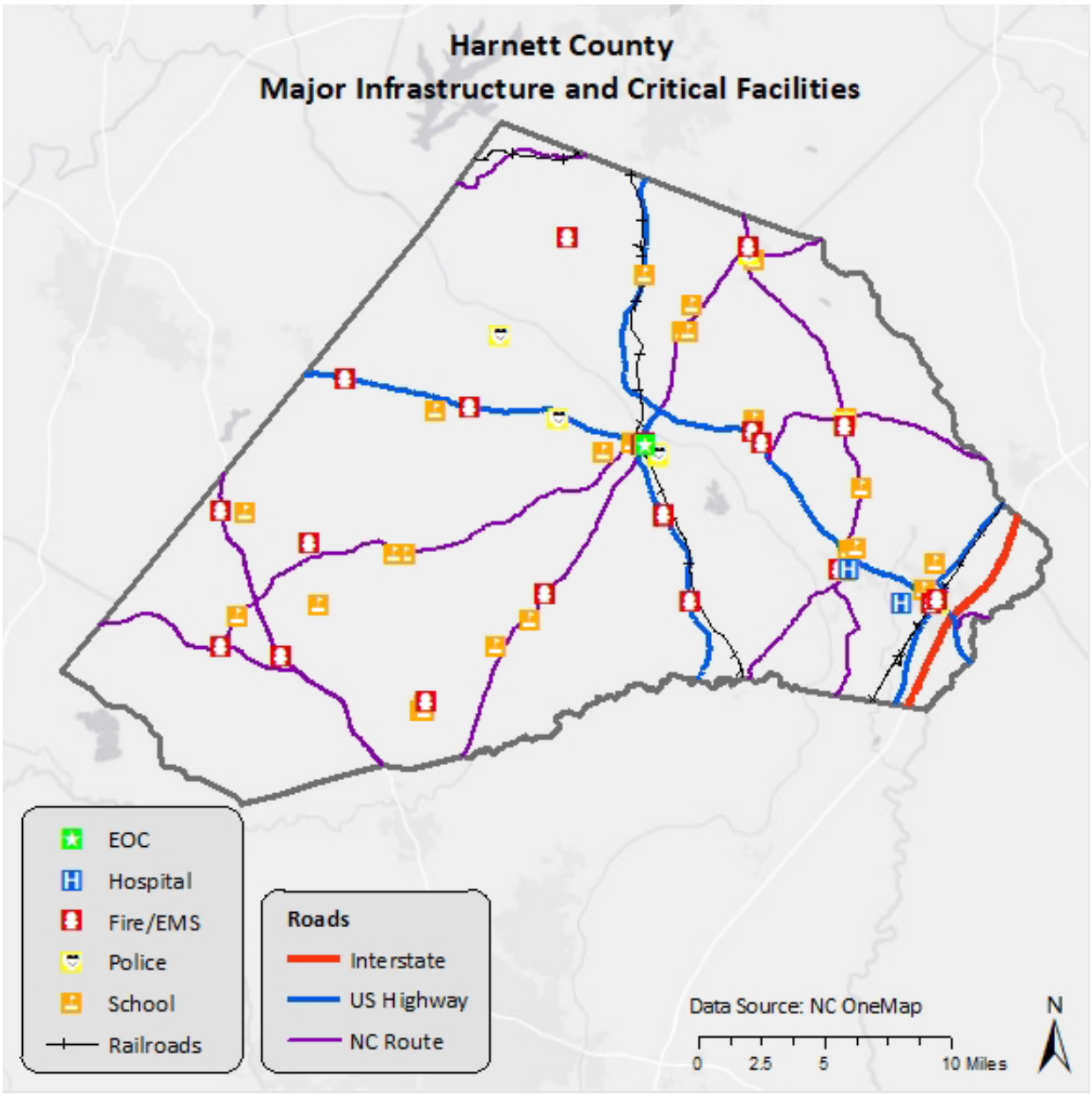

Figure 13: Harnett County Major Infrastructure and Critical Facilities
(Note: EOC stands for Emergency Operations Center)

Sampson County is located near the intersection of two major U.S. interstate highways: I-40 and I-95. In addition to interstate access, Sampson County has three U.S. Highways: 701, 4221 and 13. Along with I-40, several U.S. highways facilitate commerce in and across Sampson County such as 421 and 701. The county is linked to the Port of Wilmington via I-40. This 20-mile corridor through the county offers access through the I-95 exchange. Additionally, CSX Transportation provides service via a spur line to the City of Clinton. **Figure 14** shows the major infrastructure and critical facilities located in Sampson County. Again, fire stations, EMS facilities and schools are distributed across the county. Sampson County has one, centrally located hospital in Clinton.

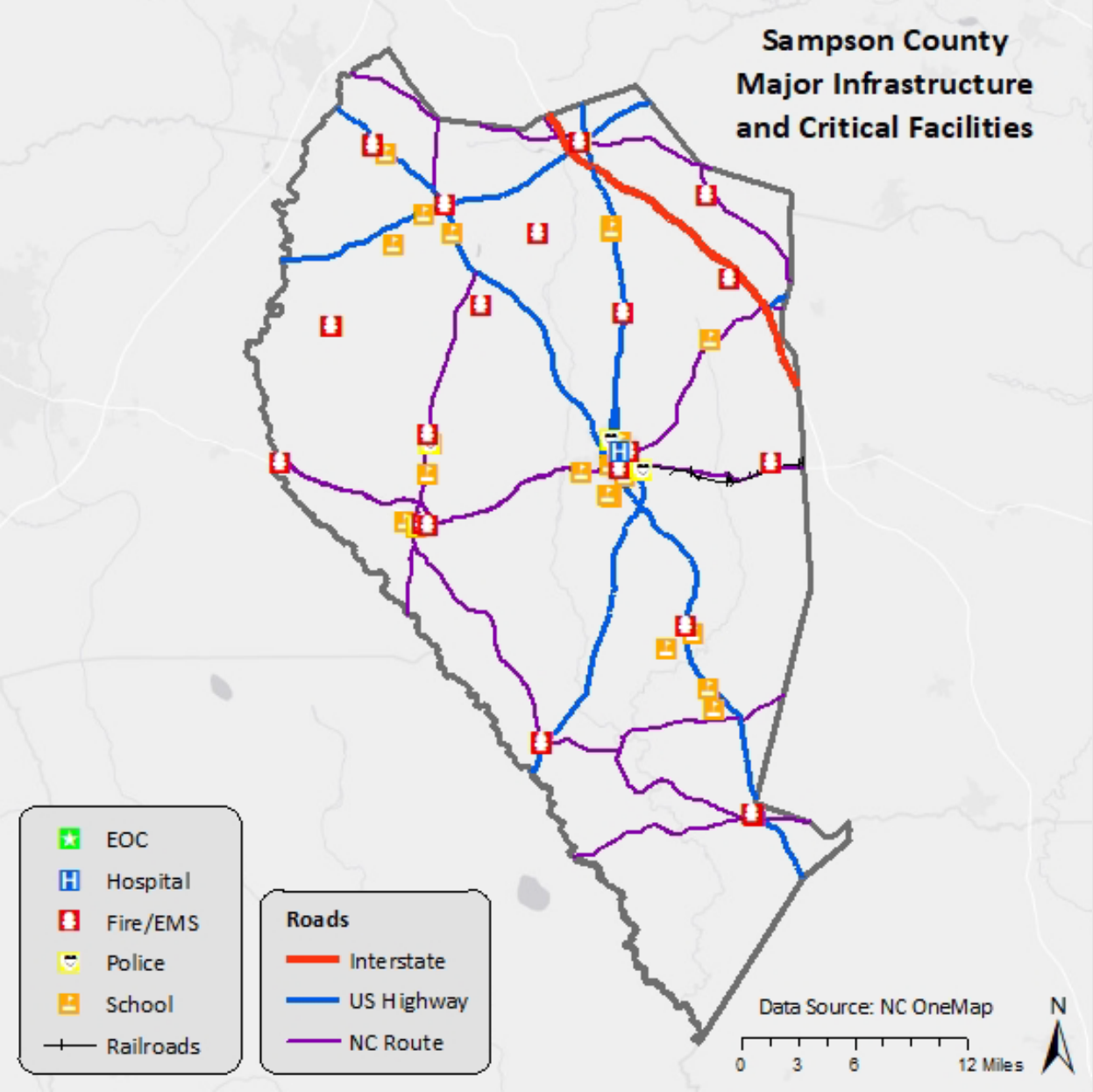

Figure 14: Sampson County Major Infrastructure and Critical Facilities
(Note: EOC stands for Emergency Operations Center)

Hurricane and Storm Impacts on Critical Infrastructure and Facilities

Many buildings and structures are at risks of impacts by a hurricane or tropical storm, including the Mid-Carolina region's local and state critical facilities such as police stations, fire stations, medical facilities and other key buildings and infrastructure. Stormwater facilities such as culverts could be damaged if they are clogged with storm debris, or their design capacity is overrun. Many utilities, especially water and wastewater infrastructure located near rivers and other water sources, are notably at risk. Power lines may be downed by falling trees or limbs, and, due to high demand across the state, utility companies may face challenges in restoring power in a timely manner.

During and after Hurricane Matthew, many critical facilities in Cumberland County were inaccessible due to flooding and downed trees. These blockages resulted in delayed restoration of power and water services,

which had economic and public health implications. Other consequences of Hurricane Matthew in Cumberland County involved low water pressure and water supply contamination at Highsmith-Rainey Specialty Hospital and power outages at shelters across the county. [45]

Harnett County infrastructure was one of the greatest areas of concern in the wake of Hurricane Matthew, which damaged or threatened several types of infrastructure in multiple locations. Locally, the greatest impact on traffic was the closure of NC 55.[46] In addition to major road closures, dams and electricity were affected. There are 30 known dams in Harnett County, and dam failure in neighboring counties is also a risk to consider. For example, during Hurricane Matthew, the Woodlake Dam failure in Moore County and the Carver Dam failure in Cumberland County caused water to collectively pour into the Little River, causing major issues for the southern portion of Harnett County. In terms of power outages, more than 32,000 customers were without power for several days and major portions of electrical infrastructure were lost.[47]

Sampson County also experienced immediate and long-term impacts from major damage to critical infrastructure during Hurricane Matthew. The City of Clinton's sewage plant released an uncontrolled discharge of approximately 8.3 million gallons of untreated or partially treated sewage into Williams Old Mill Branch. The hurricane washed out numerous roads and highways that connect large population centers (Salemburg, Newton Grove and Turkey). To increase the jurisdiction's resilience, the Sampson County Emergency Operations Center is scheduled to relocate outside of the flood hazard area in the Fall of 2022.[48]

Flooding and Heavy Precipitation Impacts on Critical Infrastructure and Facilities

Critical infrastructure located in flood-prone areas puts important functions of society, such as government services and medical care, substantially at risk. Assets such as power generation facilities, transmission infrastructure and road networks are vital to the continued operation of critical services. The incapacitation or destruction of these resources would have a debilitating and costly effect on many individuals. **Tables 12, 13 and 14** provide information on critical facilities in the floodplain in the Mid-Carolina region. Luckily, no Emergency Operation Centers are located in the floodplain, but one Fayetteville fire station is in 500-year floodplain. The Cumberland County Emergency Operation Center was close to flooding during this event. In addition, Cumberland County has multiple law enforcement facilities and two schools in the floodplain. Harnett County also has two schools in the floodplain.

In addition to what the project team found using GIS, the Hurricane Matthew Resilient Redevelopment Plan identified the following facilities have a history of flooding in Cumberland County: 12 critical facilities in downtown Fayetteville near Greene Street, the fire station and the homeless shelter on Old Wilmington Road/Monroe Road.[49] Local stakeholders also mentioned concern for stormwater systems, several dams in the City of Fayetteville and Hollywood Heights, and portions of I-95 through the county.

[45] State of North Carolina. 2017. *Hurricane Matthew Resilient Redevelopment Plan, Cumberland County*.
[46] State of North Carolina. 2017. *Hurricane Matthew Resilient Redevelopment Plan, Harnett County*. p. 3-5.
[47] State of North Carolina. 2017. *Hurricane Matthew Resilient Redevelopment Plan, Harnett County*. p. 3-6
[48] State of North Carolina. 2017. *Hurricane Matthew Resilient Redevelopment Plan, Sampson County*.
[49] State of North Carolina. 2017. *Hurricane Matthew Resilient Redevelopment Plan, Cumberland County*.

Table 12: Mid-Carolina's Critical Facilities Located in the 100 and 500-Year Floodplain

Facility Type	Hazard Type	
	Flood 100-Year	Flood 500-Year
Emergency Operation Centers	0	0
Fire/EMS	0	1
Hospitals	0	0
Law Enforcement	2	3
Schools	1	3
TOTAL	**3**	**7**

Note: Data were obtained from NC OneMap.

Table 13: Critical Facilities Located in the 100-Year Floodplain

Facility Type	Facility Name	Municipality	County
Law Enforcement	United States Marshals Service - Fayetteville	Fayetteville	Cumberland
Law Enforcement	ATF - Fayetteville	Fayetteville	Cumberland
School	Wayne Avenue Elementary	Dunn	Harnett

Note: Data were obtained from NC OneMap.

Table 14: Critical Facilities Located in the 500-Year Floodplain

Facility Type	Facility Name	Municipality	County
Fire/EMS	Fayetteville Fire Department - Station 1	Fayetteville	Cumberland
Law Enforcement	United States Marshals Service - Fayetteville	Fayetteville	Cumberland
Law Enforcement	ATF - Fayetteville	Fayetteville	Cumberland
School	Pauline Jones Elementary	Fayetteville	Cumberland
School	Walker Spivey	Fayetteville	Cumberland
School	Wayne Avenue Elementary	Dunn	Harnett
Law Enforcement	NC State Highway Patrol Troop B - District 2	Clinton	Sampson

Note: Data were obtained from NC OneMap.

Often, in the case of flooding, water and wastewater pipes and pumps are some of the most heavily impacted critical infrastructure. In the Mid-Carolina region, this infrastructure is typically located in the most flood-prone areas, which complicates recovery and impacts residents who are unable to access normal water sources for drinking, sanitation and other everyday uses. Stakeholders identified stormwater systems, several dams in the City of Fayetteville and Hollywood Heights and portions of I-95 as problematic flooding areas in Cumberland County.

Flooding on major transportation infrastructure creates challenges for public services and emergency response. For example, the movement of emergency response personnel was severely impaired when more than 1,760 roads were closed during the Hurricane Matthew event and more than 2,500 roads were shut down during Florence[50]. Getting essential supplies and services to critical areas was arduous.

[50] State of North Carolina. 2017. *Hurricane Matthew Resilient Redevelopment Plan, Cumberland County*.

Within Harnett County, Highway 27 and Nursery Road experience sheets of water across roadways during flood events, and portions of I-95 through the county experience repetitive flooding. Stakeholders noted the City of Lillington's wastewater treatment plant as an area of flooding vulnerability.

Several major highways in Sampson County experienced repetitive flooding during recent disaster events, including Highway 411, Route 701, NC Highway 41, NC Highway 24 and NC Highway 403. When flooded, some areas within the county are landlocked, prohibiting evacuation. More specifically, Route 701 floods north of Clinton and between Clinton and Garland, and NC Highway 24 typically floods between Turkey and Clinton and between Clinton and Roseboro.

The Stakeholder Partnership mentioned that, in many parts of the Mid-Carolina region, undersized culverts on state-owned roads cause flooding, and existing levees are not sufficient in size to handle runoff. Residents called out major highways throughout the region as problem areas due to repetitive flooding. Additionally, stakeholders discussed improvements being made to I-95 within Harnett and Cumberland Counties. They anticipate the elevation and widening of I-95 will also positively impact surrounding communities. Actions completed on I-95 may serve as a pilot to be replicated in the future.

Although the region has put a great deal of effort into reducing the number of critical infrastructure and facilities at risk, there are still a significant number of critical infrastructure and facilities throughout the region that are located in flood zones, or which have not been properly mitigated to reduce risk.

Extreme Temperature Impacts on Critical Infrastructure and Facilities

Extreme heat can warp critical infrastructure such as roads, railways, bridges and runways and can weaken the structural integrity of critical facilities. Additionally, extreme heat can cause cooling system failure in older buildings when inadequate ventilation or insulation cannot withstand excessive heat build-up.[51]

High temperatures also strain power and water infrastructure due to higher demand. During times of extreme heat, air conditioning units work harder and require more electricity, making brownouts and blackouts possible if electricity demands exceed generation.

Drought and Wildfire Impacts on Critical Infrastructure and Facilities

The entire Mid-Carolina region is vulnerable to drought, and lack of precipitation over a long period of time establishes wildfire conditions. Drought does not typically cause significant damage to the built environment. While all critical infrastructure and facilities are exposed to drought, vulnerability is minimal.[52] However, drought conditions lead to a substantial increase in wildfire risk, which can impact critical infrastructure and facilities. Long periods of drought can equate to more wildfires and more intense wildfires.

Human-led growth in the wildland-urban interface is particularly susceptible to wildfires. As development expands into rural and forested areas, critical infrastructure and facilities are at greater risk of wildfire and associated damages. Residents of all three counties in the Mid-Carolina region expressed concern about the increasing number of wildfires. Stakeholder Partnership representatives indicated that three to four wildfires weekly were estimated for the 2022 season compared to only three to four wildfires per year previously. Locals also mentioned that both wind patterns and human activity play a significant role in these numbers. While the events have become more frequent, stakeholders noted that the fires have been small thus far.

Wildfires can damage community infrastructure, including roadways, communication networks and facilities, power lines and water distribution systems. When fires hit power lines, transformers, cell phone towers and phone lines, emergencies are much more difficult to address. Restoring basic services, a top priority following an event, is expensive. For example, efforts to restore roadways include the cost of

[51] Cumberland Hoke Regional Hazard Mitigation Planning Committee. 2020. *Cumberland-Hoke Regional Hazard Mitigation Plan, Cumberland and Hoke Counties, NC*. p. 6-84

[52] Cumberland Hoke Regional Hazard Mitigation Planning Committee. 2020. *Cumberland-Hoke Regional Hazard Mitigation Plan, Cumberland and Hoke Counties, NC*. p. 6-11

maintenance and manage assessment teams, field data collection and replacement or repair costs. Wildfires also have important consequences for the power sector, as they can directly damage transmission poles or other electricity infrastructure.[53] Direct impacts to municipal water supply may occur through the contamination of ash and debris during the fire, destruction of above-ground distribution lines and soil erosion or debris deposits into waterways after the fire. When wildfire damages these critical resources and services, communities struggle to bounce back. **Table 15** provides information on wildfire vulnerability for the Mid-Carolina counties and municipalities. The table provides the number of buildings in each jurisdiction that intersect with "high" wildfire risk zones as determined by the Southern Wildfire Risk Assessment[54].

Table 15: Wildfire Vulnerability Data for the Mid-Carolina Region

Location	Number of Buildings at High Risk of Wildfires	Percentage of Total Buildings	Estimated Value of Buildings at Risk
Eastover	1,303	70%	$152,575,742
Falcon	76	44%	$11,889,029
Fayetteville	32,702	42%	$15,735,634,181
Godwin	24	43%	$2,628,667
Hope Mills	1,793	32%	$782,006,322
Linden	26	24%	$3,890,518
Spring Lake	1,524	42%	$292,726,349
Stedman	277	58%	$45,556,468
Wade	140	45%	$10,595,510
Cumberland County Unincorporated Areas	19,467	45%	$2,436,783,694
Cumberland County Total	**57,332**	**43%**	**$19,474,286,480**
Angier	823	45%	$170,618,424
Coats	595	58%	$117,530,495
Dunn	1,054	24%	$239,926,970
Erwin	722	33%	$136,229,699
Lillington	668	61%	$181,531,820
Harnett County Unincorporated Areas	20,445	43%	$2,571,164,376
Harnett County Total	**24,307**	**42%**	**$3,417,001,784**
Autryville	65	45%	$12,966,867
Clinton	692	17%	$240,336,184
Harrells	35	18%	$9,517,098
Garland	93	23%	$27,960,037
Newton Grove	30	7%	$9,898,677
Roseboro	234	31%	$166,363,640
Salemburg	128	36%	$59,768,342
Turkey	21	13%	$6,422,342
Sampson County Unincorporated Areas	6,095	15%	$1,024,927,944

[53] Sfetsos et al. 2021. *Assessing the Effects of Forest Fires on Interconnected Critical Infrastructures under Climate Change.*

[54] Southern Group of State Foresters. *Wildfire Risk Assessment Portal.*

Location	Number of Buildings at High Risk of Wildfires	Percentage of Total Buildings	Estimated Value of Buildings at Risk
Sampson County Total	**7,393**	**16%**	**$1,558,161,131**
Mid-Carolina Region Total	89,032	38%	$24,449,449,395

Notes: Data were obtained from Southern Wildlife Risk Assessment Portal and North Carolina Emergency Management's Risk Building-Level dataset. Buildings included in this table are located in a 6-9 WUI range, meaning moderate to high risk.

Hazard Impacts on Major Economic Development Assets

This section focuses on identifying and discussing the vulnerabilities faced by companies and workers in top industries (tourism, agriculture, etc.), paying particular attention to locating the largest employers and assets that drive revenue. The project team reviewed data from the North Carolina Department of Commerce to determine the top ten largest employers for the counties in the Mid-Carolina region.

The economy of Cumberland County is strongly focused on public administration from federal, county and city sources. Other industries that are well represented within the county include education and health services, trade, transportation and utilities. According to the U.S. Census Bureau's Longitudinal-Employer Household Dynamics Program, jobs are heavily concentrated on the west side of the county, within and west of the City of Fayetteville, along the U.S. Highway 301 and U.S. Highway 401 corridor and at Fort Bragg U.S. Army Military Installation.[55]

Cumberland County's Top 10 Largest Employers (2020) are:

1. Defense Ex Army Navy and Air Force; Public Administration; Public Sector; 1000+ employees
2. Cumberland County Schools; Educational Services; Public Sector; 1000+ employees
3. Cape Fear Valley Health Systems; Healthcare and Social Assistance; Public Sector; 1000+ employees
4. Wal-Mart Associates Inc.; Retail Trade; Private Sector; 1000+ employees
5. Goodyear Tire and Rubber Inc.; Manufacturing; Private Sector; 1000+ employees
6. County of Cumberland; Public Administration; Public Sector; 1000+ employees
7. Veterans Administration Va Ro318; Healthcare and Social Assistance; Public Sector; 1000+ employees
8. City of Fayetteville; Public Administration; Public Sector; 1000+ employees
9. Fayetteville Technical Com College; Educational Services; Public Sector; 1000+ employees
10. Food Lion; Retail Trade; Private Sector; 1000+ employees

There are many businesses that specialize in manufacturing within Harnett County. The employment clusters are concentrated around the I-95 Corridor, county government center, regional hospitals and Campbell University.[56] The top ten employers within the county represent manufacturing, public administration, education and health services.[57] Based on Economic Base Analysis, educational services is the primary driver of the county's economy while workforce development is the primary focus for attracting new companies and industries in the county.[58]

Harnett County's Top 10 Largest Employers (2020) are:

[55] State of North Carolina. 2017. *Hurricane Matthew Resilient Redevelopment Plan, Cumberland County*.
[56] Harnett County. 2021. *Strong Roots, Smart Growth: Harnett County Economic Development Plan.*
[57] State of North Carolina. 2017. *Hurricane Matthew Resilient Redevelopment Plan, Harnett County*.
[58] Harnett County. 2021. *Strong Roots, Smart Growth: Harnett County Economic Development Plan.*

1. Harnett County Schools; Educational Services; Public Sector; 1000+ employees
2. Food Lion; Retail Trade; Private Sector; 1000+ employees
3. Campbell University; Educational Services; Private Sector; 1000+ employees
4. County of Harnett; Public Administration; Public Sector; 1000+ employees
5. Betsy Johnson Memorial Hospital; Healthcare and Social Assistance; Public Sector; 500-999 employees
6. Wal-Mart Associates Inc.; Retail Trade; Private Sector; 500-999 employees
7. Carlie C's Operation Center Inc.; Retail Trade; Private Sector; 250-499 employees
8. Dept of Public Safety; Public Administration; Public Sector; 250-499 employees
9. Rooms To Go; Retail Trade; Private Sector; 250-499 employees
10. Champion Home Builders; Manufacturing; Private Sector; 100-249 employees

Sampson County is home to a diverse array of businesses from manufacturing to healthcare to agricultural companies. The largest concentrations of jobs within Sampson County are clustered within the City of Clinton, near Warsaw Road and Faison Highway.[59] The top ten employers in Sampson County represent manufacturing, agricultural, education and health services.[60]

Sampson County's Top 10 Largest Employers (2020) are:

1. Smithfield Foods Inc.; Manufacturing; Private Sector; 1000+ employees
2. Sampson County Schools; Educational Services; Public Sector; 1000+ employees
3. Prestage Farms; Agriculture, Forestry, Fishing, and Hunting; Private Sector; 500-999 employees
4. County of Sampson; Public Administration; Public Sector; 500-999 employees
5. Hog Slat Inc.; Manufacturing; Private Sector; 500-999 employees
6. Sampson Regional Medical Center; Healthcare and Social Assistance; Public Sector; 500-999 employees
7. Clinton City Schools; Educational Services; Public Sector; 250-499 employees
8. Wal-Mart Associates Inc.; Retail Trade; Private Sector; 250-499 employees
9. Dept of Public Safety; Public Administration; Public Sector; 250-499 employees
10. McDonald's; Accommodation and Food Services; Private Sector; 100-249 employees

Hurricane and Storm Impacts on Major Economic Development Assets

The economy can be severely impacted by a hurricane or tropical storm. Due to the massive scale of these events and multiple types of impacts from flooding and high winds, commerce can slow down when efforts to rebuild are underway. Businesses can be shut down for long periods as owners try to rebuild after damage from downed trees or wind. Even business owners without direct physical damage to their workplaces may be shut down temporarily by loss of power or because employees are unable to come to work as a result of road closures or personal property damage. The Mid-Carolina region has already faced these impacts from past hurricanes, and as hurricanes increase in intensity over the coming decades, businesses have a lot of work to do to increase their resilience.

Hurricane Matthew proved that electrical power is the greatest economic threat to business and industry in the Mid-Carolina region. Many businesses lost revenue when power outages ruined products and halted business operations. While the City of Fayetteville has the capacity to rebound quickly due to its resources and robust economy, smaller municipalities nearby are still recovering.[61] Power outages affected farms in rural Cumberland County, as well. Inoperable water pumps led to livestock mortality, among other issues.

[59] State of North Carolina. 2017. *Hurricane Matthew Resilient Redevelopment Plan, Sampson County*.
[60] State of North Carolina. 2017. *Hurricane Matthew Resilient Redevelopment Plan, Sampson County*.
[61] State of North Carolina. 2017. *Hurricane Matthew Resilient Redevelopment Plan, Cumberland County*.

Power outages forced institutions such as Harnett County Schools and Campbell University to close and several manufacturing companies lost production time.

Flooding and Heavy Precipitation Impacts on Major Economic Development Assets

As shown in **Figures 15, 16, and 17**, GIS analysis indicates that several top employers in the region are located within the 500-year floodplain, including Cumberland and Harnett County offices, Food Lion locations, the Veterans Affairs Administration and Wal-Mart locations. Assuming the 500-year floodplain will be more frequently inundated by the 2050s based on climate projections, the region could face job losses from flooding of these major employers.

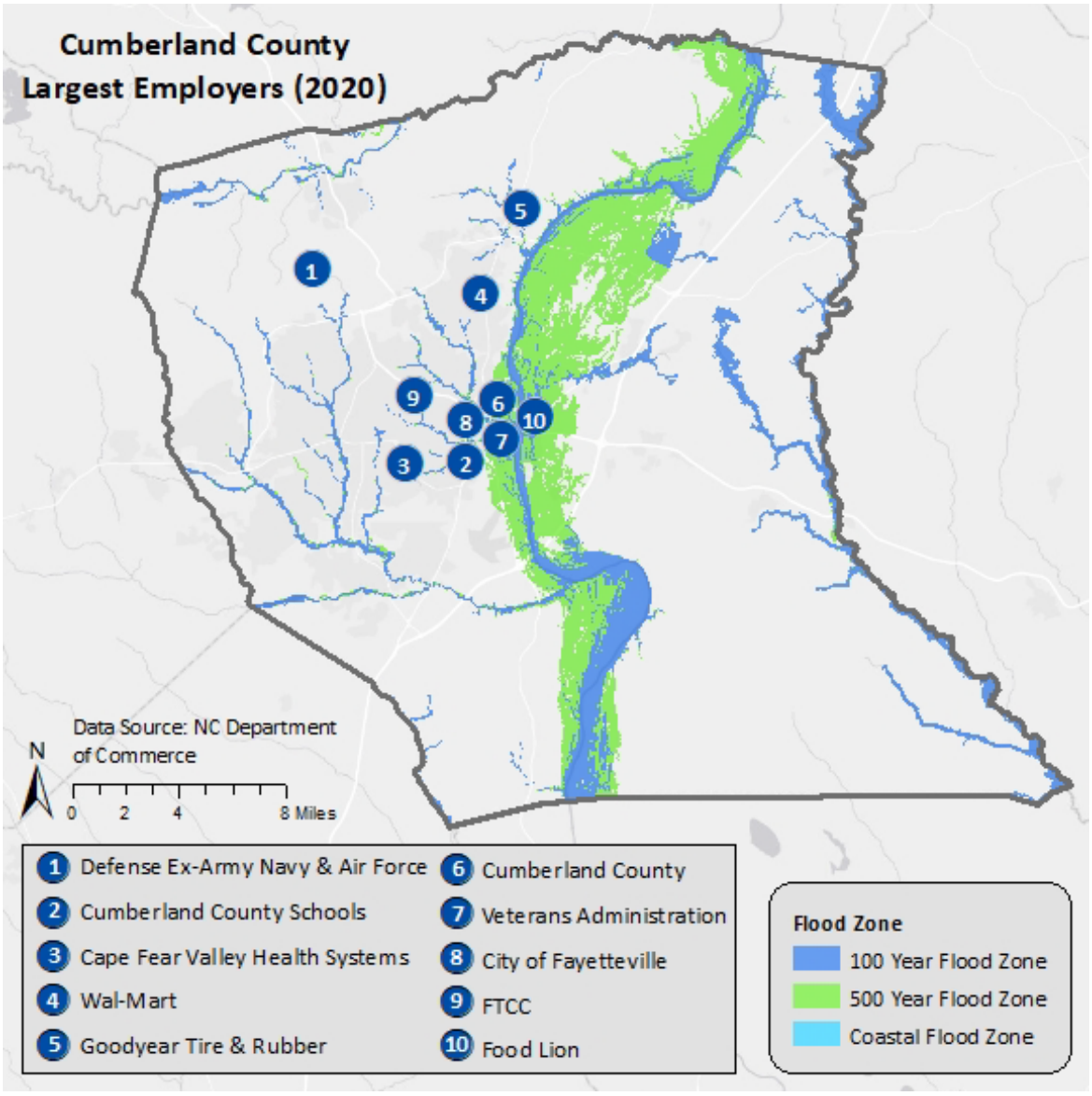

Figure 15: Cumberland County Largest Employers and FEMA Flood Zones

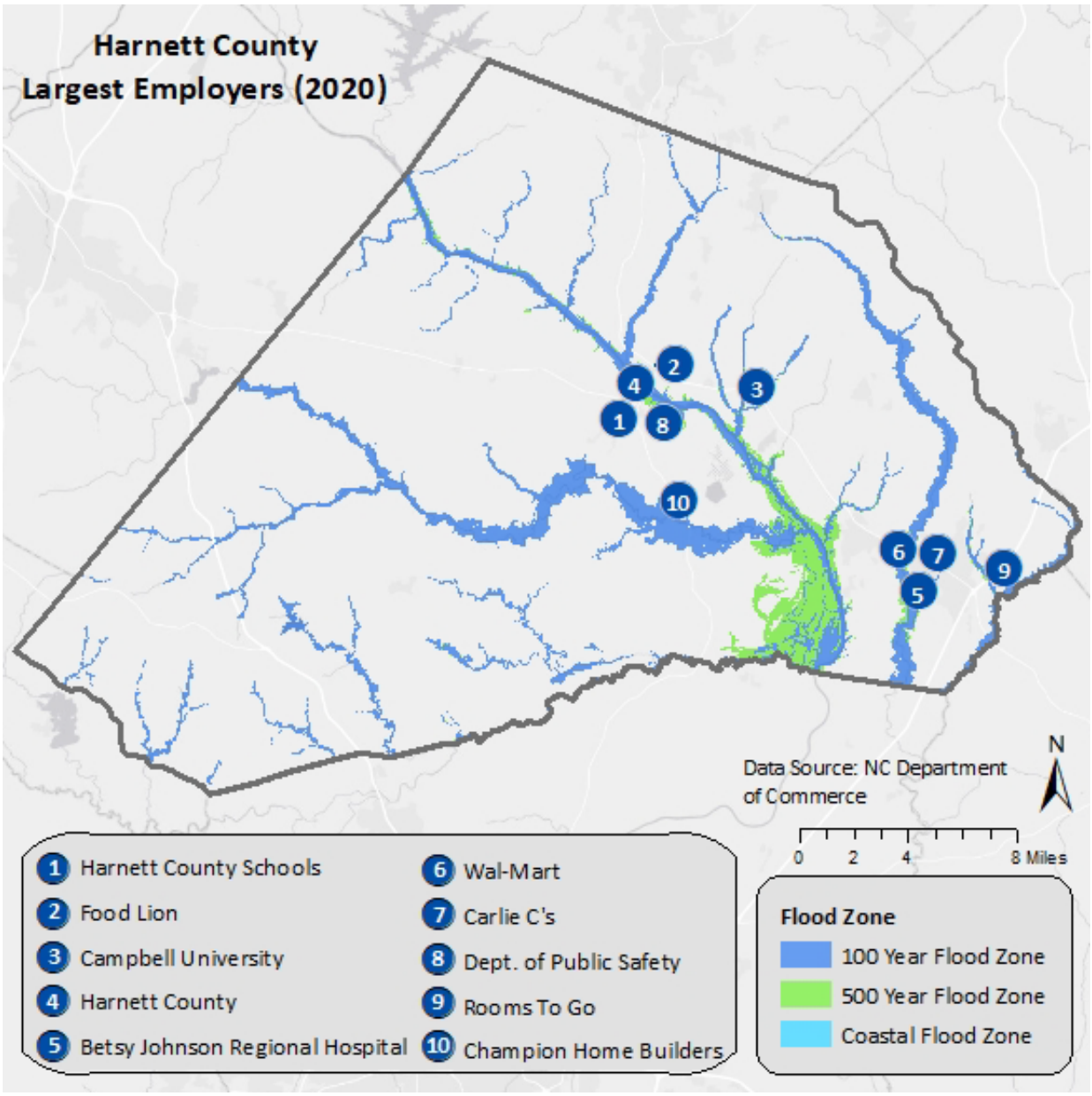

Figure 16: Harnett County Largest Employers and FEMA Flood Zones

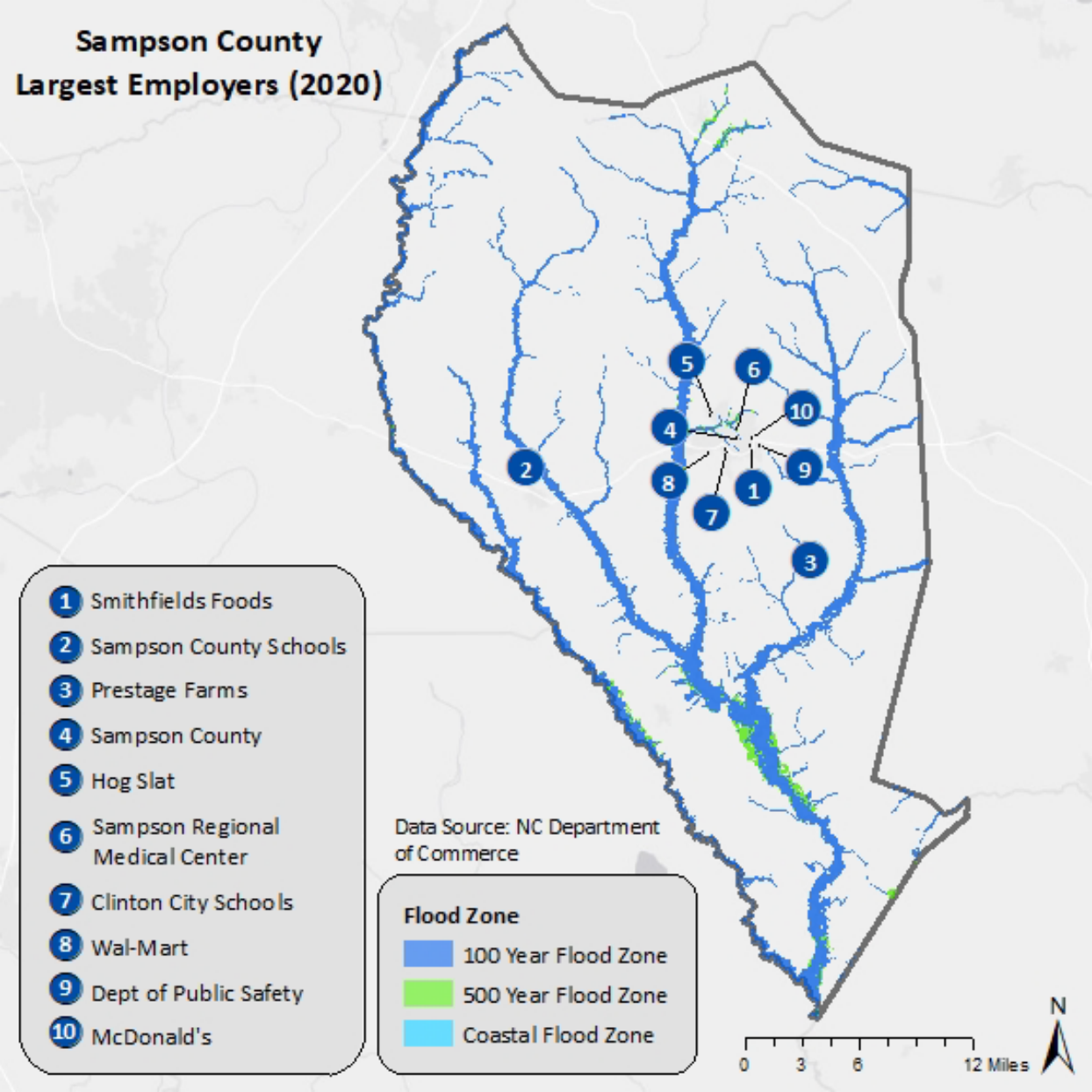

Figure 17: Sampson County Largest Employers and FEMA Flood Zones

Flooding from recent hurricanes caused many economic issues across all three counties. Many buildings flooded in historic downtown Fayetteville, including the Greene Street area. This flooding caused road closures that limited access to surrounding businesses, including top employers in Cumberland County such as Fort Bragg, the Crown Complex and the Cumberland County Board of Education (warehouse facility), Sheriff's Office and Training Center, and the Public Library. Furthermore, the urban water supply was contaminated as a result of low water pressure, further affecting business and hospital operations. Small and large businesses in Sampson County and Harnett County could not operate due to major road closures and detours, which caused traffic congestion on alternative routes.

Some businesses that shut down after a major disaster never re-open. In fact, FEMA reports that almost 40 percent of small businesses never reopen after a disaster since even small amounts of flood water can cause thousands of dollars in damage. The shutdown of these businesses can be devastating as many

small, rural communities in the region rely heavily on small businesses as economic drivers and the base of the local economy.

Agriculture, another major asset to economic development in the Mid-Carolina region, is also impacted by flood waters. Agricultural flooding can lead to livestock mortality, unusable fields, damage or destruction of existing crops and rapid depletion of the soil's oxygen, which is essential for plant growth and development. These impacts can cause significant harm to agricultural interests in areas of the region where it is a key economic driver.

Across the region, businesses are reluctant to invest in properties that flooded or were proven to be flood-prone in previous disasters. This reluctance could potentially impact future growth and development, creating a sense of disinvestment. Businesses are vital community facilities; when they close for several days, their recovery and reopening are crucial for the local economy.

Extreme Temperature Impacts on Major Economic Development Assets

Heat waves can have a short-term, negative impacts on the economy. On hot days, local officials advise the public to stay indoors, causing a reduction in consumer spending and subsequent reduction in revenue for businesses within the community. Additionally, extreme heat events can result in decreased worker productivity as high temperatures cause decreased energy, lack of concentration and heat-related illnesses that may disrupt the regular pace of work across the local economy. Extended periods of extreme heat may also decrease agricultural, dairy and livestock production, resulting in income loss for farmers and other related industries. Consumers may even see increased prices. All of these impacts are likely to become more prevalent as heat waves become more frequent by the 2050s.

Drought and Wildfire Impacts on Major Economic Development Assets

Agriculture is a large component of the region's economy, and agricultural crops are most directly affected by drought. In fact, in the last two decades, drought has contributed to a reduction in the number of local farmers. While it is estimated that annualized losses due to drought will decrease over time, this estimate is largely the result of decreasing agricultural production within the region.[62] Efforts to mitigate against drought, such as using irrigation equipment, have a high initial cost, including additional management, increases in operation and maintenance costs and lack of quality water resources—which would be severely affected during times of drought.

As a largely agrarian community, Sampson County relies heavily on the agricultural industry and has identified drought as a hazard of concern. Stakeholders acknowledged that drought is becoming more pervasive and that long-term strategies should be considered, such as capturing rainfall.

Wildfires can also have short-term and long-term impacts on the local economy. For example, fire-damaged properties may reduce recreation and tourism revenue as well as harm local property values. Additionally, extensive fires can alter local timber supply as time is needed to salvage undamaged timber and regrow crops. On the other hand, wildfires can positively impact the local economy through economic activity during fire suppression and post-fire rebuilding. These activities may include performing forestry support work or providing goods, services and amenities to firefighting teams.

Hazard Impacts on Public Health

This section provides an analysis of the climate threats, vulnerabilities and adaptive capacities applicable to the region's public health. Public health is a pressing concern for residents in the Mid-Carolina region. Higher daytime and nighttime temperatures impact the health of outdoor workers, mold grows in homes where residents cannot afford to replaced flooded drywall, algal blooms impact water quality, septic systems overflow, and the trauma of natural disasters weighs heavily on residents.

[62] Harnett County. 2020. *Cape Fear Regional Hazard Mitigation Plan*. p. 6-34

The North Carolina Climate-Health Scorecard considers the following health impacts within the state: air and respiratory diseases, heat-related deaths and illnesses, mental health, thunderstorm deaths and injuries, hurricane deaths and injuries, water and food-borne diseases, flood deaths and injuries, vector-borne diseases, tornado deaths and injuries, cancer and winter weather impacts. These health impacts are ranked based on burden, vulnerability, urgency and strength of evidence. In terms of health risks, air quality and respiratory diseases ranked highest while heat-related deaths and illnesses ranked second for the State of North Carolina. Thunderstorm, hurricane and flood deaths and injuries received the same score in the coastal plain.[63]

Hurricane and Storm Impacts on Public Health

Hurricanes in the Mid-Carolina region have the potential to cause injury and loss of life, displace residents from their homes, and cause long-standing mental health issues from the trauma. High winds can shatter glass and cause personal injury. Residents can also be permanently displaced and require longer term housing after a major event. Furthermore, hurricanes can also impact the mental health of those experiencing the stress and trauma of losing loved ones, homes and possessions to a storm. Navigating recovery programs can also be especially stressful for those who have been displaced. The thought of facing more and stronger hurricanes in the future, as the impacts of climate change progress, is daunting to residents and local leaders.

Flooding and Heavy Preiciptation Impacts on Public Health

During floods, people are often stranded and have to be rescued by first responders. Often lives are lost or people are injured. Even when injuries and fatalities are avoided, individuals experience the trauma of being forced into shelters or finding temporary lodging as they wait for flooding to recede. They may be unable to return to their homes if the damage is great and may find their homes uninhabitable if personal property has become waterlogged and unusable.

After the water recedes, public health issues often increase. Homes and personal property that were covered in water may become infested with mold, which can create serious health risks. Additionally, waterborne diseases can be pervasive in areas impacted by flooded sewer and water systems. Mosquitoes and other carriers of illnesses often thrive in post-flood conditions as well, increasing the chances of vector-borne disease transmission.

Extreme Temperature Impacts on Public Health

Excessive heat is a dangerous and deadly occurrence in North Carolina. According to the National Weather Service, extreme heat hazard is the leading cause of weather-related deaths. It can affect many people at varying degrees. The elderly and very young are susceptible to the most detrimental impacts, but heat stroke and exhaustion can plague anyone. People who are overweight, overexert during work or exercise and are ill or taking certain medications are also at greater risk of suffering from heat-related illness. Risks from exposure to extreme heat include heat cramps, heat exhaustion, heat stroke and death. Many impacts of extreme heat are the result of heat exhaustion or improperly functioning air conditioning units.

During the Stakeholder Partnership meetings, Sampson County identified extreme heat as a major hazard of concern. The county has a large migrant population that works in the farming and agricultural industry. These workers are at increased risk of heat-related illness and death because they are exposed to extreme temperatures while working long hours outdoors. Also, none of Sampson County's estimated ten shelters are outfitted to provide adequate heating or cooling to serve as relief centers. Residents of Cumberland County indicated that they have some infrastructure in place for heating and cooling centers, such as the Salvation Army, transit center and Dream Center, but those locations are not adequately distributed throughout the county.

[63] DHHS. *Building Resilience Against Climate Effects.*

Many impacts of extreme heat are the result of heat exhaustion from nonexistent or improperly functioning air conditioning units. Although cooling centers are relatively common throughout the City of Fayetteville, including at all library branches, stakeholders have reported insufficient locations across the county and in areas close to where homeless individuals, who are often not permitted to remain indoors in shelters, spend time. Additionally, rural and smaller communities within the region do not have the same safeguards in place to address extreme heat and heat island effects.

Drought and Wildfire Impacts on Public Health

Droughts are concerning to public health across the Mid-Carolina region because there is a strong reliance on surface water and private wells for drinking water. Surface water is at risk due to population growth. Well water is at-risk from contaminants that may enter waterways during heavy rains and flooding, and from contaminants that concentrate in soil as streams, rivers and lakes dry up.[64] Human and agricultural activities will place a larger demand on the use of wells as surface waters diminish.

Drought can also have a detrimental effect on the livelihood of farmers and agricultural producers in North Carolina. Efforts to mitigate against drought, such as using irrigation equipment, have a high initial cost, including additional required management, increases in operation and maintenance costs and lack of quality water resources—which would be severely affected during times of drought.

The health risk from wildfires and the resulting diminished air quality are also concerns in the region. Loss of life and injury due to severe burns, and health hazards from smoke inhalation, which can worsen chronic breathing and cardiovascular disease, are two examples. Smoke and air pollution pose a high risk for children, the elderly and those with respiratory and cardiovascular problems. Even healthy residents are vulnerable to minor symptoms, including sore throats and itchy eyes.

Hazard Impacts on Historic and Cultural Resources

As valued assets within a community, historic buildings and sites are typically vulnerable to the impacts of climate change as a result of their age and integrity. Without established plans for disaster preparedness, emergency response, recovery and resilience, all historic and cultural resources are placed at a larger risk. According to the National Register of Historic Places, there are 71 historic properties listed in Cumberland County, 18 in Harnett County, and 50 in Sampson County. Within Cumberland County, 57 of the properties are located in Fayetteville, while many of the historic properties in Sampson County are in Clinton. These sites include rail stations, churches, Civil War sites, early taverns, public buildings, cemeteries and historic districts.

Defining Historic and Cultural Resources

Historic resources refer to a district, site, building, structure or object that is significant in history, architecture, engineering, archaeology or culture of the state, community or nation. Preserving the history of place through its significant historic resources gives a community its unique character. Historic preservation provides a link to the community's heritage and its people and adds to the quality of life making for a more livable community.

[64] Cumberland Hoke Regional Hazard Mitigation Planning Committee. 2020. *Cumberland-Hoke Regional Hazard Mitigation Plan, Cumberland and Hoke Counties, NC*.

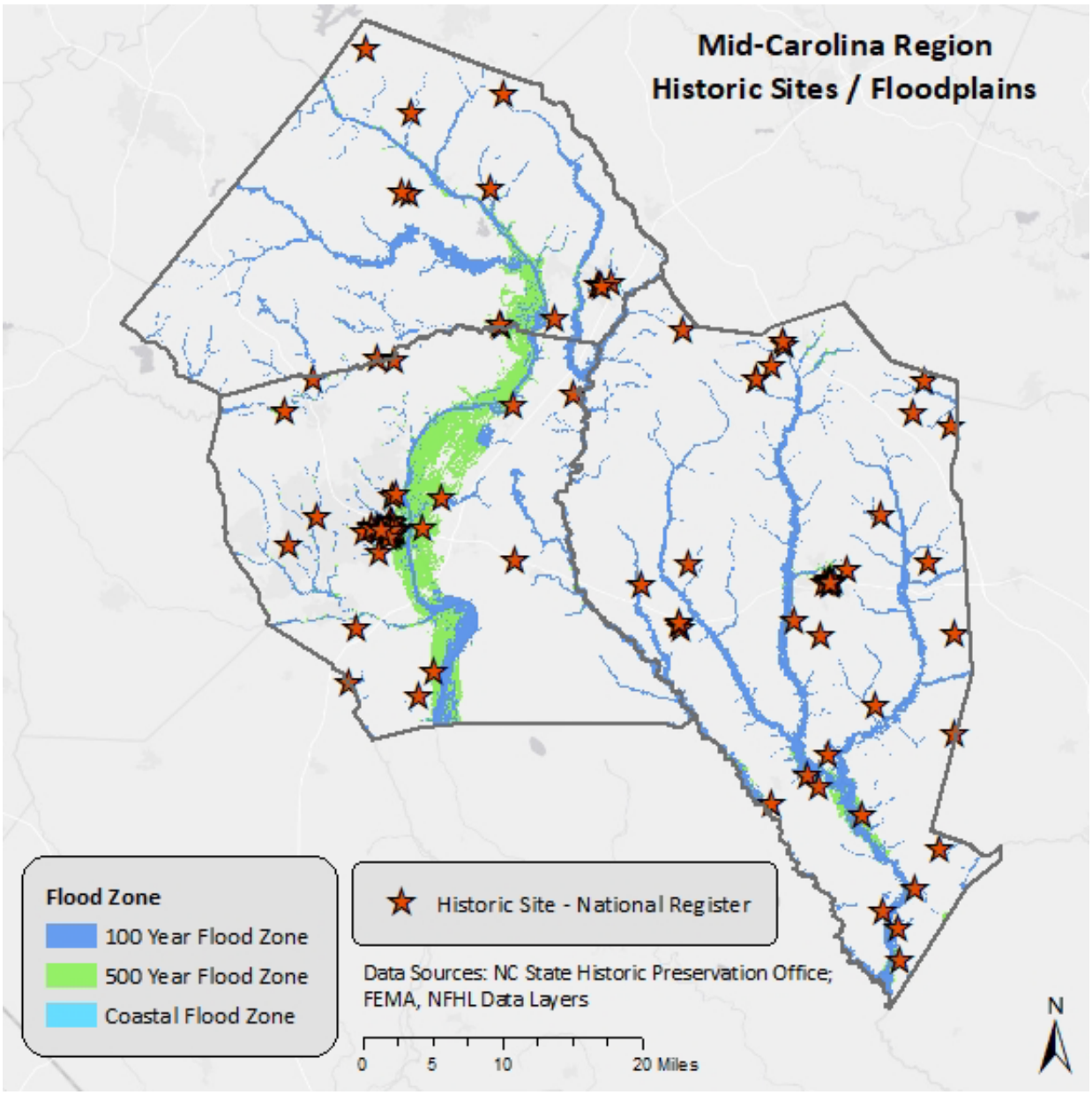

Figure 18: Mid-Carolina Region Historic Sites / Floodplains

Flooding and Heavy Precipitation Impacts on Historic and Cultural Resources

The Mid-Carolina region has several historic properties at risk of flooding. According to GIS analysis, there are 36 historic properties located in the 500-year floodplain across the Mid-Carolina region. These sites are shown in **Figure 18**. Five are located in Sampson County, three in Harnett County and 28 in Cumberland County. This heightened number in Cumberland County can be attributed to the clustering of historic sites in and around the City of Fayetteville, which falls within portions of the 500-year floodplain. There are three sites located in Cumberland County that fall within the 100-year floodplain: the Mansard Roof House in Fayetteville, Gully Mill in Fayetteville and Phoenix Mason Lodge #8 in Fayetteville. These three important cultural and historic resources have already been damaged severely during past events. As the number of heavy precipitation events increases with climate change, the Mid-Carolina region's historic and cultural resources are progressively at risk.

Hurricane and Storm Impacts on Historic and Cultural Resources

Cultural resources, including archeological sites, historic properties and historic districts, are vulnerable to hurricane and wind damage. Wind events can have short-term and long-term impacts on historic structures, including missing shingles and siding, uprooted trees, disrupted powerlines and even total destruction of the structure. Older structures tend to be more vulnerable to storms because of their aging condition. Historic structures face challenges because there is a need to retrofit the structure while maintaining the historical integrity of the building. This relationship places limitations on both aspects: resilience and historical value. Additionally, most historic properties in the region are located in the City of Fayetteville. Increased population, continued urbanization, and high concentration of impervious surfaces heightens the risk to structures within this area.

Extreme Temperature Impacts on Historic and Cultural Resources

Most historic properties in the Southeastern United States were built with flooding and extreme heat in mind because the southern coastal region is hot, humid, and prone to flooding. However, in coming decades, these properties that were once well-adapted to local conditions will face a more severe climate than that for which they were designed.[65] As temperatures continue to rise, historic properties will experience impacts. Temperature fluctuations can cause structural issues as different materials move at different rates in response to temperature changes. Similarly, rising temperatures can increase the rate of various chemical reactions causing materials to deteriorate more quickly.[66] Again, many historic properties are in the City of Fayetteville, which is the most urbanized portion of the Mid-Carolina region, heightening exposure to potential heat island effect.

Wildfire and Drought Impacts on Historic and Cultural Resources

Agriculture is an important industry within the Mid-Carolina region. Not only does agriculture contribute to the economy, but it also plays a large role in the region's cultural landscape. Drought and wildfire can have considerable negative effects on crops and livestock, which in turn, would negatively impact the rural character of the region. Agricultural forestry is Sampson County's largest industry. According to FEMA's National Risk Index, the likelihood of drought in Sampson County is *very high.*

Regarding the impacts of drought and wildfire on historic properties within the region, drought can cause the ground underneath structures to physically crack and shift, leading to compound issues with the structure's frame, roof, doors, windows and basement. Drought also heightens the risk of wildfire. The City of Fayetteville, due to continued development into the wildland urban interface, is at a heightened risk of wildfire. The prevalence of historic properties within the city contributes to increased vulnerability.

Hazard Impacts on Natural Environmental Systems

This section includes an analysis of the climate threats, vulnerabilities, and adaptive capacities applicable to the region's natural environmental systems.

Environmental Profiles by County

Cumberland County

Cumberland County has an abundance of waterways, parks and areas high in biodiversity. Its many rivers, streams, lakes and wetlands help manage the movement of water throughout the region. Cumberland County is located mostly within the Cape Fear River Basin, with only a small portion of the southern county boundary along the Cold Camp Creek draining to the Lumber River Basin. The Cape Fear River is an important contributor to the county's recreational identity, natural resources, history, geology and scenic views.

[65] Dyer, Jenny. 2022. *Historic Houses in the Shifting Landscape of Climate Change.*
[66] Quadriga. *The Effects of Climate Change on Historic Buildings.*

Aquatic habitats are found along the Cape Fear River Basin as well as in the 45 named streams, 24 swamps and multiple lakes. Known basins and flats within the county include Bear Path, Big Pond Swamp, Bucks Bay, Galiberry Swamp, Reedy Marsh and Vineyard Swamp. Three major rivers flow through the county: South River, Little River and Cape Fear River. Rockfish Creek, Little Rockfish Creek, Cross Creek, Little Cross Creek and their tributaries are significant to the hydrology of the county. There are sizeable wetlands on the east side of Cumberland County between Cape Fear River and South River. These wetlands can hold significant amounts of water, reducing flooding elsewhere during and after heavy precipitation.

Parks and protected public lands provide improved water quality, groundwater protection, flood prevention, improved air quality and vegetative buffers. The county has a considerable number of municipal-level recreational and park facilities, including 12 recreation centers, 10 parks, the Cape Fear River Trail and the Cape Fear Mountain Bike Trail. Carvers Creek State Park is located in northern Cumberland County and is owned and operated by the State of North Carolina. The Park is over 4,000 acres in size and includes a 100-acre millpond. Fort Bragg is the largest managed area within the county. Managed areas are properties and easements where natural resource conservation is one of the current primary management goals, or they are of conservation interest. Fort Bragg is managed by the U.S. Department of Defense and is located in the northern portion of Cumberland County.

In addition to managed parks, there are several notable natural areas in Cumberland County. These areas include Bushy Lake State Natural Area, Big White Bay and Simmons Mill Pond. According to the North Carolina Natural Heritage Program, areas with the highest rating of biodiversity include the southeast portion of the county, on or contiguous to Fort Bragg Military Installation and stretches of the Cape Fear River, Little River and Rockfish Creek.[67]

Harnett County

Harnett County is characterized by a plethora of water resources, natural areas, managed areas, biodiversity, wildlife habitat and recreation opportunities. The most prominent river in Harnett County is the Cape Fear River. It runs the entire length of the county from the northwest to the southeast. a major ecotourism source for the region. Raven Rock State Park is home to Lanier Falls and serves as a natural oasis for hiking, fishing, canoeing and camping on the Cape Fear River. Raven Rock State Park covers roughly seven square miles.[68]

According to the North Carolina Natural Heritage Program's biodiversity and wildlife habitat assessment, areas with the highest rating for biodiversity and wildlife habitat in Harnett County are along the Cape Fear River and its tributaries.

There are several notable natural areas in Harnett County, one being Raven Rock State Park, a major ecotourism source for the region. Raven Rock State Park is a managed area, is home to Lanier Falls and serves as a natural oasis for hiking, fishing, canoeing and camping on the Cape Fear River. Raven Rock State Park covers roughly seven square miles.[69]

The Harnett County Parks and Recreation Department maintains several parks and facilities in Harnett County. The facilities available through the county's park system include Neill's Creek County Park, Barbeque Creek County Park, South Harnett Park, Anderson Creek County Park, Cape Fear River Trail Park, Boone Trail Community Center and Dunn-Erwin Rail Trail.

Sampson County

Sampson County is also full of natural areas with significant waterways, biodiversity and parks. Six Runs Creek and Great Coharie Creek are blackwater streams—a slow-moving waterway flowing through forests,

[67] State of North Carolina. 2017. *Hurricane Matthew Resilient Redevelopment Plan, Cumberland County*.
[68] State of North Carolina. 2017. *Hurricane Matthew Resilient Redevelopment Plan, Harnett County*.[69] State of North Carolina. 2017. *Hurricane Matthew Resilient Redevelopment Plan, Harnett County*.
[69] State of North Carolina. 2017. *Hurricane Matthew Resilient Redevelopment Plan, Harnett County*.

swamps or wetlands[70]—beginning in swamps north of Clinton in Sampson County. Little Coharie Creek begins in northwest Sampson County between the South River and Great Coharie Creek watersheds. It flows south passing just east of Roseboro and joins Great Coharie Creek. The Black River is formed by the confluence of Great Coharie and Six Runs Creeks, 15 miles south of Clinton. It picks up the South River and flows into the Cape Fear River above Wilmington.

According to North Carolina Natural Heritage Program's biodiversity and wildlife habitat assessment, areas with the highest rating for biodiversity and wildlife habitat in Sampson County are along the Black River and Cape Fear River Basins and its tributaries. According to the North Carolina Natural Heritage Program, there are two notable natural areas in Sampson County. These areas are both related to the Great Coharie Creek, which is swampy in its headwaters, as are most Sampson County rivers. The banks rise downstream where it becomes a blackwater river confined to a single channel.

The Sampson County Parks and Recreation Department manages two community parks: Western District Park and Weeks Park. Both facilities feature recreation resources.

Hurricane and Storm Impacts on Natural Environmental Systems

Hurricanes and other storms can be just as disruptive in natural areas as in developed areas. Hurricane winds can down trees and cause disruptions to local ecosystems, especially if damage is heavy in areas where endangered or protected species are present. Depending on the strength, severity and duration of the event, hurricanes can remove the foliage from forest canopies and drastically alter habitats causing the indigenous animal populations to suffer. High winds from hurricane events can also strip fruits, seeds, and berries from bushes and trees, resulting in specific food shortages.

Flooding and Heavy Precipitation Impacts on Natural Environmental Systems

Modifying stream banks and removing vegetation from a riverside can create negative consequences from flooding. When these modifications are present, flooding can cause unnatural erosion of sediment into the waterway and create an imbalance of nutrients in the water, which may harm ecosystems and have a negative impact on downstream water quality.

Natural areas are often, but not always, adept at managing inundations. The fluctuation of water levels in a wetland, especially flood water, supports the biological diversity of low-lying areas by releasing nutrients into the soil and germinating wetland flora. Flooding also offers some control of invasive water weeds. Most features of the environment have adapted to the effects of a flood and respond quickly, although it is possible that some species may not be resilient enough to survive and will experience population loss.

Extreme Temperature Impacts on Natural Environmental Systems

The natural environment is also impacted by extreme heat. Plants and animals that are not able to withstand the heat may die off, just as crops and livestock may be impacted by unusually high temperatures, resulting in death or illness. Heat waves can also contribute to higher levels of air pollution. Hot air is more likely to become stagnant and trap emitted pollutants, often causing increased levels of surface ozone.

Drought and Wildfire Impacts on Natural Environmental Systems

Like other hazards, wildfires and droughts impact ecosystems. Wildfires have the potential to damage or destroy forage on grazing lands, destroy secondary forest products and cause degradation and loss of wildlife habitat on public lands. On private lands, vegetation losses could include agricultural crops that are either burned or impacted by wildfire smoke. Indirect impacts could include loss of growing stock and irrigation systems. Another potential loss includes damage and destruction to a wide variety of common or protected habitats in the state. Finally, the release of smoke from wildfires can pollute the air and reduce air quality.

[70] Ogeechee Riverkeeper. 2020. *Tannins and Blackwater Rivers.*

It should also be noted, however, that wildfires are a naturally occurring element of the environment and play an important part in the development of many ecosystems. Wildfires regenerate and provide vital nutrients the soil needs to sustain a forest habitat for all the organisms living within it. Therefore, although there are some negative impacts of wildfire, there are some positive environmental impacts as well.

Natural areas are often adept at managing drought, but not always. Drought can increase pollution levels in water sources since there is an insufficient supply of rainwater to dilute industrial and agricultural chemical runoff. This contamination poses a risk to plants and animals and makes it difficult to maintain a clean drinking water supply. Lack of rainfall may also cause the ground to become dry, bare and unstable. The resulting lack of ground cover can then lead to severe erosion and loss of topsoil when high-intensity rainfall returns. These environmental impacts often lead to degraded habitats.

Social Vulnerability

Natural hazards threaten a community's health and safety, and individuals already challenged by one or more an existing vulnerabilities are especially at risk to disasters and public health emergencies. Factors such as socioeconomic status, the number of elderly and youth in a household, race, housing type, and access to transportation impact the ease at which families can respond to hurricanes, heat waves, and other hazards. The United States Department of Health and Human Services' Geospatial Research, Analysis, and Services Program created and maintains the Centers for Disease Control and Prevention (CDC) Agency for Toxic Substances and Disease Registry Social Vulnerability Index (SVI)[71] to help public health officials and emergency planners better understand and meet the needs of socially vulnerable populations in emergency response and recovery efforts. This section uses the SVI to analyze areas of highest social vulnerability in the Mid-Carolina region and examines how changes in climate may make vulnerable residents' lives more challenging.

The CDC provides the follow description of its SVI tool:

> *"CDC SVI uses U.S. Census data to determine the social vulnerability of every census tract. Census tracts are subdivisions of counties for which the Census collects statistical data. CDC SVI ranks each tract on 15 social factors, including poverty, lack of vehicle access, and crowded housing, and groups them into four related themes."*[72]

The four SVI themes are socioeconomic status; household composition; race, ethnicity and language, and housing and transportation. See **Figure 19** below for the social factors included in each theme. Each census tract receives an overall SVI score from 0-1, with 1 representing the highest social vulnerability. CDC SVI also displays the SVI score for each of the four themes, so the public can better understand what factors may be driving an area's vulnerability. **Table 16** shows how scores relate to level of vulnerability according to the SVI tool.

[71] ATSDR. 2020. *CDC Social Vulnerability Index (CDC SVI)*.
[72] ATSDR. 2020. *CDC Social Vulnerability Index (CDC SVI)*.

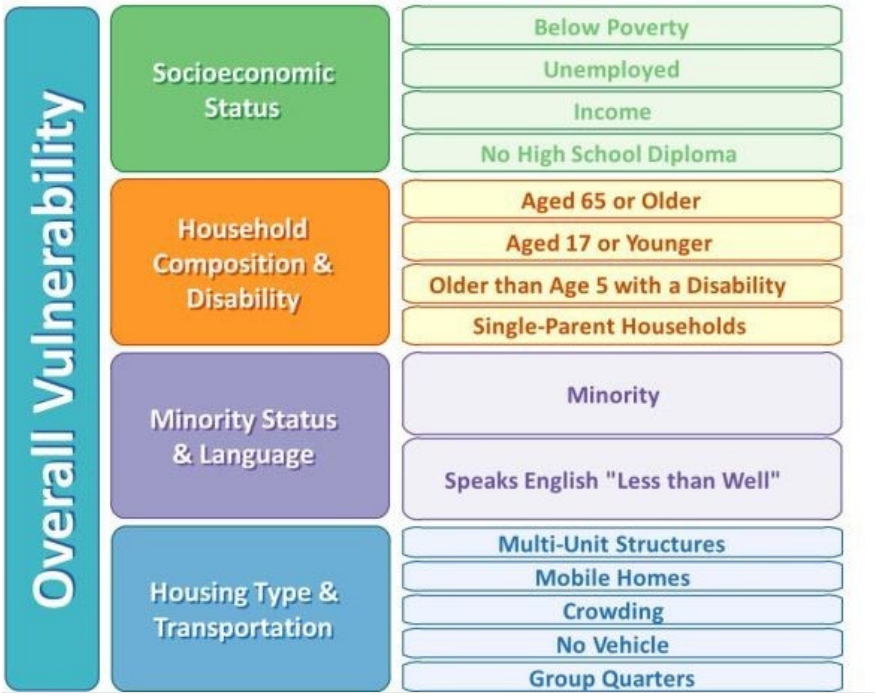

Figure 19: CDC Social Vulnerability Index Themes
Note: this graphic was obtained from https://svi.cdc.gov/Documents/Data/2018_SVI_Data/SVI2018Documentation.pdf

Table 16: Summary of SVI Scores for Vulnerability Identification

Vulnerability Indication	CDC SVI Score
High vulnerability	0.7501 – 1.000
Moderate to high vulnerability	0.5001 - 0.7500
Low to moderate vulnerability	0.2501 – 0.5000
Low vulnerability	0.000 - 0.2500

Note: Information was obtained from https://svi.cdc.gov/Documents/Data/2018_SVI_Data/SVI2018Documentation.pdf

Table 17: SVI Scores by Theme for the Counties in the Mid-Carolina Region

County	2018 Overall SVI Score	Theme 1: Socioeconomic Status	Theme 2: Household Composition and Disability	Theme 3: Minority Status and Language	Theme 4: Housing Type and Transportation
Cumberland	0.8640	0.6780	0.7943	0.8532	0.8567
Harnett	0.7869	0.7497	0.5654	0.8144	0.5982
Sampson	0.9723	0.9252	0.9255	0.9427	0.7902

Notes: Data were obtained from the CDC SVI Interactive Map (2018 data) at https://svi.cdc.gov/map.html; The CDC developed these results using data from the 2014-2018 American Community Survey.

In the Mid-Carolina region, county-wide scores across all themes fall in the moderate to high, and high vulnerability categories. **Table 17** above shows that Sampson County has the highest overall vulnerability score within the region. The jurisdiction's scores indicate that Sampson County residents experience high vulnerability due to socioeconomic status, household composition and disability, minority status and language, and housing type and transportation. Cumberland County ranked second, with high vulnerability

scores in household composition and disability, minority status and language, and housing type and transportation. Harnett County ranked third, with high vulnerability scores in socioeconomic status, minority status and language, and housing type and transportation. These findings are consistent with information gathered from stakeholders during the Stakeholder Partnership meetings as well as during the public workshops.

The information from the CDC SVI tool is helpful to understand the region's vulnerabilities, but to enable local leaders to make decisions on this information, the project team identified the specific census variables driving the results. **Tables 18** shows that Sampson County's high vulnerability ranking for socioeconomic status is driven by the percentage of the population living in poverty (20.89%), per capita income ($22,875) and the percentage of the populations with less than a high school diploma (20.67%). Both percentages are substantially higher than the national averages, 11.4% and 8.9%, respectively, and the per capita income is lower than the national average of $35,805. The percentage of unemployed people in Sampson County (6.91%) is higher than the national average (3.7%). Cumberland County's unemployment rate is the highest of the three counties (8.46%). These results suggest that, across the region, there is a high percentage of families with working adults who are already struggling with their finances. These individuals and families will very likely have a harder time bouncing back if a flood hits their home, for example.

Table 18: A Breakdown of SVI Socioeconomic Status Variables by County

County	Estimated number (percent) of people living in poverty	Estimated number (percent) of unemployed people (age 16+)	Estimated per capita income	Estimated number (percent) of people (age 25+) with less than a high school diploma
Cumberland	58,132 (18.37%)	11,752 (8.46%)	$24,936	18,606 (9.04%)
Harnett	20,331 (15.8%)	4,012 (7.11%)	$23,767	10,720 (12.53%)
Sampson	13,059 (20.89%)	2,022 (6.91%)	$22,875	8,793 (20.67%)

Note: These data are based on the 2015-2019 American Community Survey and was obtained from www.policymap.com/newsmap#/

Table 19 shows that Sampson County's high vulnerability ranking for household composition and disability is driven by the percentage of the population who are 65 and older (17.43%; national average: 16.00%) and who have one or more disability (17.62%; national average: 12.70%), as well as the number of youths. All three counties' high vulnerability ranking for household composition and disability is driven by the number of people under 18 years old (Harnett: 26.38%; Cumberland: 25.73%; Sampson: 24.54%; national average: 23.60%). Cumberland County has a notably high percentage of single-parent households (19.08%; national average: 23%) and percentage of people with at least one disability (17.50%; national average: 19.30%). These results suggest that, when prioritizing resilience projects, Sampson County should consider support and check-in programs for individuals 65 and older and individuals living with a disability, especially during heat waves, in advance of hurricanes and other severe weather events. Cumberland County should consider the needs of single-parents and people living with a disability, and all three counties should consider programs to support families with young children, as well.

Table 19: A Breakdown of SVI Household Composition and Disability Variables by County

County	Estimated number (percent) of people 65 or older	Estimated number (percent) of people under 18	Estimated number (percent) of people with one or more disabilities	Estimated number (percent) of single-parent households with children
Cumberland	38,522 (11.57%)	82,308 (24.73%)	52,852 (17.50%)	14,916 (19.08%)
Harnett	16,089 (12.16%)	34,091 (26.38%)	16,751 (13.26%)	4,673 (14.69%)
Sampson	11,045 (17.43%)	15,556 (24.54%)	11,052 (17.62%)	2,384 (15.18%)

Note: These data are based on the 2015-2019 American Community Survey and was obtained from www.policymap.com/newsmap#/

Table 20 shows that Cumberland County has the highest percentage of minorities when compared to Harnett and Sampson Counties. On the other hand, Sampson County has the highest percent of people who speak English less than well. Based on the census data, there is a correlation between county population size and number of languages spoken at home. This correlation indicates that larger populations have more diversity, and therefore, more languages spoken within the community. For example, at least thirty-two languages were documented for Cumberland County with a population of 334,278 while eleven languages were documented for Sampson County with a population of 59,036.

One of the key takeaways from the available data involves the large Spanish speaking community in Sampson County. Nearly 10% of the county population speaks English less than well, and Spanish speaking individuals account for more than 9% of that county total. Using census tract level mapping, the highest percentage of Spanish speaking population is located south of Clinton. Stakeholders noted that many migrant workers live in the southern portion of the county due to the close proximity to labor camps. Additionally, Stakeholders noted the large concern for migrant workers and the challenges posed that disrupt consistent communication to keep them safe during extreme heat events. A second important takeaway is the large minority population in Cumberland County. Census tract level mapping indicates these populations reside in central, western and northwestern portions of the county, including Fayetteville, Spring Lake and Hope Mills. These areas were identified during Stakeholder Partnership meetings as problems areas as they have experienced repetitive flooding.

Table 20: A Breakdown of SVI Minority Status and Language Variables by County

County	Estimated number (percent) of minorities*	Estimated number (percent) of people who speak English less than well
Cumberland	201,238 (60.21%)	10,269 (3.5%)
Harnett	55,697 (41.7%)	1,043 (3.78%)
Sampson	23,992 (40.64%)	5,672 (9.51%)

Notes: These data are based on the 2011-2015 American Community Survey and 2020 Census Data and was obtained from www.policymap.com/newsmap#/*; the ACS defines "minority" as all persons except white, non-Hispanics*

Table 21 explains that Cumberland County, when compared to Harnett and Sampson, has significantly more medium and large multi-family units indicating an overall higher density. Similarly, Cumberland County has the highest percentage of households with no vehicles within the region. Households with no vehicle were most prevalent in the City of Fayetteville. These numbers reflect the larger population of Cumberland County and the City of Fayetteville. Additionally, alternative modes of transportation are common and often preferred within a city setting. Sampson County ranked second highest for households with no vehicle, and this was most prevalent in and around the Town of Garland. Limited to no vehicle poses major challenges to evacuation and transportation needs during a natural disaster.

Table 21: A Breakdown of SVI Housing Type and Transportation Variables by County

County	Estimated number (percent) of medium multi-family units (20-49)	Estimated number (percent) of large multi-family units (50 or more)	Estimated number (percent) of households with no vehicle
Cumberland	6,768 (4.60%)	1,250 (0.85%)	8,803 (6.9%)

Harnett	218 (0.41%)	145 (0.28%)	2,244 (4.82%)
Sampson	199 (0.71%)	54 (0.19%)	1,309 (5.65%)

Note: These data are based on the 2016-2020 American Community Survey and was obtained from www.policymap.com/newsmap#/

In addition to the countywide data analyzed above, **Figures 20 – 25** below depict social vulnerability by census tract. Like the results found above, nearly all of the census tracts in Sampson County in **Figure 24** are dark blue, indicating the highest vulnerability ranking. The same is true for socioeconomic status and race/ethnicity/language maps in **Figure 25**. Cumberland County and Harnett County have pockets of high vulnerability centralized in specific census tracts.

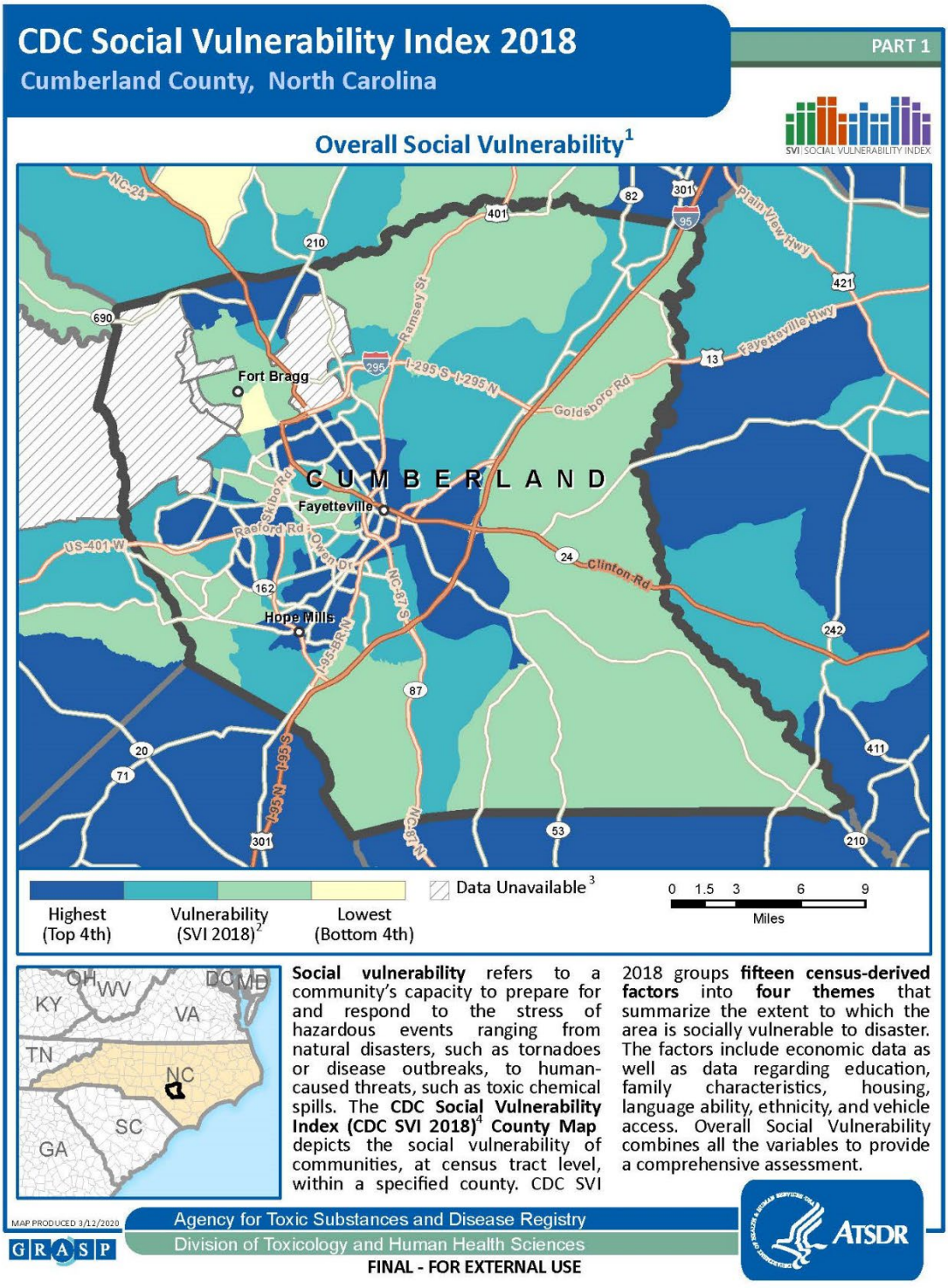

Figure 200: Cumberland County's Overall Social Vulnerability, by Census Tract
Note: This figure was obtained from the CDC.

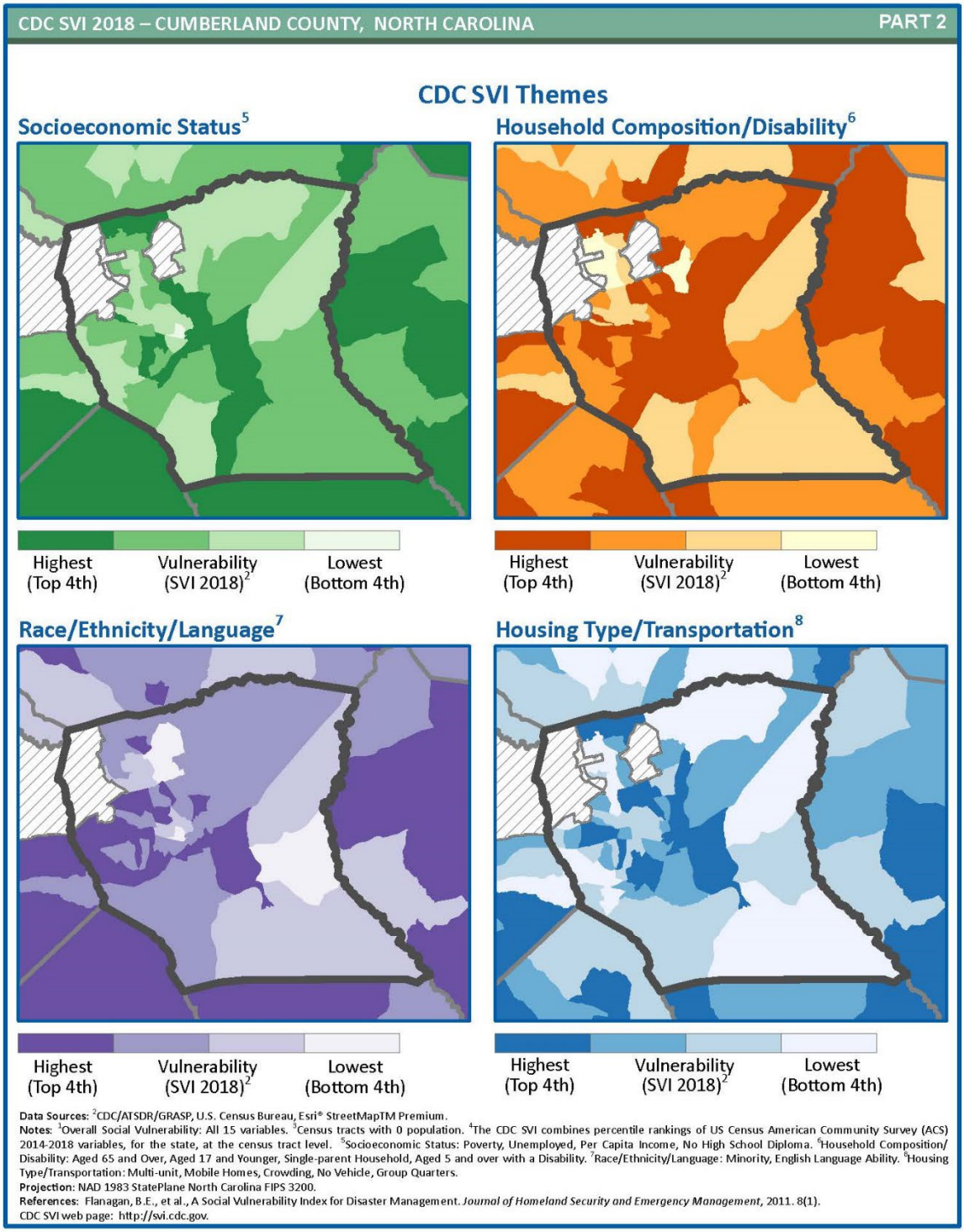

Figure 211: Cumberland County's Social Vulnerability by SVI Theme and Census Tract
Note: This figure was obtained from the CDC.

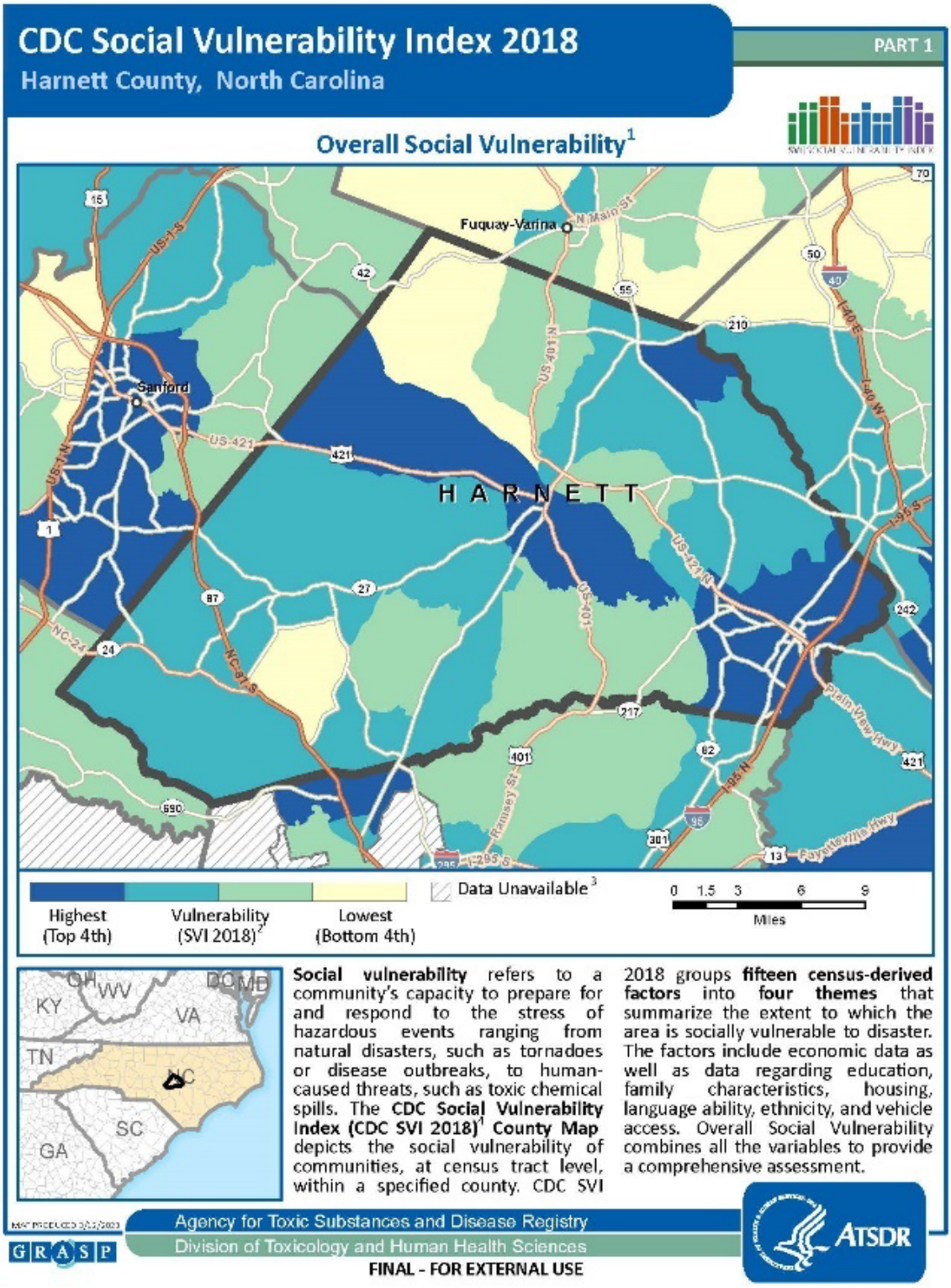

Figure 222: Harnett County's Overall Social Vulnerability, by Census Tract
Note: This figure was obtained from the CDC.

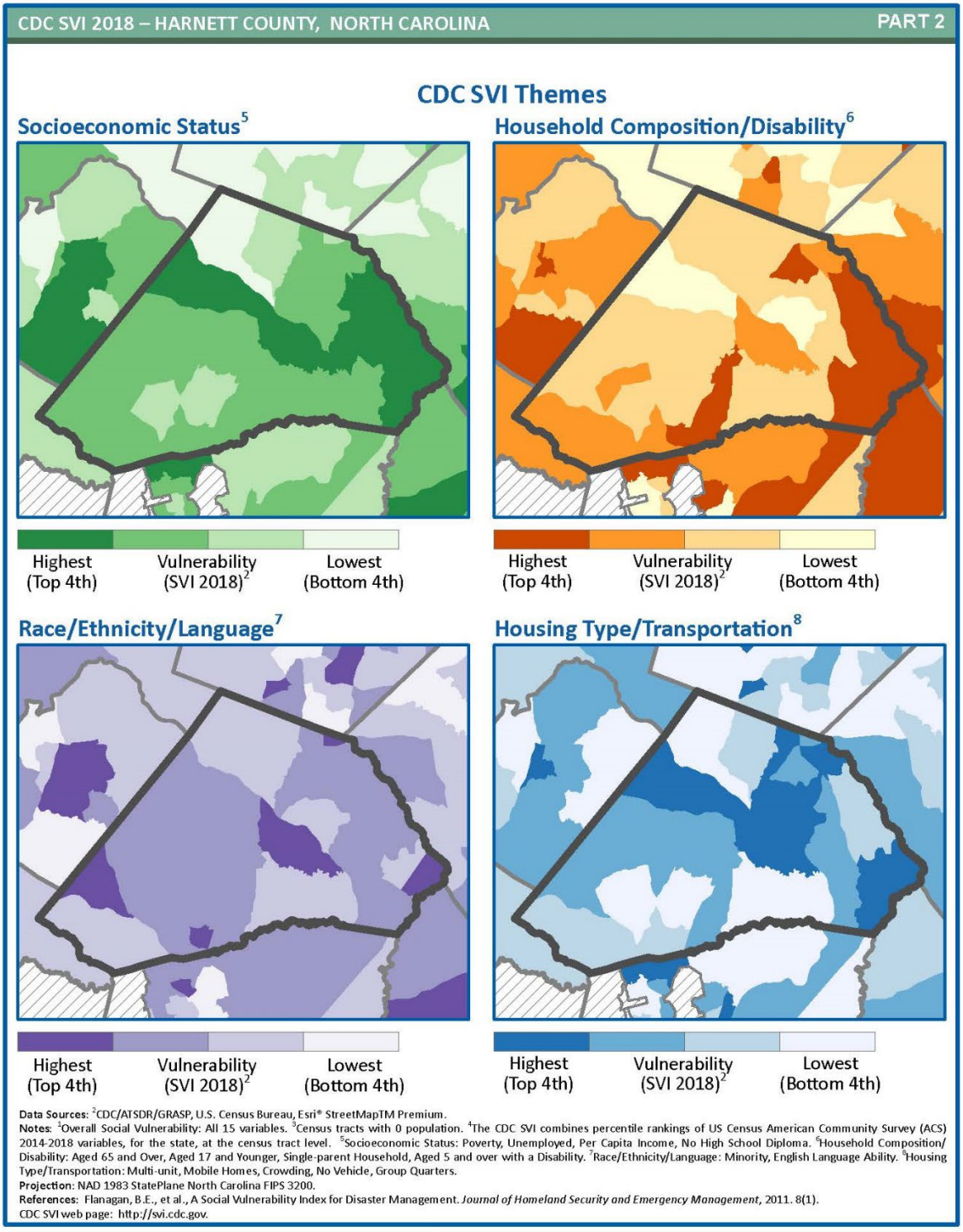

Figure 233: Harnett County's Social Vulnerability by SVI Theme and Census Tract
Note: This figure was obtained from the CDC.

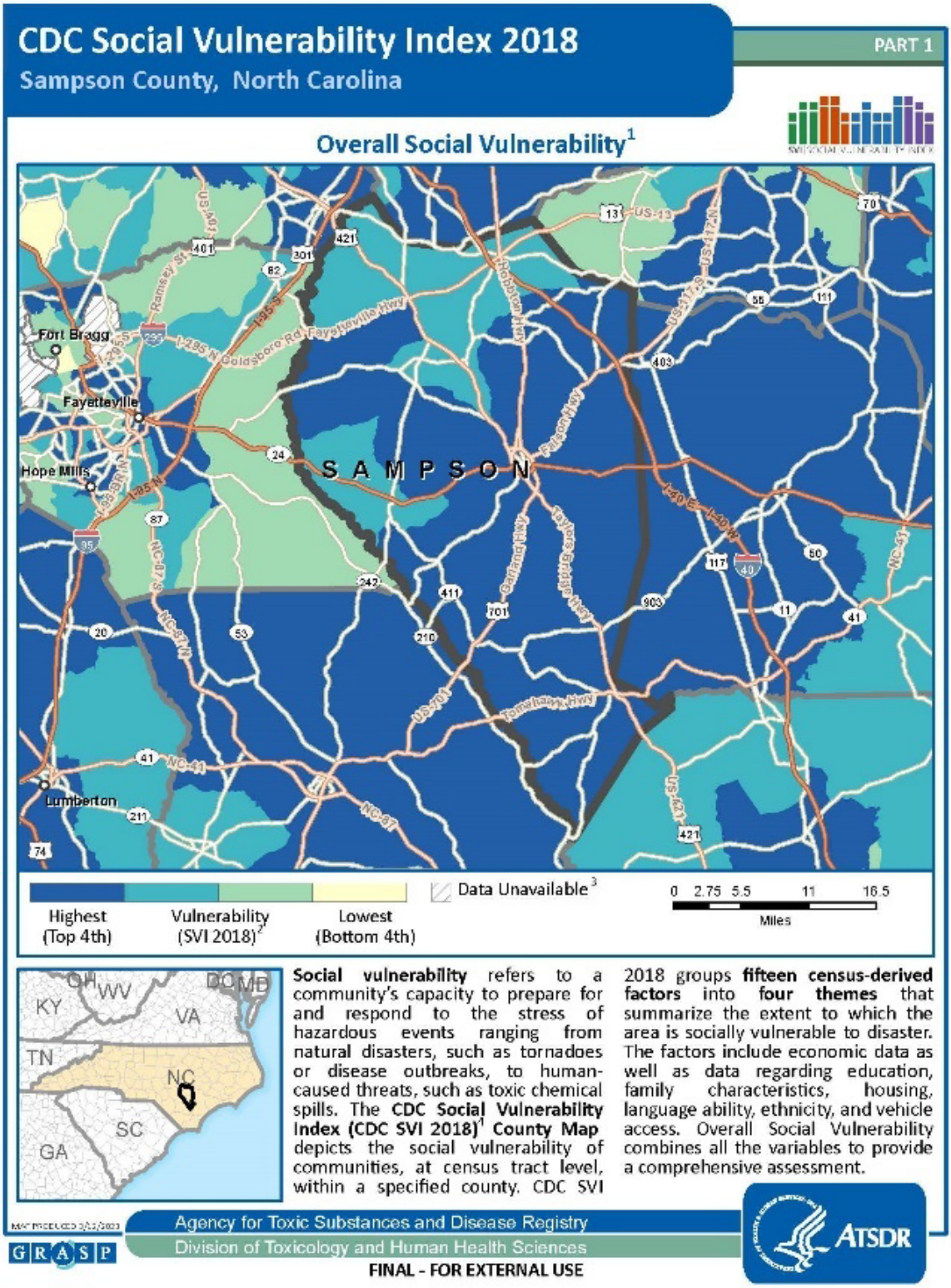

Figure 244: Sampson County's Overall Social Vulnerability, by Census Tract
Note: This figure was obtained from the CDC.

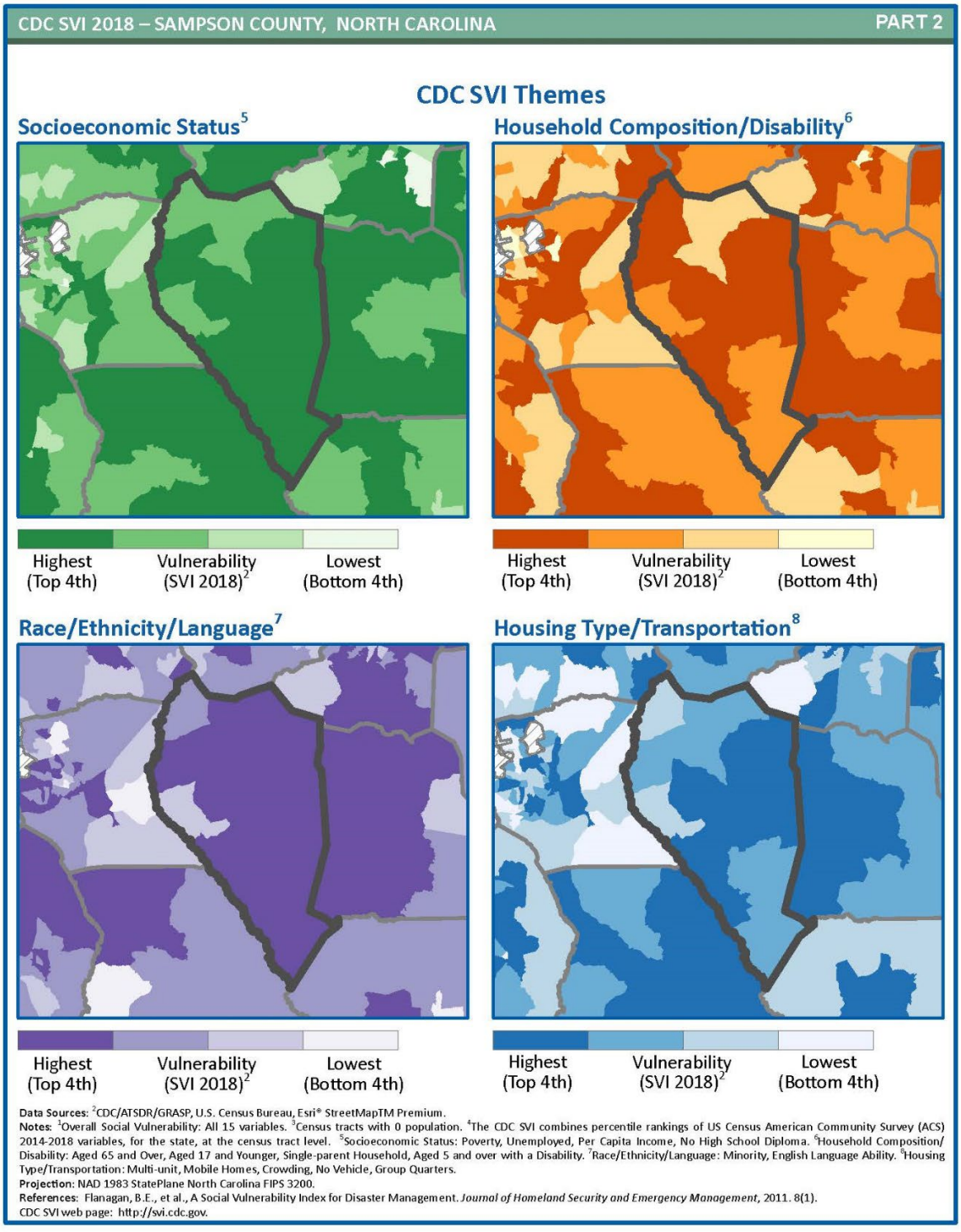

Figure 255: Sampson County's Social Vulnerability by SVI Theme and Census Tract
Note: This figure was obtained from the CDC.

Social Vulnerability as Noted by the Stakeholder Partnership and the Public

In addition to reviewing available census data and the CDC's SVI, the project team asked local stakeholders to identify socially vulnerable populations within their communities. The following subsections provide information about socially vulnerable populations as identified by the Stakeholder Partnership and from public input. Input collected during the stakeholder and public meetings coincided with much of the existing data but offered a more qualitative approach to identifying areas of social vulnerability within the region.

Cumberland County

Hurricanes Matthew and Florence significantly impacted low-and-moderate income communities in Cumberland County. While waiting for assistance following these disasters, many residents were unable to pay their bills, leading to higher eviction rates and damaged credit scores. Residents identified Wilmington Road as a low-income neighborhood that is predominantly African American. This community experienced repetitive flooding from nearby Blunts Creek. Even households that do not fall in the low-and-moderate income category are on the cusp and remain financially strained following these hurricanes. Still, low-and-moderate income residents were hit hardest. Many were unable to rebuild due to inadequate insurance and had to relocate.

Cumberland County also has a large retiree population, which was disproportionately impacted by Hurricanes Matthew and Florence. The county's elderly population is a major concern as there are not enough case workers to provide them with necessary assistance, causing residents to act independently rather than request information and assistance from available local resources. Communication is also an issue with Cumberland County's senior living facilities, of which there are an estimated three to four throughout the county.

Harnett County

During the public meeting, Harnett County residents mentioned that language, income and access impact social vulnerability in the area. They suggested churches and community organizations as ideas for connection points. They also stated that having "boots on the ground" involvement and bilingual information would help address social vulnerability.

Sampson County

People who live and work in Sampson County identified non-English-speaking populations and the elderly as the most vulnerable countywide. Sampson County has a large migrant population that lives in the rural, southern portion south of Highway 24, an area identified as lower income. Residents are concerned for migrant workers' ability to withstand high summer temperatures, especially considering how the heat index is expected to rise because of climate change.

Education and outreach are critical for non-English-speaking populations and the elderly. In addition to the language barrier, migrant workers carry distrust and fear toward the government and its agencies, so communication and assistance can be difficult. Residents mentioned a high proportion of Spanish-speaking individuals as well a large Thai population. Communication is an issue with Sampson County's elderly population, as well, across the estimated three to four senior living facilities throughout the county. Social media is the primary source of communication between the county and its residents, which is problematic when trying to convey important information to the elderly, non-English-speaking populations and residents who do not have access to the internet.

Cascading Impacts

All of the hazards discussed throughout this document have secondary and tertiary impacts. These cascading climate impacts are already happening in the Mid-Carolina region. More frequent and heavier precipitation events often lead to devastating flooding events such as those already experienced from Hurricanes Matthew and Florence. These two disasters, which occurred just two years apart, strained local and state resources.

Delivery of utilities and economic impacts surfaced as a major concern from stakeholders and the project team, especially seeing what has happened in past events. In the Mid-Carolina region, water and wastewater pipes and pumps are typically located in the most flood-prone areas, which complicates recovery and impacts residents who are unable to access normal water sources for drinking, sanitation and other everyday uses. Hurricane Matthew demonstrated that loss of electrical power is one of the greatest threats to businesses and industries in the region. Many businesses lost revenue when power outages ruined products and halted business operations including top employers and small businesses alike. The shutdown of these businesses can be devastating as many small, rural communities in the region rely heavily on small businesses as economic drivers and the base of the local economy.

Roadway flooding was also identified as a major concern across the region, often leaving neighborhoods landlocked, prohibiting evacuation and creating access issues for emergency responders. A lot of this flooding is driven by undersized culverts and increased development regionwide. The region's top roadway flooding concerns are Interstate 95, Route 701, NC Highway 24, NC Highway 411 and NC Highway 217.

Other cascading impacts that could occur from heavy precipitation in the Mid-Carolina Region include crop damage, soil erosion and flash flooding—all of which have environmental and economic impacts. In addition, flooding can lead to injuries, deaths, property damage and mold, the latter of which can lead to series health impacts. Additionally, runoff from precipitation can impair water quality as pollutants deposited on land wash into water bodies. Furthermore, recurring high temperatures lead to drought, which can lead to wildfires.

6. Vulnerability Hot Spots

As climate change causes natural hazards to hit Mid-Carolina communities harder and more often, the impacts affect our most vulnerable residents first and hardest. Across the region, people of color and low-income households are more likely to live in the floodplain and not have easy access to air conditioning to cool down during the hotter summers. These residents are also more likely to live in older houses and mobile homes, which often do not hold up to high winds, flood waters and increasing temperatures. The high proportion of youth, elderly individuals and people living with one or more disabilities will have a harder time dealing with heat waves. Residents and migrant workers who do not speak English well or at all are at risk of not understanding when a natural hazard is coming or what to do when it does. There are a myriad of challenges facing the Mid-Carolina region—some that exist without regard to climate change that will make building resilience even harder. This section aims to highlight the most pressing concerns—or "hot spots"—identified by stakeholders (see **Appendix A** for more details) and by overlapping social vulnerability data with hazard maps.

The Mid-Carolina region's high rates of social vulnerability put individuals and families at risk of substantially greater climate impacts. The region struggles with housing, poverty and challenging family situations. The area is above average for the number of renters, especially in Cumberland County, and for mobile homes, especially in Harnett and Sampson Counties where income is low and poverty rates are high. Likewise, while the average energy burden for the State of North Carolina is 9%, the average energy burden for low-income households in the Mid-Carolina region is more than twice as high. There are high numbers of single-parent households, youth and residents aged 65 and older.

Based on the CDC SVI Interactive Map and indicators, **Figure 26** displays the 15 most vulnerable census tracts within the Mid-Carolina Region. As shown, seven of the 15 tracts are in Sampson County. These tracts take up a large portion of the county indicating widespread vulnerability. The eight vulnerable census tracts within Cumberland County are relatively contained to the central portion of the county in and adjacent to the City of Fayetteville. Harnett County has one census tract that ranked in the highest 15 tracts, which coincides with Harnett County stakeholder discussions lacking detailed insight toward issues and needs. Although some tracts did not fall within the top 15 based on CDC indicators, social vulnerability exists and challenges the entire region.

Continuing to look at Figure 26, nearly all of the region's 15 most vulnerable tracts intersect the 100 and 500-year floodplains. Given that a high proportion of residents within these census tracts are faced with non-climate challenges, their ability to prepare for, respond to, and recover from floods will likely be more challenging compared to other residents. The region should focus on these areas when identifying climate resilience solutions.

The region is very diverse, with over 50% of residents who identify as a person of color in Cumberland County and above average rates of people of color across all three counties. This diversity comes with the additional challenges that people of color face, especially when confronted with the impacts of climate change. And Sampson County, especially, struggles with a high percentage of individuals who speak English less than well. Cumberland County has a large retiree population that was disproportionately impacted by Hurricanes Matthew and Florence. The county's elderly population is a major concern as there are not enough case workers to provide them with necessary assistance, causing residents to act independently rather than request information and assistance from available local resources. When heat waves, hurricanes, droughts, wildfires, and heavy precipitation events occur, these vulnerable residents will face much greater challenges compared to their more privileged neighbors.

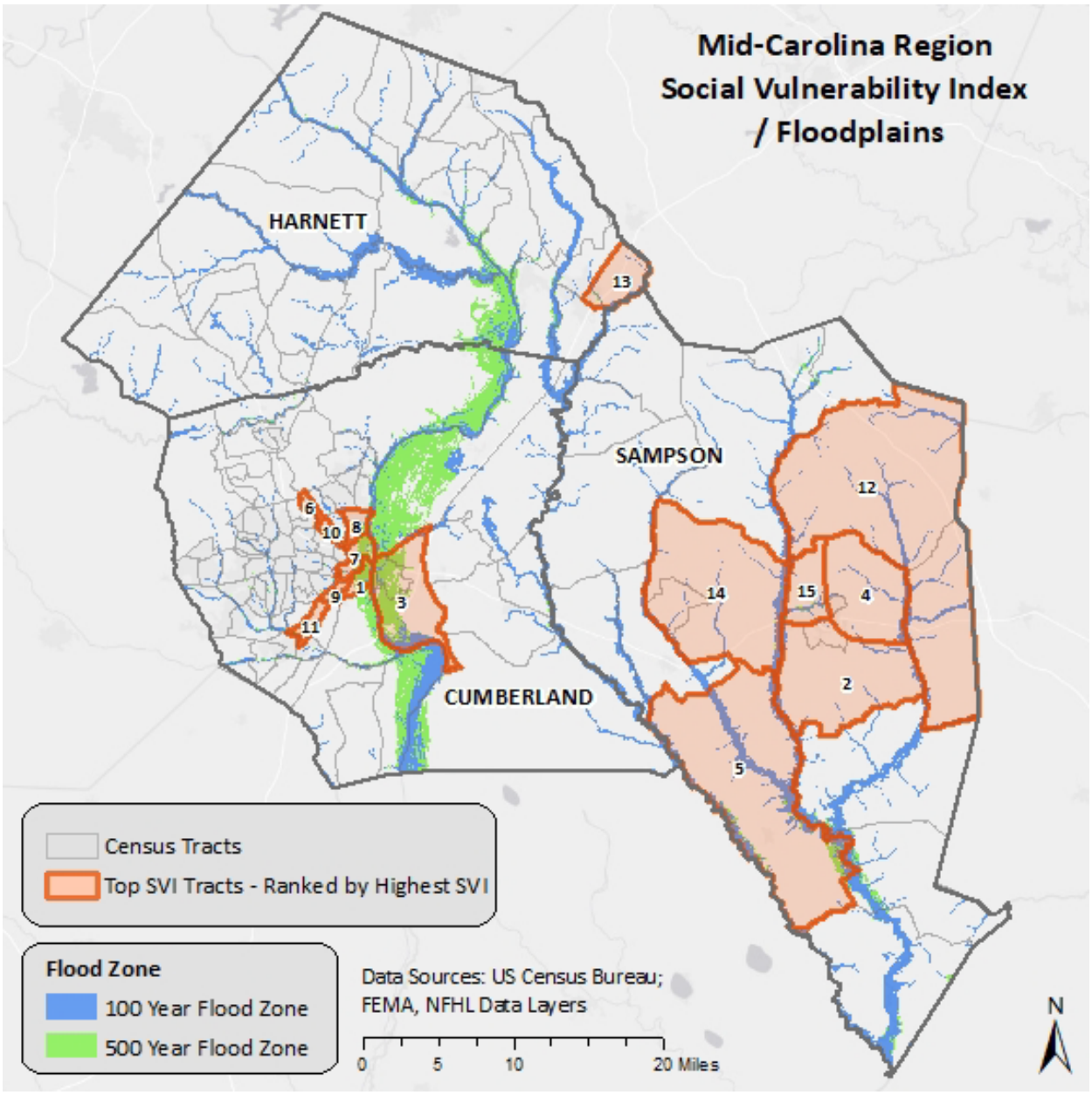

Figure 266: Mid-Carolina Region's Floodplains Overlaid with the Top 15 Most Socially Vulnerable Census Tracts

As shown in **Figure 27**, Fayetteville, Spring Lake, Hope Mills, unincorporated southern Harnett County, and Clinton have high population densities that intersect flood prone areas. The higher the population density, the more people will be exposed to flooding and the associated impacts. Continued population growth and development can lead to an increase in flooding in future years.

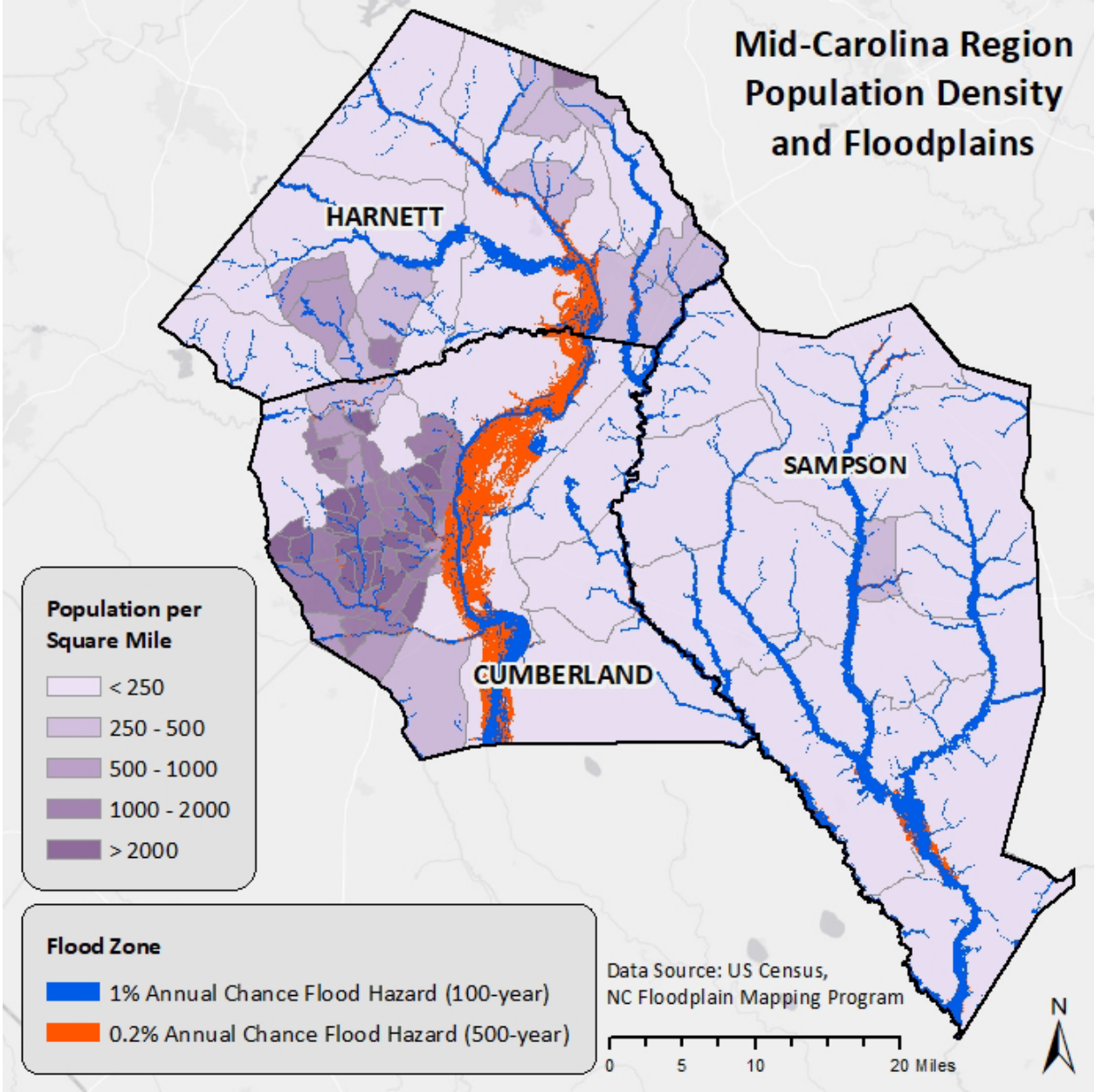

Figure 277: Mid-Carolina Region Population Density and Floodplains

Figure 28 shows where there is an overlap between high amounts of impervious surfaces and elderly populations throughout the region. Impervious surfaces, such as roads and sidewalks, absorb temperatures and slowly release them throughout the day and into the evening, contributing to the heat island effect. The elderly are one of several populations disproportionately impacted by extreme heat events. According to the United States Global Change Research Program, heat waves are occurring more frequently in major cities across the country. These events can have detrimental impacts on public health. Heat islands play a role in these extreme events; buildings and impervious surfaces tend to retain heat, so developed areas usually have higher temperatures than rural areas.[73] Figure 28 shows the areas within the Mid-Carolina region that have a relatively high elderly population (greater than 25%) and are largely made up of

[73] Earth Data. 2021. *Extreme Heat Toolkit.*

impervious surfaces. These areas include the Fayetteville, Clinton, Hope Mills, Erwin and Dunn. Nursing homes are generally located in developed areas, where there is more likely to be high amounts of impervious surfaces. Communities should assess infrastructure and surface materials surrounding individual elderly homes and could even measure nearby surface and air temperatures to better understand the potential impact of high temperatures on nursing home residents.

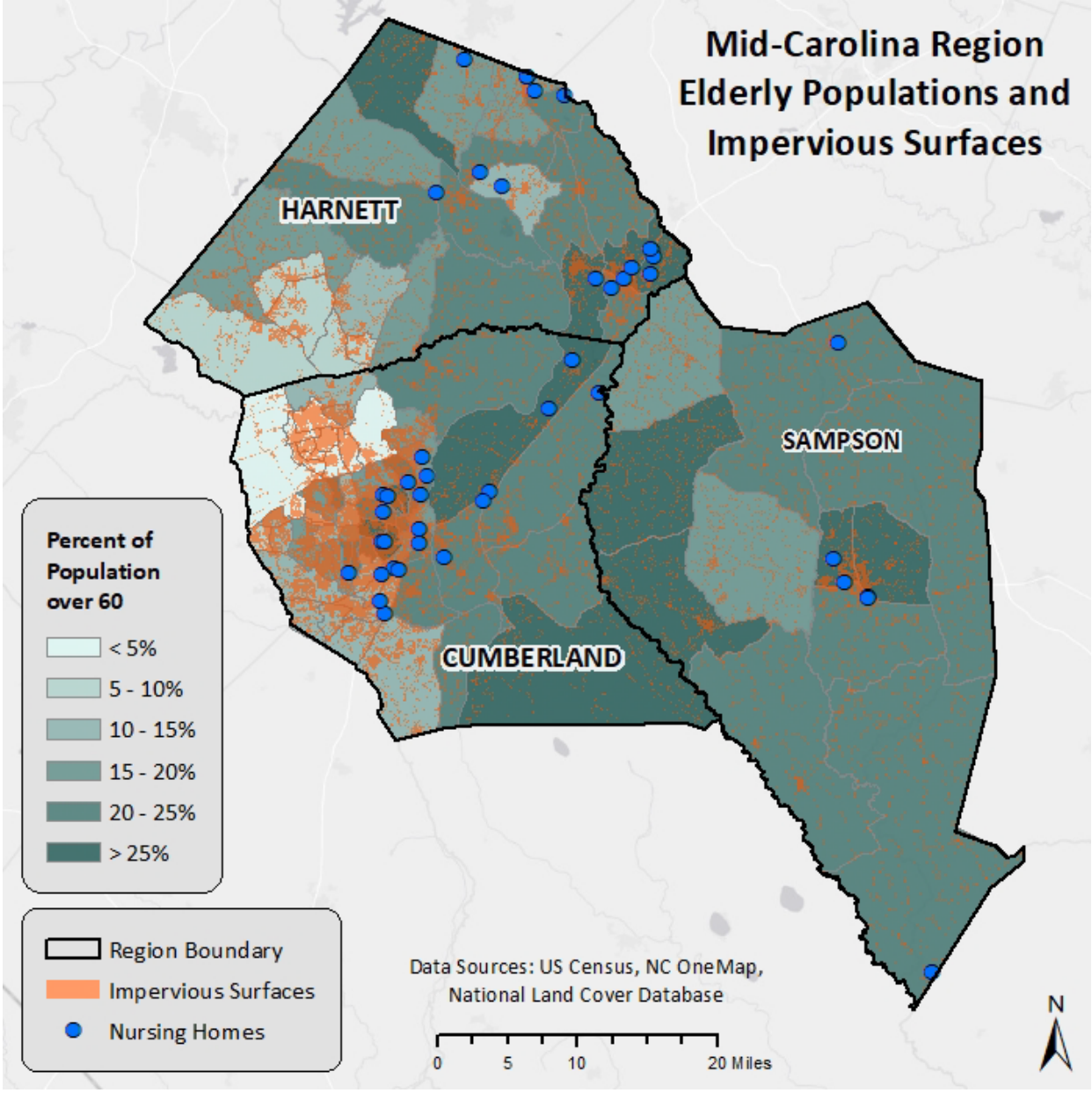

Figure 288: Mid-Carolina Region Elderly Populations and Impervious Surface

Reviewing problem areas county by county can also provide insight on region-wide needs. A majority of the vulnerable hot spot areas in Cumberland County are in the northern and central sections of the county. Flooding in Cumberland County is primarily attributed to proximity to streams/tributaries, undersized culverts, debris build up and delinquent dam maintenance. These floods result in property damage to homes, roads and businesses. Of particular concern is that the Cumberland County Emergency Operation

Center nearly flooded during Hurricane Matthew. As hurricanes and other heavy precipitation events deliver more water, the Emergency Operation Center will need to remain dry and functioning.

Waterways identified in Cumberland County that are susceptible to flooding and experience debris buildup include Little River, Locks Creek, Rockfish Creek, Rose Pond, Rose Lake and Blunts Creek. An unmapped stream in the Town of Linden has caused significant street flooding in the past. Delinquent dam maintenance is another large issue that contributes to flooding. Dams have broken or breached due to lack of maintenance and erosion. This occurs in highly populated areas such as the City of Fayetteville and Hollywood Heights. There are several privately-owned dams in the City of Fayetteville. Private ownership of dams places limitations on maintenance, repair, and retrofits to heighten resilience and mitigate against hazards. Many of the vulnerability hot spot areas within Harnett County are located in the southern portion of the county near the county boundary with Cumberland County. Flooding is a primary concern for Harnett County, which is attributed to proximity to streams/tributaries, ditch maintenance, low-lying areas, debris build up and the development of farmland. These issues cause roadway flooding, property damage and erosion. A solar farm located within the County has flooded several times. Waterways that experience repetitive flooding include Upper Little River, Lower Little River, Barbeque Creek, Black River and Cape Fear River. Towns most at-risk of flooding include Erwin, Lillington and Dunn. When considering mitigation efforts, there are several factors that pose challenges, including historic sites such as Mill Town and sites contaminated with fly ash.

Similar to the other counties in the Mid-Carolina region, flooding is a major concern for Sampson County. Floodwater inundation occurs due to proximity to streams/tributaries, run-off, low-lying areas, delinquent ditch maintenance and debris build up. Waterways that have a relatively high frequency of flooding include Great Coharie Creek, Six Runs Creek, South River and Black River. Municipalities that are significantly impacted during flood events include, but are not limited to, Ivanhoe, Autryville and Garland. Major highways impacted include Highway 41, Route 701, NC Highway 41, NC Highway 24 and NC Highway 403.

As a largely agrarian community, Sampson County relies heavily on the agricultural industry and has identified drought and extreme heat as hazards of concern. Stakeholders acknowledged that drought is becoming more pervasive and that long-term strategies should be considered, such as capturing rainfall. The county's large migrant farmworker population are at increased risk of heat-related illness and death because they are exposed to extreme temperatures while working long hours outdoors.

Related to this extreme heat and drought, Sampson County has recently experienced an overall increase in wildfires, particularly in 2022. These burns occur three to four times per week. Although the frequency has drastically increased, the magnitude has decreased. These burns are easily contained and last no more than a few hours on average. Furthermore, drought and wildfire combined pose a serious threat to the county's agricultural economy.

7. Conclusion

Conducting this vulnerability assessment for the Mid-Carolina region allows the stakeholders within the region to have a better understanding of the challenges to resilience that Cumberland, Harnett and Sampson County communities face—together and individually. Moreover, conducting the assessment at a regional level helps local leaders identify the broader issues that are either repeated across all three counties or are happening in one area and impacting another. This knowledge will allow stakeholders to find strategies to address these challenges and increase community resilience.

Summary of Key Vulnerabilities for the Mid-Carolina Region

- The Mid-Carolina region's high rates of social vulnerability put individuals and families at risk of substantially greater climate impacts. The region struggles with high rates of poor housing conditions, poverty and challenging family situations. The area is above average for the number of renters, mobile homes, renters, single-parent households, youth, residents aged 65 and older, people with disabilities and people of color. Energy burden is a serious concern across the region and will only get worse as climate change continues. While Sampson County is ranked by the CDC Social Vulnerability Index as having high vulnerability in all categories across the entire county, Cumberland and Harnett Counties experience varying rates of vulnerability that are centralized in certain census tracts. When heat waves, hurricanes, droughts, wildfires, and heavy precipitation events occur, these vulnerable residents will need more assistance than their less-encumbered neighbors.
- Delivery of utilities and economic impacts also surfaced as a major concern, especially seeing what has happened in past events. In the Mid-Carolina region, water and wastewater pipes and pumps are typically located in the most flood-prone areas, which complicates recovery and impacts residents who are unable to access normal water sources for drinking, sanitation and other everyday uses. Stakeholders noted the City of Lillington's wastewater treatment plant as an area of flooding vulnerability. Hurricane Matthew demonstrated that loss of electrical power is one of the greatest threats to businesses and industries in the region. Furthermore, some of the region's largest employers are located in the 500-year floodplain, an area that is very likely to flood more frequently in the coming decades. Small businesses, because of their size, are at risk of closing from even the smallest amount of flooding, which can lead to expensive repairs.
- Urbanization and development are increasing the impacts of the hazards discussed in this report. Proximity to the wildland-urban interface increases wildfire risks, and the increase in impervious surfaces contributes to greater flood exposure and higher temperatures, which are absorbed and released by asphalt and concrete. The wildfire risk in the Mid-Carolina region is most noticeable in Cumberland and portions of Harnett Counties. All developed areas in the region face some risk of wildfire, but the wildland-urban interface, which indicates high wildfire risk, is especially concerning in Fayetteville, Hope Mills, Stedman, Coats, Lillington, Autryville and Roseboro. Each county and some of the municipalities in the region have areas of known flooding concerns. These areas fall both inside and outside of the floodplains as mapped by FEMA. Residents are concerned that these areas are flooding more frequently than in the past as a result of development and climate change. Undersized culverts on state-owned roads are an area of vulnerability that regional stakeholders are interested in addressing.
- Flooding of structures, especially critical facilities, is also happening in the Mid-Carolina region. The Cumberland County Emergency Operation Center nearly flooded during Hurricane Matthew. The Sampson County Emergency Operations Center is scheduled to relocate outside of the flood hazard area in the fall of 2022. Across the region, there are schools, fire stations and law enforcement facilities in the floodplain. Cumberland County has a homeless shelter in the floodplain. There are three historical and cultural sites located in Cumberland County that fall within the 100-year floodplain: the Mansard Roof House in Fayetteville, Gully Mill in Fayetteville and

Phoenix Mason Lodge #8 in Fayetteville. These three important resources have already been damaged severely during past events.

- Dams are also a topic of concern. Many dams across the region are privately owned and are delinquent on maintenance. For example, during Hurricane Matthew, the Woodlake Dam failure in Moore County and the Carver Dam failure in Cumberland County caused water to collectively pour into the Little River, causing major issues for the southern portion of Harnett County.
- Many residents are concerned with the amount of debris in waterways. Some projects to remove debris have already been completed in Harnett County. Of course, local governments should coordinate debris removal regionwide as removing debris in one area can lead to more flooding in another.
- Rising temperatures are a concern within the region, especially since heat relief strategies have not been a priority in previous planning efforts. Residents are particularly concerned about migrant farmworkers in Sampson County who often have trouble with English and are at increased risk of heat-related illness and death because of their exposure from working long hours outdoors. High daytime and nighttime temperatures are also troubling due to the high population of elderly throughout the Mid-Carolina region. Cumberland County is worried because there are not enough case workers to provide the aging with necessary assistance.
- Based on information provided through existing plans and the North Carolina Natural Heritage Program, a large majority of the biodiversity and wildlife within the region stems from the Cape Fear River Basin. Blackwater streams and rivers in the lower Cape Fear include the South River, Black River and the Northeast Cape Fear River. Species found in the Sandhills and Coastal Plain have a high rate of endemism—meaning that they only live in that that particular location—due to unique habitats in those ecoregions. There are 35 species of greatest conservation need in the basin including two aquatic snails, two crayfish, 18 freshwater or anadromous fishes and 13 mussels.[74] The biggest challenges the Cape Fear River faces include polluted runoff from growing urban centers, agricultural operations, flooding and drought caused by climate change, unregulated chemical pollutants used by the manufacturing industry, a growing demand for limited clean water supplies, and habitat destruction due to urbanization. [75]

The next step in the RISE Regional Resilience Portfolio Program is for the project team and local stakeholders to use the information in this assessment to identify five to 10 priority resilience strategies to address vulnerabilities that impact the Mid-Carolina region. The project team will place those priority projects in a published portfolio that outlines mechanisms for implementation, project leaders and partners, potential challenges and relevant funding opportunities. NCORR has already identified funding to support some project implementation. Individuals interested in participating in the process of selecting and prioritizing key projects for tri-county area should email resilience@ncdps.gov. That process will take place summer – fall 2022.

[74] North Carolina Wildlife. 2015. *North Carolina Wildlife Action Plan.*
[75] American Rivers. Cape Fear River North Carolina.

8. References

Written Literature

American Rivers. Cape Fear River North Carolina. https://www.americanrivers.org/river/cape-fear-river/

ATSDR. 2018. *CDC's Social Vulnerability Index*. Interactive Map. https://svi.cdc.gov/map.html.

ATSDR. 2020. *CDC Social Vulnerability Index (CDC SVI)*. https://www.atsdr.cdc.gov/placeandhealth/svi/fact_sheet/pdf/SVI_FactSheet_v10152020-H.pdf.

ATSDR. 2020. *CDC SVI 2018 Documentation*. January 31, 2020. https://svi.cdc.gov/Documents/Data/2018_SVI_Data/SVI2018Documentation.pdf.

ATSDR. 2021. *CDC/ATSDR SVI Data and Documentation Download*. https://www.atsdr.cdc.gov/placeandhealth/svi/data_documentation_download.html.

Brady, Jennifer. 2018. *The High Cost of Hot.* *http://assets.climatecentral.org/pdfs/June2018_CMN_Heat.pdf*

Center for Climate and Energy Solutions. *Extreme Precipitation and Climate Change.* *https://www.c2es.org/content/extreme-precipitation-and-climate-change/*

Cumberland Hoke Regional Hazard Mitigation Planning Committee. 2020. *Cumberland-Hoke Regional Hazard Mitigation Plan, Cumberland and Hoke Counties, NC*. https://www.cumberlandcountync.gov/docs/default-source/emergency-services-documents/cumberland-hoke_regional_hazard_mitigation_plan__06-08-2016.pdf.

Davis, C. & Dello K. 2020. *Inside the Greenhouse: North Carolina's Hottest Year on Record.* *https://ncseagrant.ncsu.edu/coastwatch/current-issue/summer-2020/inside-the-greenhouse/*

DHHS. *Building Resilience Against Climate Effects.* https://epi.dph.ncdhhs.gov/oee/climate/ClimateAndHealthProfile.pdf

DHS. 2022. *Aging Infrastructure: Issues, Research, and Technology.* https://www.dhs.gov/xlibrary/assets/st-aging-infrastructure-issues-research-technology.pdf

DHS. 2022. *Critical Infrastructure.* https://www.dhs.gov/science-and-technology/criticalinfrastructure#:~:text=Critical%20infrastructure%20includes%20the%20vast,rely%20on%20these%20vital%20systems.

DOA. 2020. *N.C. Tribal and Urban Communities.* https://ncadmin.nc.gov/public/american-indians/map-nc-tribal-communities

DOE. 2020. *Low-Income Energy Affordability Data (LEAD) Tool. ACS 5-Year Average 2012-2015.* https://www.energy.gov/eere/slsc/maps/lead-tool.

DOE. 2020. *Low-Income Energy Affordability Data (LEAD) Tool.* Fact Sheet. https://lead.openei.org/assets/docs/LEAD-Factsheet.pdf.

Dyer, Jenny. 2022. *Historic Houses in the Shifting Landscape of Climate Change.* https://www.aam-us.org/2022/08/03/historic-houses-in-the-shifting-landscape-of-climate-change/

Earth Data. 2021. *Extreme Heat Toolkit.* https://www.earthdata.nasa.gov/learn/toolkits/disasters-toolkit/extreme-heat-toolkit\

EMAP. 022. *Emergency Management Accreditation Program (EMAP)*. https://www.emap.org/.

EPA. 2022. *Climate Change Indicators: Greenhouse Gases*. https://www.epa.gov/climate-indicators/greenhouse-gases.

EPA. 2021. *Excessive Heat Events Guidebook. https://www.epa.gov/heatislands/excessive-heat-events-guidebook*

FEMA. 2021. *Disaster Declarations for States and Counties*. Database.

FEMA. 2021. *Mitigation Planning and Grants*.https://www.fema.gov/emergency-managers/risk-management/hazard-mitigation-planning/requirements

FEMA. 2021. *National Flood Hazard Layer*. https://www.fema.gov/flood-maps/national-flood-hazard-layer.

Flavelle et al., 2020. *New Data Reveals Hidden Flood Risk Across America. https://www.nytimes.com/interactive/2020/06/29/climate/hidden-flood-risk-maps.html.*

Flood Science Center. 2020. *Building Coastal Resilience through Capital Improvements Planning.* https://floodsciencecenter.org/projects/building-coastal-resilience-capital-improvements-planning/

Gauthier, Taylor. 2021. *The Devastating Effects of Climate Change on US Housing Security*. April 9, 2021. https://www.aspeninstitute.org/blog-posts/the-devastating-effects-of-climate-change-on-us-housing-security/.

Harnett County. 2020. *Cape Fear Regional Hazard Mitigation Plan*. https://www.johnstonnc.com/emerserv/em/emfiles/Cape_Fear_Regional_HMP_2020.pdf.

Harnett County. 2021. *Strong Roots, Smart Growth: Harnett County Economic Development Plan. http://harnettedc.org/land-use-plan.asp.*

Headwaters Economics. *Neighborhoods at Risk Tool. https://headwaterseconomics.org/apps/neighborhoods-at-risk/37051/explore/map*

Headwaters Economics. 2022. Mobile Home Residents Face Higher Flood Risk. https://headwaterseconomics.org/natural-hazards/mobile-home-flood-risk/

Joint Center for Housing Studies of Harvard University. 2022. *America's Rental Housing 2022*. https://www.jchs.harvard.edu/americas-rental-housing-2022.

Konrad, Christopher. 2016. *Effects of Urban Development on Floods. https://pubs.usgs.gov/fs/fs07603/*

National Drought Mitigation Center. 2022. *US Drought Monitor*. https://droughtmonitor.unl.edu/.

National Weather Service. *Floods.* https://www.weather.gov/pbz/floods

Native Land Digital. 2021. https://native-land.ca/

NOAA. 2022. *National Integrated Drought Information System*. https://www.drought.gov/states/north-carolina/county.

NOAA. Glossary. https://forecast.weather.gov/glossary.php?word=Excessive%20Heat

NOAA. 2022. Storm Events Database.

NOAA. 2021. *Weather Related Fatality and Injury Statistics*. https://www.weather.gov/hazstat/.

North Carolina Drought Management Advisory Council. 2022. *US Drought Monitor of North Carolina*. https://www.ncdrought.org/.

North Carolina Forest Service. 2017. *The Wildland/Urban Interface*. http://ncforestservice.gov/fire_control/fc_wui.htm.

North Carolina Forest Service. 2020. *2020 North Carolina Forest Action Plan*. https://www.ncforestactionplan.com/PDF/2020/FINAL-NC2020FAP.pdf.

North Carolina Institute for Climate Studies. 2020. *North Carolina Climate Science Report*. September 2020. https://files.nc.gov/ncdeq/climate-change/climate-scinece-report/NC_Climate_Science_Report_FullReport_Final_revised_September2020.pdf.

North Carolina Wildlife. 2015. *North Carolina Wildlife Action Plan.* https://www.ncwildlife.org/Portals/0/Conserving/documents/2015WildlifeActionPlan/Section-4-5-5-Cape-Fear-River-basin-1st-Draft.pdf.

NWS. 2020. *Weather Related Fatality and Injury Statistics*. https://www.weather.gov/hazstat/.

Ogeechee Riverkeeper. 2020. *Tannins and Blackwater Rivers.* *https://www.ogeecheeriverkeeper.org/tannins-and-blackwater-rivers/*

PolicyMap. 2022. 2010 Census Data. https://www.policymap.com/newmaps#/.

PolicyMap. 2022. *ACS 5-year estimates 2015-2019*. https://www.policymap.com/newmaps#/.

PolicyMap. 2022. *ACS 5-year estimates 2016-2020*. https://www.policymap.com/newmaps#/.

PolicyMap. 2022. 2020 Census Data. https://www.policymap.com/newmaps#/.

Quadriga. *The Effects of Climate Change on Historic Buildings.* *https://www.quadrigaltd.com/the-effects-of-climate-change-on-historic-buildings/.*

Radeloff, Volker C., David P. Helmers, H. Anu Kramer, and Susan I. Stewart. 2018. “Rapid growth of the US wildland-urban interface raises wildfire risk.” *Proceedings of the National Academy of Sciences*. March 12, 2018.

Reed, Kevin. 2018. Estimating the Potential Impact of Climate Change on Hurricane Florence. https://you.stonybrook.edu/kareed/2018/09/12/estimating-the-potential-impact-of-climate-change-on-hurricane-florence/.

Sampson County. 2020. *Sampson Duplin Regional Hazard Mitigation Plan*. https://cms1files.revize.com/revize/sampsoncounty/document_center/EMS/Hazard%20Mitigation/Sampson_Duplin_Regional_HMP_2020-11-24%20(1)[2305843009214674415].pdf.

Sfetsos et al. 2021. *Assessing the Effects of Forest Fires on Interconnected Critical Infrastructures under Climate Change.* https://www.mdpi.com/2412-3811/6/2/16/htm.

Southern Group of State Foresters. *Wildfire Risk Assessment Portal.* https://southernwildfirerisk.com/.

State of North Carolina. 2017. *Hurricane Matthew Resilient Redevelopment Plan, Cumberland County*. May 2017.https://files.nc.gov/rebuildnc/documents/matthew/rebuildnc_cumberland_plan_combined.pdf.

State of North Carolina. 2017. *Hurricane Matthew Resilient Redevelopment Plan, Harnett County*. May 2017. https://files.nc.gov/rebuildnc/documents/matthew/rebuildnc_harnett_plan_combined.pdf.

State of North Carolina. 2017. *Hurricane Matthew Resilient Redevelopment Plan, Sampson County*. May 2017. https://files.nc.gov/rebuildnc/documents/matthew/rebuildnc_sampson_plan_combined.pdf.

State of North Carolina. 2018. *North Carolina Enhanced State Hazard Mitigation Plan*. February 2018. https://files.nc.gov/ncdps/documents/files/State%20of%20North%20Carolina%20Hazard%20Mitigation%20Plan%20Final%20As%20Adopted.pdf.

United Nations Population Fund. 2013. *Sustainable Development and Population Dynamics: Placing People at the Centre*. https://www.unfpa.org/press/sustainable-development-and-population-dynamics-placing-people-centre.

US Census Bureau, American Community Survey 5-year Estimates (2011-2015), Table B25002, "Occupancy Status"; Table B25003, "Tenure"; Table B25024 “Units in Structure”; Table B25077, "Median Value (Dollars)." National Housing Preservation Database.

US Census Bureau. 2019 Estimates. https://www.census.gov/quickfacts/fayettevillecitynorthcarolina.

US Climate Resilience Toolkit. 2021. *Glossary*. *https://toolkit.climate.gov/content/glossary.*

Weeden, Sophia. 2022. *The Threat of Environmental Hazards to the Rental Stock*. March 9, 2022. https://www.jchs.harvard.edu/blog/threat-environmental-hazards-rental-stock.

Datasets

- **Parcel Data –** NC One Map (https://www.nconemap.gov/pages/parcels)

  Used to calculate estimated number of buildings and estimated damages for all hazards

- **Historic Hurricane Tracts** – National Centers for Environmental Information (NCEI) (https://www.ncei.noaa.gov/products/international-best-track-archive?name=wmo-format)

- **Floodplains** – FEMA Flood Map Service Center (https://msc.fema.gov/portal/home)

- **Wildfire Risk Data –** Southern Group of State Foresters - Wildfire Risk Assessment Portal (https://www.southernwildfirerisk.com/)

  Utilized the professional viewer to download WUI raster datasets by county

- **Critical Facilities –** NC One Map
  - **Hospitals** (https://www.nconemap.gov/maps/hospitals)
  - **Fire Stations** (https://www.nconemap.gov/datasets/6f4fe0c55b0d4cbb92877e461d698c29_0/explore?location=34.759777%2C-80.017373%2C7.05)
  - **EMS** (https://www.nconemap.gov/datasets/nconemap::emergency-medical-services/explore)
  - **Police** (https://www.nconemap.gov/maps/law-enforcement-locations)
  - **Public Schools** (https://www.nconemap.gov/maps/public-schools)

- **Largest Employers -** NC Department of Commerce (https://d4.nccommerce.com/QCEWLargestEmployers.aspx)

Appendix A – Areas of Vulnerability Identified by the Stakeholder Partnership

The project team created an interactive mapping tool for the Stakeholder Partnership and the public to use during Stakeholder Partnership meetings and public workshops. Users of the tool could map and makes notes about problem areas. They could include the hazard of concern, the event in which the impact occurred and the issue to be addressed. This visualization and information helped the project team locate specific sites in need of solutions.

The maps on the following pages show the specific locations identified in the interactive mapping tool, and the table thereafter provides summary information for each area.

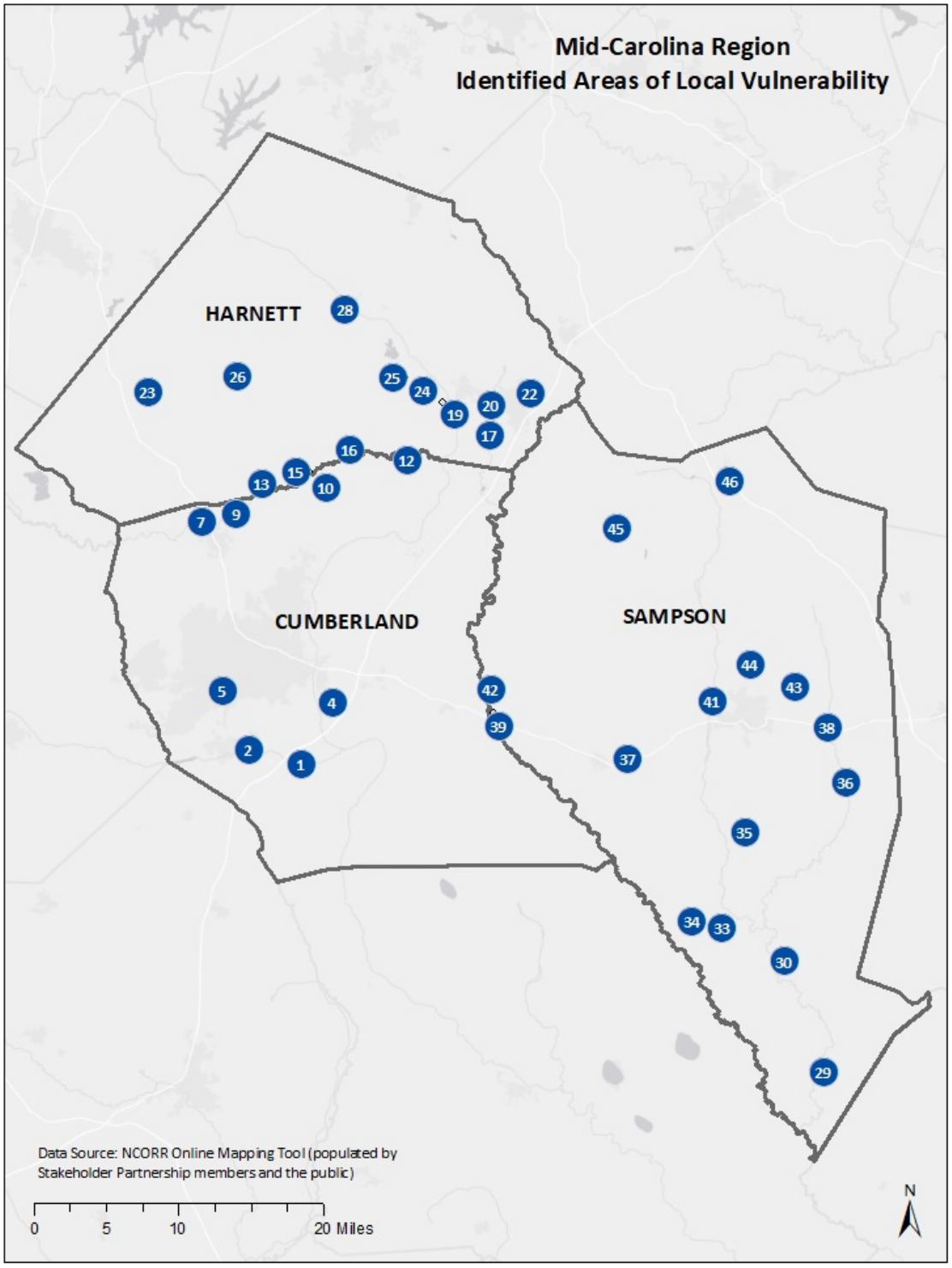

Figure A-1. Areas of Vulnerability Identified by Stakeholders in the Mid-Carolina Region

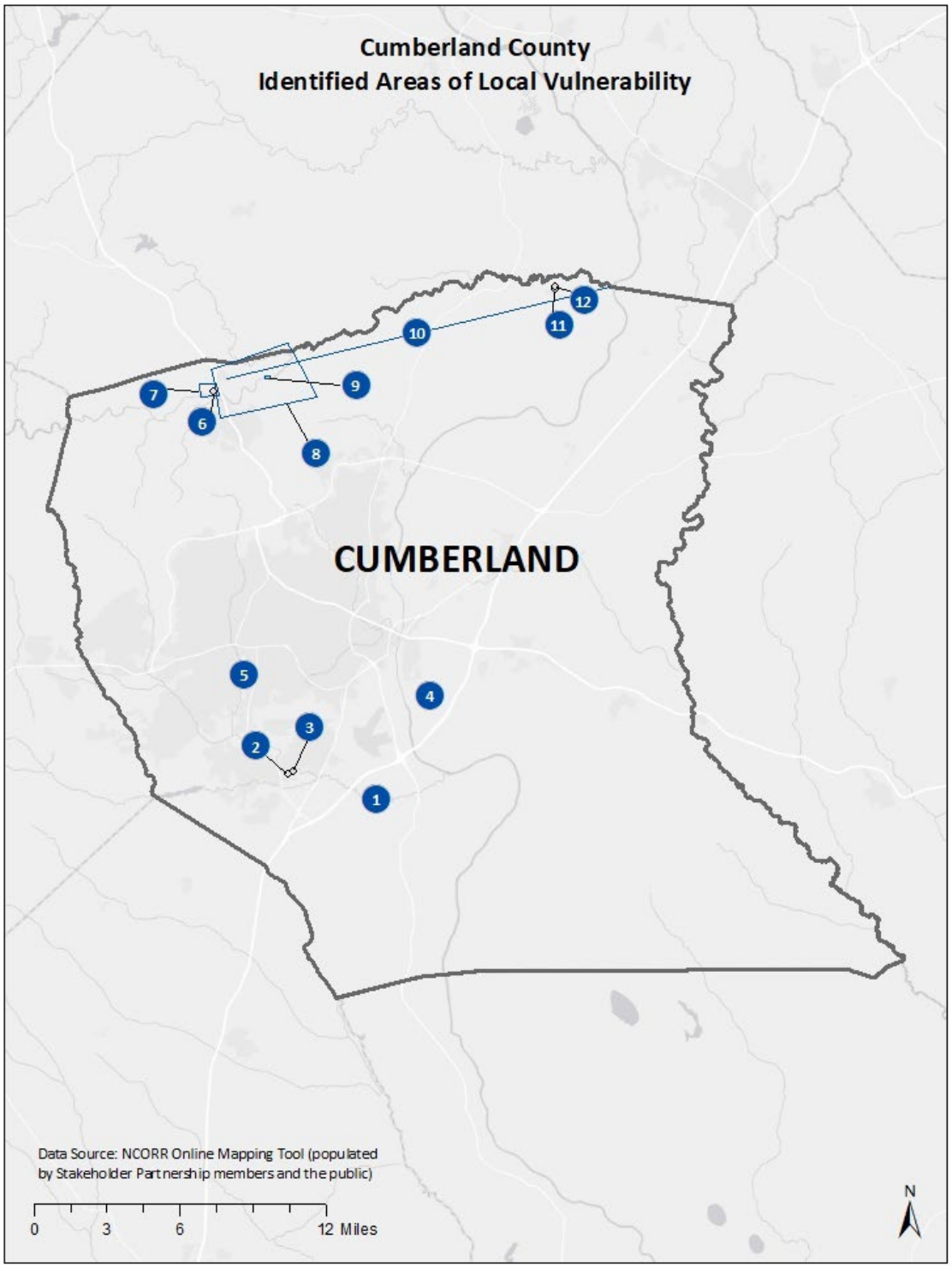

Figure A-2. Areas of Vulnerability Identified by Stakeholders in Cumberland County

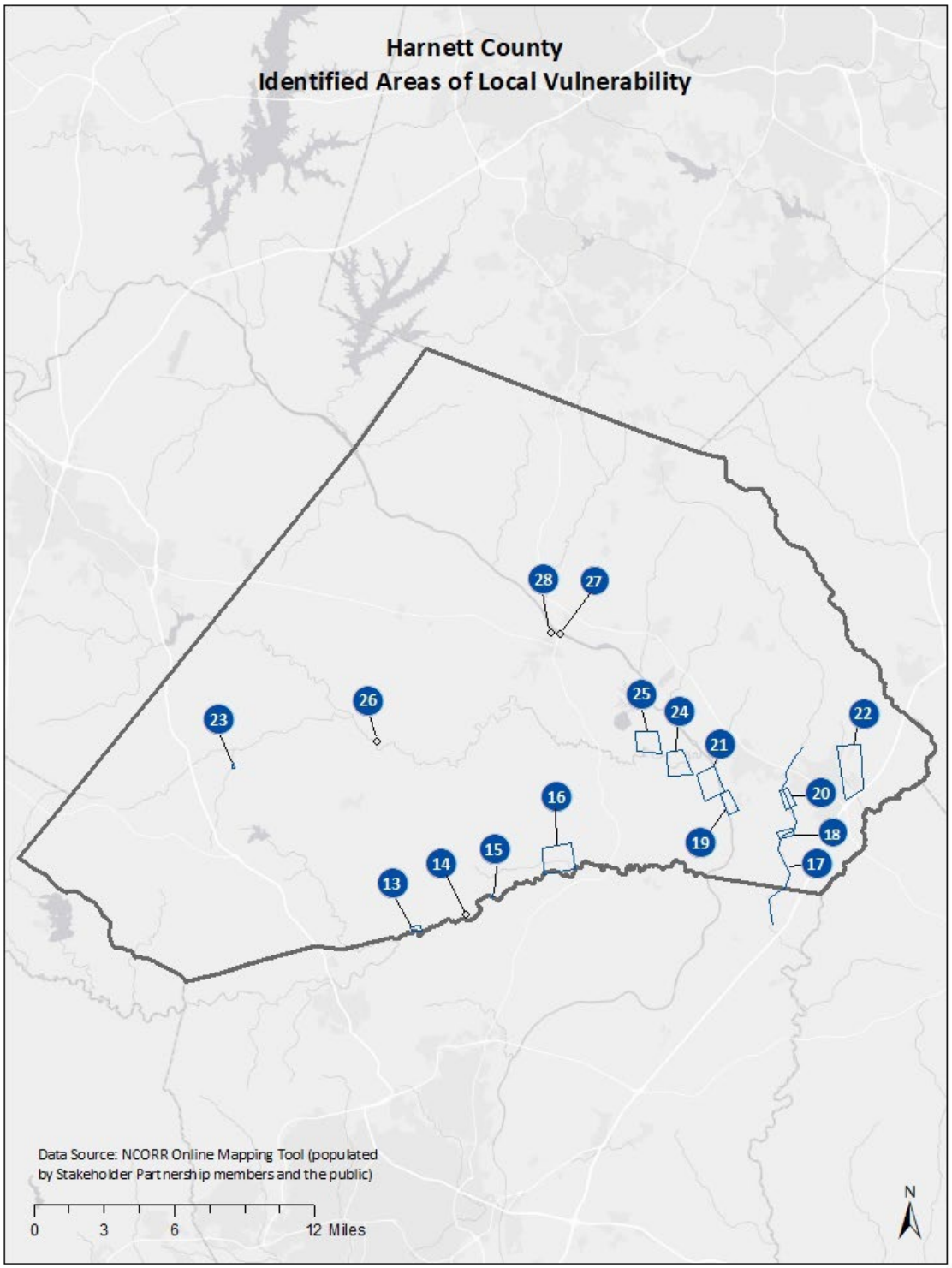

Figure A-3. Areas of Vulnerability Identified by Stakeholders in Harnett County

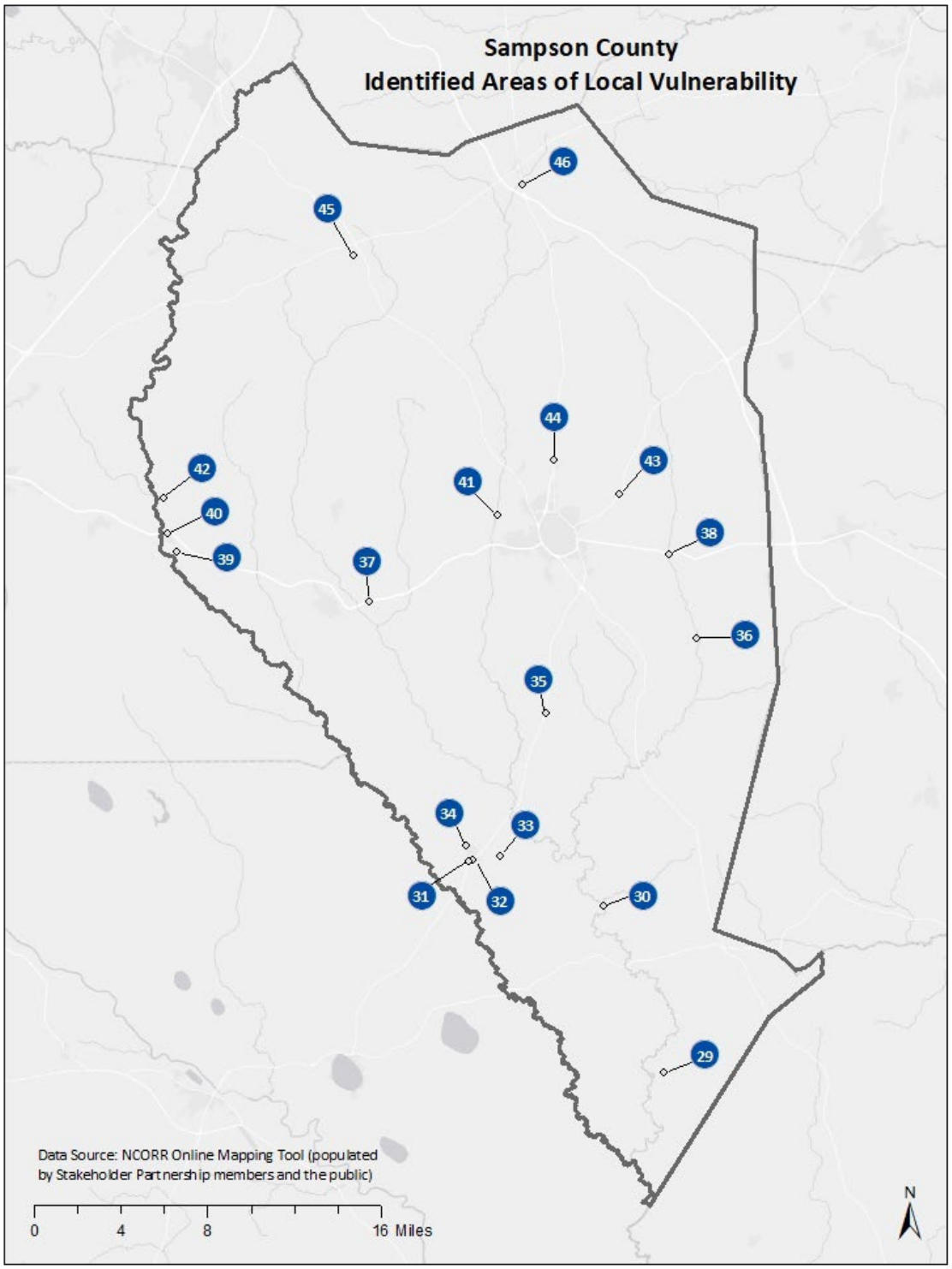

Figure A-4. Areas of Vulnerability Identified by Stakeholders in Sampson County

Table A-1. Information for Problem Areas Identified in Figures A-1 – A-4

ID	Hazard	Event	Issue
CUMBERLAND COUNTY			
1	Flooding	Reoccurring	Flooding into residential neighborhoods.
2	Flooding	Hurricane Matthew	Dentist office flooded and relocated after Matthew
3	Flooding	Hurricane Matthew	5-6 homes flooded here during Matthew
4	Flooding	Reoccurring	Area subject to frequent flooding - Added from article https://carolinapublicpress.org/53060/fixing-local-flooding-when-feds-deny-its-in-a-floodplain/
5	Flooding	Hurricane Matthew	Dam breach during Hurricane Matthew
6	Flooding	Hurricane Florence	Area flooded during Hurricane Florence
7	Flooding	Hurricane Florence	Area subject to repetitive flooding
8	Flooding	Hurricane Florence	Big problem area during Hurricane Florence
9	Flooding	Hurricane Florence	Several houses were flooded out along this corridor
10	Flooding	Reoccurring	Debris, flat, low, development pressure from Bragg and Pope, public water and sewer
11	Flooding	Reoccurring	Undersized culvert
12	Flooding	Reoccurring	Heavy storm debris
HARNETT COUNTY			
13	Flooding	Reoccurring	Area subject to repetitive flooding
14	Flooding	Reoccurring	Wastewater Treatment Plant subject to flooding
15	Flooding	Reoccurring	Area subject to repetitive flooding - three houses
16	Flooding	Reoccurring	Area subject to repetitive flooding
17	Flooding	Reoccurring	Impervious surface impacts to flood stage water. Debris collection concerns.
18	Flooding	Reoccurring	Area subject to repetitive flooding
19	Flooding	Reoccurring	Area subject to repetitive flooding - near Chicora Golf Club
20	Flooding	Reoccurring	Area subject to repetitive flooding
21	Flooding	Reoccurring	Riverside - grant to clean out the river in that area
22	Flooding	Reoccurring	Dam washed out - Hannah's Lake/Pond. The County has been awarded funding to study this area and identify potential upstream mitigation opportunities.
23	Flooding	Reoccurring	Low area - LOMR will fix some but still an issue
24	Flooding	Reoccurring	Area subject to repetitive flooding
25	Flooding	Reoccurring	Area subject to repetitive flooding
26	Flooding	Reoccurring	Road subject to frequent flooding - 2 manufactured homes that flood along NC-27 and Nursery Rd
27	Flooding	Reoccurring	Critical Bridge Crossing
28	Flooding	Reoccurring	Wastewater Treatment Plant subject to flooding
SAMPSON COUNTY			
29	Flooding	Reoccurring	Black River runs through this community
30	Flooding	Reoccurring	There is a gauge at this location however gauge does not have forecast abilities as other do in the NC FIMAN Network

ID	Hazard	Event	Issue
31	Flooding	Reoccurring	Area subject to frequent flooding
32	Flooding	Reoccurring	Highway washout, lose access, river on each side
33	Flooding	Reoccurring	Washout 2 miles from Garland to Roseboro, Harrells
34	Electrical Outage	Reoccurring	Well does not have back-up generation power (does not turn on automatically) supply part of county residents not just town
35	Flooding	Reoccurring	Area subject to frequent flooding
36	Flooding	Reoccurring	High water issues affect nearby roadways
37	Flooding	Reoccurring	Highway 24 between Clinton & Roseboro - At risk of flooding
38	Flooding	Reoccurring	Area subject to frequent flooding
39	Wildfire	Reoccurring	3-4 a year to 3-4 a week (increased frequency)
40	Flooding	Hurricane Matthew	Roads closures were on & off, high water, runoff from Fayetteville to Raleigh, South River
41	Flooding	Reoccurring	Major water that drains into the Black River - Tends to flood, vegetation/overgrowth has exacerbated issue
42	Flooding	Reoccurring	Flood tendency especially within low lying areas
43	Flooding	Reoccurring	Highway 43 north of Clinton - At risk of flooding
44	Flooding	Reoccurring	Area subject to frequent flooding
45	Flooding	Reoccurring	Area subject to frequent flooding
46	Flooding	Reoccurring	Area subject to frequent flooding

Appendix B – Public Survey

The following pages contain the questions of the public survey used to increase opportunities for the public to submit comments about the Mid-Carolina region's hazards and vulnerabilities.

Appendix C – Flood Hazard Maps

The maps below, obtained from the North Carolina Floodplain Mapping Program, show the 100- and 500-year flood zones for each county and municipality within the Mid-Carolina region.

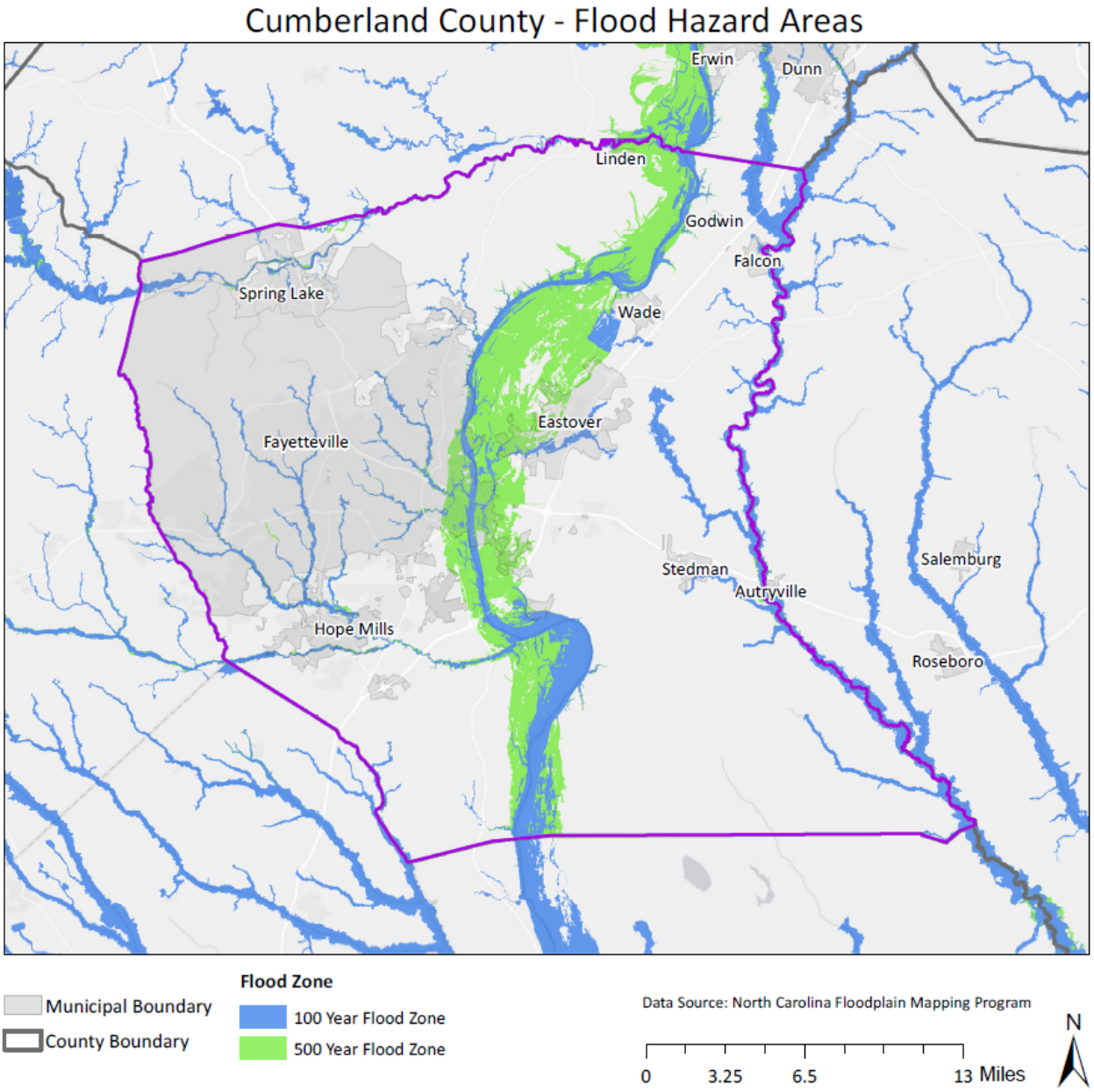

Figure C-1. Flood Hazard Areas in Cumberland County, NC

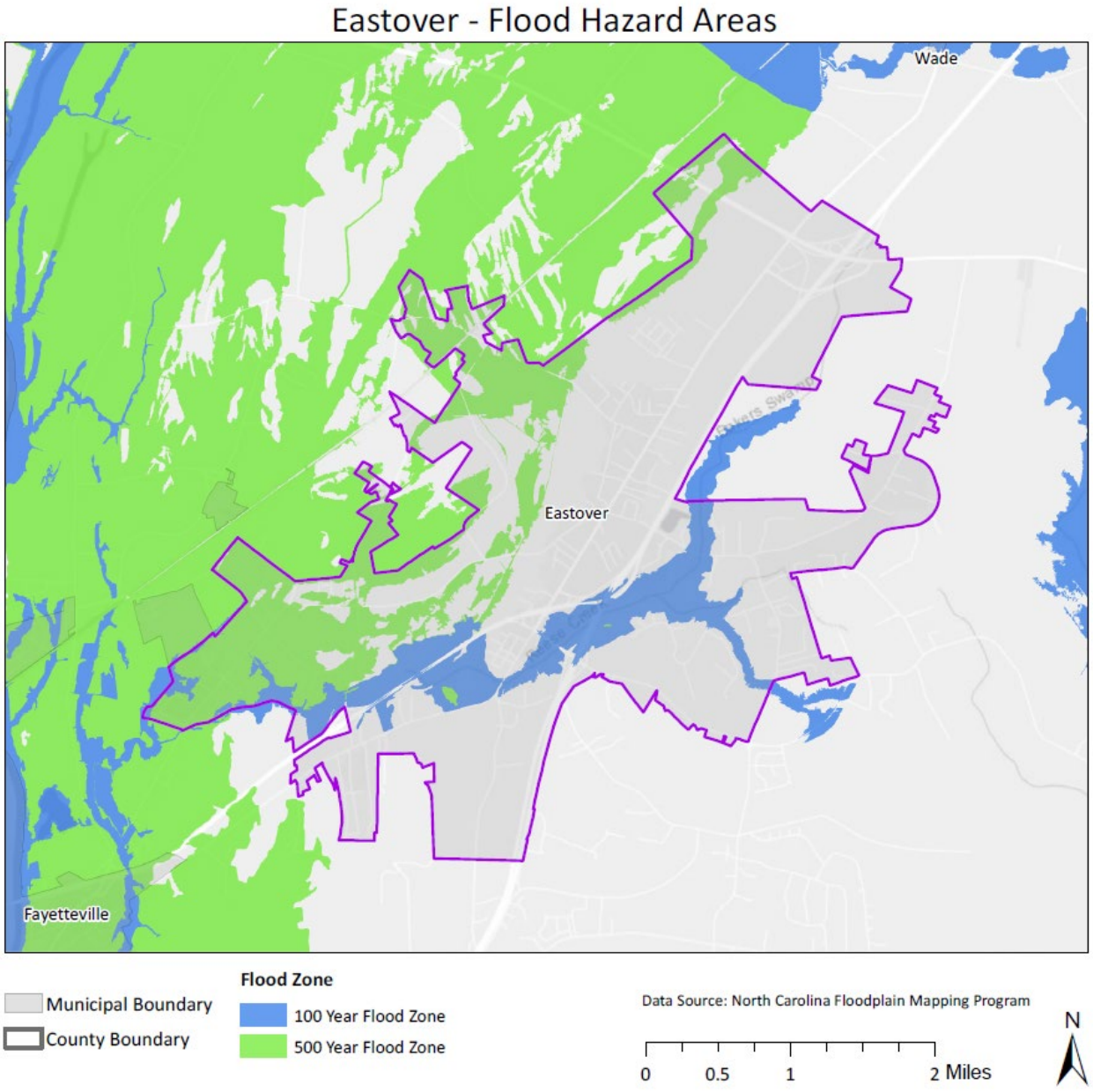

Figure C-2. Flood Hazard Areas in Eastover, Cumberland County, NC

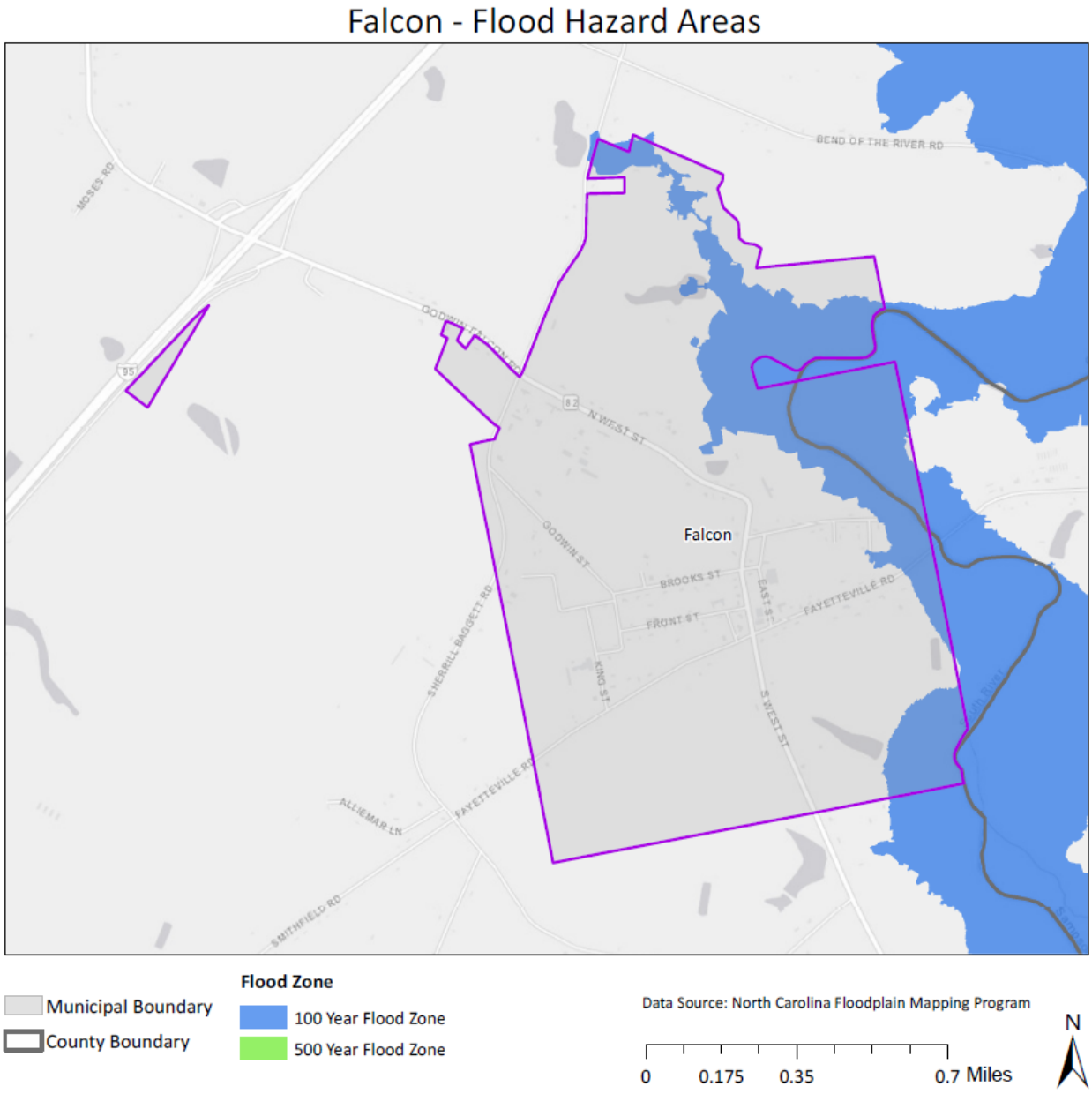

Figure C-3. Flood Hazard Areas in Falcon, Cumberland County, NC

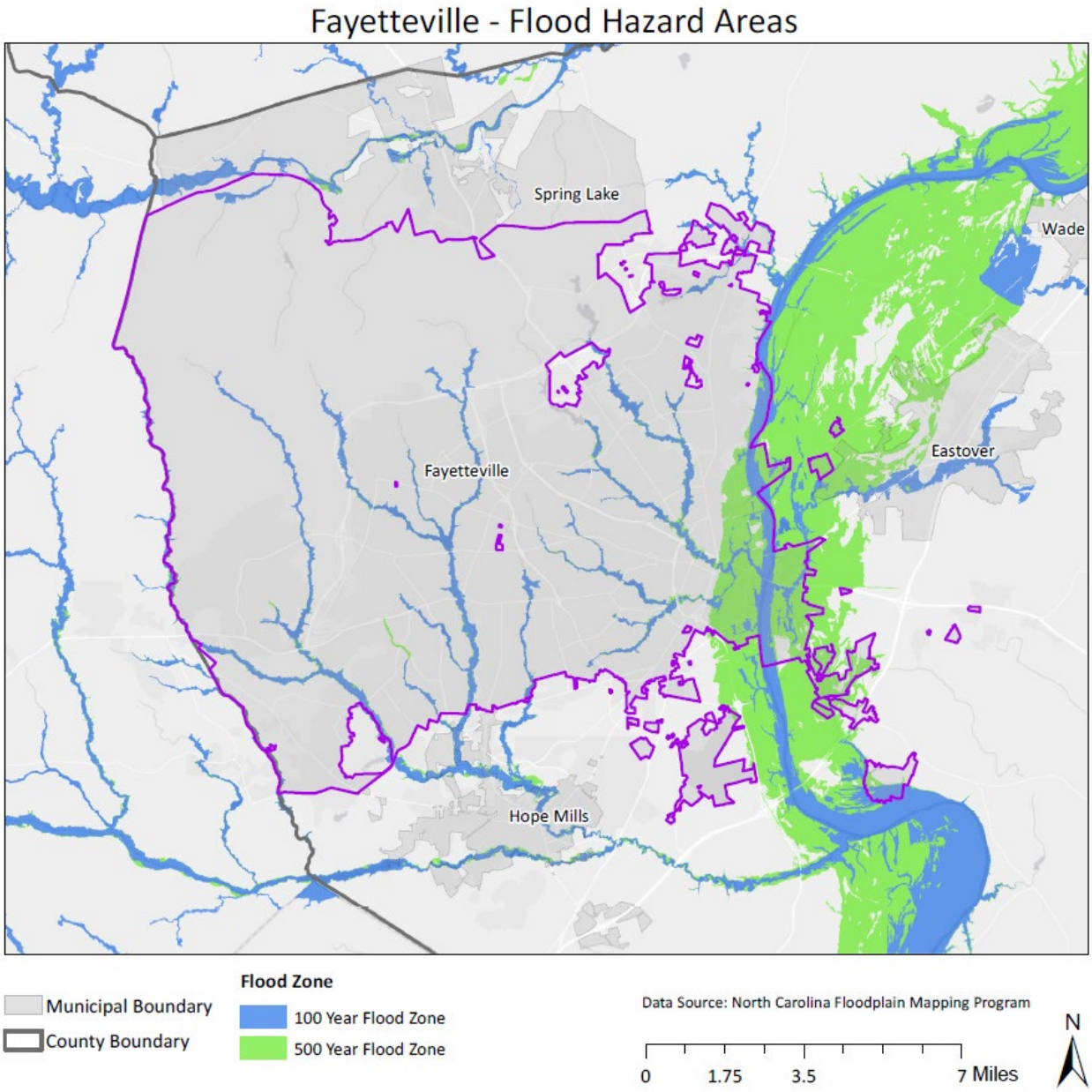

Figure C-4. Flood Hazard Areas in Fayetteville, Cumberland County, NC

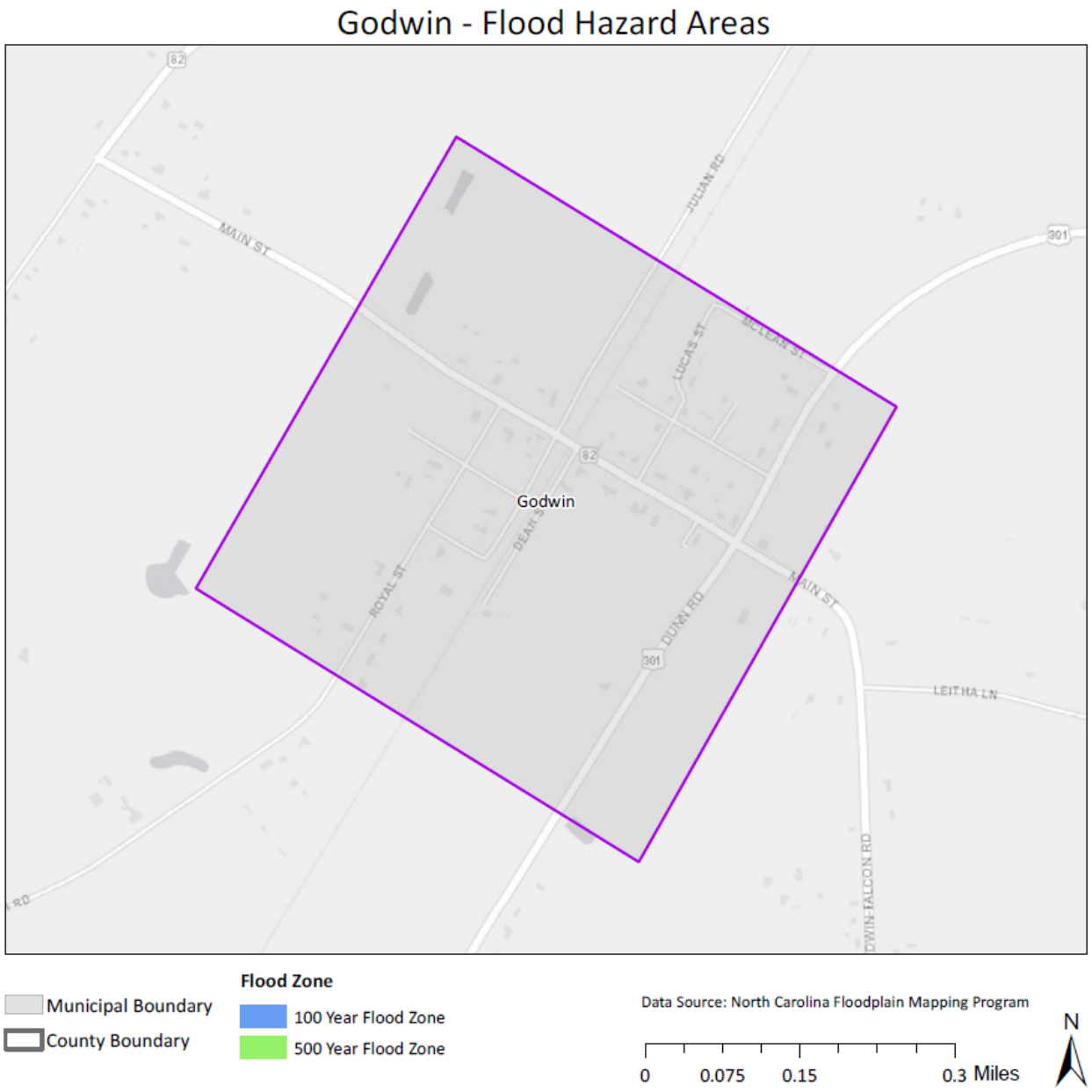

Figure C-5. Flood Hazard Areas in Godwin, Cumberland County, NC

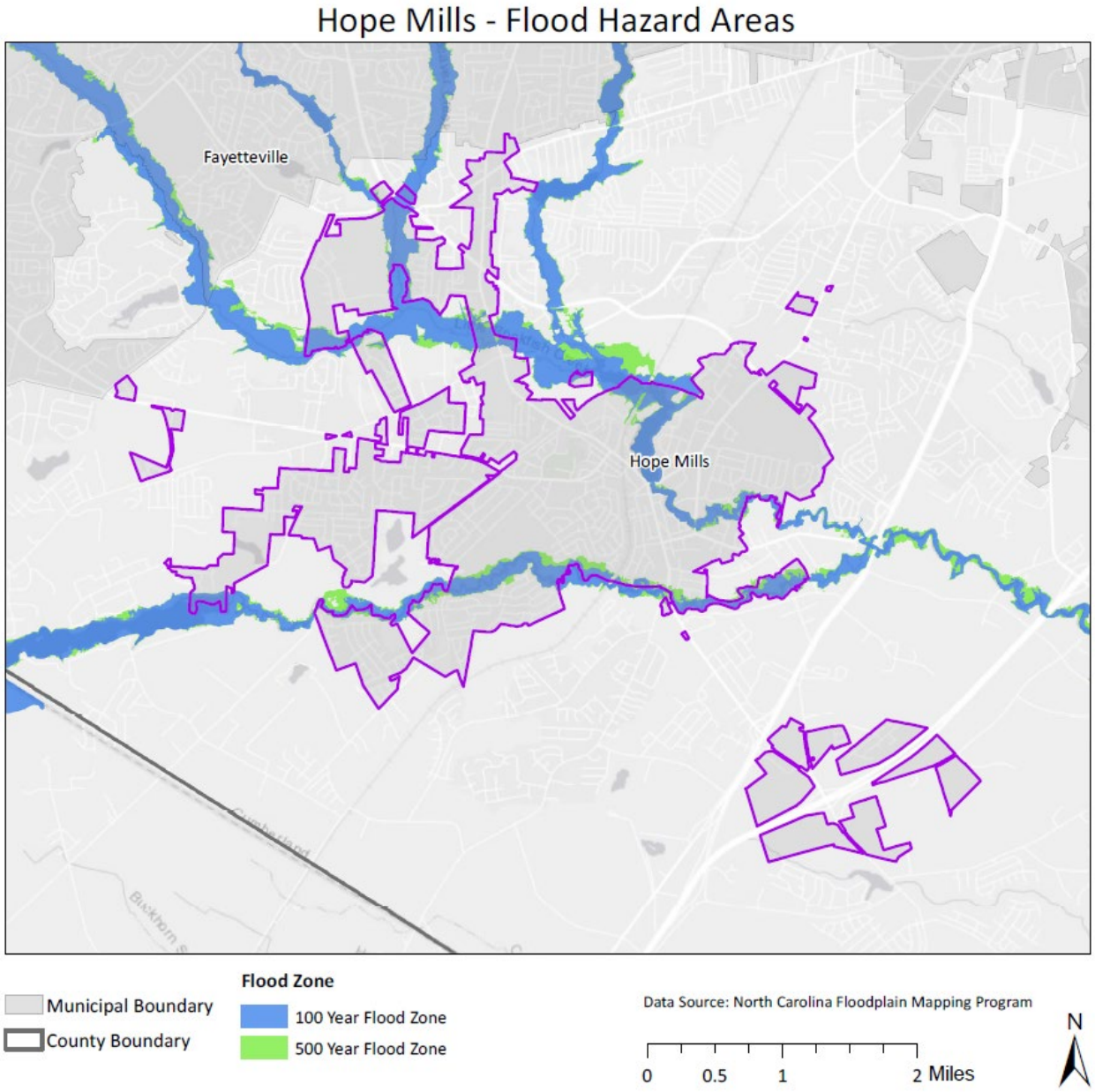

Figure C-6. Flood Hazard Areas in Hope Mills, Cumberland County, NC

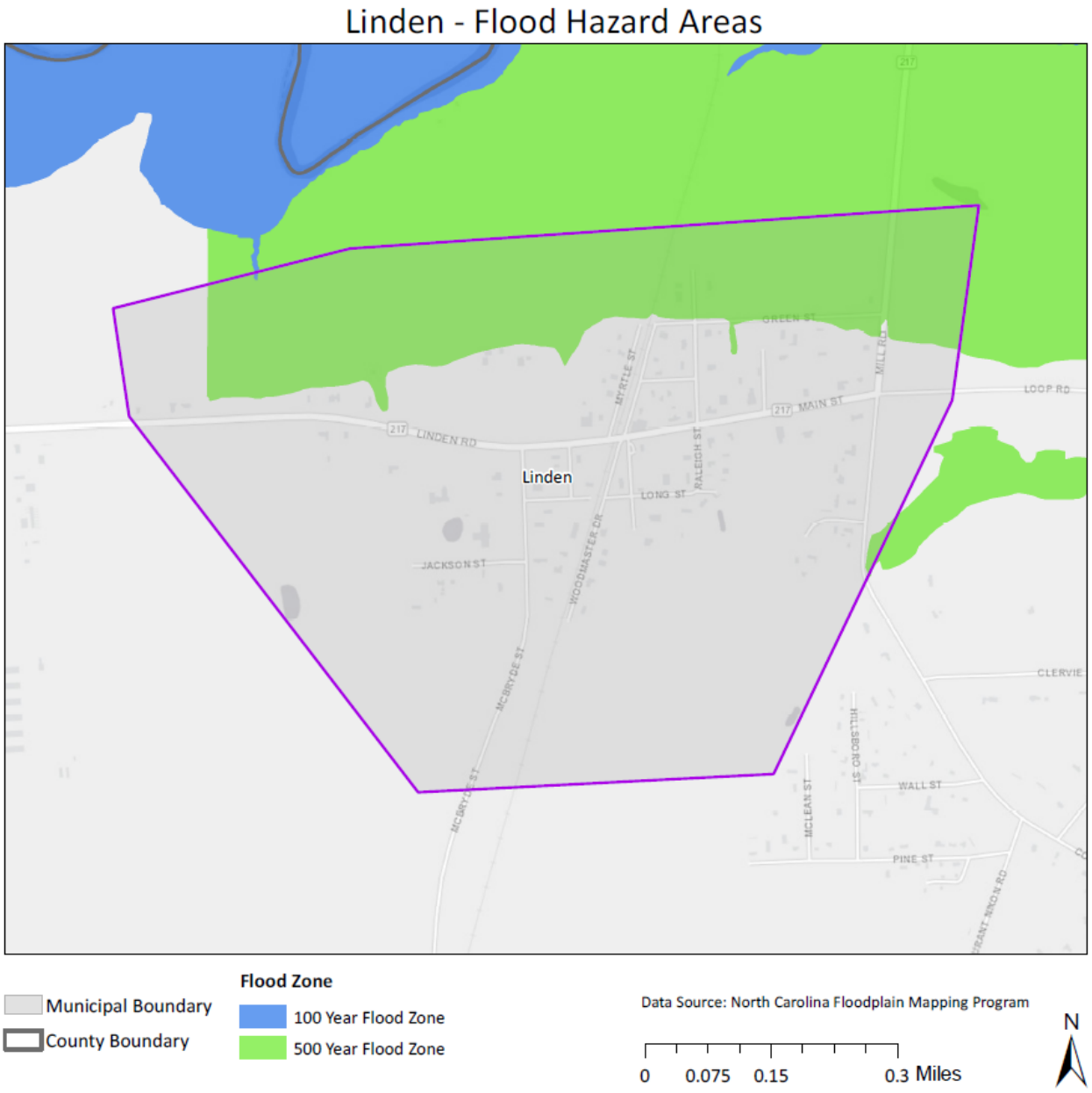

Figure C-7. Flood Hazard Areas in Linden, Cumberland County, NC

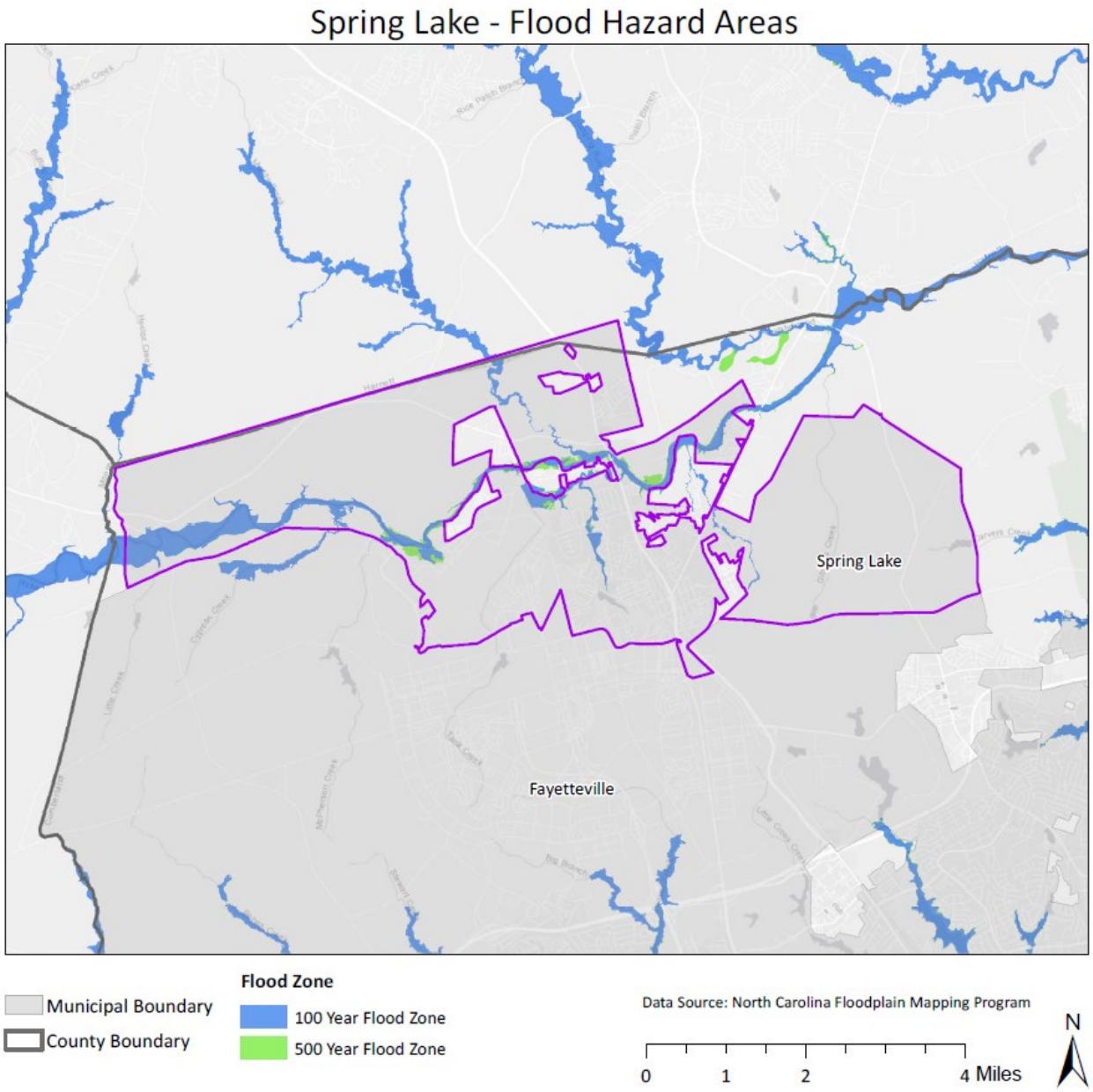

Figure C-8. Flood Hazard Areas in Spring Lake, Cumberland County, NC

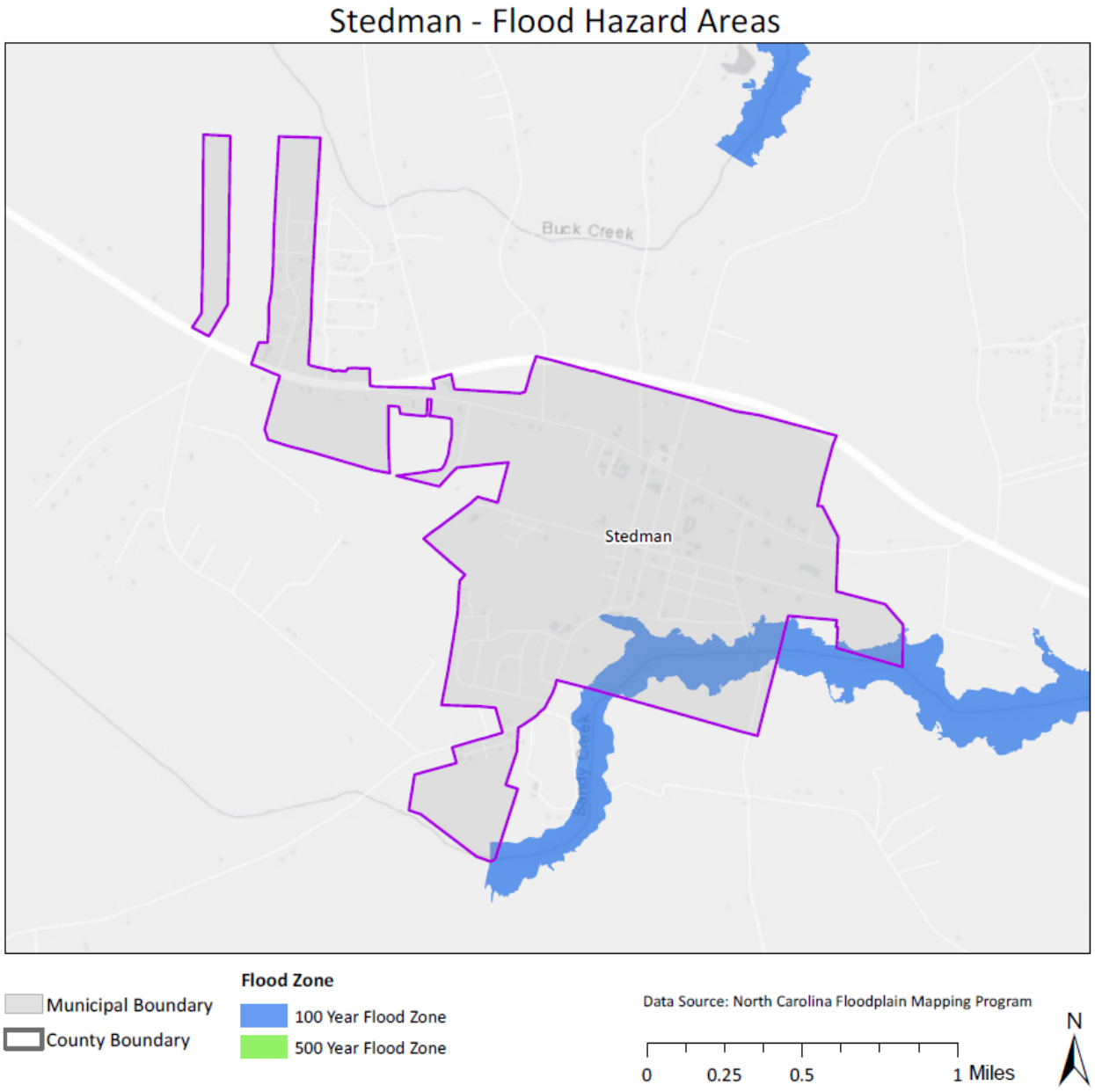

Figure C-9. Flood Hazard Areas in Stedman, Cumberland County, NC

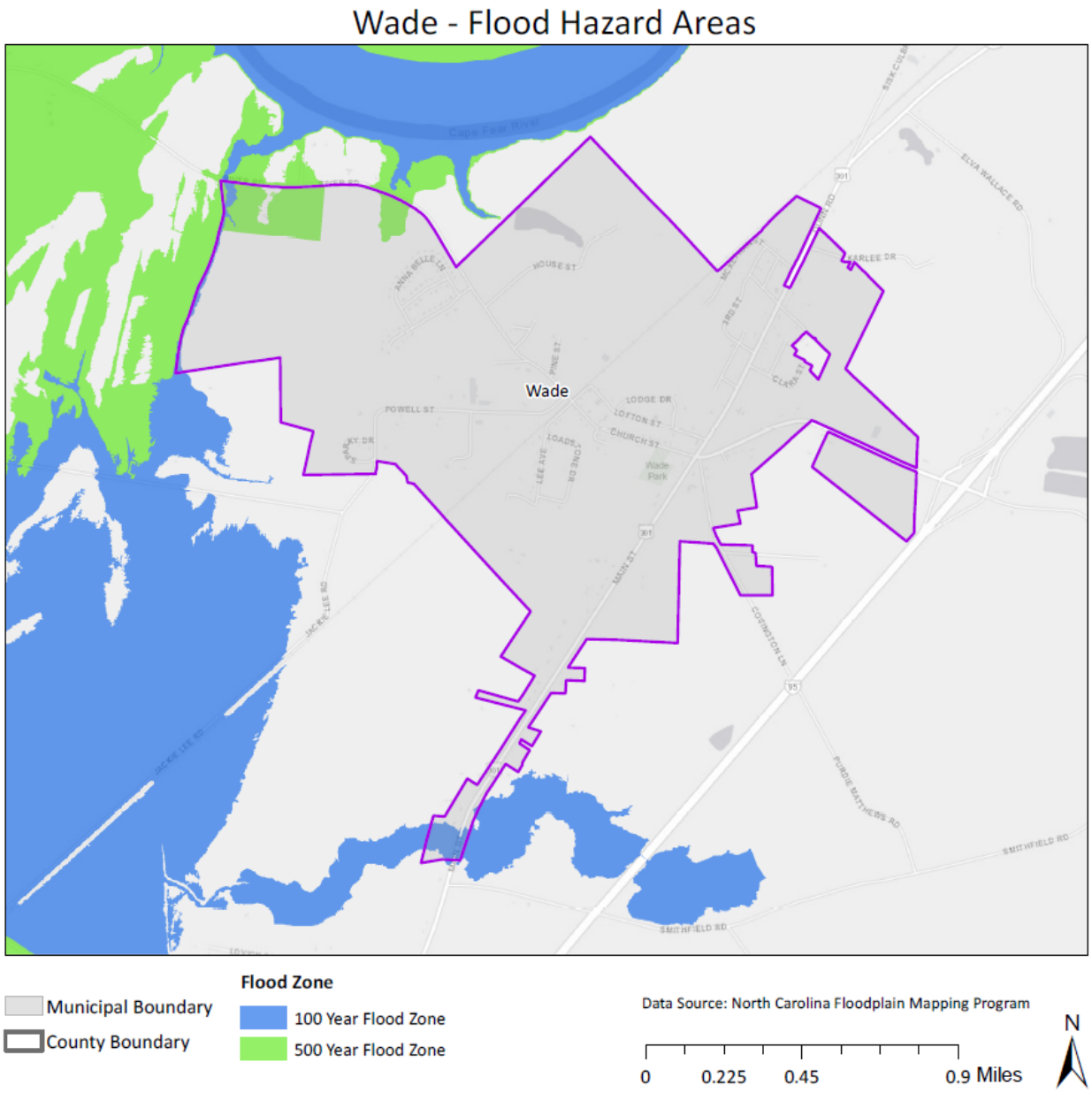

Figure C-10. Flood Hazard Areas in Wade, Cumberland County, NC

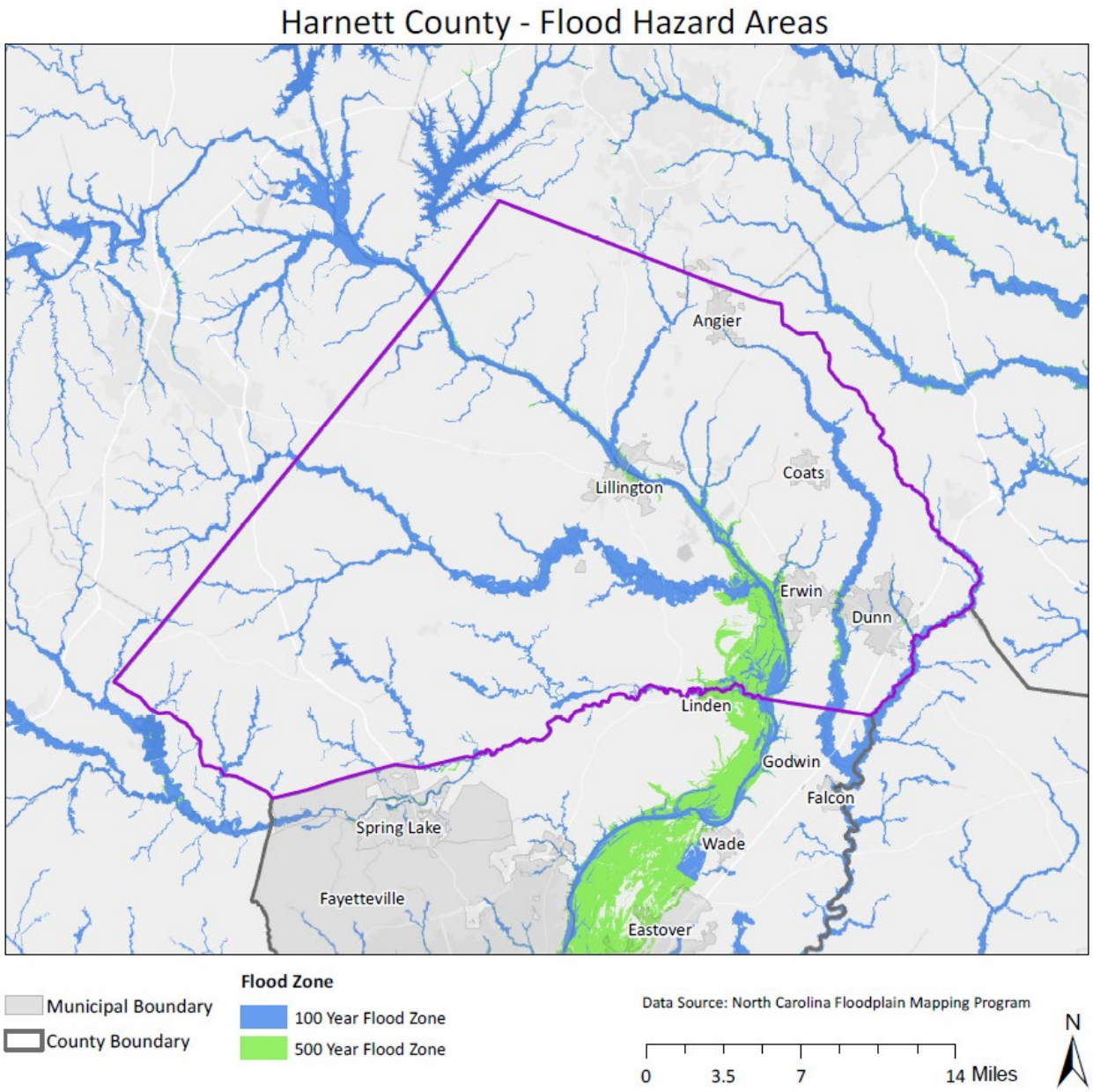

Figure C-11. Flood Hazard Areas in Harnett County, NC

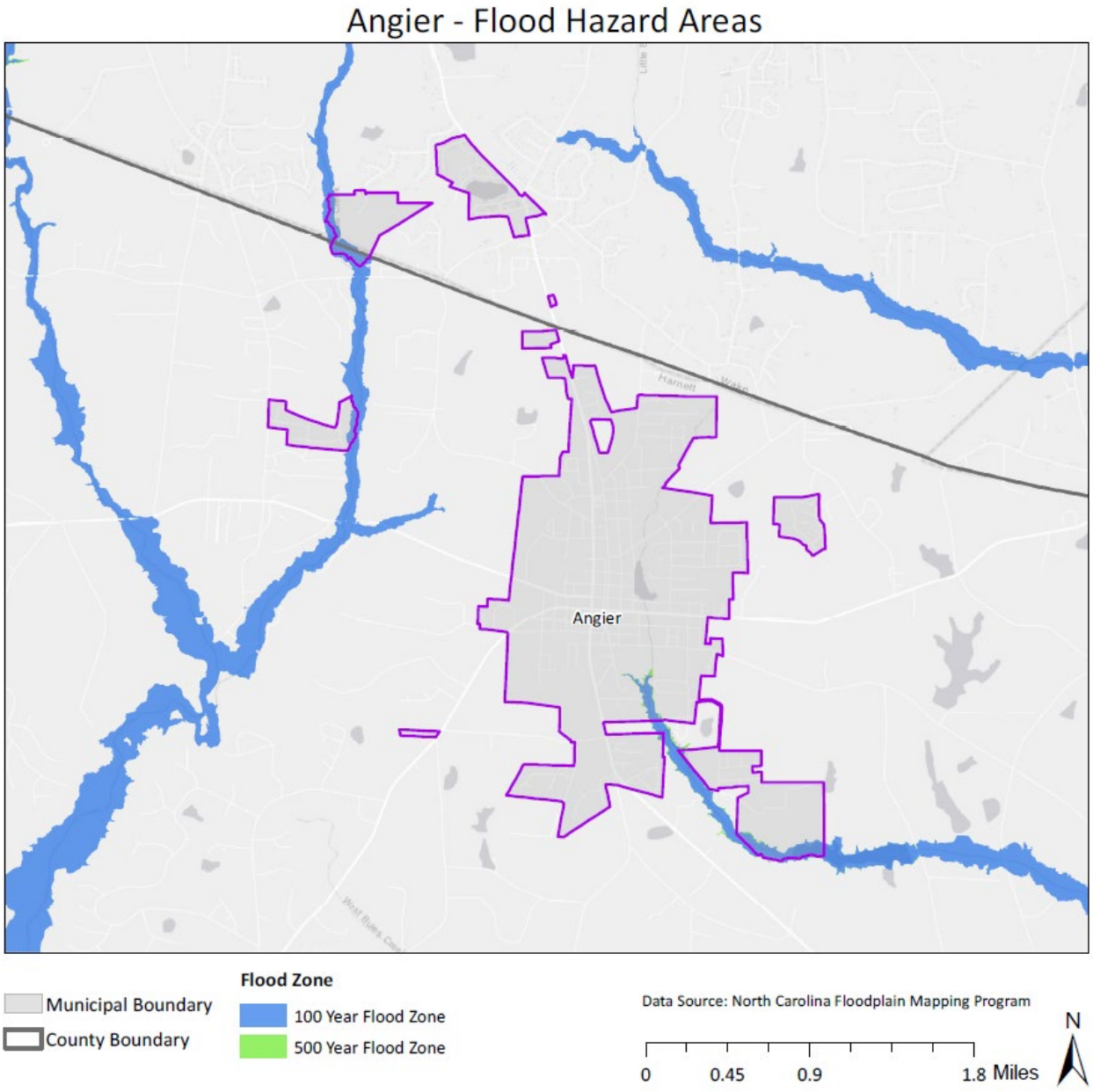

Figure C-12. Flood Hazard Areas in Angier, Harnett County, NC

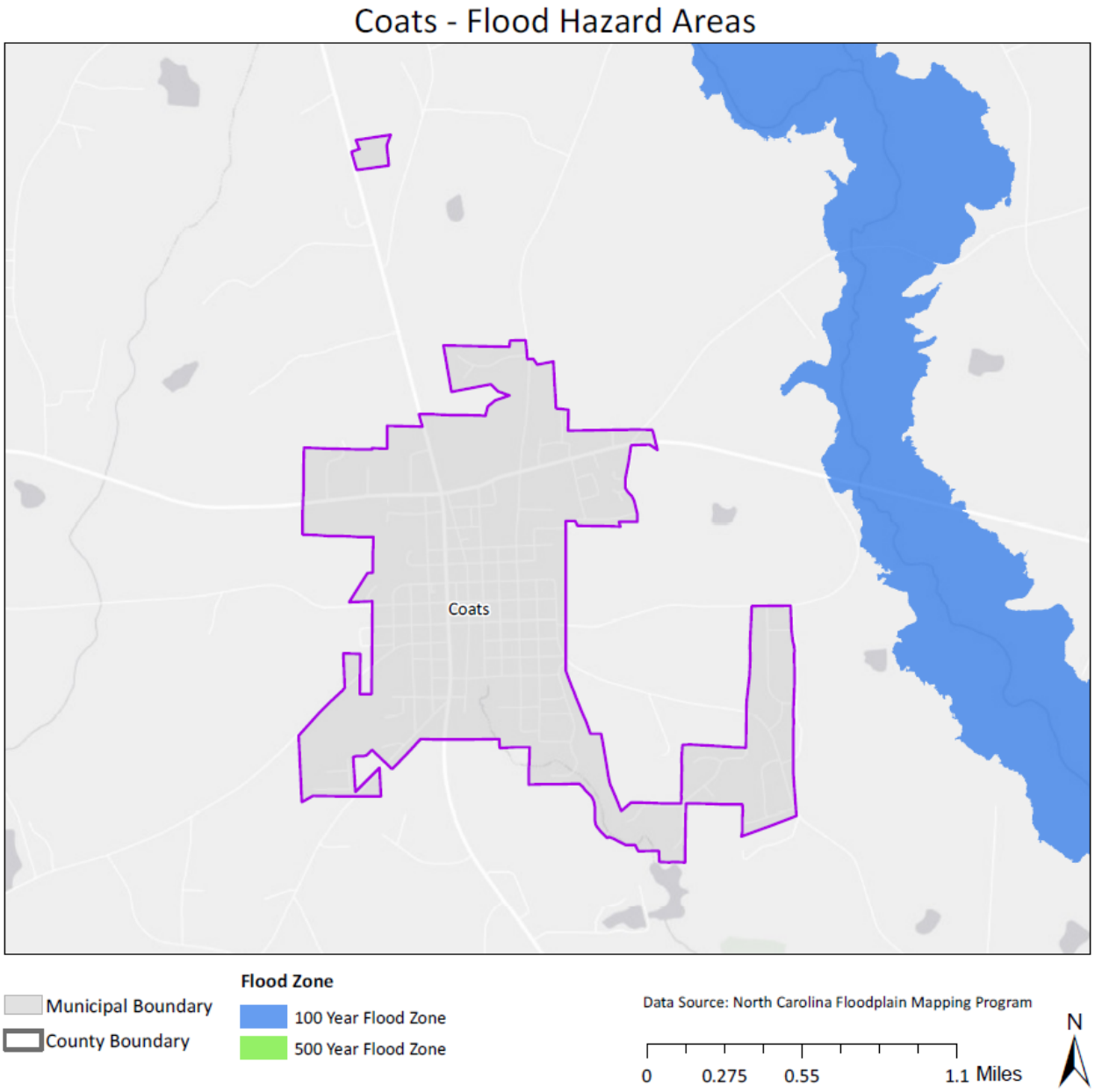

Figure C-13. Flood Hazard Areas in Coats, Harnett County, NC

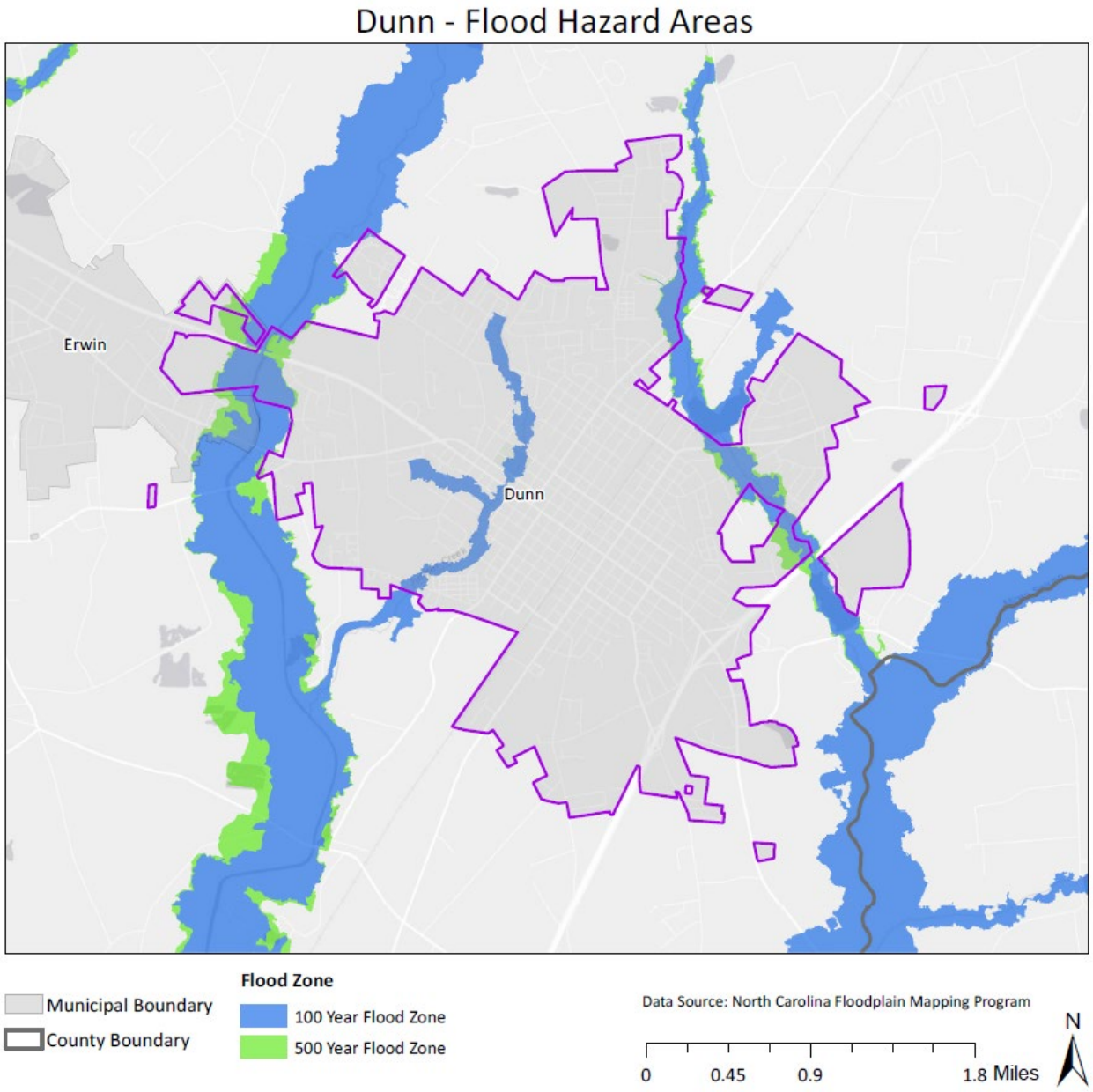

Figure C-14. Flood Hazard Areas in Dunn, Harnett County, NC

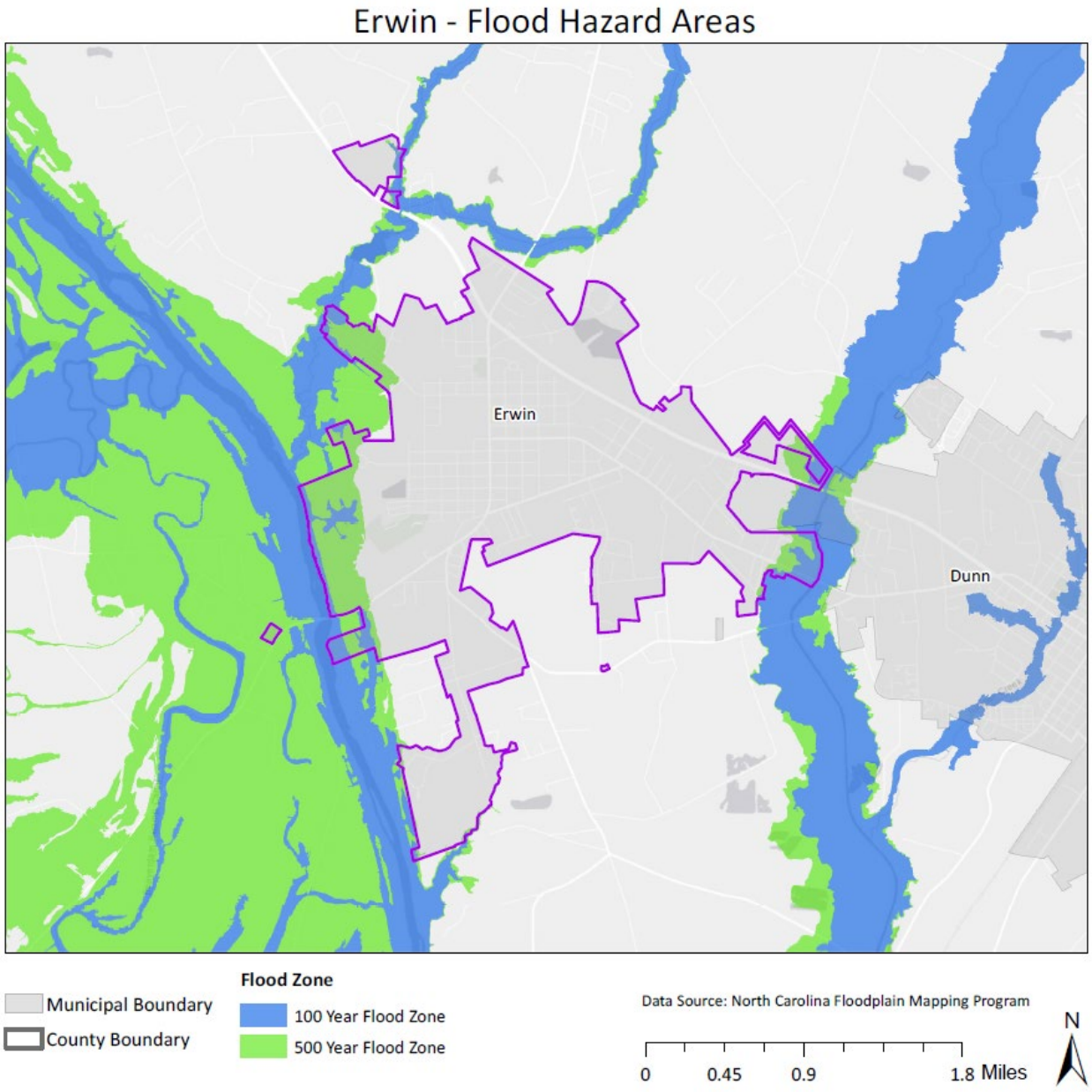

Figure C-15. Flood Hazard Areas in Erwin, Harnett County, NC

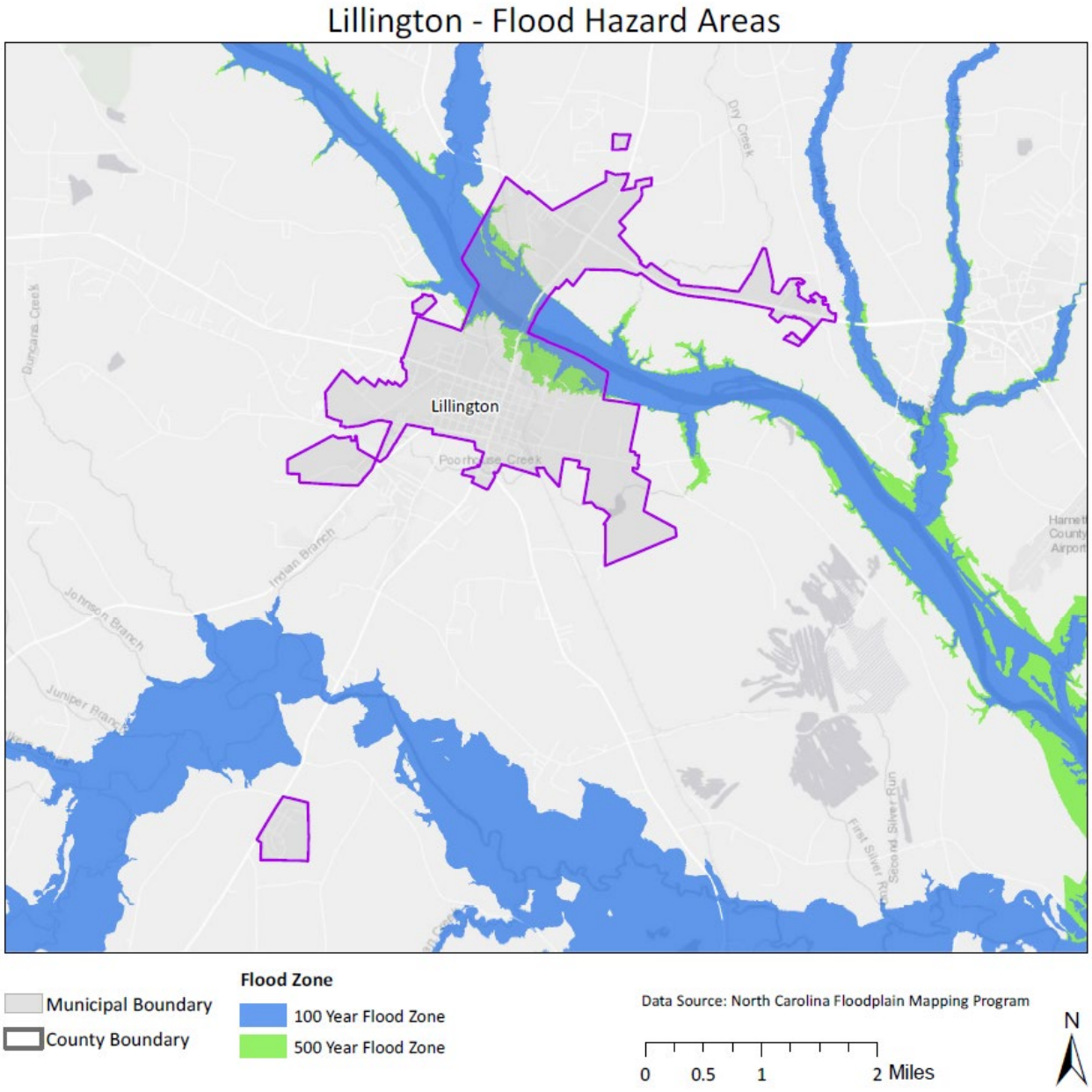

Figure C-16. Flood Hazard Areas in Lillington, Harnett County, NC

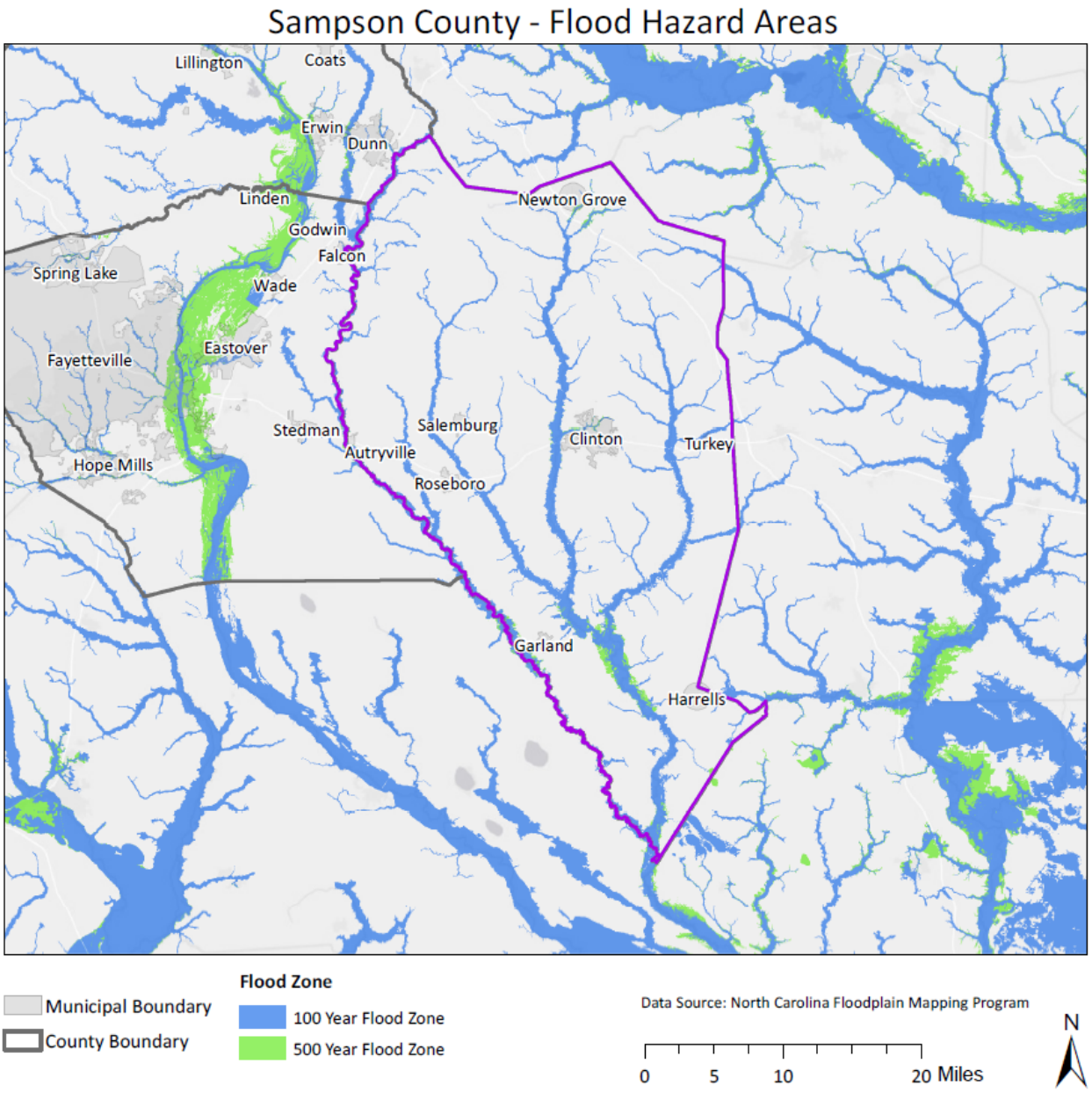

Figure C-17. Flood Hazard Areas in Sampson County, NC

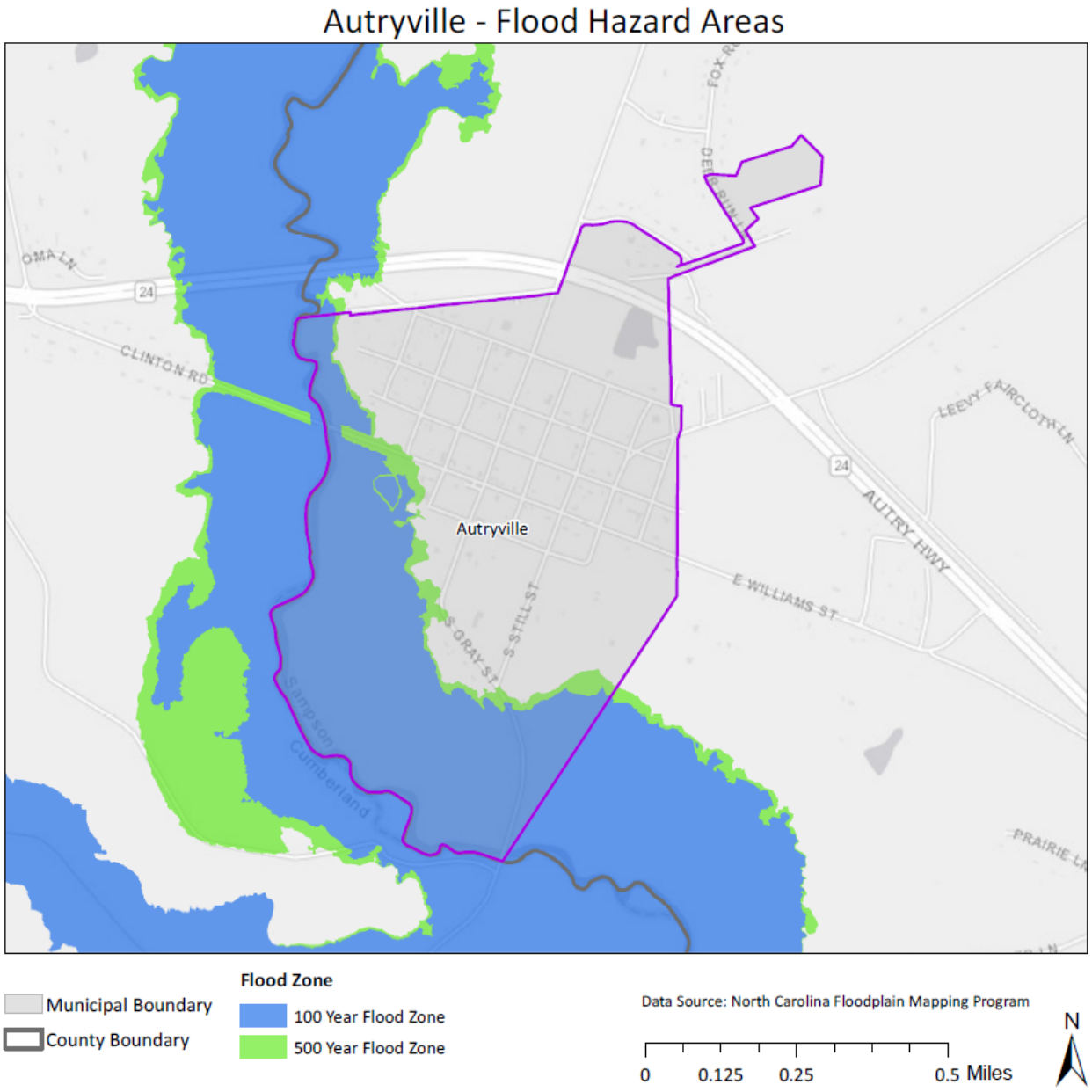

Figure C-18. Flood Hazard Areas in Autryville, Sampson County, NC

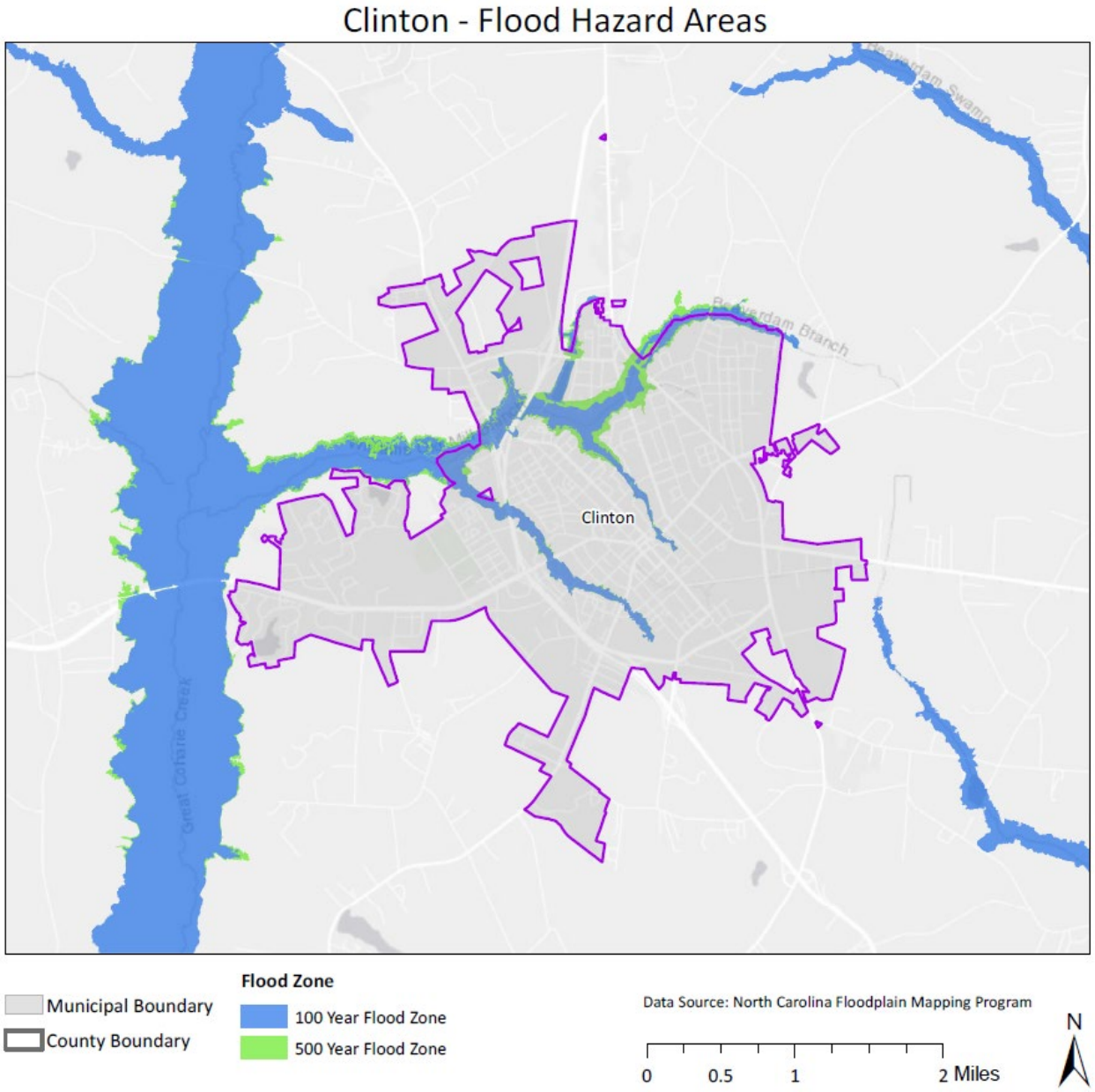

Figure C-19. Flood Hazard Areas in Clinton, Sampson County, NC

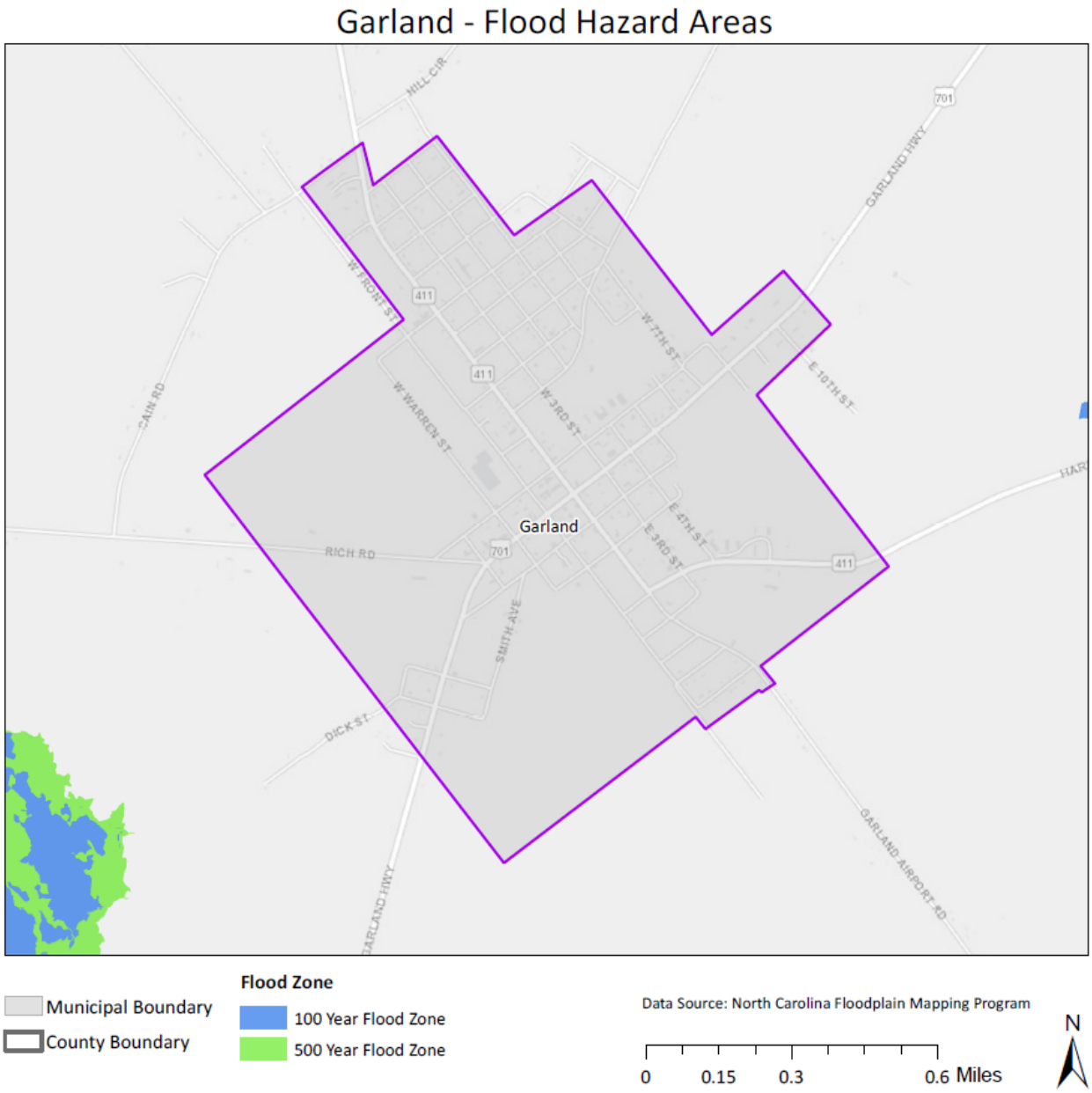

Figure C-20. Flood Hazard Areas in Garland, Sampson County, NC

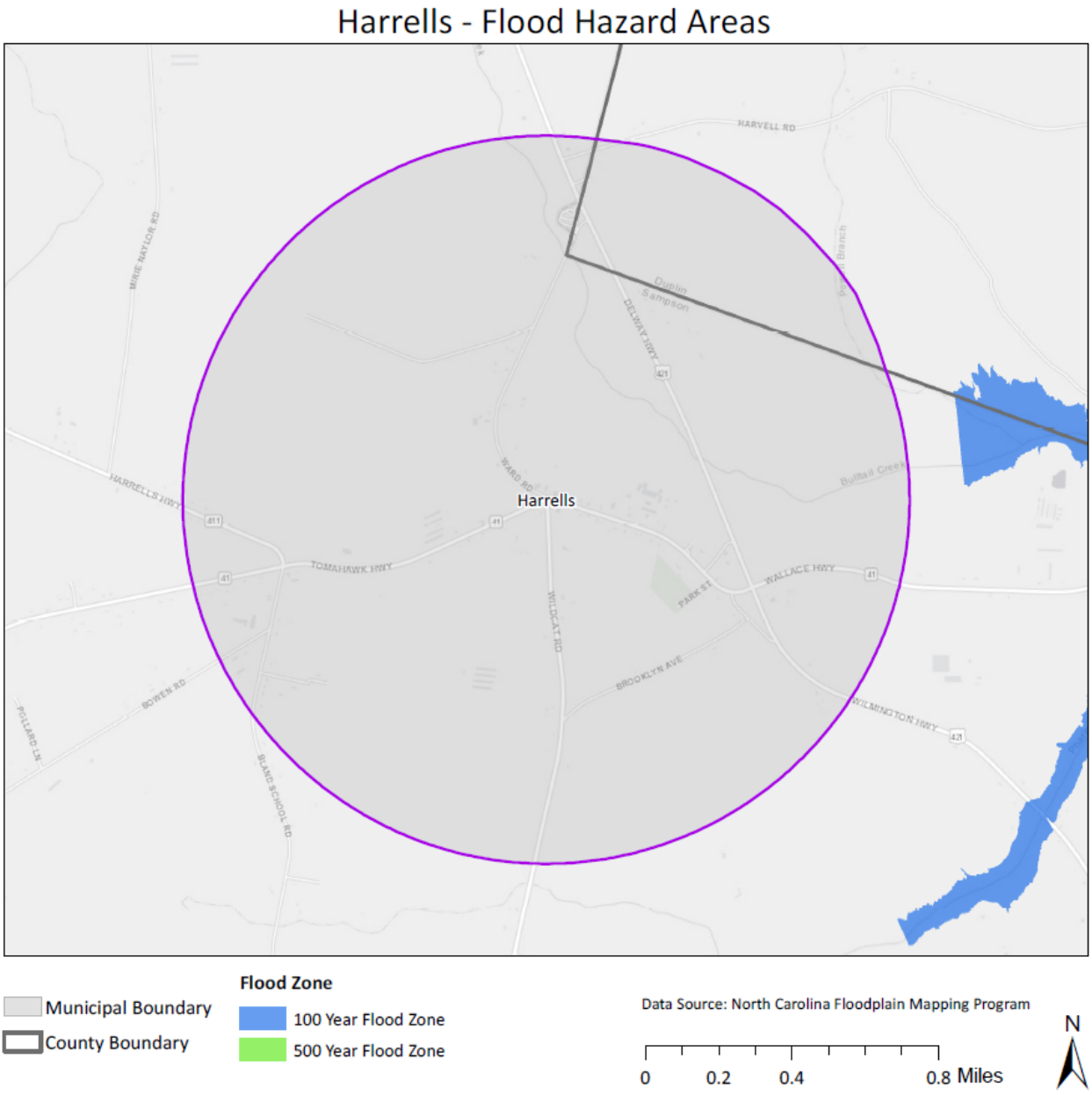

Figure C-21. Flood Hazard Areas in Harrells, Sampson County, NC

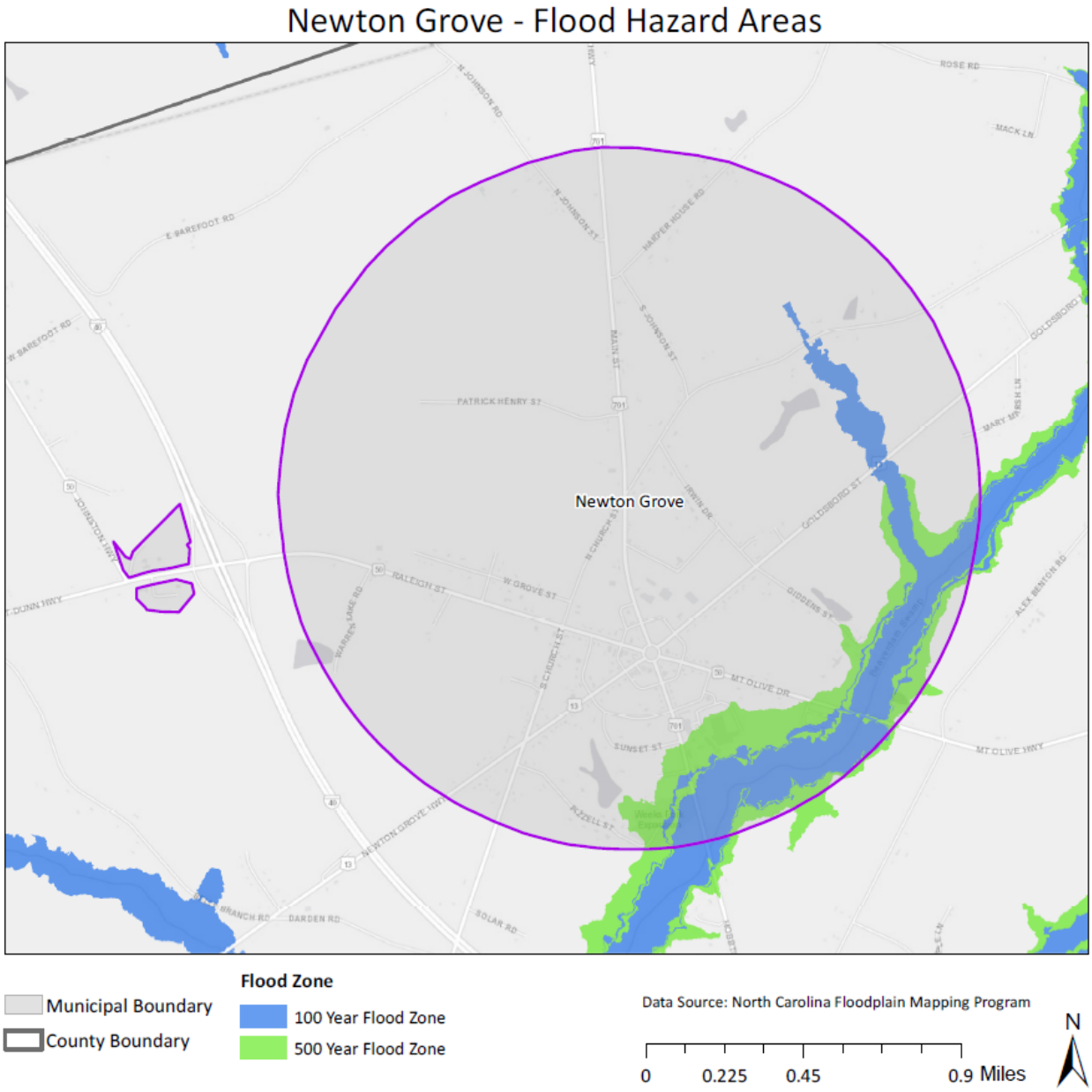

Figure C-22. Flood Hazard Areas in Newton Grove, Sampson County, NC

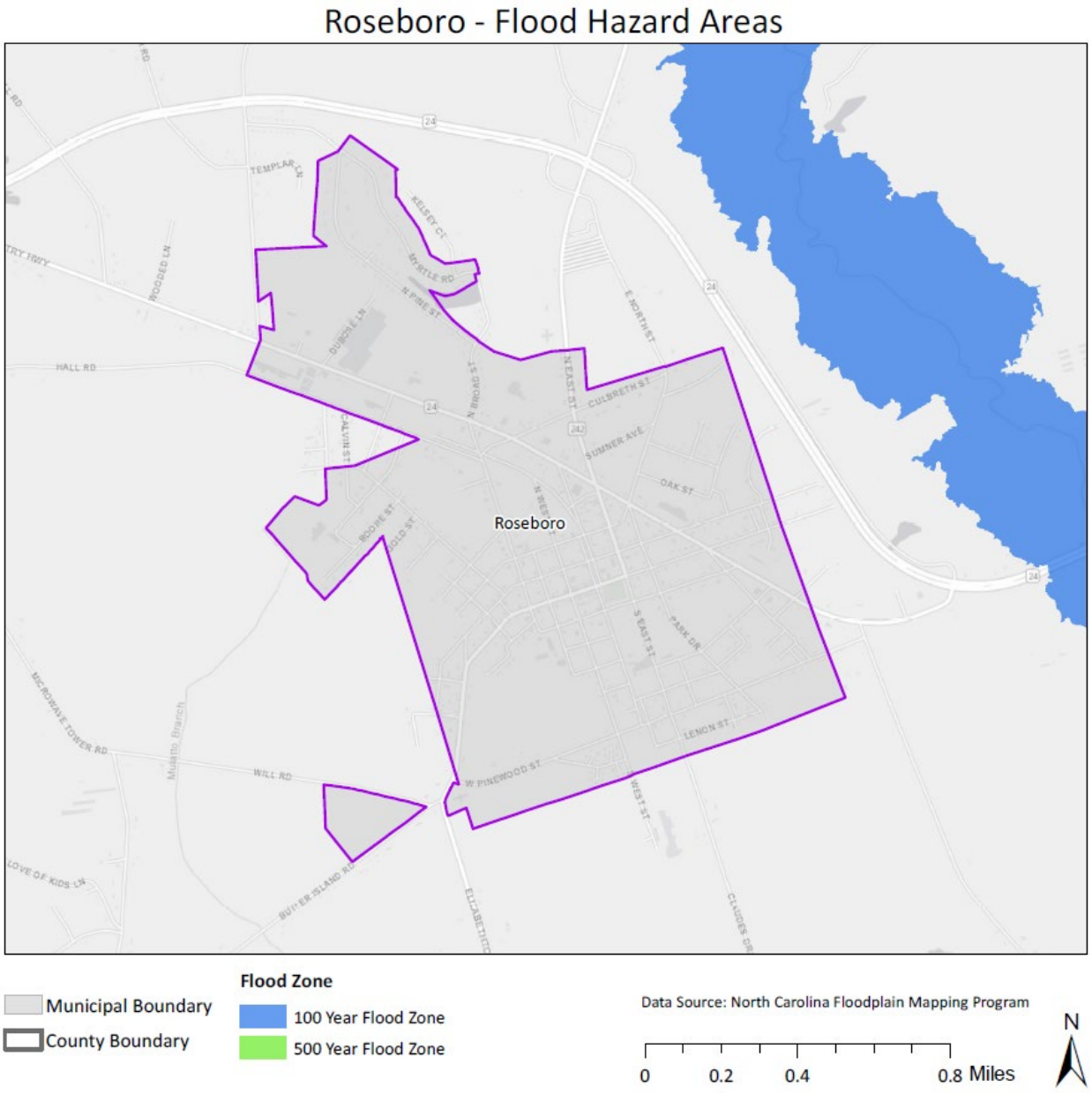

Figure C-23. Flood Hazard Areas in Roseboro, Sampson County, NC

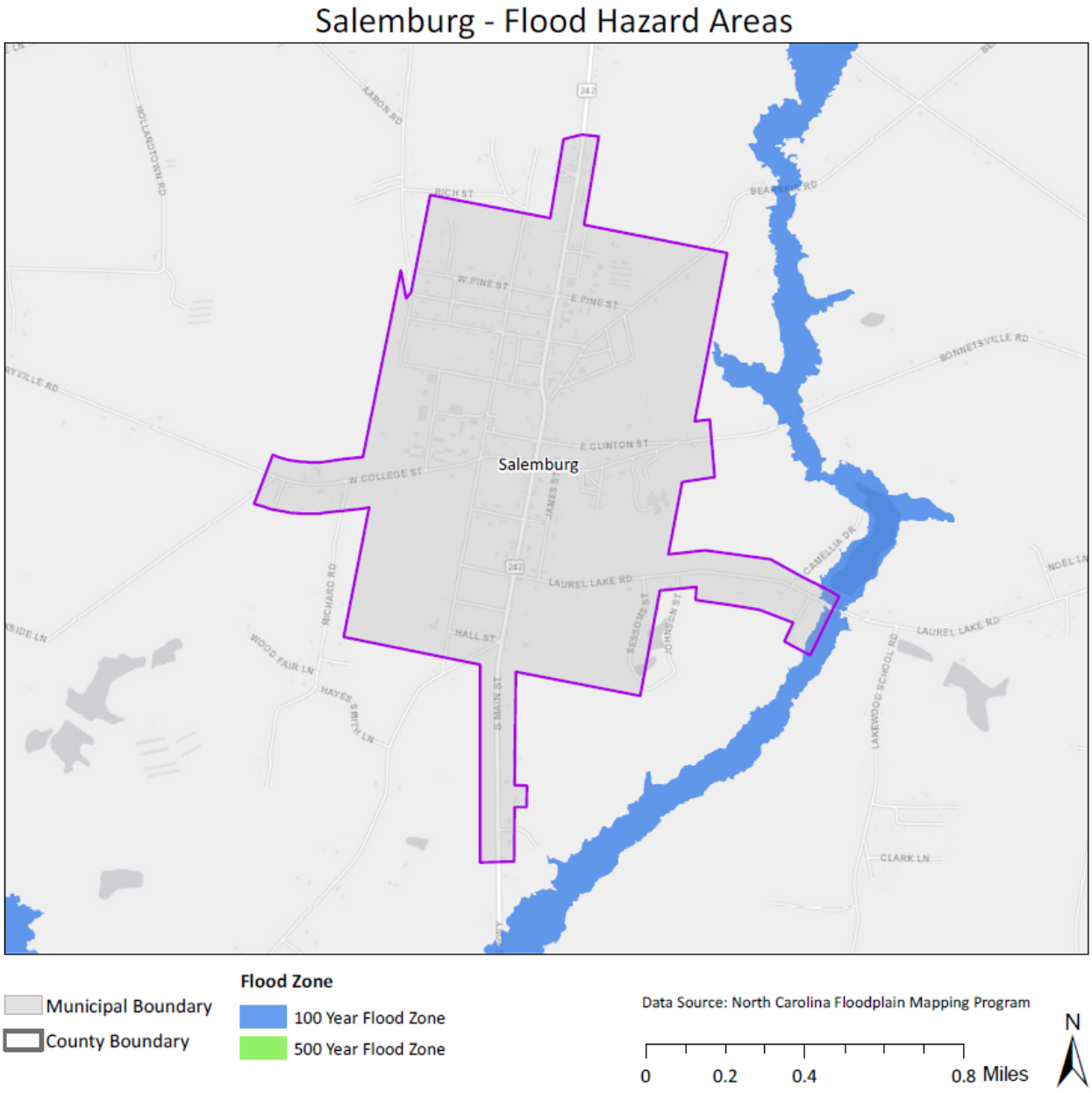

Figure C-24. Flood Hazard Areas in Salemburg, Sampson County, NC

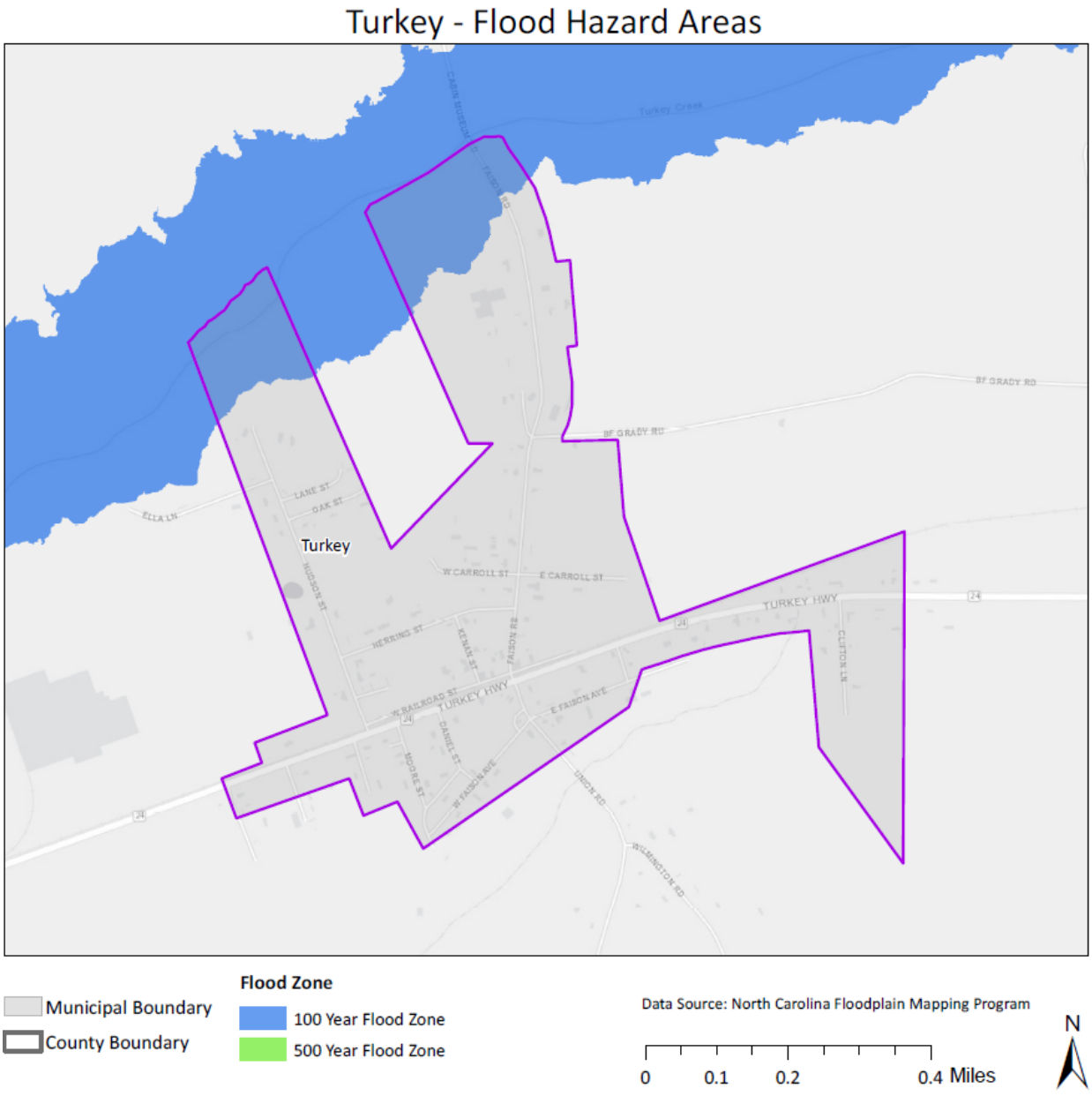

Figure C-25. Flood Hazard Areas in Turkey, Sampson County, NC

Appendix D – Wildfire Hazards Maps

Wildfire hazard maps for each county and municipality in the Mid-Carolina region are found below. These maps, obtained from the Southern Group of State Foresters Wildfire Risk Assessment Portal, show the Wildland Urban Interface risk index. They depict local and regional wildfire concerns.

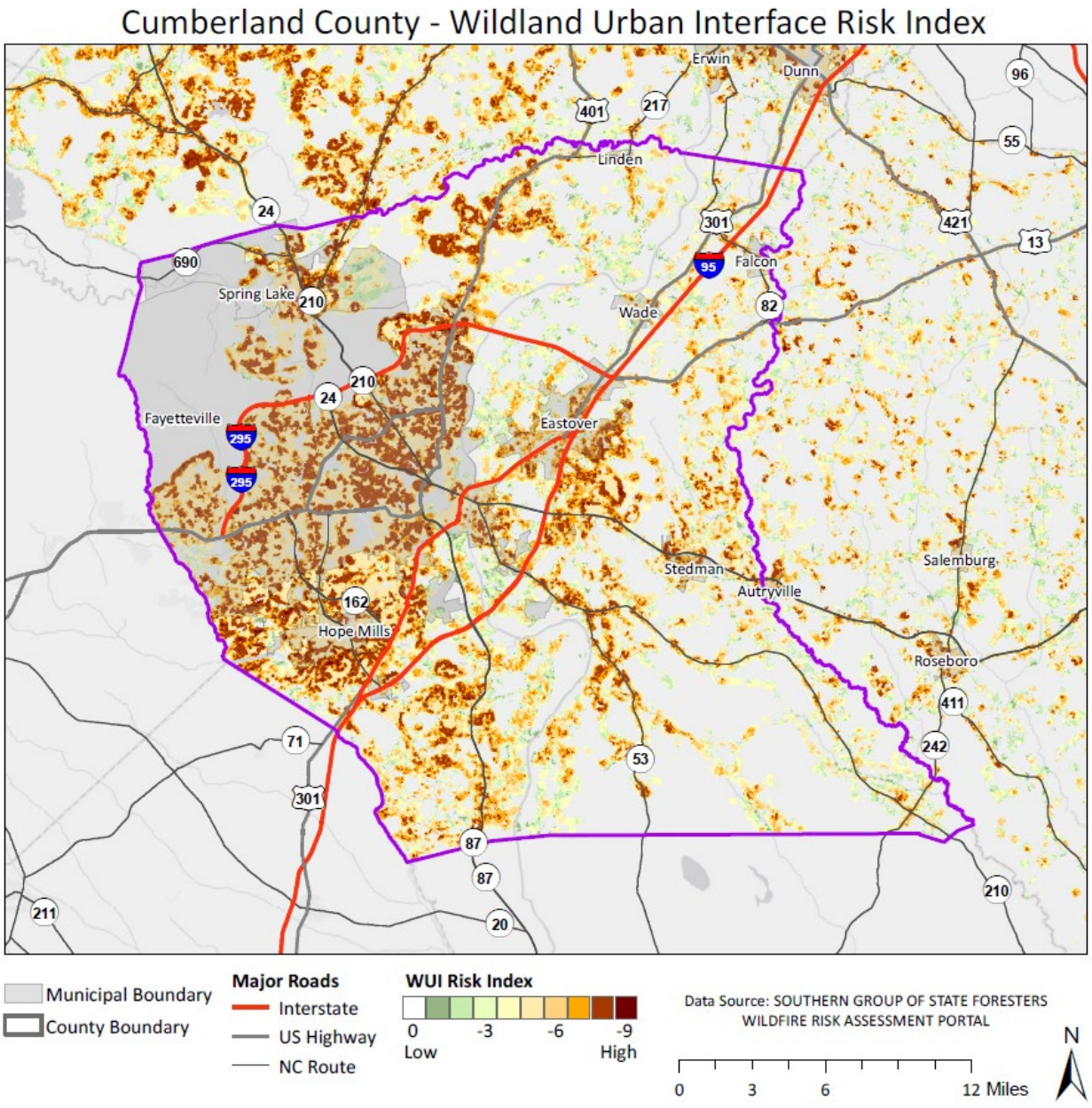

Figure D-1. Wildfire Risk Zones in Cumberland County, NC

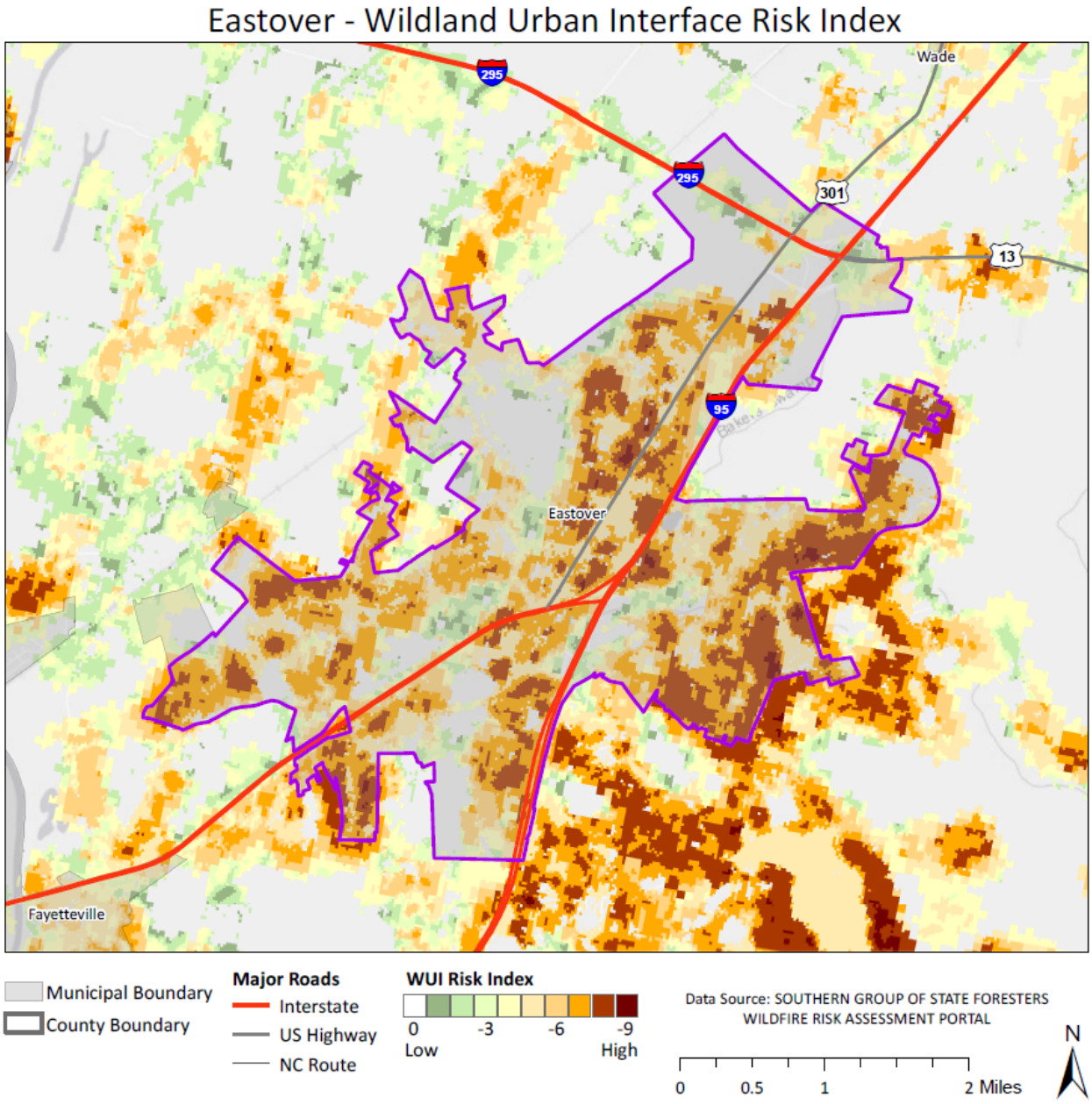

Figure D-2. Wildfire Risk Zones in Eastover, Cumberland County, NC

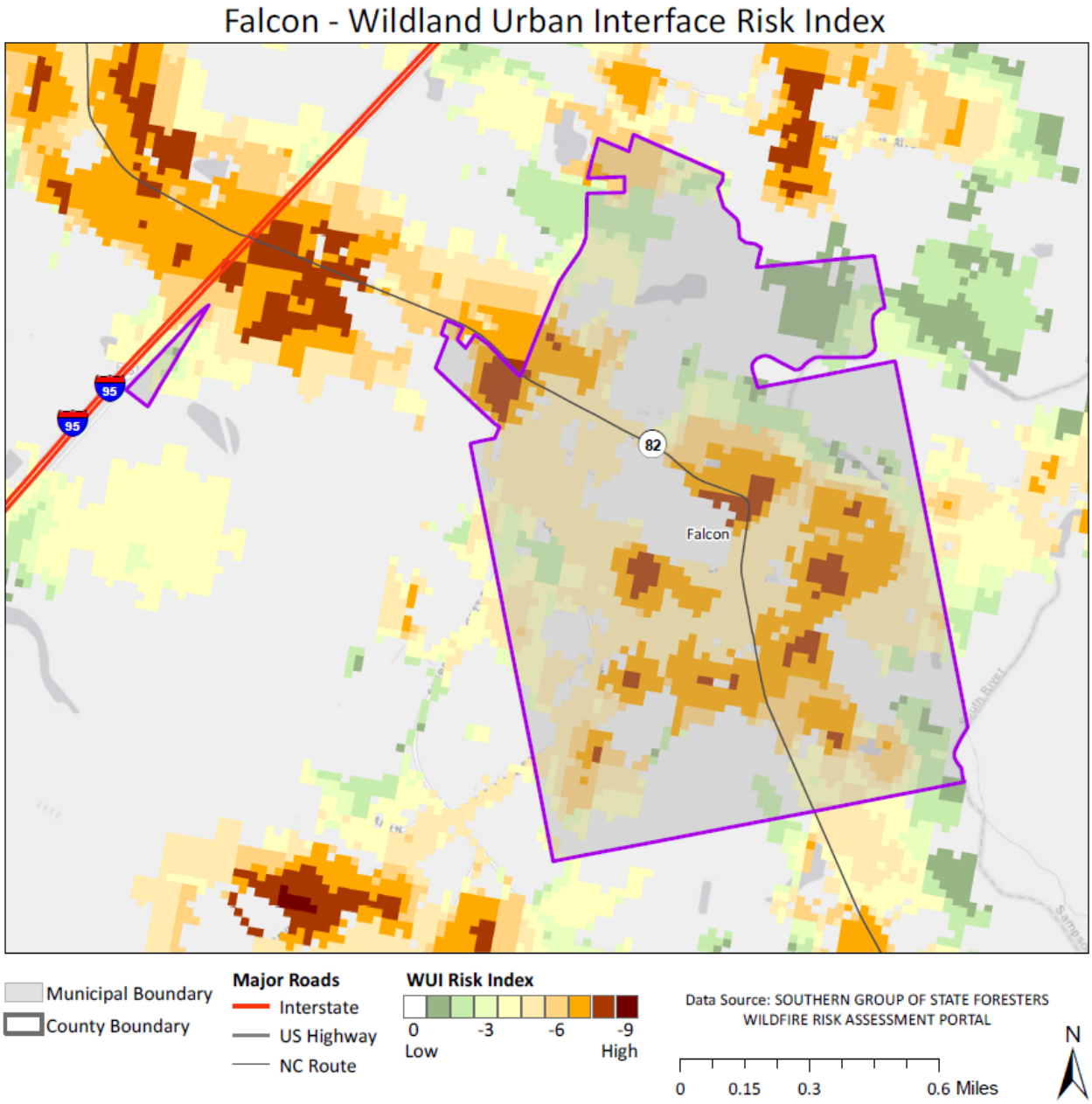

Figure D-3. Wildfire Risk Zones in Falcon, Cumberland County, NC

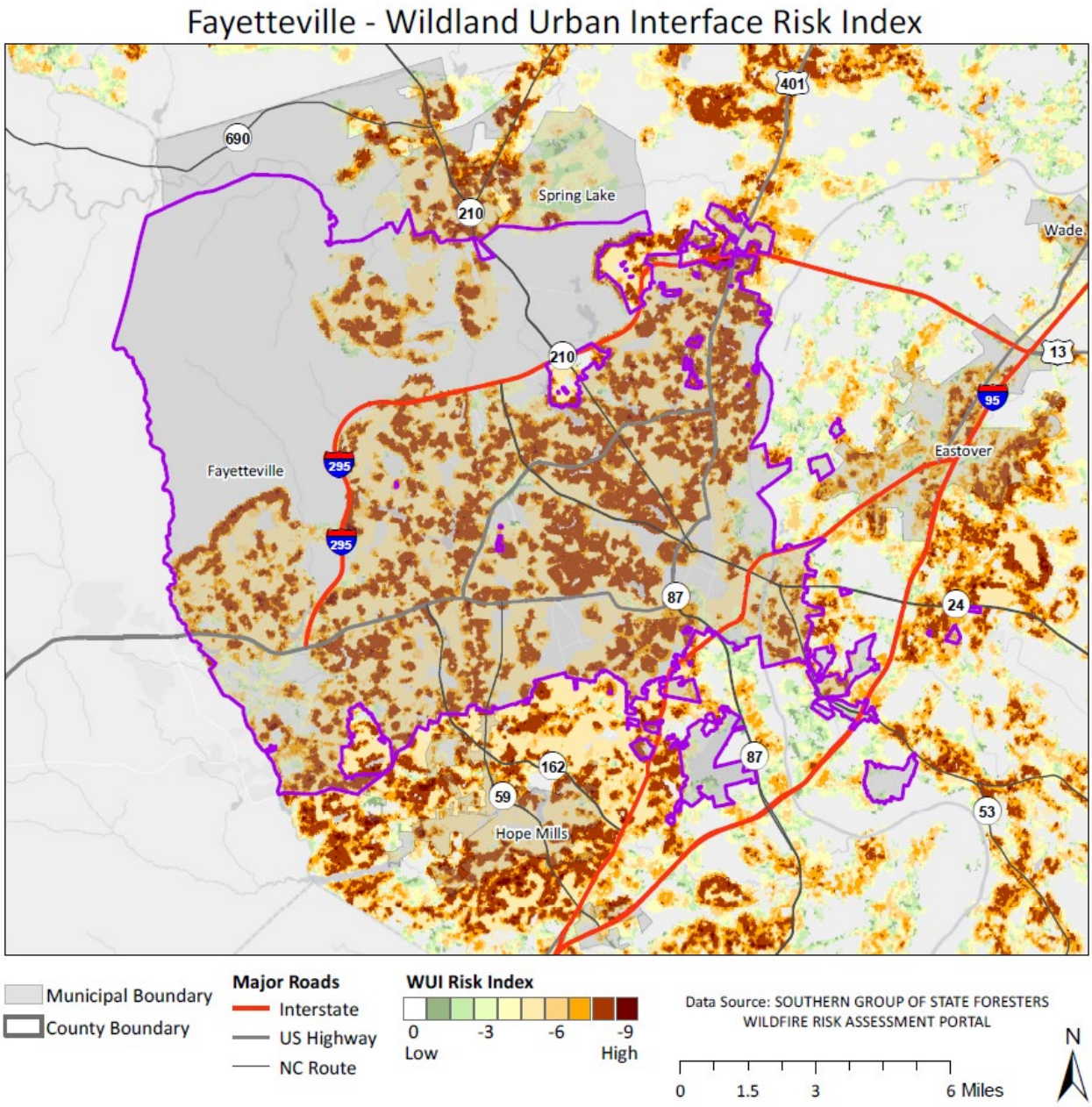

Figure D-4. Wildfire Risk Zones in Fayetteville, Cumberland County, NC

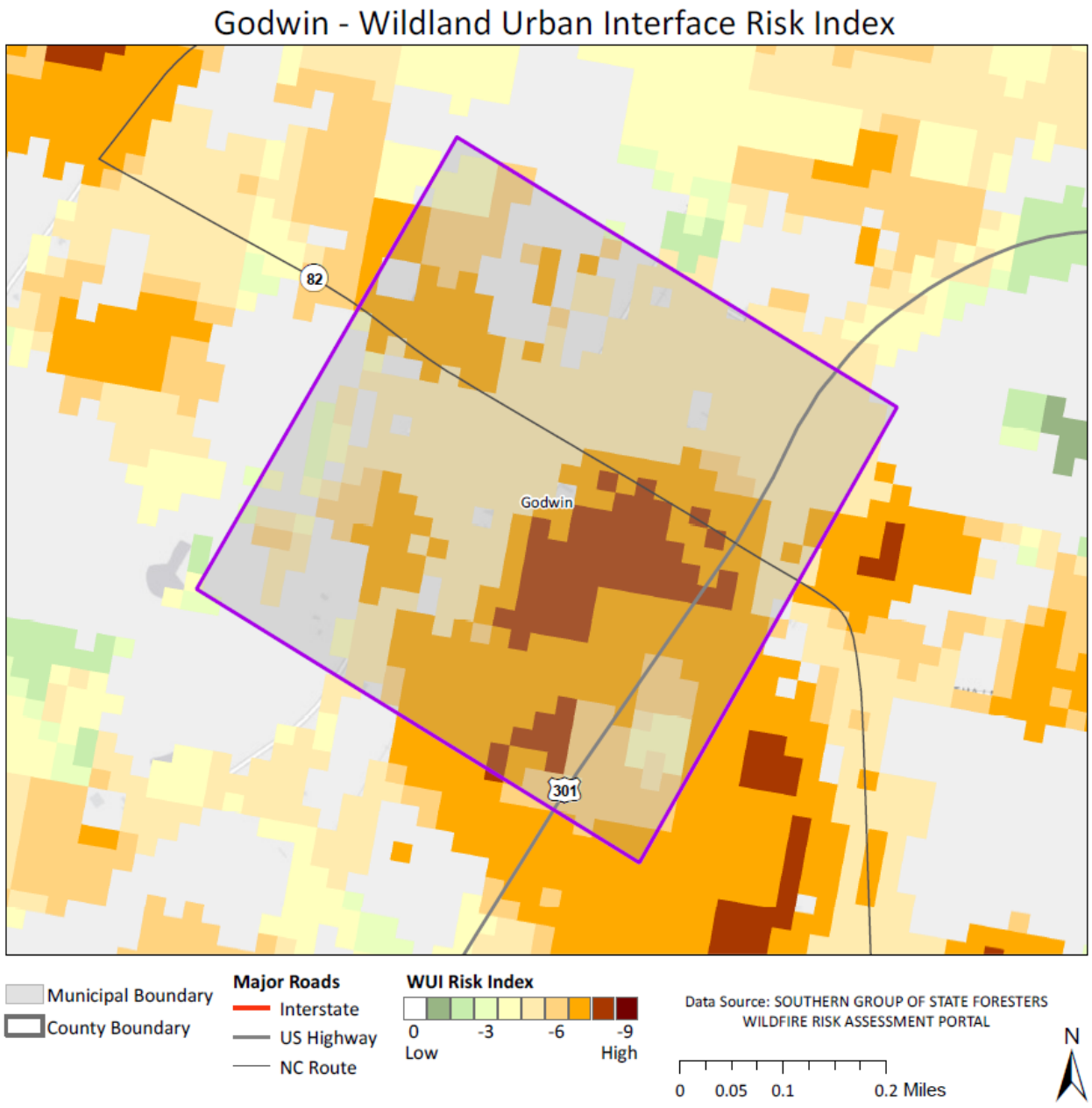

Figure D-5. Wildfire Risk Zones in Godwin, Cumberland County, NC

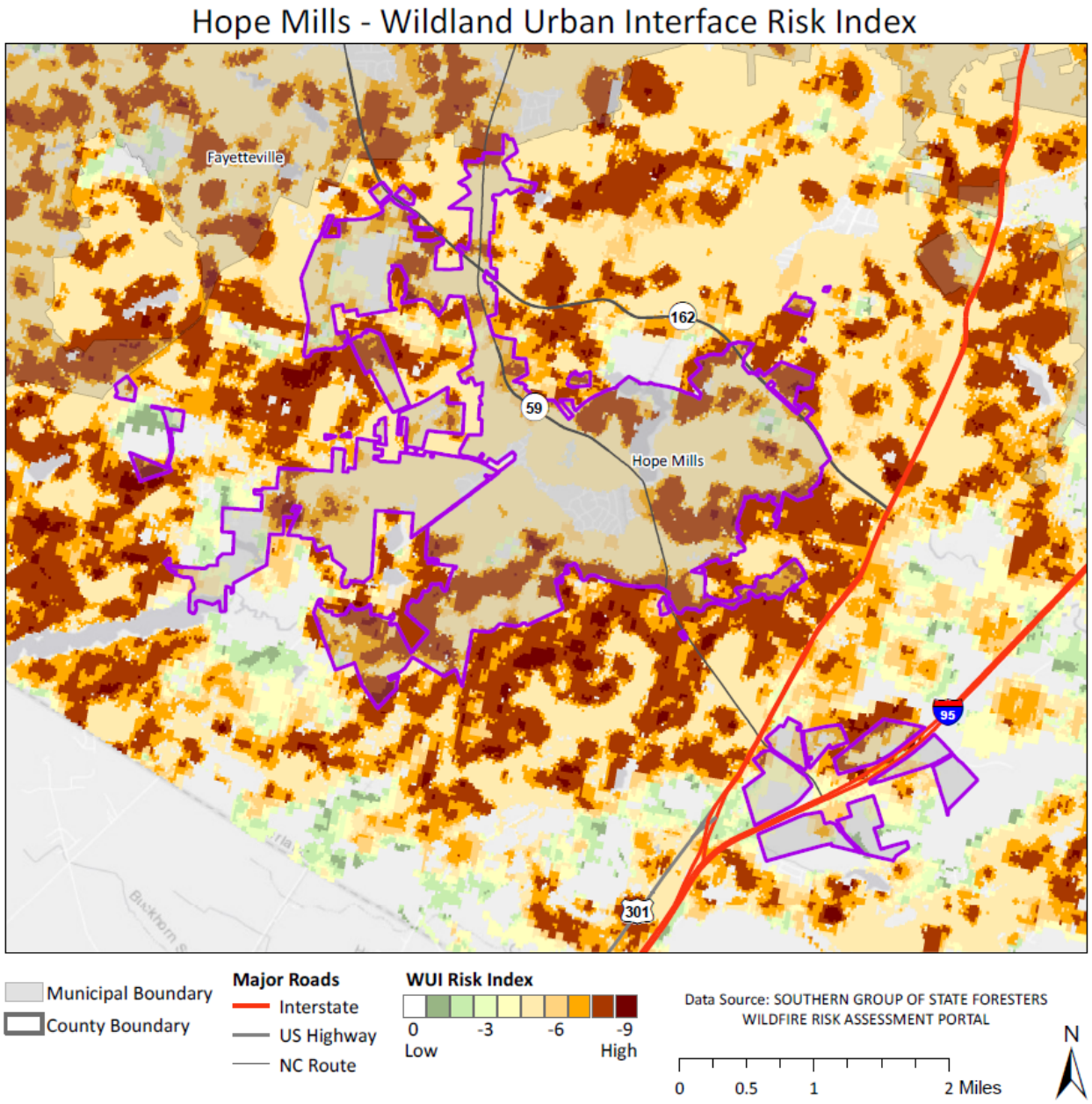

Figure D-6. Wildfire Risk Zones in Hope Mills, Cumberland County, NC

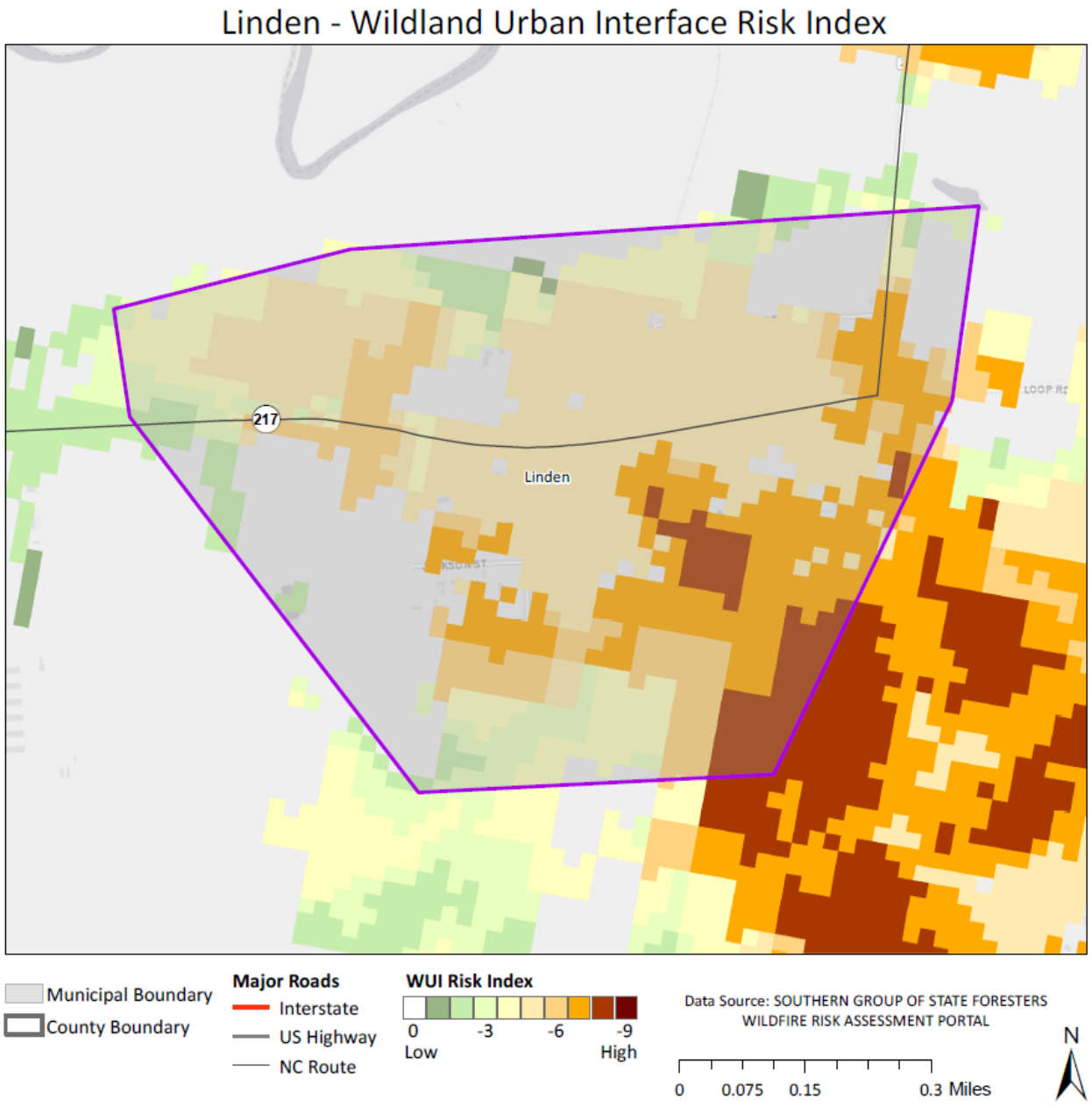

Figure D-7. Wildfire Risk Zones in Linden, Cumberland County, NC

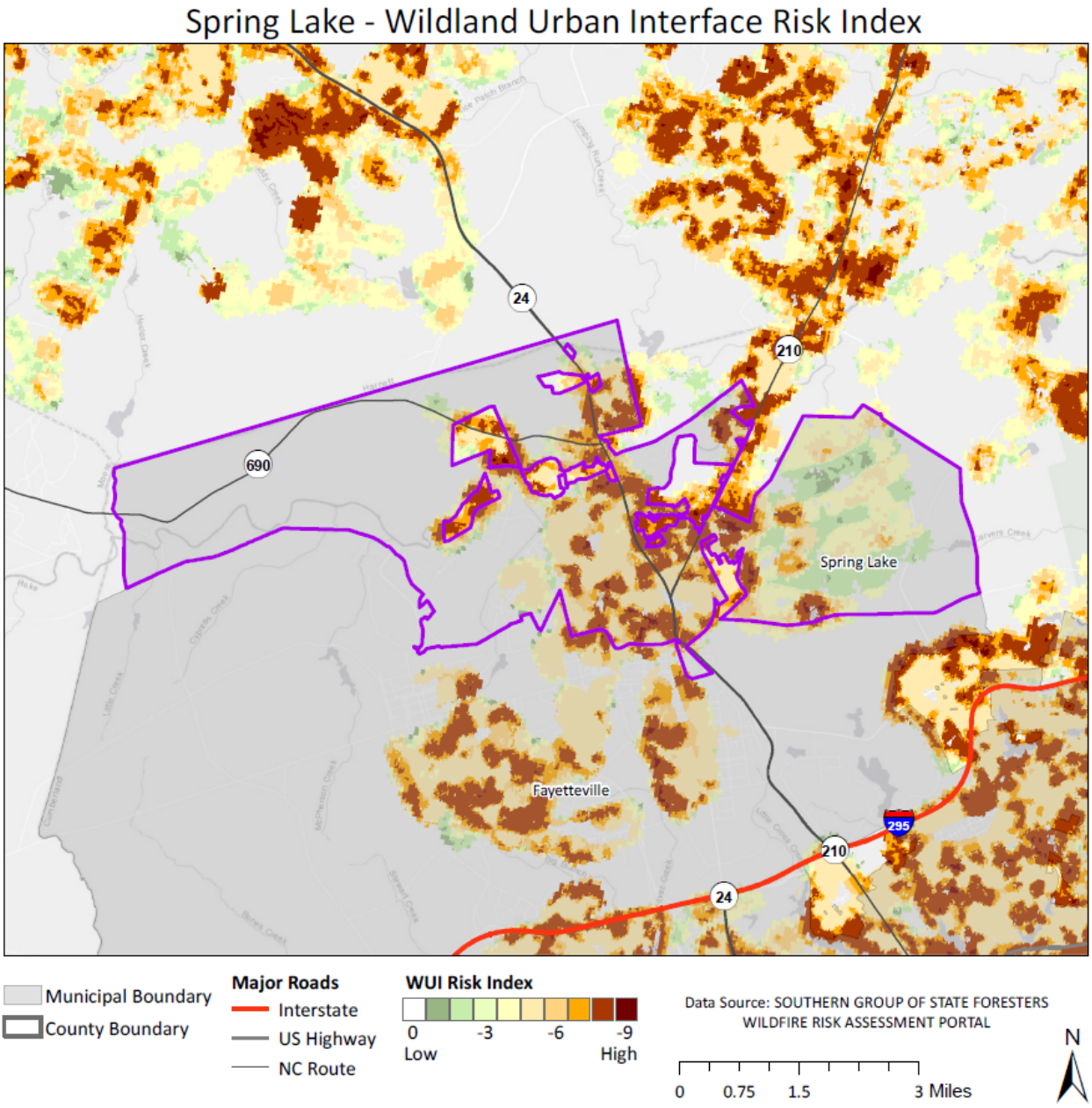

Figure D-8. Wildfire Risk Zones in Spring Lake, Cumberland County, NC

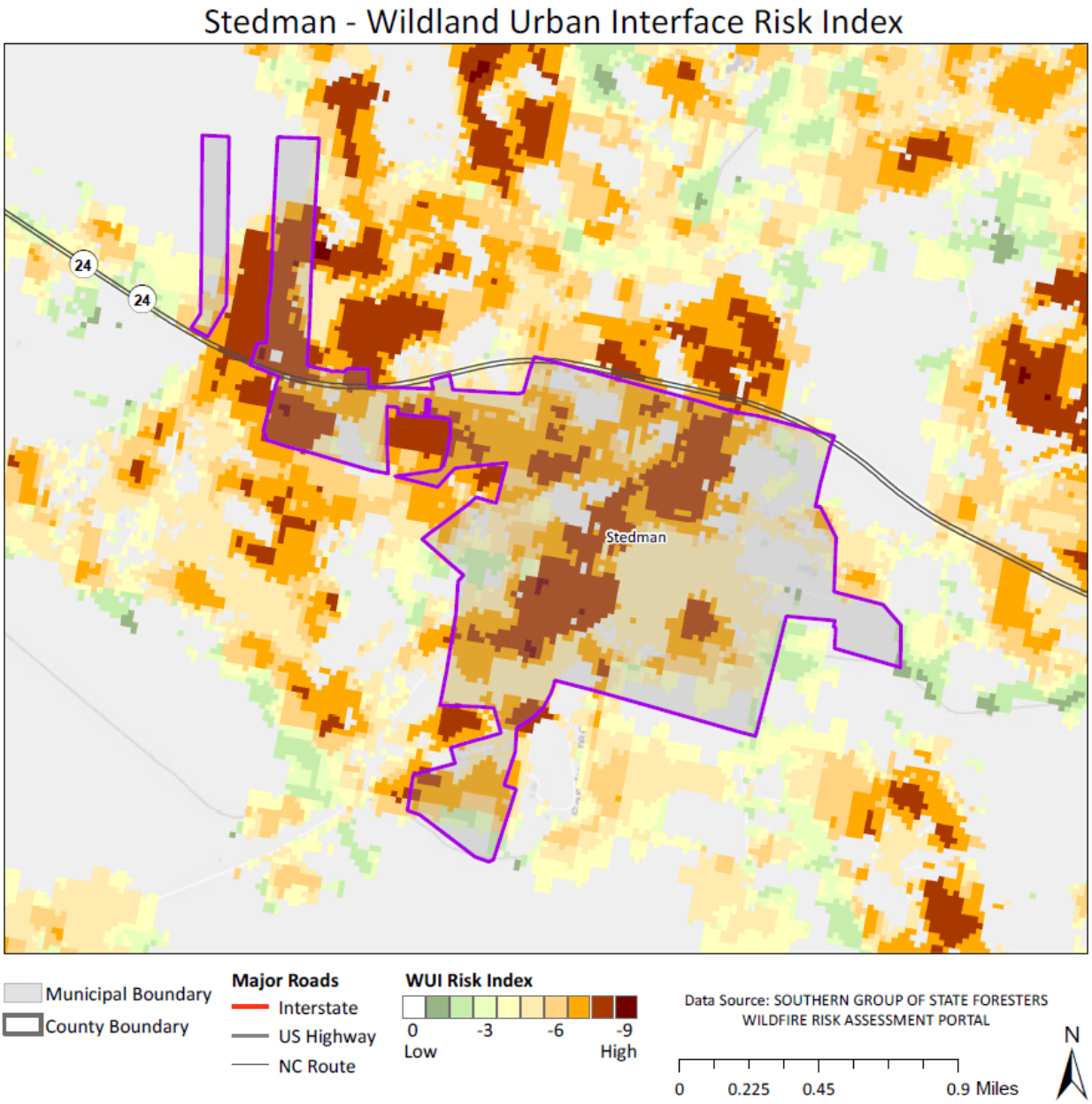

Figure D-9. Wildfire Risk Zones in Stedman, Cumberland County, NC

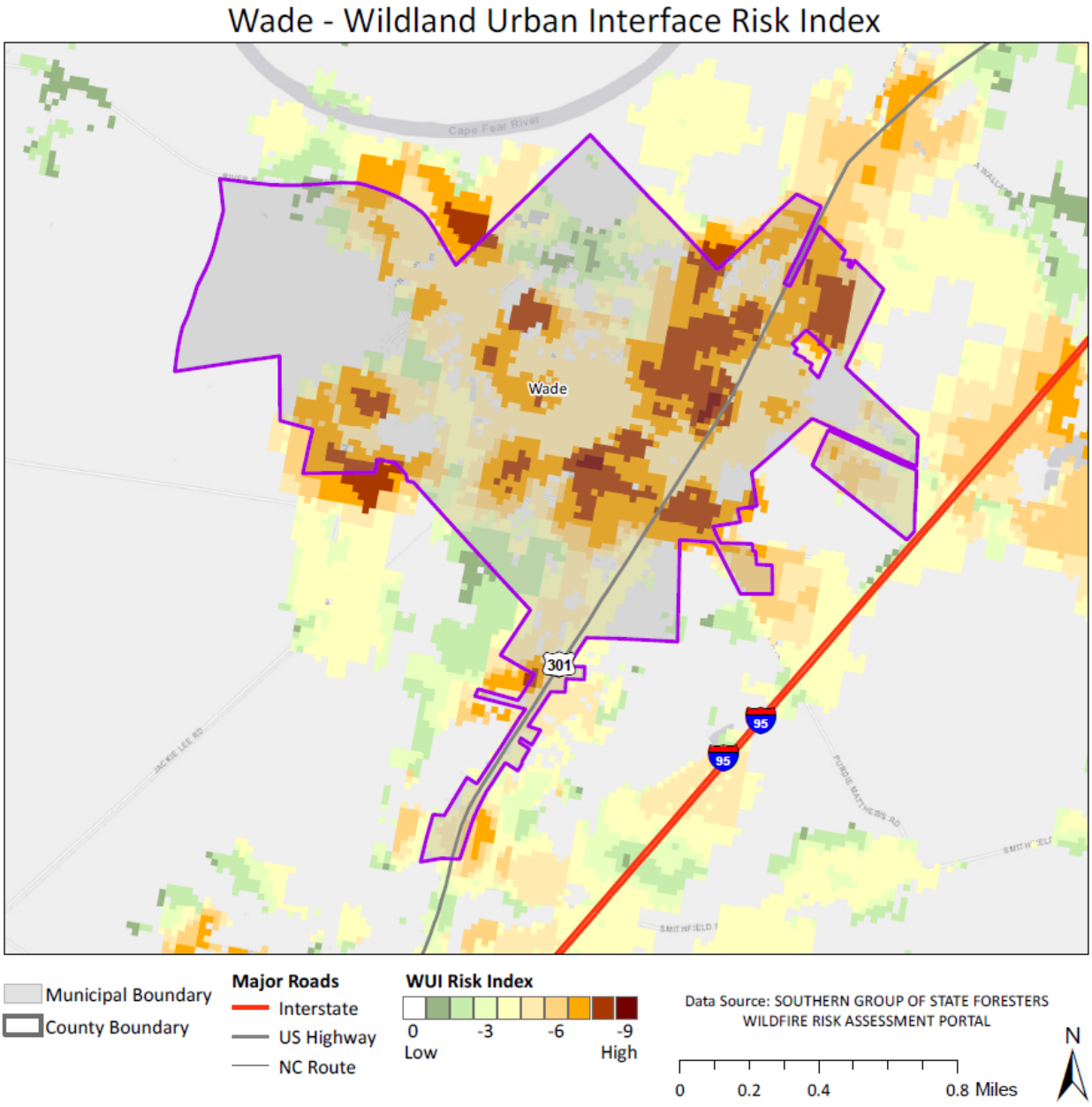

Figure D-10. Wildfire Risk Zones in Wade, Cumberland County, NC

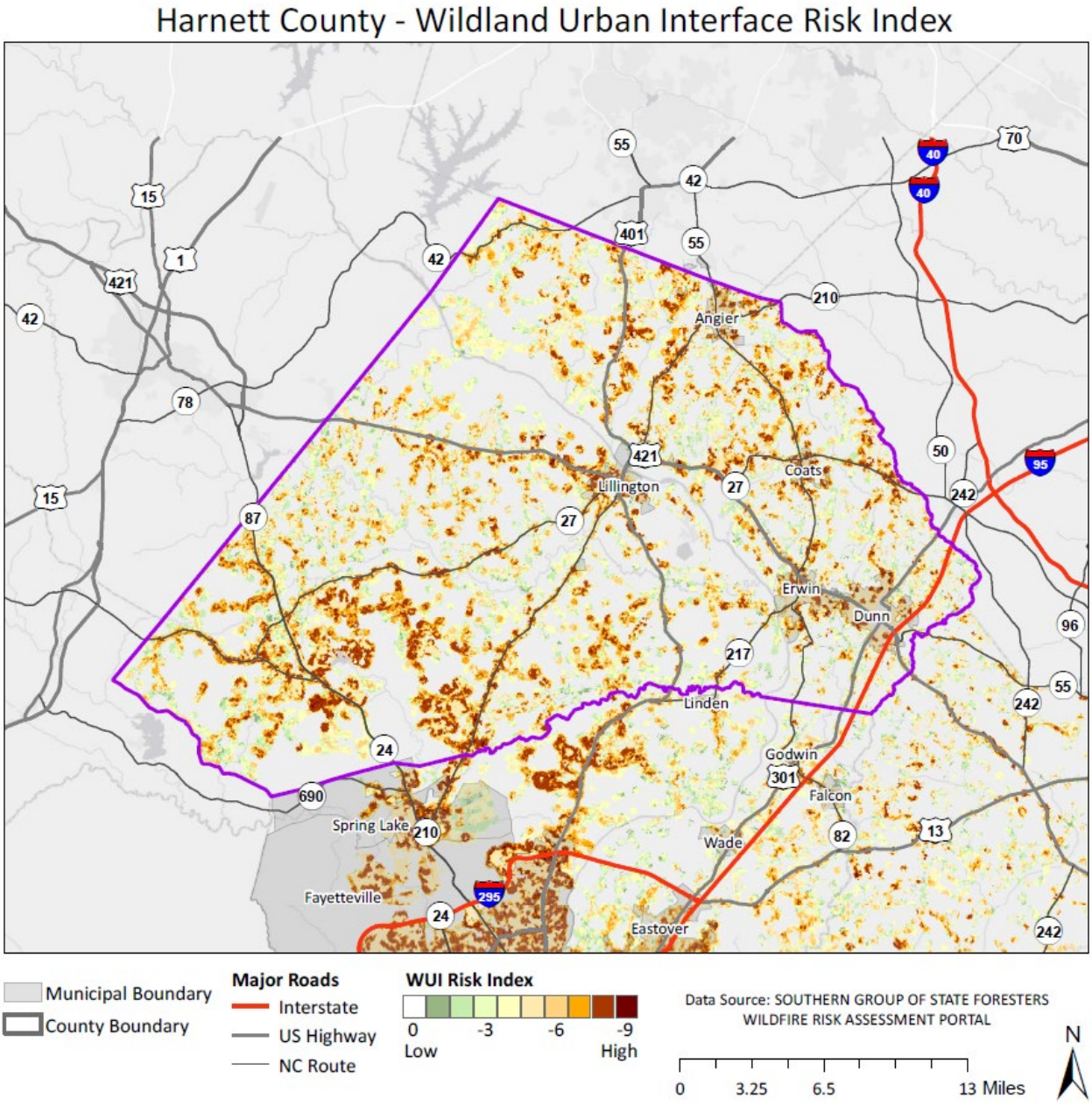

Figure D-11. Wildfire Risk Zones in Harnett County, NC

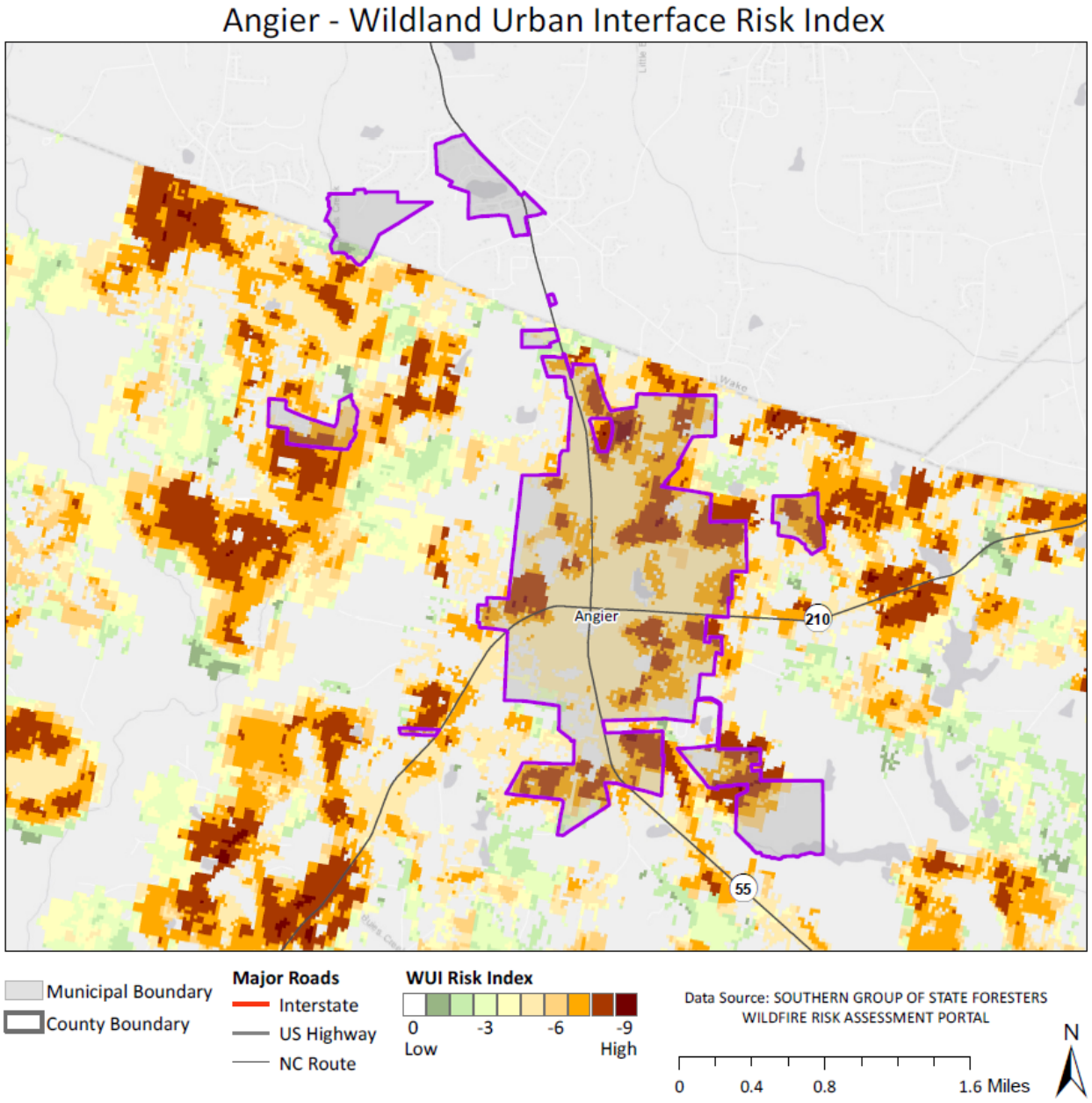

Figure D-12. Wildfire Risk Zones in Angier, Harnett County, NC

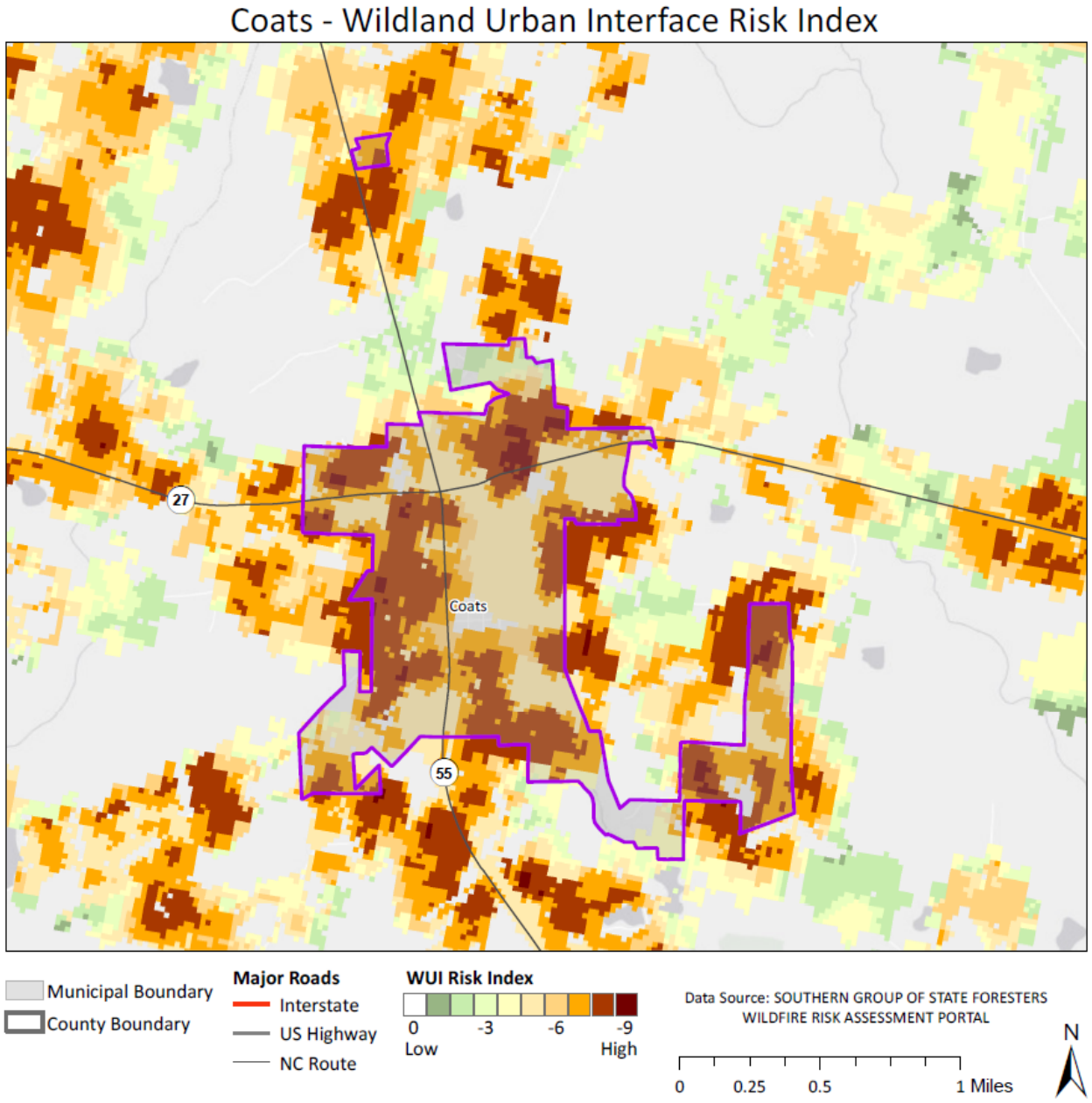

Figure D-13. Wildfire Risk Zones in Coats, Harnett County, NC

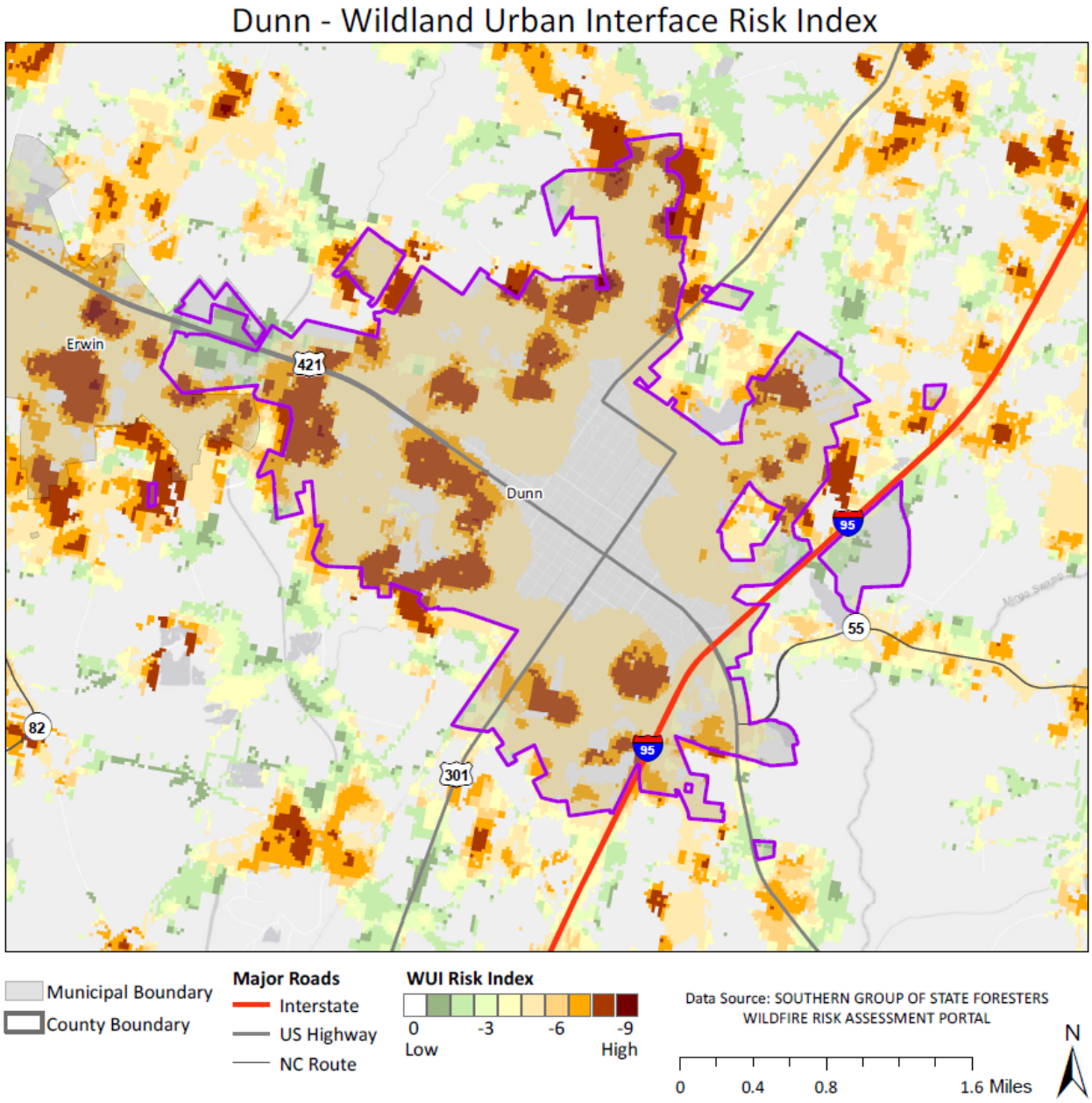

Figure D-14. Wildfire Risk Zones in Dunn, Harnett County, NC

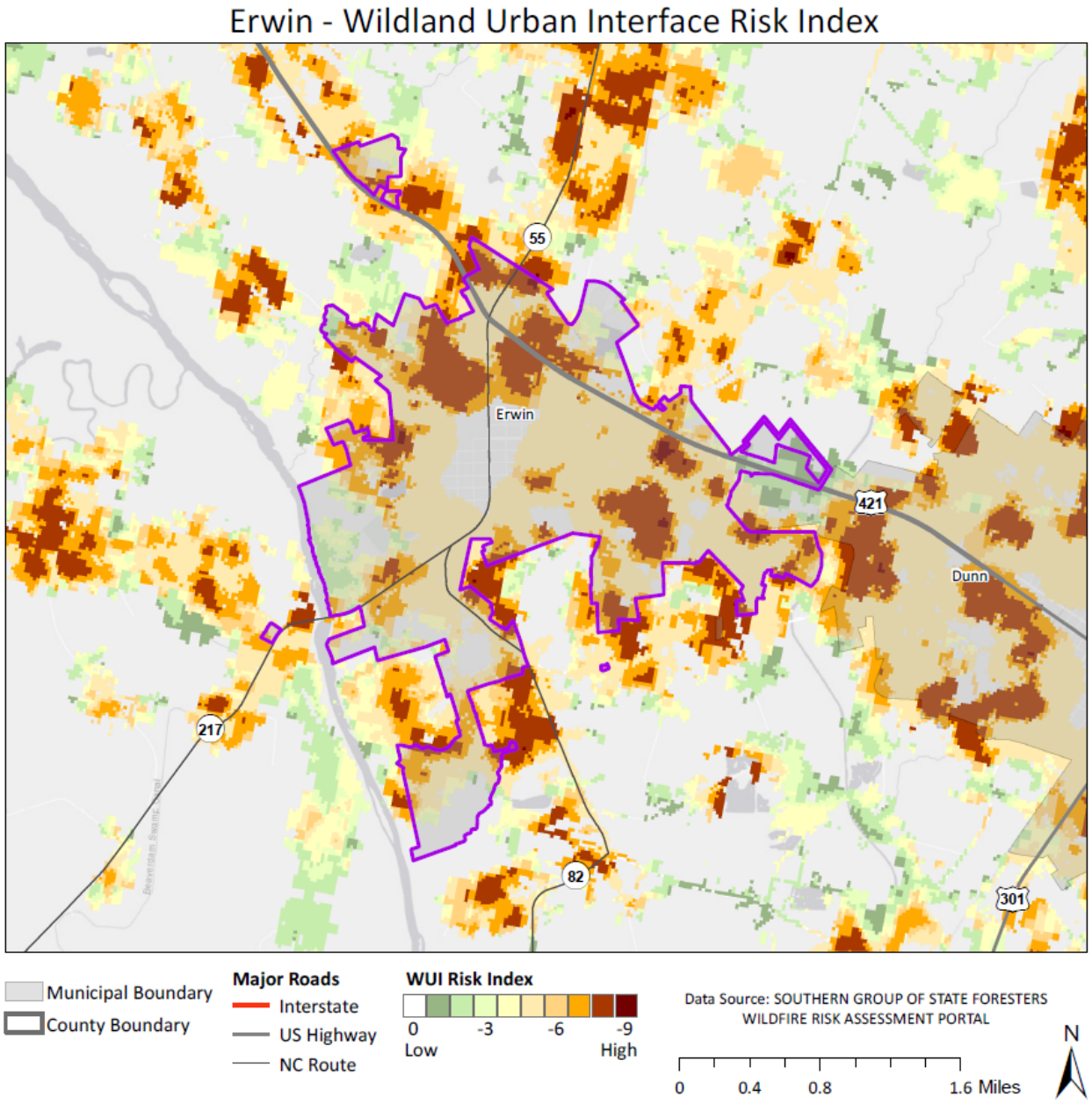

Figure D-15. Wildfire Risk Zones in Erwin, Harnett County, NC

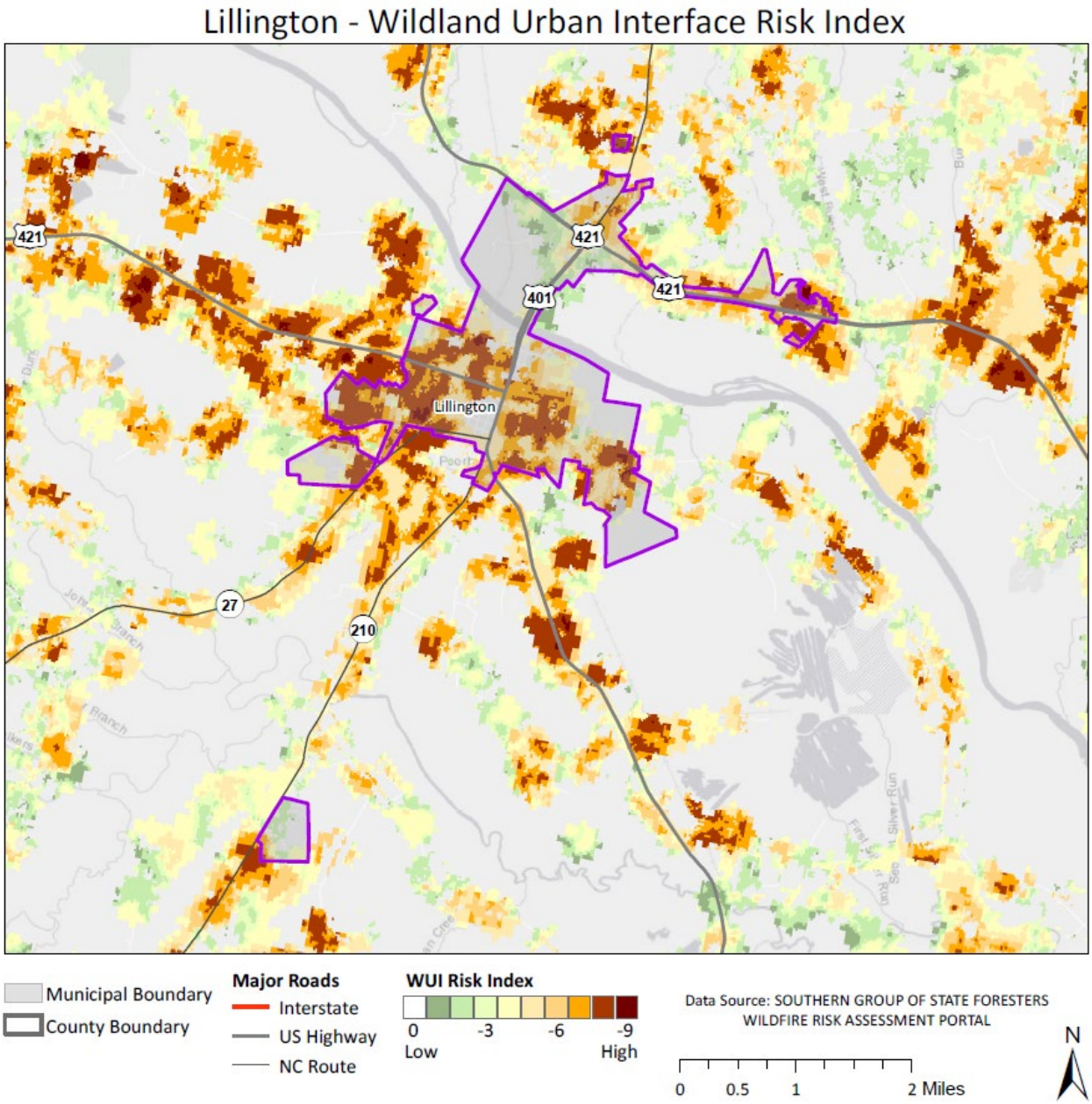

Figure D-16. Wildfire Risk Zones in Lillington, Harnett County, NC

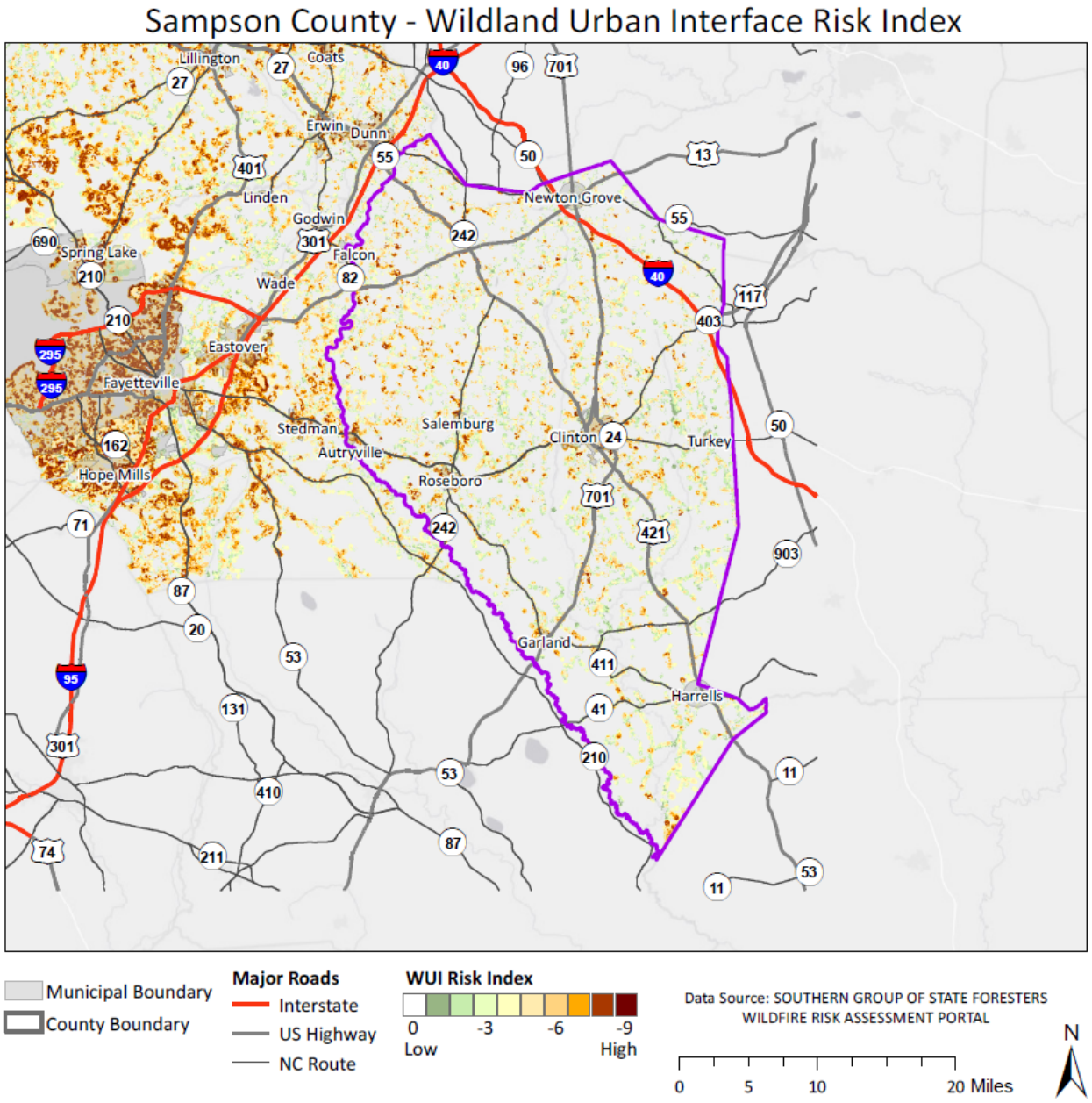

Figure D-17. Wildfire Risk Zones in Sampson County, NC

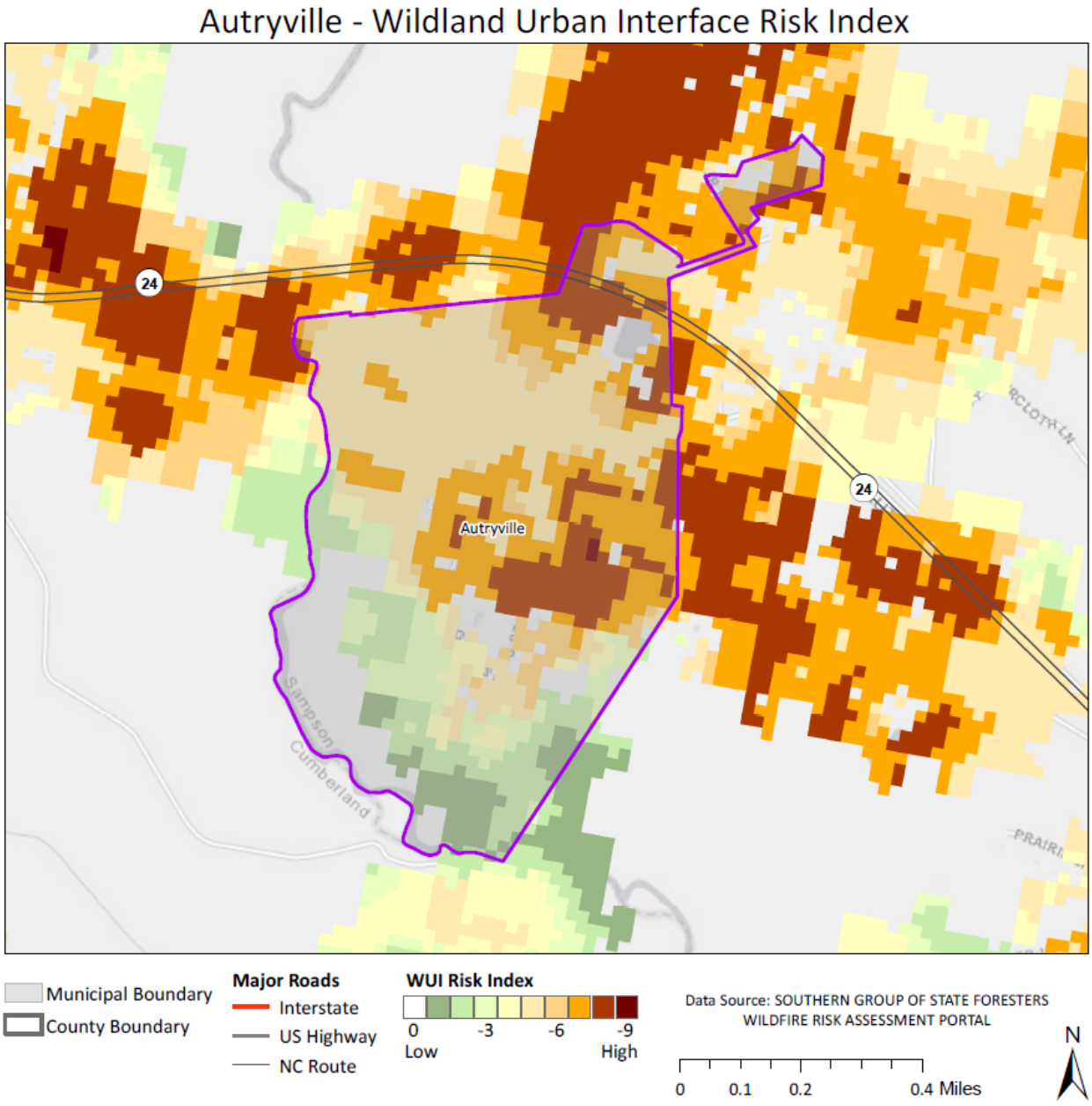

Figure D-18. Wildfire Risk Zones in Autryville, Sampson County, NC

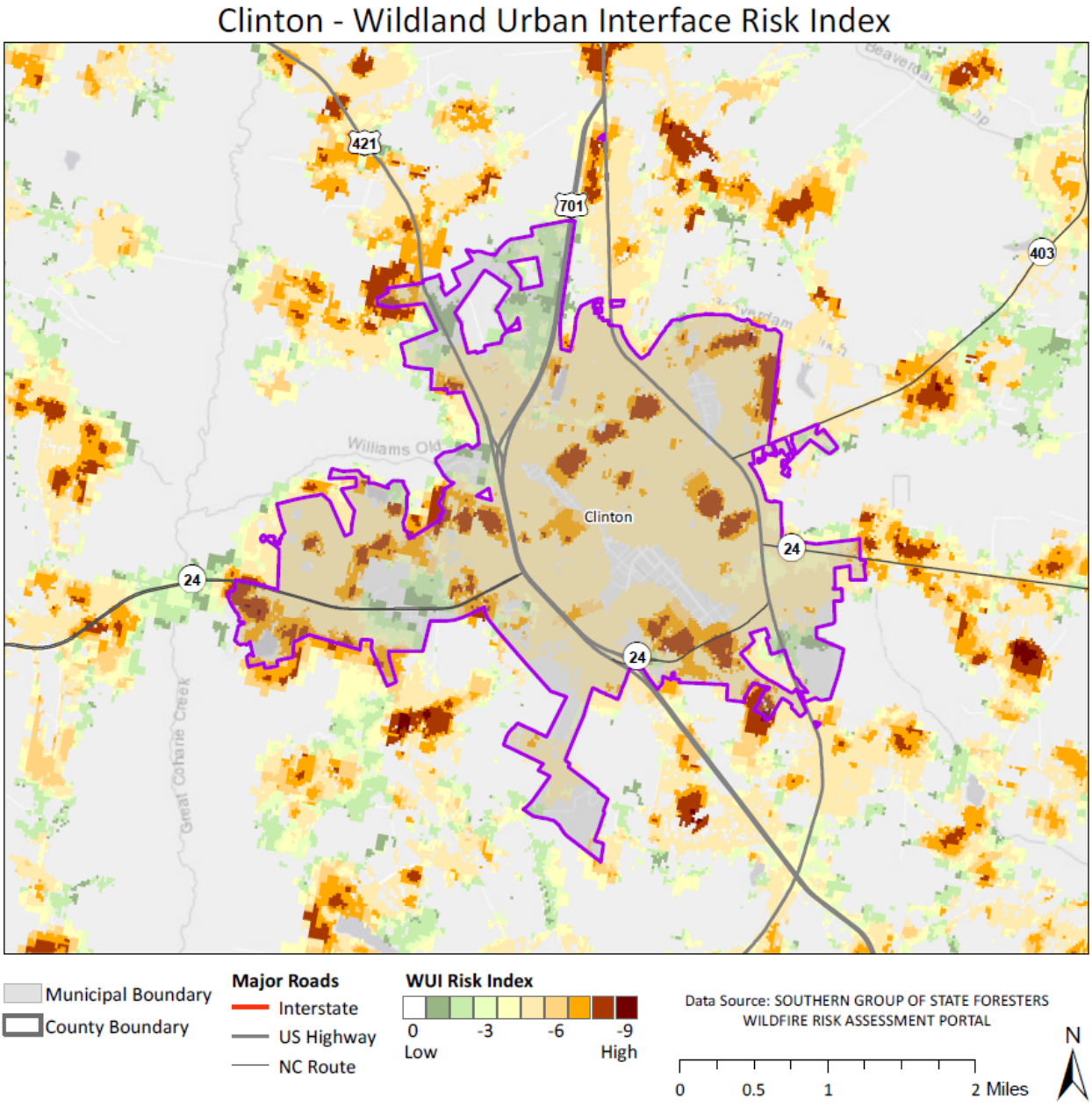

Figure D-19. Wildfire Risk Zones in Clinton, Sampson County, NC

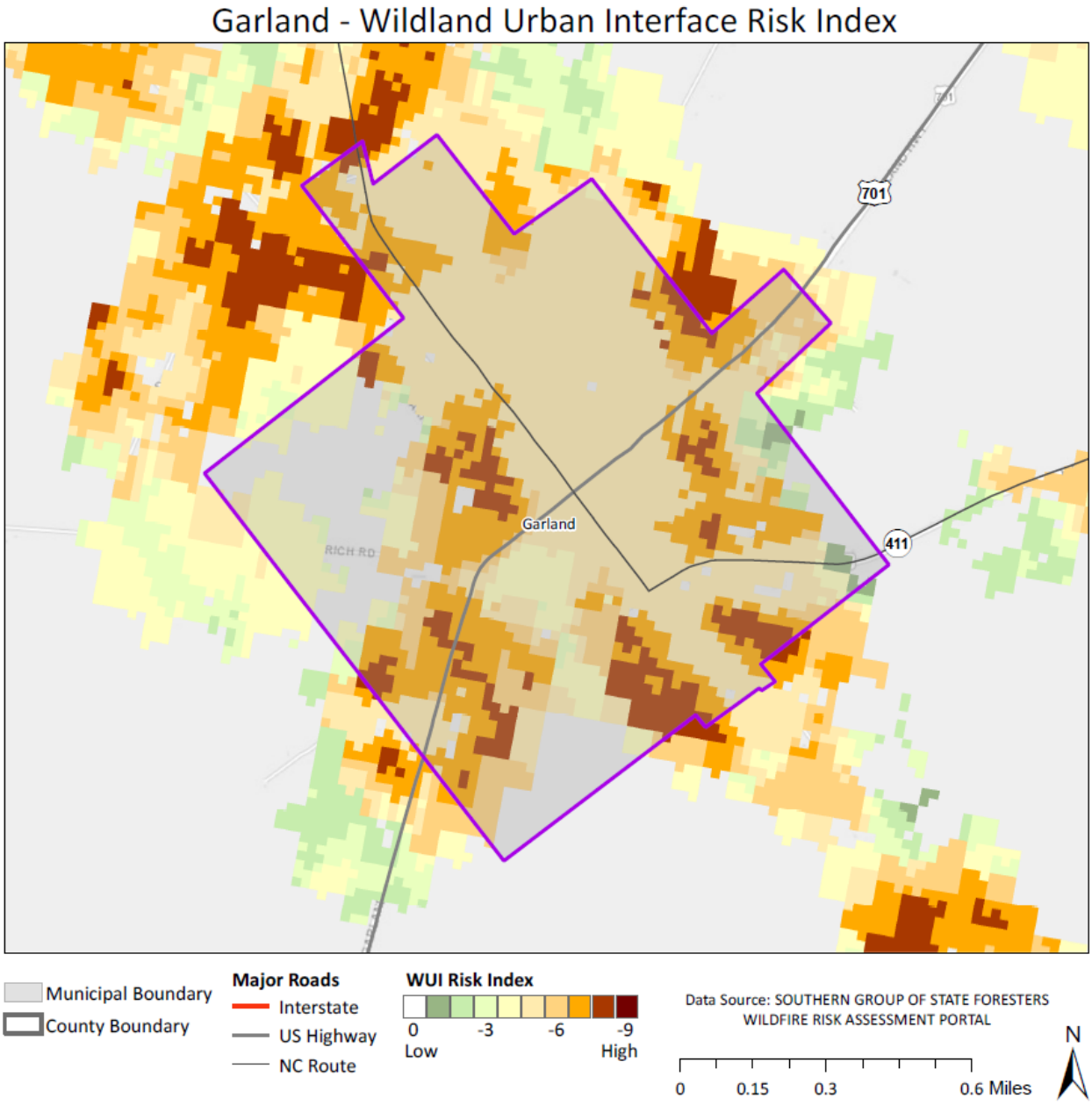

Figure D-20. Wildfire Risk Zones in Garland, Sampson County, NC

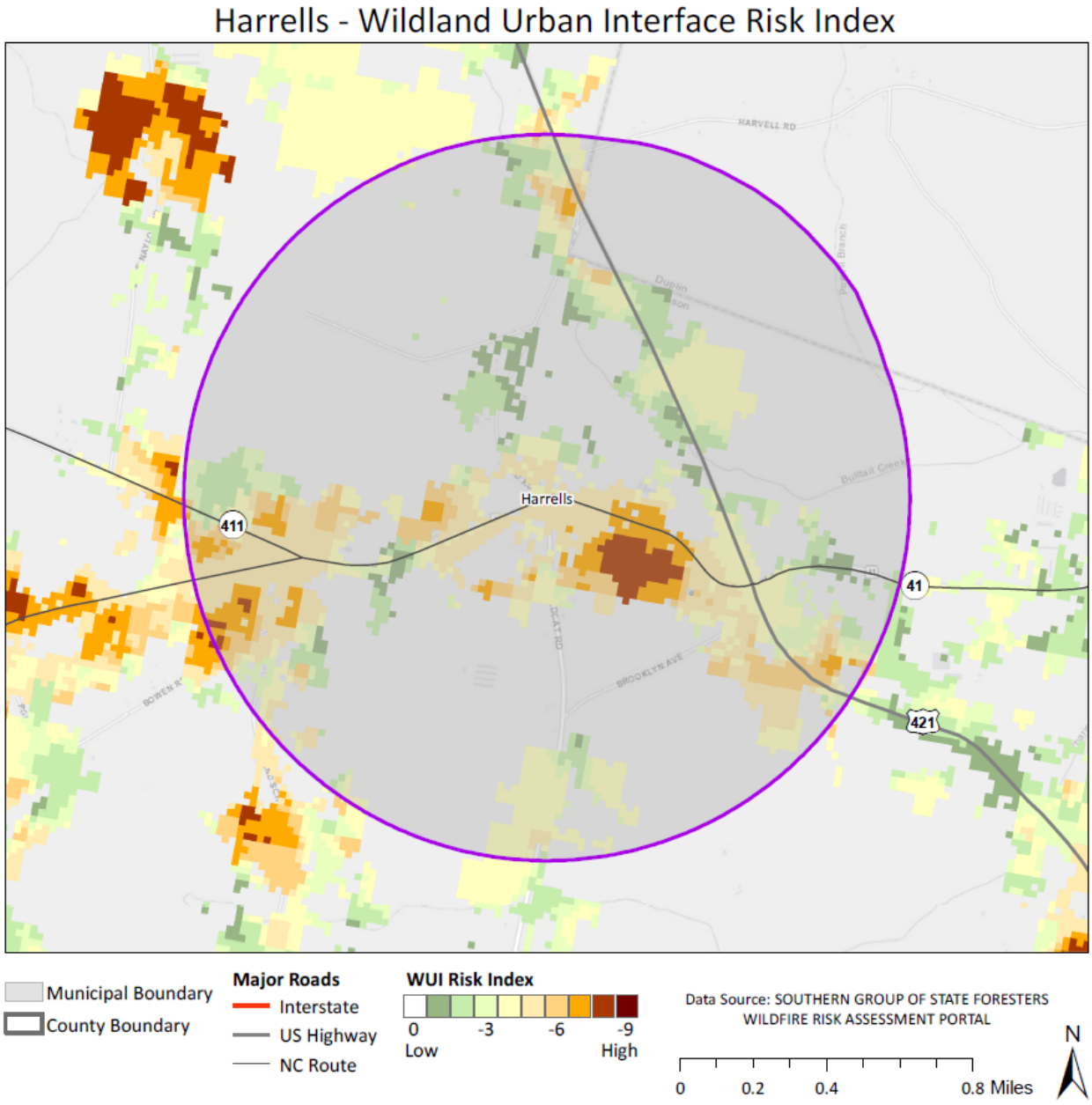

Figure D-21. Wildfire Risk Zones in Harrells, Sampson County, NC

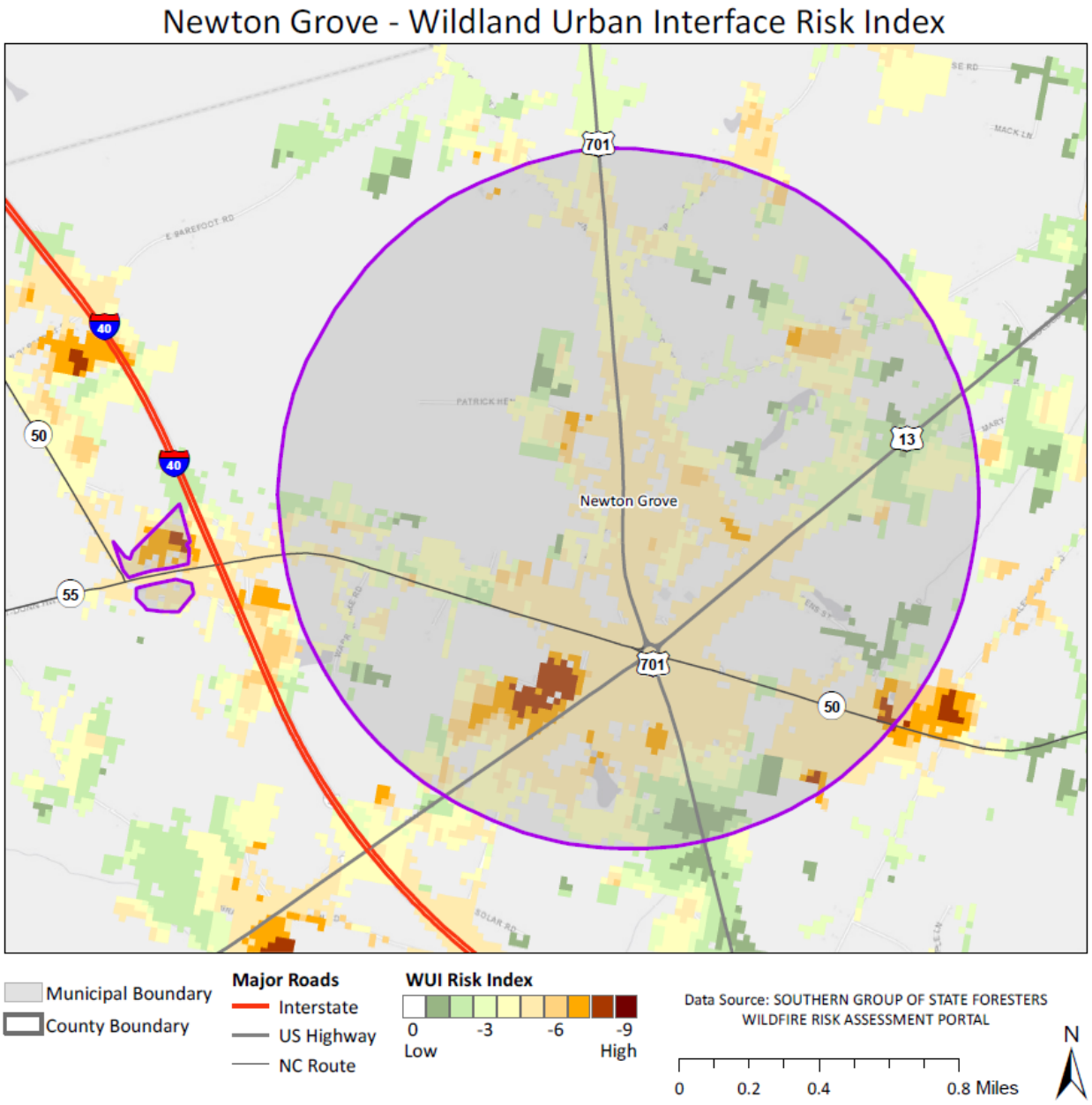

Figure D-22. Wildfire Risk Zones in Newton Grove, Sampson County, NC

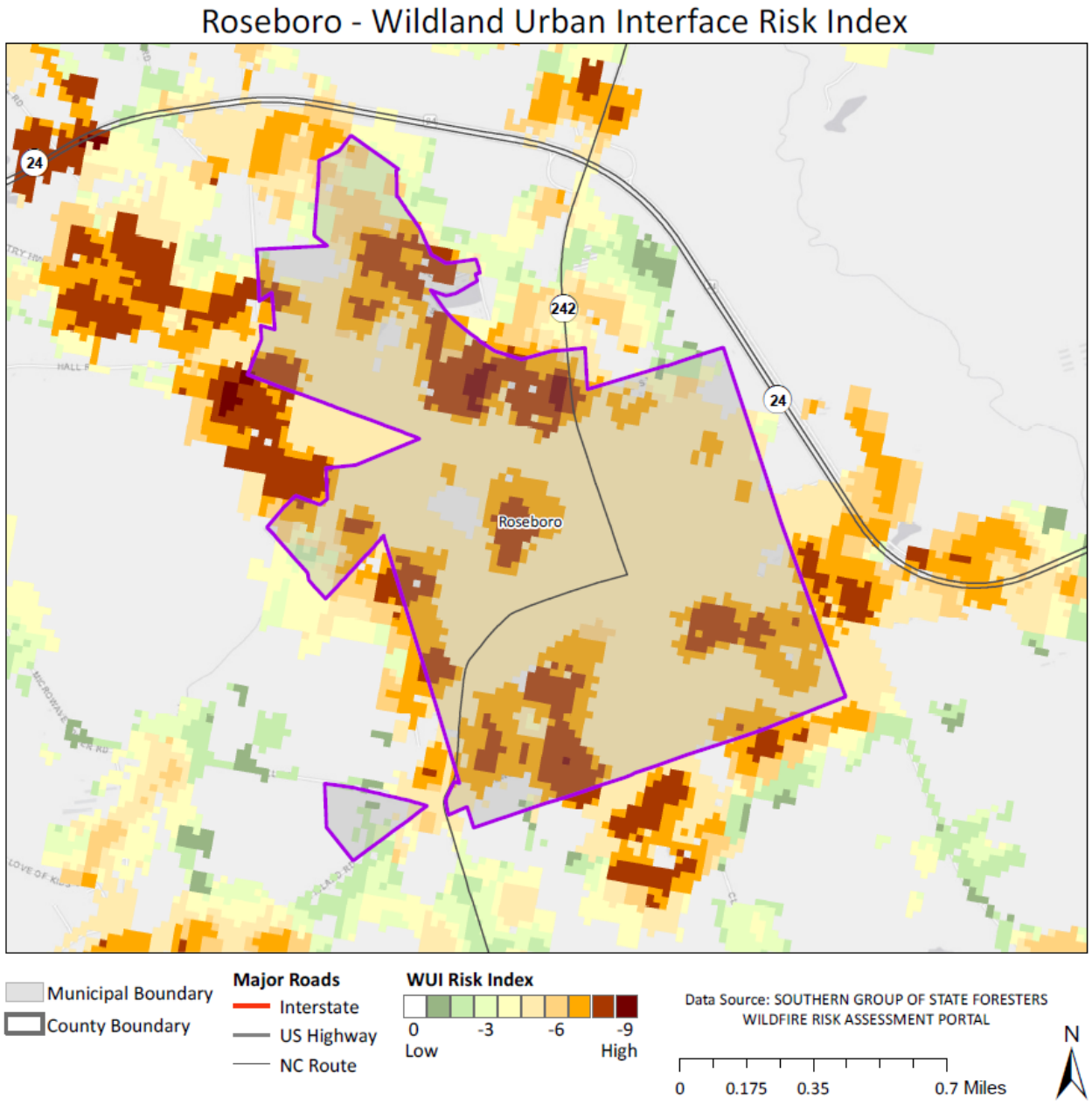

Figure D-23. Wildfire Risk Zones in Roseboro, Sampson County, NC

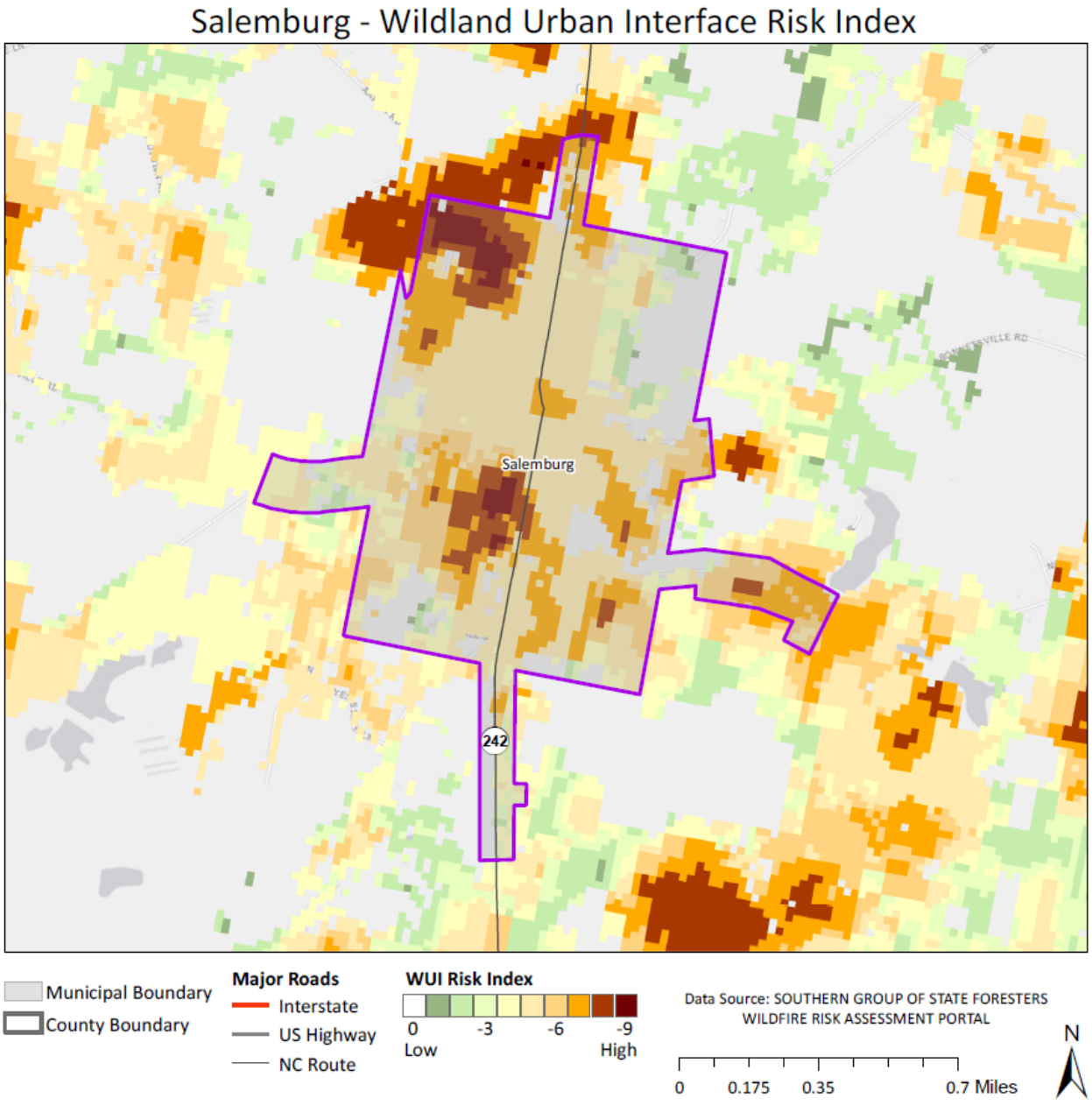

Figure D-24. Wildfire Risk Zones in Salemburg, Sampson County, NC

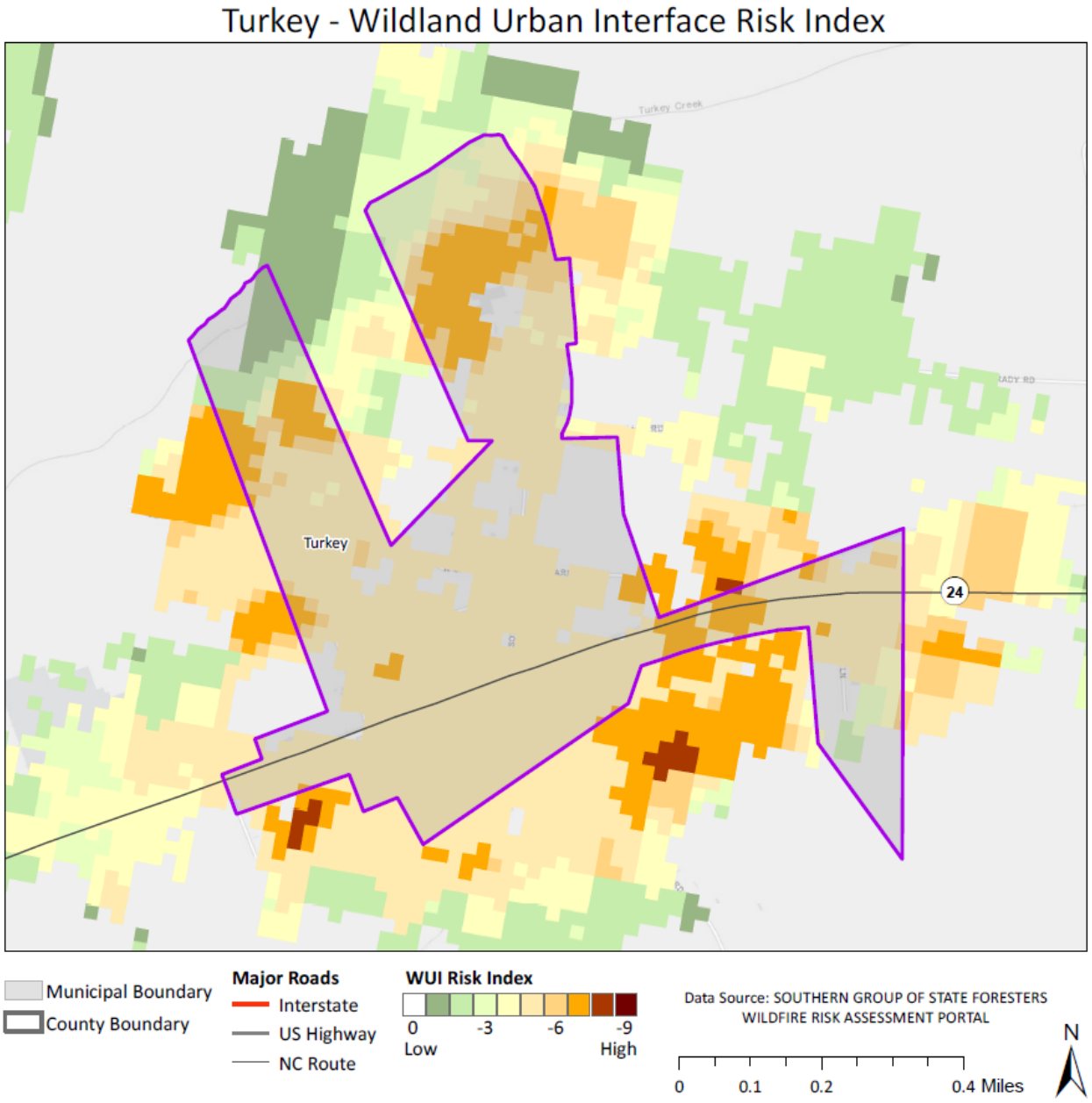

Figure D-25. Wildfire Risk Zones in Turkey, Sampson County, NC