

Nashville Area Metropolitan Planning Organization

Building Resilience: A Climate Adaptation Plan

DRAFT

Respectfully prepared in partnership with Climate Solutions University for the citizens of Davidson, Maury, Robertson, Rutherford, Sumner, Williamson, and Wilson Counties by the:

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Partial funding for this document was provided by the U.S. Department of Transportation Federal Highway Administration and Federal Transit Administration, the Tennessee Department of Transportation, and local government members of the Nashville Area Metropolitan Planning Organization.

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Foreword

In 2015, the Model Forest Policy Program (MFPP), the Cumberland River Compact (CRC), and the Nashville Area Metropolitan Planning Organization came together to create a climate adaptation plan for Davidson, Wilson, Williamson, Sumner, Rutherford, Robertson, and Maury Counties in Middle Tennessee. Development of the plan came about because all parties recognized the critical need for local community and regional resilience against the impacts of climate change by protecting forest and water resources. This climate adaptation plan for the Nashville Area MPO region presents the results of a regional team effort, deep and broad information gathering, critical analysis and thoughtful planning. The Nashville Area MPO took a local leadership role to engage with the Climate Solutions University: Forest and Water Strategies program (CSU) and lead the region toward climate resilience with an adaptation plan that addresses the local climate risks and fits local conditions and culture. This achievement was made possible by the guidance and coaching of the CSU program created by the MFPP in partnership with the CRC. The goal of CSU is to empower rural and urban underserved communities to become leaders in climate resilience using a cost effective distance-learning program. The result of this collaborative effort is a powerful climate adaptation plan that the region can support and implement in coming years. The outcome will be a region that can better withstand impacts of climate upon their natural resources, economy, and social structure in the decades to come. The prior efforts of the NashvilleNext planning process and the 2010 Sumner County Climate Adaptation Plan were critical precursors to this document.

Acknowledgements

Climate Solutions University would not have been possible without the major funding of The Kresge Foundation and other funders, which allowed development of the in-depth curriculum and the ability to provide coaching support to community participants.

The team that leads the CSU program includes: Nancy Gilliam, Gwen Griffith, Toby Thaler, Margaret Hall, Alyx Perry, Deb Kleinman, Vanitha Sivarajan, Beth Ross, Josh Dye, and Spencer Phillips.

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Executive Summary



Figure 1: Radnor Lake
Photo by Danna Haile

This plan was developed by the Nashville Area Metropolitan Planning Organization (MPO) in collaboration with Climate Solutions University (CSU), the Cumberland River Compact, and the Model Forest Policy Program. The purpose of the document is to identify the primary climate and non-climate stressors facing the Middle Tennessee region and to propose solutions to address these risks. These solutions generally fall into two categories, mitigation, which attempts to slow the progression of climate change itself, and adaptation, which attempts to lessen the impacts of climate and non-climate stressors. Adaptation solutions have the ability to increase our region’s resilience to these stressors and bounce back from shocks. Many solutions will have significant co-benefits that achieve both mitigating and adaptive goals. To date, the primary response to climate stressors has been mitigation, but this alone is not enough. Many communities, including those in Middle Tennessee, are already experiencing significant impacts as a result of climate change. These impacts are projected to increase in the future, even with robust mitigation efforts. Therefore, our region must significantly increase our efforts to adapt to these changing conditions. While this document primarily serves as an adaptation action plan for the region, it is also essential to reduce greenhouse gas emissions and lessen the region’s contribution to climate related stressors.

Our region is already experiencing impacts from climate change. Extreme weather events, increasing temperatures, changing precipitation patterns, and rapid growth and development pose threats to the

ecosystems, infrastructure, and people of our region and require collaborative action at all levels (government, nonprofit, business, and citizen) to respond adequately. These changes will impact the region's access to clean drinking water, clean air, fertile soil, outdoor recreation, economic opportunity, and can pose serious public health risks. These changes have a disproportionate impact on the communities and people in the region that are most vulnerable because of their socioeconomic status, health, age, or preexisting conditions.

The Nashville Area MPO is particularly concerned with the impacts of climate change on the region's transportation system, and has chosen to incorporate climate change considerations into planning activities and programs to improve the efficiency and cost-effectiveness of infrastructure protection and public safety. This adaptation plan includes analysis of the transportation system's vulnerability to climate change and recommends adaptation solutions.

Through collaborative partnerships, people, government, business, organizations, and the natural and built environment can become resilient to the climate and non-climate stressors facing Middle Tennessee. The region will support livable, prosperous, sustainable, and diverse communities when leaders and citizens across all sectors and jurisdictions prioritize and sustain collaborative action for climate resilience.

As part of the development of this plan, four goals were identified to achieve climate resilience in the region:

- Goal 1:** The region implements preemptive adaptation measures and responses to extreme weather events that are planned, coordinated, and timely.
- Goal 2:** The leaders and residents of the region value and protect water resources and prioritize improved water quality and conservation for the benefit of human and natural systems.
- Goal 3:** The region's growth and development promotes equitable prosperity and is sustainable for people and natural resources.
- Goal 4:** The region's leaders and organizations work collaboratively and effectively in all resilience actions.

Throughout this planning process, care was taken to recognize the impact of climate and non-climate risks on vulnerable populations to ensure that underrepresented groups were considered and consulted during the development of adaptation solutions. These solutions are varied but incorporate the following core strategies: partnerships, education initiatives, policy changes, monitoring and evaluation, and capacity building. Preemptive adaptation actions will allow our region to be more resilient to the negative impacts of climate change and growth and development. As solutions are implemented, this plan will continue to develop and evolve, requiring the continued collaboration of the stakeholders including governmental, civic, and business leaders as well as vulnerable populations.

Building on the momentum of stakeholder engagement during the planning process of this document, the MPO will be taking the lead on the creation of a Regional Resilience Working Group (RRWG) in service of goal 4 of the action plan to increase regional collaboration. This will be a diverse group of stakeholders, representing all sectors and geographies of the region. During the first 6-12 months, the RRWG will initiate the following actions:

- Explore effective government/nonprofit partnerships to expand government’s capacity to affect change.
- Meet regularly to monitor and evaluate resilience progress and increase partnerships between government, nonprofits, and business sectors.
- Maximize the utilization of volunteers to perform direct action resilience efforts.
- Conduct outreach on the findings of this plan throughout the region to create engagement with and support for the action plan.
- Monitor and review progress and success and continuously reprioritize goals and actions to represent need, capacity, and opportunity.

1.0 Introduction to People and Place

1.1 The Community

Middle Tennessee is one of the fastest growing regions in the country. More than half of the state’s population growth between 2010 and 2040 is anticipated to occur within the ten counties around Nashville. The region is expected to welcome 1.3 million more people in the next 25 years, which is a 76% increase in population. The rolling hills and numerous lakes and streams are host to rich species diversity, including rare and endangered species and habitats found nowhere else in the world, such as the Cedar Glades in Rutherford County. Outdoor recreation opportunities abound, and the region is investing in parks, open space, greenways, and trail systems for hiking, running, and biking. The region also has a diverse cultural heritage, from agriculture to the arts. Entertainment options, including professional sports teams, symphony orchestras, restaurants, and the world famous honky tonks of downtown Nashville are a rich resource for residents and tourists alike.

The booming economy and growing population in the region have bolstered Nashville’s image as an “it city”. The presence of numerous universities, a strong culture of creativity, and flourishing entrepreneurship has established a diverse local economy, which extends throughout the region. The health care, publishing, music production and recording, tourism, and emerging technology sectors are all major contributors to the region’s economic vitality and ongoing population boom. The region is attractive to a diverse array of individuals, and the fastest growing populations include millennials, retirees, and immigrants. For example, Nashville is home to the largest population of Kurdish immigrants in the country.

In addition to the numerous benefits that result from the region’s amenities, thriving economy, and population growth, these factors also present the region with challenges as it moves forward. Growing income disparity and rapidly rising housing costs have occurred as the economy continues to grow. Many vulnerable populations are experiencing displacement from urban areas and are relocating to suburban developments, which decreases their access to economic opportunity and increases their

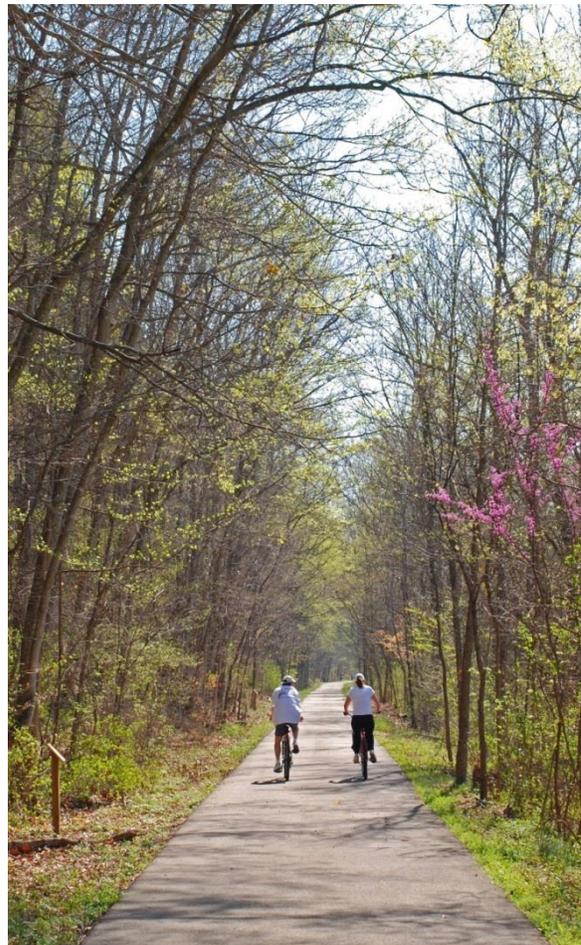


Figure 2: Bicycling in the region
Photo source: MPO

transportation-related financial burdens. In many cases, growing housing needs and economic development has led to sprawling land use patterns that encroach on environmentally sensitive areas and negatively impact water quality and species' habitats. These patterns also contribute to longer commute times, and increased congestion and greenhouse gas emissions.

The region has experienced numerous extreme weather events in recent decades, and these events are expected to continue into the future with increasing frequency and severity. Significant flooding events in 2010 and 2014, a record heat wave in the summer of 2012, and a severe ice storm in the winter of 2014 have signaled to the region that additional actions are required to become more resilient to the impacts of climate change and growth and development. This plan addresses both the need to address these issues as well as solutions and an action plan to do so. While the threats to our region are real, so are the numerous assets we possess. This document serves as a call to action and proposes steps that should be taken to protect our people, landscapes, and economy to create a resilient and vibrant region for decades to come.

The Nashville Area MPO:

The Nashville Area Metropolitan Planning Organization (MPO) is the lead transportation policy, planning, and programming agency for Middle Tennessee and serves more than 1.6 million people throughout Davidson, Maury, Robertson, Rutherford, Sumner, Williamson, and Wilson counties. Acting as a regional partnership among the local elected leadership, transit agencies, the Tennessee Department of Transportation, and federal agencies, the MPO represents a forum for the business community and citizens across the seven-county area to help decide how federal and state funds will be used to improve roads, bridges, public transit, and walking and bicycling conditions. The vision of the MPO is to develop policies and programs that direct public funds to transportation projects that increase access to opportunity and prosperity, while promoting the health and wellness of Middle Tennesseans and the environment. The MPO leads in the development of the metropolitan area's long-range transportation plan and near-term transportation investment program.

In addition to the development of these transportation plans, and in collaboration with regional partners, the MPO contributes to ongoing conversations about issues such as economic development, land use, climate change and the environment, safety and security, housing, and public health. Because climate resilience is directly related to the health and prosperity of the region's future, and because the MPO believes that climate change must be considered for all future transportation and land use planning activities, this Climate Adaptation Plan is a necessary addition to the MPO's planning efforts.

The Region:

Our region is located in Middle Tennessee, and encompasses a 7-county area: Davidson, Maury, Robertson, Rutherford, Sumner, Williamson, and Wilson counties. This area covers more than 3,000 square miles and is populated by more than 1.6 million people.

The Nashville-Davidson and Murfreesboro Urbanized Areas have populations greater than 50,000 people. The designation “Urban Cluster” refers to areas that have a population between 2,500 and 50,000 people. This classification system, created by the U.S. Census Bureau and using demographic data, focuses on the actual distribution of residential, commercial, and non-residential land uses, not local municipal boundaries.

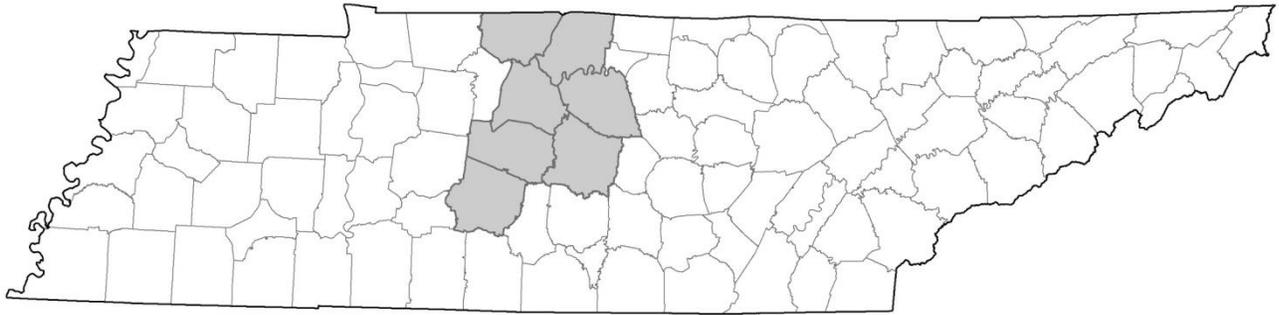


Figure 3: Tennessee and the Nashville MPO Planning Area. The MPO Planning Area is shown in gray

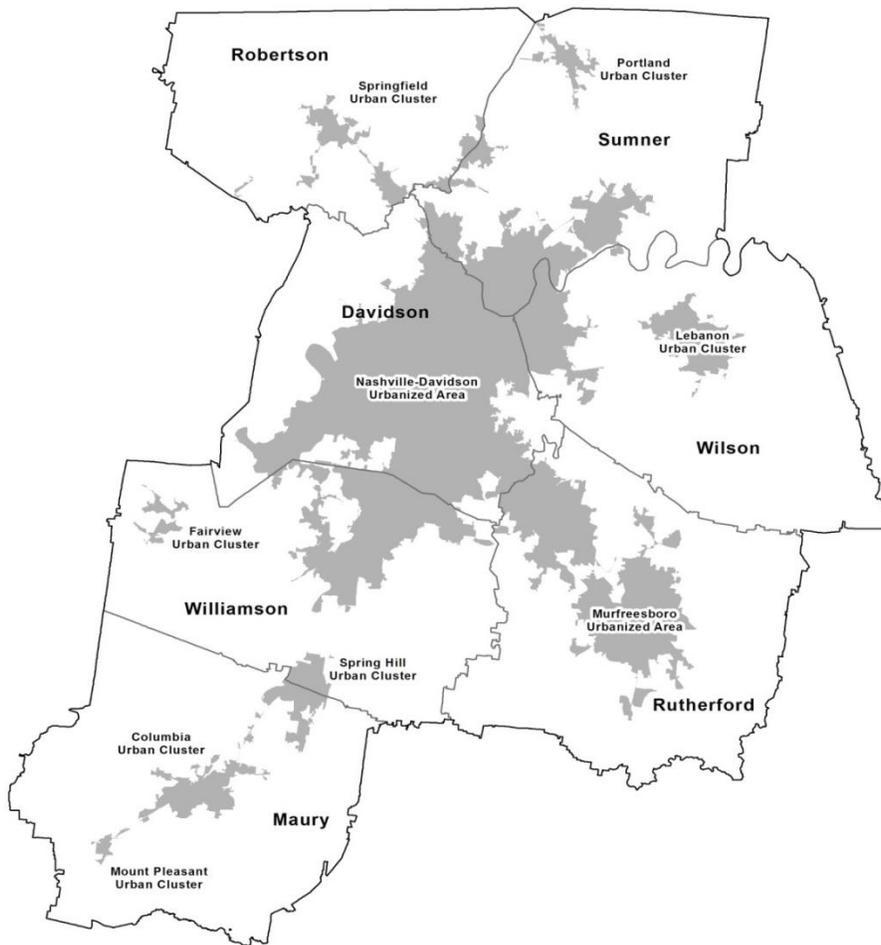


Figure 4: MPO planning area & census urban areas

Our region is home to a wealth of diverse species and ecological systems, rich cultural diversity, and a strong and growing economy. As climate change increasingly impacts precipitation patterns, regional temperatures, and ecosystem processes, we must work to plan for a future that considers the health and well-being of our most vulnerable people, plants, and animals.

1.2 Anticipated Risks and Motivation for Adaptation

Climate change is a global, unequivocal reality – the Intergovernmental Panel on Climate Change reports that climate change has already impacted “natural and human systems on all continents and across the oceans”. Regional impacts in Tennessee include increased temperatures, more frequent extreme weather events, threats to ecosystem services, and negative economic and socio-economic effects. Specific local weather events, such as the 2010 flood in Nashville, major hailstorms, heat waves, and extreme cold, have increased over the past three decades. The broad impacts of climate change to public health, infrastructure, and socioeconomics require immediate and concerted action to avoid further impacts and adapt to those already occurring. The Nashville Area MPO undertook an effort to bring an ecosystem services framework to our analysis of risks and impacts. This approach allowed the MPO to identify the important ecosystem processes and ecosystem benefits in our region.

The purpose of this plan is to identify the climate and non-climate stressors that pose risks to the MPO’s seven county planning area in Middle Tennessee and develop strategies to address those risks to benefit the people and natural systems of the region. This includes strategies to protect nature’s benefits that communities rely upon for air quality, water supply, food and fiber, mitigation of natural hazards, and other ecosystem services that serve as the foundation of our socioeconomic systems. Perhaps the greatest risk is from the region’s rapid rate of existing and projected growth and development.

The region’s growth and development is evidence of a robust and growing economy, but, if improperly managed, the associated sprawl will negatively impact the region’s natural systems and ecosystem services. Loss of green space and productive farmland is the most obvious result of development, but there are also negative impacts on our regional hydrologic cycles and habitats that result from increased impervious surface area. Additionally, growth and development pose numerous risks to the built environment, increased housing costs, gentrification, and transportation issues, all of which can become barriers to economic opportunity and serve to further marginalize vulnerable populations.

Unless we address these risks now, our region’s growth will become unsustainable. As we continue to struggle with infrastructure limitations, our changing climate will magnify existing conditions that strain our public health, food production, and ecological systems. It is important to note that while most of our region currently enjoys a healthy supply of water and forest resources, rapid population growth and climate change can pose a serious risk to the future availability of these resources. Fortunately, many of the tools used to properly address growth and development also alleviate risks associated with climate stressors.

Population in the MPO planning area is expected to increase by 76 percent between 2010 and 2040. This is an increase from about 1.5 million in 2010 to about 2.65 million by 2040, or over a million more

people in the MPO 7-county region. Understanding where those people will live, work, recreate, and shop within our region is critical to determining how to improve the region's resiliency. To predict these trends, the MPO employs a land use model that considers economic and market forces, local land use policies, land development regulations, topography, and other environmental features.

In addition to the risks associated with sprawling growth, we have identified a number of climate stressors that pose the greatest risks to our region. These are primarily extreme weather related and include: flooding, extreme heat, drought, ice storms and winter events, and tornadoes and wind events. Our region is already experiencing these risks, and projections show clear trends for increasing extreme weather events in the future. As such, immediate adaptation and mitigation action is required to avoid increasing harm. As the region experienced in the aftermath of the historic flood of 2010, these events can have devastating impacts to the region's ecosystem processes and benefits, its economy, and its people.

1.3 Examples of Successful Adaptation and Resilience

Fortunately, in response to the serious nature of these risks, there are successful examples and models for improving community resilience currently underway in Middle Tennessee.

Green Alleys Project:

One example of a local on-the-ground adaptation approach is a green infrastructure project currently taking place in the MPO region, called the "Green Alleys" project. This project is a joint effort led by the Cumberland River Compact and includes government, homeowners, businesses, and community volunteers. The project provides free rain garden materials and volunteer labor to interested residents in the alleyways of "The Nations" neighborhood of Nashville/Davidson County. This project is collaborative, low-cost, and replicable, and its benefits are manifold. In addition to the environmental benefits of stormwater absorption and management and the minimization of pollution runoff into nearby streams, the project also has secondary co-benefits. The rain gardens beautify the alleyways and encourage their use by pedestrians in the neighborhood, encourage active transportation, which can lead to public health benefits for the residents of the community, and also enhance the safety of the area. This type of project could be replicated in many neighborhoods throughout the region and gives community members educational opportunities, encourages civic participation, and provides a sense of ownership in the neighborhood.

EARS:

Another example of successful adaptation in our region is the creation of the organization EARS, Emergency Awareness and Readiness Services for the Deaf and Hard of Hearing. This is an educational initiative that addresses the needs of a vulnerable population. EARS is currently working toward 501(c)3 status and provides emergency preparedness training and early warning equipment to the deaf and hard of hearing. EARS also coordinates with emergency management personnel and first responders to help these agencies better understand how to address the needs of the deaf and hard of hearing

community and ensure that these agencies are communicating appropriately during extreme weather events and emergencies. This model can be replicated throughout the MPO region and can be used to address the needs of a variety of vulnerable populations, such as immigrants or people with limited English proficiency.

Flood Home Buyout Program:

The Home Buyout Program was initiated after the historic flood of May 2010 to purchase homes destroyed by the flood, help displaced residents, and convert lots in the floodplain to open space. As of August 2014 the flood-buyout program had purchased 228 homes and returned 160 acres to open space. After purchasing and demolishing the damaged structures, the city uses its non-profit partners, primarily the Cumberland River Compact, to engage volunteers to re-establish stream buffers along creeks by planting trees and shrubs or by allowing the properties to re-establish naturally. Ownership of some of the properties has been transferred to Metro parks, and permits have been issued to nonprofit groups for urban farms. As a result of the flood buy-out, as of August 2014 the total open space for Nashville/Davidson County is over 13,740 acres. This increase in open space, along with an expansion of the city's greenway system, has resulted in a 25 percent increase in park land within the county.

These are just a few examples of multi-beneficial approaches to resilience initiatives. The key to building lasting resilience is for climate considerations to become integrated throughout the many policy, planning and practice procedures that are carried out by agencies, organizations, and businesses across the region. Each one stands to benefit by being aware of the changing conditions and factoring those considerations into their decision making and normal procedures. In addition, when those entities collaborate across sectors and jurisdictions, their efforts can be coordinated and the entire region reaps the benefits.

2.0 Resilience Planning - Scope and Methods

This Climate Adaptation Plan (CAP) will be adopted in early 2016 as a companion to the 2040 Regional Transportation Plan, a long-range planning document released by the MPO every five years. The MPO considers the impacts of climate change on the region to be relevant to current planning activities, and the CAP will serve as an environmental action plan for the region, impacting 1.6 million residents in seven counties, many of whom are vulnerable to the effects of regional growth and development and climate change.

2.1 Collaborative Process and Community Engagement

The Nashville MPO's planning process brought local governments, nonprofit and for profit businesses, and citizens together to protect our region's people, infrastructure, natural resources, and built environment from the risks and impacts of climate change and rapid growth and development. The MPO gathered input in a variety of ways, including in person meetings and forums, presentations to community groups, telephone conversations, surveys, and informal chats. This collaboration and the utilization of an ecosystem services framework allowed the MPO to identify and prioritize the risks that most directly impact the region's people, environment, economy, and infrastructure. Our stakeholders' insights were invaluable during the analysis of the region's ecosystem processes, risks to vulnerable communities, and potential socio-economic costs and benefits of possible action. They also provided crucial information regarding actions our region is already implementing to build resiliency as well as the opportunities for additional action.

The core team of stakeholders was vital to the success of this project, and will continue to be instrumental actors for implementation of the plan. This team is composed of representatives from organizations that engage with the elderly, disabled, low income persons, immigrants, and homeless populations in both urban and rural areas, and environmental policy and natural resources experts from the government, nonprofit, and private sectors. Their input into the risk identification process and ideas for improved resilience helped guide policy recommendations based on their perceived gaps in existing services, provided a link to individuals who were able to give direct testimony to their experiences, and their final review of the plan was essential and much appreciated. Many members of the core team expressed gratitude for the opportunity to collaborate and an interest in continuing to work together as a Regional Resilience Working Group.

CORE TEAM LIST:

- Center for Independent Living of Middle TN
- Cumberland River Compact (CRC)
- Fifty Forward
- Hands On Nashville
- Lipscomb University Institute for Sustainable Practice
- Metro Nashville Office of Emergency Management
- Metro Nashville Public Health Department
- Metro Nashville City Horticulturist
- Metro Water
- Nashville Mayor's Office
- Emergency Awareness and Readiness Services (EARS)
- Rutherford County Planning Department
- Schneider Electric
- Tennessee Department of Transportation (TDOT)
- Tennessee Department of Environment and Conservation (TDEC)
- Tennessee Disability Coalition
- Tennessee Immigrant and Refugee Rights Coalition (TIRRC)
- Tennessee State University (TSU)
- Tennessee Wildlife Resource Agency (TWRA)
- Urban Green Lab
- Vanderbilt Institute for Energy and the Environment (VIEE)

In addition to the stakeholders listed above the Nashville Area MPO also took advantage of its current governance structure and standing committees to increase participation in our planning process. As a result, the Nashville Area MPO was able to both educate and solicit input from its Executive Board and Technical Coordinating Committee. The utilization of these existing boards and committees was crucial because of the inherent difficulties of soliciting meaningful stakeholder participation over a large seven county geography.

The Executive Board consists of elected officials representing Davidson, Maury, Robertson, Rutherford, Sumner, Wilson, and Williamson counties, as well as cities in those counties with a population of over 5,000. Additional board members include the Governor, federal and local transportation and transit

agency representatives, and an elected official from the Greater Nashville Regional Council. The Board provides policy direction and is a forum for transportation and air quality decisions. The Board meets as needed to approve major planning reports and documents. The Technical Coordinating Committee (TCC) consists of administrators, planning directors, and transportation engineers from local governments and transportation related agencies. The basic responsibilities of the TCC include collaborating with staff to provide recommendations to the Executive Board in the development of regional transportation plans and programs.

This collaborative adaptation planning process was facilitated by the MPO's participation in the Climate Solutions University (CSU) 2015 curriculum for climate adaptation planning. The CSU 11-month virtual curriculum provides a series of facilitated learning modules that guides community leaders through a risk assessment and planning process to identify climate risks, other non-climate stressors, and develop adaptation strategies that build local and regional resilience. The MPO participated in the CSU curriculum along with leaders from Sustainable Sandhills of Cumberland County, North Carolina, The City and County of El Paso, Texas, and the 22-county region of the Sierra Business Council of California.

2.2 Agile Strategic Planning for Responsive Risk Reduction

We employed an agile planning process for the development of this Climate Adaptation Plan. From the beginning of the process, in collaboration with our stakeholders, we identified our ideal future for the region. This “desired future condition” (DFC) attempts to explain what success looks like once resilience is achieved. This is a practical vision for the near future, which sets aside current limitations to implementing adaptation solutions. The development of the plan has been iterative, and solutions to the risks facing our communities and natural systems have been proposed, rejected, revised, and reimaged. Additionally, the risks themselves have been refined as additional information has been obtained throughout the planning process, and the proposed solutions have been similarly revised. The plan is designed to be regularly reviewed and revised as tasks are completed and risks or priorities change. This adaptive nature allows the plan to stay relevant to changes in funding or organizational capacities and capitalize on opportunities as they present themselves.

2.3 Implementing Adaptation Strategies

There are numerous methods available to implement the adaptation strategies proposed in this plan. Regional collaboration for climate resilience is a key factor, and the following methods are also required:

- **Education and behavior change:**

Full understanding of the projected impacts of climate change on our region's people, environment, economies, and infrastructure will encourage individual and collective action to mitigate and adapt to these risks and can provide politicians with the support and motivation needed to enact change.

- **Public policy and financial systems:**

Policies that incentivize environmental stewardship, conservation, ecosystem health, and sustainable growth will minimize risks and lead to long-term economic and social well-being.

- **On-the-ground conservation, infrastructure improvements, restoration and resource management practices:**

Adaptation and mitigation actions such as stream restoration, native plantings, riparian buffer restoration, species reintroduction or relocation, and forest management will reduce the negative impacts of human development currently being experienced and will prevent further environmental degradation in the future.

- **Markets and funding sources:**

Sustainable, dedicated funding for resilience activities and adaptation in the short term will reduce the need for expensive emergency responses in the future. Increased focus on collaboration could produce unique opportunities for funding sources through public-private partnerships or other sources.

3.0 Ecosystem Services Framework

3.1 People and the Benefits of Ecosystem Processes

Ecosystem services are the beneficial effects on human well-being that result from nature’s ecological processes. Core ecosystem processes, like waste assimilation, produce beneficial services such as water purification and a clean water supply. These benefits, which can be tangible or intangible, are directly enjoyed or consumed by humans¹. Ecosystem benefits have an economic value that can be estimated and should be considered in making decisions about how to manage them. Ecosystem services form the foundational elements that support water security, food security, public health and safety, and basic socioeconomic stability for all communities.

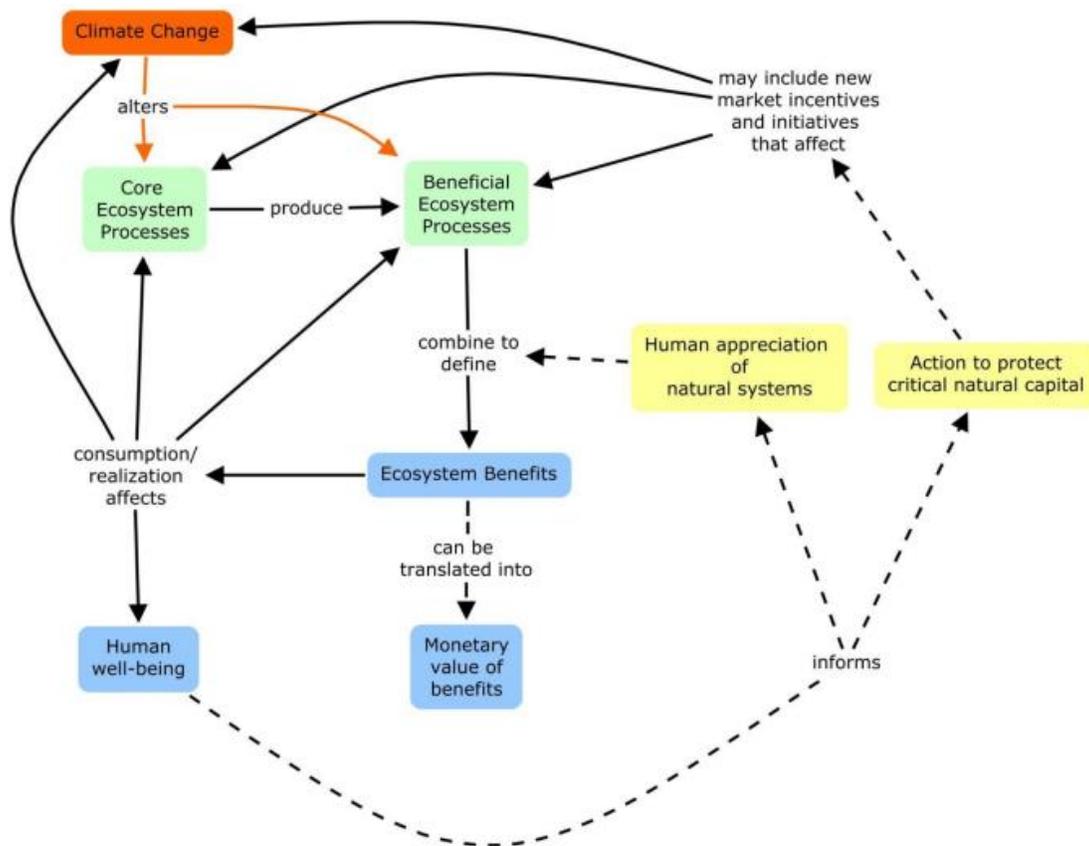


Figure 5: Core ecosystem processes, related benefits, and system feedbacks
Source: Phillips, Spencer, 2013. Key-Log Economics, LLC

¹ Phillips, Spencer. 2013. *A user’s guide to ecosystem services: moving from understanding to action*. Charlottesville, Virginia: Key Log Economics, p. 3.

Ecosystem services and benefits change in relative importance depending on the geographic study area and types of social and economic activity present in that area. For this reason, it was imperative to query the communities and stakeholder groups that were integral to the development of this Climate Adaptation Plan. We utilized an Ecosystem Services Assessment Tool (ESAT²) to frame our discussion of ecosystem processes, their current importance to humans, and possible changes to these processes that would result from climate change and other non-climate stressors.



Figure 6: Drivers of change, ecosystem services wheel
 Source: Jessica Jahre, EPA Contractor

² Phillips, pp. 1-15.

Healthy ecosystems provide numerous beneficial services to humans, including carbon sequestration, water purification, and climate regulation. Ecosystem services can be altered by climate change, resulting in changes in the availability of these services to humans. With the ESAT, we were able to identify and prioritize ecosystem benefits that were most important for our region and that were most negatively affected by climate change.

Our ecosystem services assessment identified the following high priority benefits at risk for our region:

- Local climate regulation (including temperature and precipitation),
- Water quality and timing (which impacts droughts and flooding), and
- Formation of species habitat (as an indicator of a healthy ecosystem as a whole).

3.2 Climate Impacts on Processes and People

When considering the effects of climate change on these services, we focused primarily on how these changes would affect vulnerable populations, because our biggest climate risks most greatly impact people with limited resources and mobility. Indicators of vulnerability included: socioeconomic status (income, poverty, employment, and level of education), disability, household composition (single parent households, the elderly, and households with dependents), minority status, English-language proficiency, housing, and transportation access³. Our focus on vulnerable populations reflects an understanding that certain populations in our communities have traditionally been overlooked during disaster preparation and response or are disproportionately impacted by the effects of climate change.

The ESAT also helped develop our understanding of the complex relationship between urban and rural areas and their differing experiences of ecosystem services and climate change. These areas are highly interdependent, with rural areas providing food, energy, land, labor, and recreation to metropolitan consumers, and urban areas serving as a market for rural production, a source for jobs, a provider of specialized services, and as a location for investment⁴.

³ Flanagan, Barry E.; Gregory, Edward W.; Hallisey, Elaine J.; Heitgerd, Janet L.; and Lewis, Brian (2011) "A Social Vulnerability Index for Disaster Management," *Journal of Homeland Security and Emergency Management*: Vol. 8: Iss. 1, Article 3, p. 4.

⁴ Dabson, Brian. (2007). Rural-Urban Interdependence: Why Metropolitan and Rural America Need Each Other. Washington, DC: The Brookings Institution, p. 4.



Figure 7: Our changing climate will impact valuable natural resources
Photo source: MPO

Rural and urban areas experience different challenges related to climate change. Urban areas tend to have highly interconnected infrastructure systems that serve large populations. Water and sewer systems, transit, power plants, health care systems, banking and finance sectors, and information technology systems are all vulnerable to disruptions caused by extreme weather and climate variability. When one sector experiences interruptions, others are also affected. Pre-existing urban stressors, such as high population density, concentrated impoverished areas and vulnerable communities, and aging infrastructure multiply the negative impacts of climate change. In addition, our urban centers are highly dependent on commuters and economic activity from neighboring, more rural counties, so addressing infrastructural and social vulnerabilities in urban areas will have positive impacts throughout the region.

Rural areas are generally characterized by their relative physical isolation, higher poverty rates, less diversified economies, and aging populations. These demographic and geographic realities pose challenges to climate adaptation. Rural communities are more dependent on natural resources (water, forests, etc.) that will be affected by climate change, and risk impacts for these communities include:

- Crop and livestock loss or damage from droughts and floods
- Infrastructure damage from extreme weather
- Economic impacts from climate-driven shifts in planting and harvesting times
- Declines in recreational tourism as suitability and wildlife habitats shift

Rural areas may have fewer social and economic resources to address these issues, requiring regional collaboration to address vulnerabilities⁵. Achieving the goal of regional resilience requires addressing the particular risks identified for both urban and rural conditions of the region.

⁵ Melillo, Jerry M., Terese (T.C.) Richmond, and Gary W. Yohe, Eds., 2014: Climate Change Impacts in the United States: The Third National Climate Assessment. U.S. Global Change Research Program, 841 pp. doi:10.7930/J0Z31WJ2.

4.0 Assessment for Climate and Non-Climate Stressors

As identified through the ecosystem services assessment process and through prioritization with our stakeholders, the greatest climate and non-climate risks facing the Middle Tennessee region as a result of climate change were identified as extreme weather, water quality and quantity, and growth and development. The non-climate risk of improperly managed growth and development exacerbates the impacts of climate risks in our region. The current conditions, projections, and impacts related to each of these risks are described below.

4.1 Extreme Weather

Current conditions:

Extreme weather affects every county in Middle Tennessee and across the state. In the past three decades, the state has incurred more than \$1 billion in damages from fifteen weather disasters⁶, and the 2014 National Climate Assessment states that extreme weather events, especially heat waves and droughts, will worsen as the climate warms⁷. Locally, the Nashville area has experienced extreme flooding, a major hail storm, tornadoes, a heat wave, and extreme cold, all in the past few years.

The National Weather Service (NWS) catalogues and records the following types of extreme weather events throughout the state: cold, heat, and wind events, twisters, hydrologic events, lightning, hail, drought, and winter events. From the 27,000 extreme weather events recorded in the NWS database, the average annual extreme weather events per county can be seen in Figure 8.

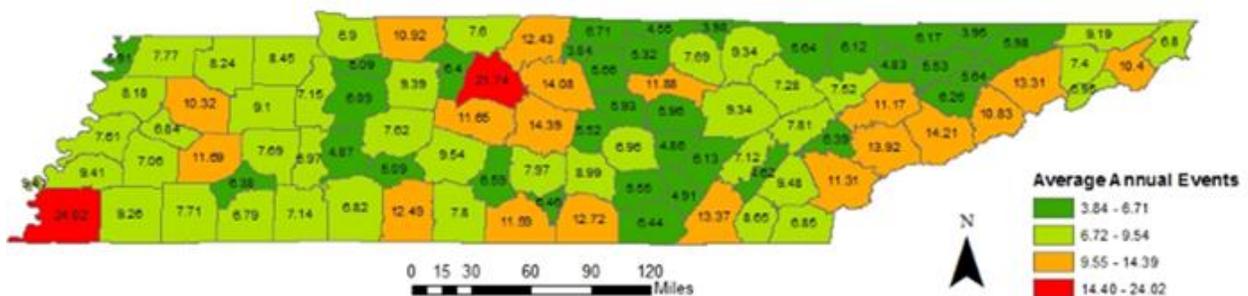


Figure 8: Average annual extreme weather events by county
Source: TDOT Vulnerability Assessment, p. 22

⁶ Tennessee Department of Transportation, Assessing the Vulnerability of Tennessee Transportation Assets to Extreme Weather, Final Report, 2015.

⁷ Melillo, et al.

Projected changes:

Extreme heat is of particular concern for our region, because it is a threat the region already experiences, and the majority of climate models are confident in their projections of increasing temperatures⁸. Prolonged and intense periods of extreme heat, such as the record high of 109F in the summer of 2012, are expected to increase in intensity and frequency in the future. The projected increase in average days above 95 F from the baseline of 10 days per year to an estimated 59 days per year by 2046 is a highly significant shift in the temperature profile of the region (Figure 9). The impacts to people of these heat events will also be intensified by the urban heat island effect as the region continues to become more urbanized over time.

Projected Changes in Temperature		
	Baseline (1961-2000) Observed Value	Mid-Century (2046-2065) Projected Value
Average days per year above 95° F	10 days	59 days
Consecutive days per year above 95°F	4 days	21 days

Figure 9: Projected increases of extreme heat to the middle of the century

Source: TDOT Vulnerability Assessment, Data for Tennessee

Figure 10 below shows the thermal conditions on October 14, 2015. Radiant heat is greatest in the urbanized areas, because of increased impervious surface area and lack of tree cover. Similarly, the largely agricultural land in Robertson County in the top left portion of the map shows higher temperatures than more heavily forested areas throughout the region, which are displayed in blue. Increasing tree cover throughout the region will improve local temperatures and prevent temperature extremes.

⁸ Melillo et al.

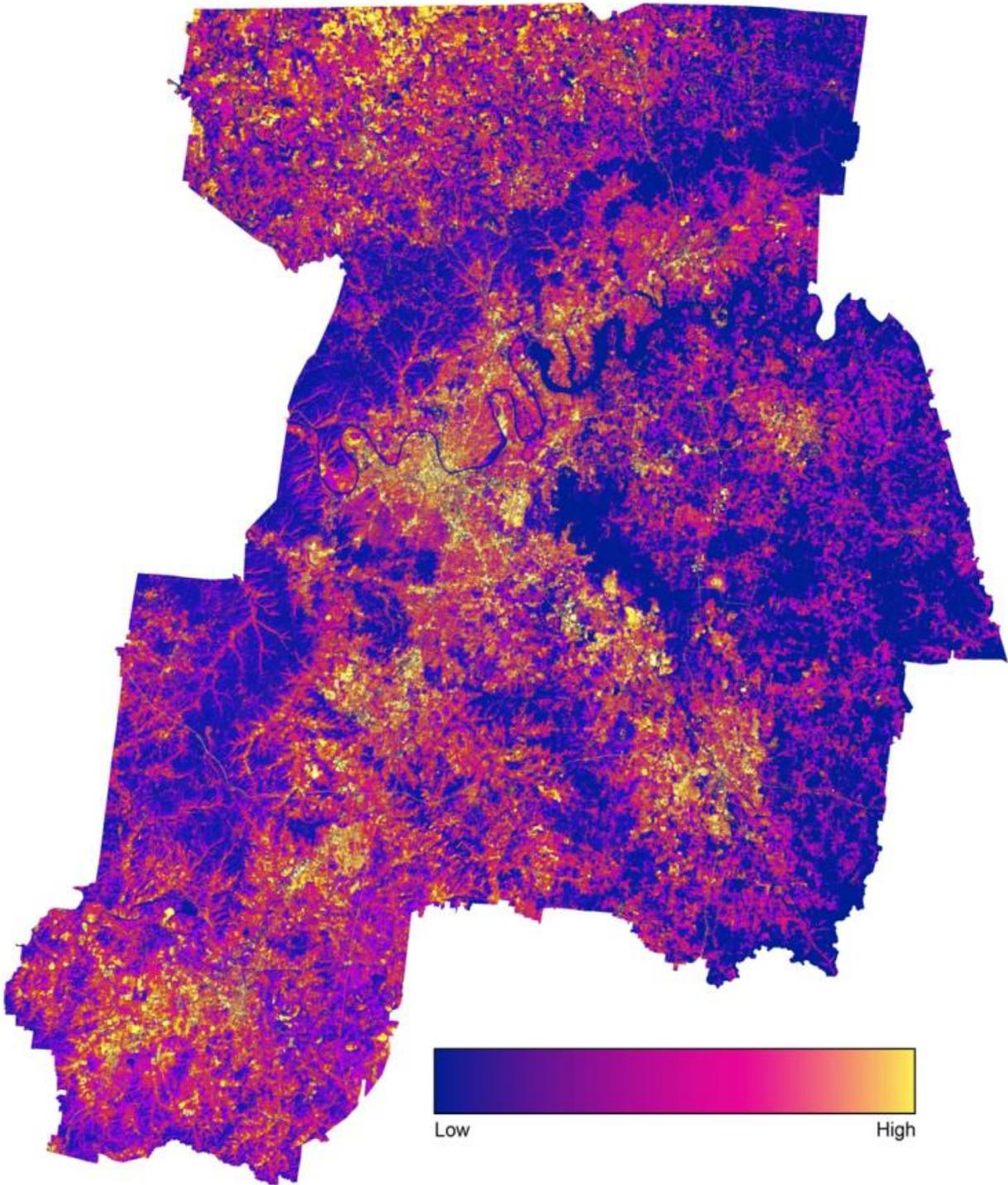


Figure 10: Far-infrared emissions (heat), MPO region
Data Source: Landsat8

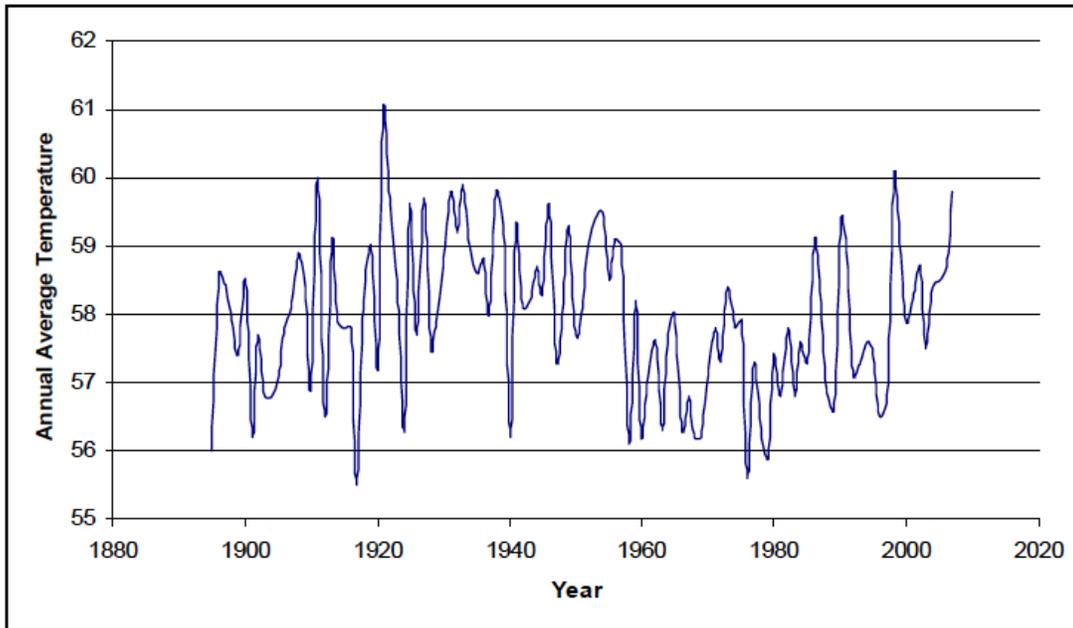


Figure 11: Average annual temperature variability, 1895 – 2006

Source: TWRA Wildlife Technical Report 09, p. 14

Historically, average annual temperatures in the region have varied considerably. Figure 11 shows this range in Tennessee over the last 111 years, from 55.5 F to 61 F. In the future, it is likely that Tennessee will experience increased warming relative to the global average, and mean annual temperatures are estimated to increase by at least 6.3° F (3.5° C), as seen in Figure 12 below⁹

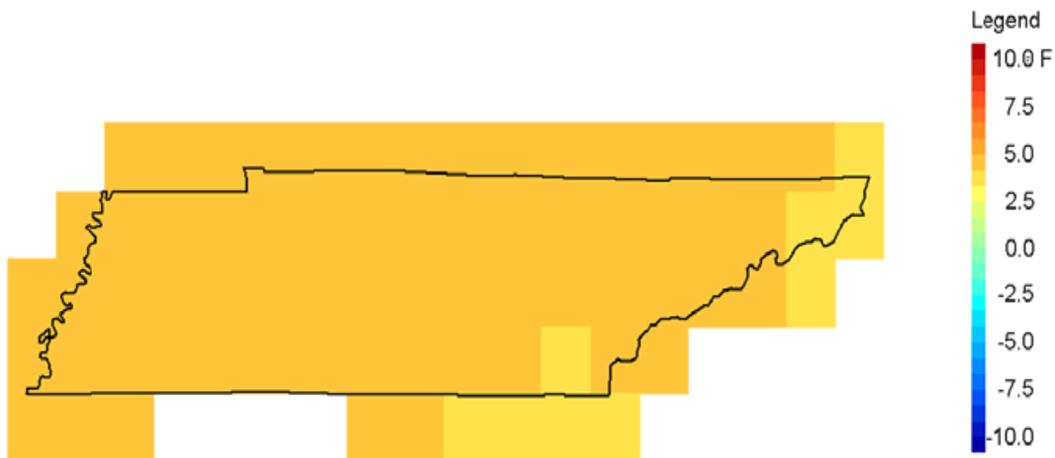


Figure 12: Projected future temperature increases from 2010-2060

Source: TWRA Wildlife Technical Report 09-09, p. 14

⁹ Tennessee Wildlife Resources Agency, *Climate Change and Potential Impacts to Wildlife in Tennessee - An Update to Tennessee's State Wildlife Action Plan*. Technical Report 09-09. p. 14.
<https://www.tn.gov/assets/entities/twra/attachments/tncclimatechange.pdf>

Impacts:

The impacts of extreme weather vary in intensity and scope and require adaptation actions to reduce the impacts to people, ecosystem services, and the built environment.

People

Public health impacts from extreme heat include heat stroke, heart attack, decreased air quality, and the associated increased risk of asthma. The elderly, impoverished people, farm and other outdoor workers, and those who rely on public transit are particularly vulnerable to the negative health impacts of extreme heat. People with limited incomes may not be able to afford to sufficiently cool their homes during prolonged periods of extreme heat, and being outdoors during these times increases one's vulnerability to heat-related illnesses. Other types of extreme weather, such as tornadoes, floods, lightning, and high wind events also impact public health and safety. Flooding exacerbates indoor air quality problems that are caused by mold and trigger asthma. Property damage and dislocation caused by flooding is financially devastating, especially for people without access to a personal vehicle, or whose homes are located in flood zones. Early warning systems, storm shelters, and green infrastructure can lessen the negative impact of these events.

Ecosystem services

Extreme heat stresses livestock production, increases the risk of wildfire, damages habitats, is correlated with agricultural production loss, and results in loss of biodiversity for plants and animals that cannot withstand extreme temperatures. Warmer temperatures stress delicate forest and aquatic ecosystems¹⁰. Flood events flush streams with roadway pollutants and sediment, water temperatures vary wildly, and changes in flow depth during floods and droughts can make some areas non-viable for aquatic species. Other events such as tornadoes and wind events can cause serious damage to vegetation and block or impair waterways. Crop loss can also result from extreme weather.



Figure 13: Species diversity is vital to regional resilience

Photo by Danna Haile

Built environment

Resilience to extreme weather is a high priority for the region's infrastructure, especially our roadways, bridges, and buildings. Climate variability and change is one of the most serious threats to the U.S. transportation system. The transportation sector is the second largest emitter of greenhouse gas

¹⁰ Tennessee Wildlife Resources Agency, *Tennessee State Wildlife Action Plan*, 2015, p. 236.
<http://www.tnswap.com/pdf/2015swap.pdf>

emissions (GHG) in the country after the electricity sector, accounting for 27% of GHG emissions in 2013¹¹. As our population grows, these emissions will increase. These GHG emissions have been directly linked to our changing climate, and the associated increased prevalence of extreme weather require mitigation and adaptation solutions to ensure the long-term viability of our transportation system. While reducing emissions is a mitigation strategy, it is an important policy goal for the MPO. In addition to mitigating climate change, emissions reductions have significant public health benefits as a result of improved air quality.

The region's transportation system is vital on many levels: the local economy depends on a safe, efficient system to transport goods and access markets, emergency services must be able to move quickly to address emergency situations, and people's quality of life and economic prosperity is improved when their mobility is assured. Middle Tennessee's highways and interstates are also important nationally because the state is utilized as a major east-west and north-south corridor.

While the transportation sector is a major contributor to climate change, it is also directly impacted by climate change itself, and adaptation strategies must be pursued to ensure the reliability and functionality of the region's transportation network. In recognition of this need, the Tennessee Department of Transportation, in partnership with Vanderbilt University and the University of Tennessee, conducted a study assessing the vulnerability of Tennessee's transportation assets to extreme weather. This is the first time this kind of assessment has been done for this region, and the report's findings have been vital to the development of this climate adaptation plan and have helped inform the recommended solutions in this report.



Figure 14: Growing congestion is a concern within the region.

Photo source, MPO

The TDOT report identified critical transportation assets on a statewide level, defining these as “any portion of the transportation system without which there would be an immediate and substantial disruption to the transportation system at the local, regional or national level”¹². Historic extreme weather events and future extreme weather scenarios were used to conduct an impact assessment on these assets. A vulnerability score for each infrastructure asset associated with a certain type of extreme weather event was established, and scores were calculated for every county in the state.

¹¹ USDOT, Climate Adaptation Plan, 2014. *Ensuring Transportation Infrastructure and System Resilience*, p. 7. <https://www.transportation.gov/sites/dot.gov/files/docs/2014-%20DOT-Climate-Adaptation-Plan.pdf>

¹² TDOT Vulnerability Report, p. 6.

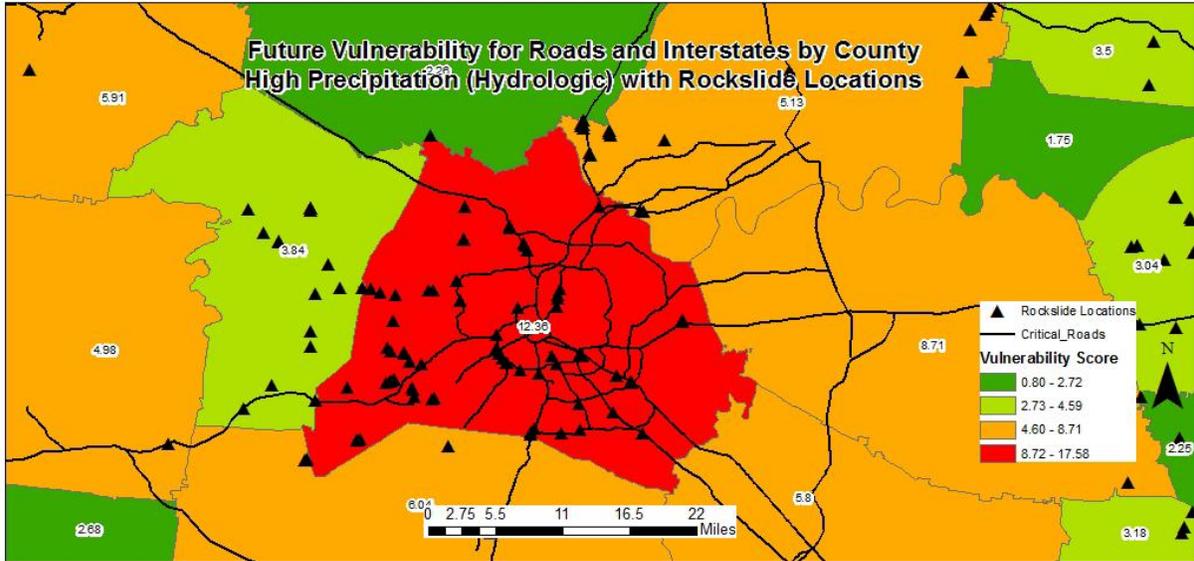


Figure 15: Future vulnerability for critical roads to hydrologic events & rockslides
 Source: TDOT vulnerability report, p. 33

In addition to the county-wide vulnerability assessment, the report also listed multiple asset-weather combinations for each county, and Figure 11 is an example of one of these assessments for Davidson County. This map shows the future vulnerability for roads and interstates to high precipitation events with high-risk rockslide areas superimposed on top. Davidson is particularly vulnerable to such events because steep slopes and limestone formations are common in this area. We can see that neighboring counties also show relatively high vulnerability to these risks. This is a regional issue.

The report identified critical weather risks to the MPO region’s transportation infrastructure as: extreme heat, high winds and thunderstorms, tornadoes, heavy precipitation and flooding, lightning, hail, drought, and winter storm events. The counties with the locations of the most vulnerable critical assets and their associated weather categories are listed in Figure 16 below.

Transportation Asset Type	Wind	Hydrologic
Ports	Davidson	Davidson
Roads	Davidson, Rutherford, Wilson	Davidson
Railroads	Davidson	Davidson
Rail Yards	Davidson	Davidson
Airport Runways	Davidson	Davidson
Locks	Davidson	Davidson

Transportation Asset Type	Wind	Hydrologic
Maintenance and Salt Facilities	Davidson	Davidson
Bridges over Navigable Waterways		Davidson
TDOT Buildings	Davidson	Davidson
Transit	Davidson	Davidson
Pipelines		Davidson

Figure 16: Transportation vulnerability - most vulnerable counties

Source: TDOT Vulnerability Report, p. 32

The intensity of extreme weather events was more heavily weighted for more populated counties in the study region where a greater number of people and infrastructure would be exposed to such events. This explains Davidson County’s high concentration of vulnerable assets in the table above - there are a large number of transportation-dependent people and businesses in the county and there were more observed extreme weather events in this urbanized area¹³. Coordinated, regional effort will be the most successful way to respond to these risks, and preemptive mitigation and adaptation solutions will reduce the region’s risk exposure and vulnerability into the future.

One of the most important steps to advance transportation adaptation is to take climate change into account in all planning and funding decisions from the very beginning of a project’s development. Environmental reviews required as part of the National Environmental Policy Act (NEPA) are integrated into the analysis of projects approved to receive federal funds through the MPO. While this process is relatively comprehensive, it could benefit from more stringent considerations of GHG emissions, climate risk, and adaptation measures¹⁴, particularly during the alternatives analysis phase. Additionally, the NEPA process is bypassed altogether by projects that do not receive federal funds and these projects should, at a minimum, include analysis of GHG emissions, climate risk, and adaptation measures. Projects should be prioritized for funding based on their adherence with these climate adaptation goals.

¹³ TDOT Vulnerability Report, p. 17.

¹⁴ The Council on Environmental Quality, *Revised Draft Guidance on Consideration of Greenhouse Gas Emissions and Climate Change in NEPA Reviews*, 2014.

https://www.whitehouse.gov/sites/default/files/docs/nepa_revised_draft_ghg_guidance_searchable.pdf

4.2. Water Quality and Quantity

Current resources and projected changes

The MPO region contains portions of nine different watersheds. The four major watersheds are the Old Hickory, Middle Cumberland, Stones River, and Harpeth River watersheds. The Old Hickory Lake and dam are located within the Old Hickory watershed, which, at 983 square miles, is the largest in the region. West of the Old Hickory watershed is the Middle Cumberland watershed, the most highly developed in the area. The Cumberland River runs through this area and drains into the Cheatham reservoir. The Harpeth River watershed is south of the Middle Cumberland and contains the Harpeth River, the Little Harpeth, Big Turnbull Creek, Jones Creek, and other streams. This area is home to many natural resources, including the Natchez Trace Parkway, Radnor Lake, and the Montgomery Bell and Harpeth River state parks. East of this region is the Stones River watershed, which contains the Percy Priest Lake and dam, created in 1968. The Cedars of Lebanon State Forest is located within the Stones River watershed, which is also home to ten other state natural areas.

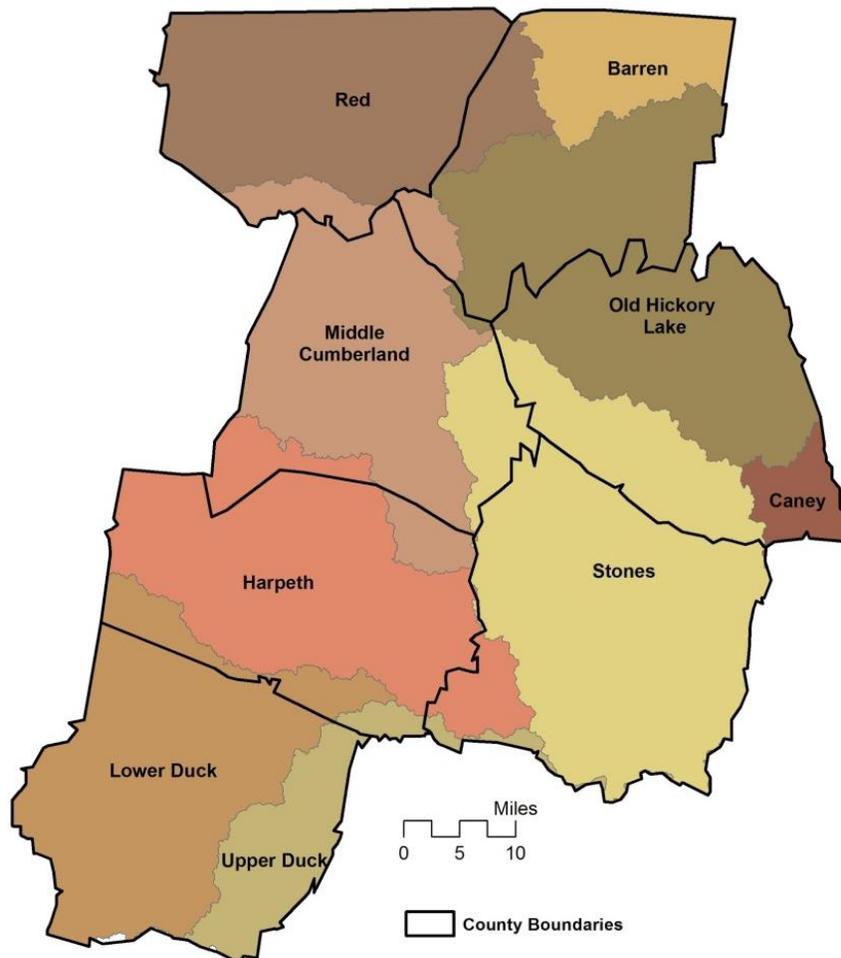


Figure 17: Regional watersheds and county boundaries

Source: National Hydrology Database

The Tennessee Department of Environment and Conservation (TDEC) estimates that nearly 40 percent of the state’s streams and 32 percent of the state’s reservoirs are impaired and not supporting their designated uses. Further, The 2012 305(b) Report identified approximately 32 percent of total lake and reservoir acres as impaired and over 54,000 wetland acres lost or impaired¹⁵.

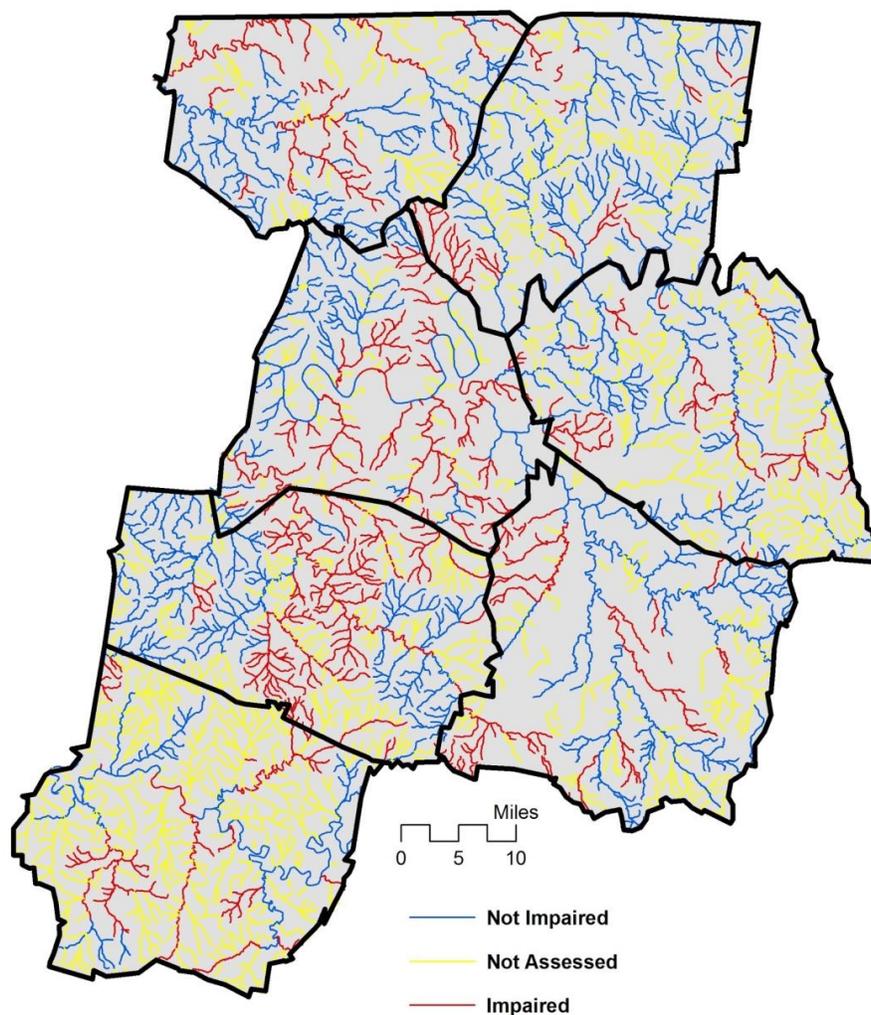


Figure 18: The region’s impaired, not impaired, and unassessed streams for 2014.
 Data source: State of Water Quality of Tennessee, Report 2014 303(d)

Precipitation in the state is influenced by the Gulf of Mexico with a general decrease in precipitation levels from south to north¹⁶. Much of the state’s precipitation occurs in winter and early spring with a

¹⁵ Tennessee Permanent Stormwater Management and Design Guidance Manual, Chapter 2: *Why Green Infrastructure as a Stormwater Solution for Tennessee*, p. 12. <http://tnpermanentstormwater.org/manual/04%20Chapter%202%20Why%20Runoff%20Reduction%20in%20Tennessee.pdf>

¹⁶ TWRA Wildlife Technical Report 09-09, p. 12.

secondary peak in mid-summer. Over the past 111 years, average annual precipitation ranged from a low of 35.6 to a high of 66.6 inches per year with considerable variability¹⁷, as shown in Figure 19:

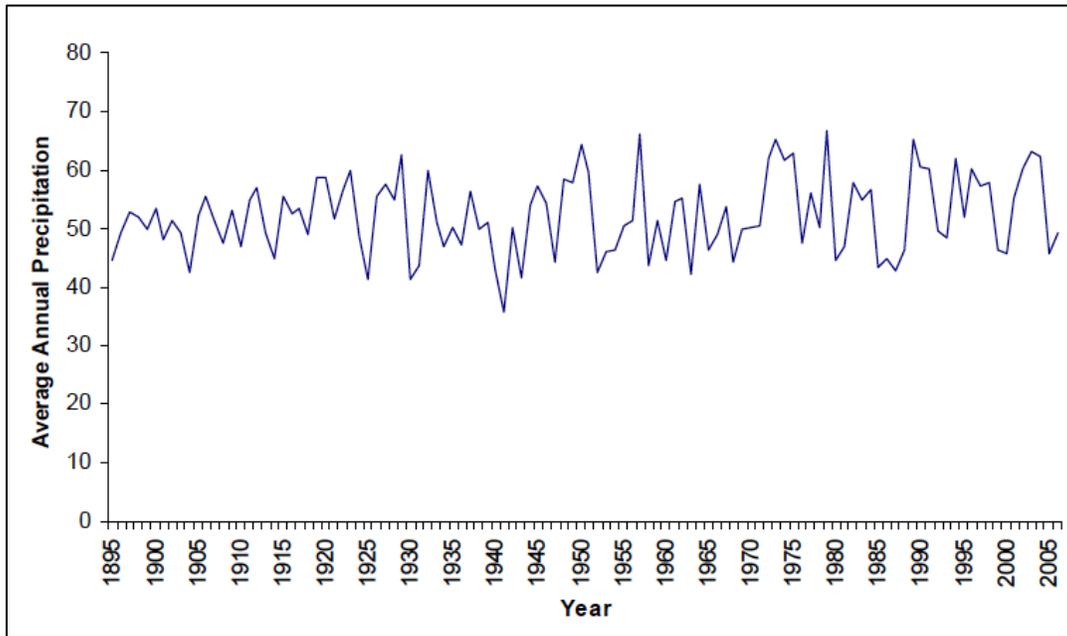


Figure 19: Average annual precipitation, 1895 - 2005

Source: TWRA Wildlife Technical Report 09-09, p. 13

Changing precipitation estimates as a result of climate change show that Tennessee could see a range relative to the current climate with a decrease of 3 percent to an increase of 15 percent, with an average increase of 7 percent. Much of the increased precipitation will occur during the winter, with near neutral conditions in the summer¹⁸. The frequency of precipitation events has increased across the U.S., and this region is expected to experience more extreme precipitation events¹⁹ and flooding.

¹⁷ TWRA Wildlife Technical Report 09-09, p. 13.

¹⁸ University of Maryland, Center for Integrative Environmental Research, *Economic Impacts of Climate Change on Tennessee*, 2008, p. 6.

¹⁹ TDOT Vulnerability Report, p. 24.

The report stated the following middle-of-the-road estimates of projected changing precipitation and temperature patterns due to climate change:

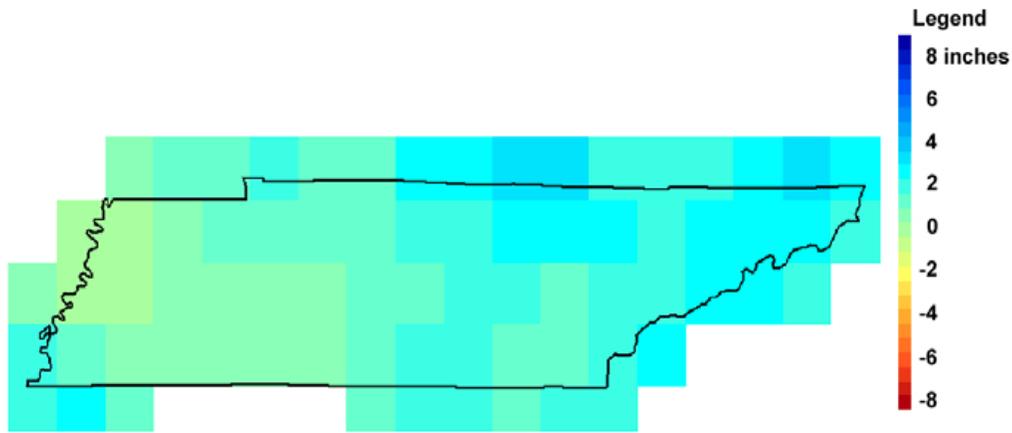


Figure 20: The region’s estimated change in precipitation from 2010 to 2060

Source: TWRA Wildlife Technical Report 09-09, p. 14

While the region may experience more intense precipitation events, these will be interspersed with more frequent periods of drought. Even in areas where precipitation does not decrease, higher surface temperatures increase evaporation rates, which leads to hotter summers and a drier climate overall. The National Climate Assessment states that under high emissions scenarios, widespread drought in the central and southern United States, and consequently, our region, will become more common²⁰.

Impacts:

People

Water quality and quantity directly impact human communities - we need plentiful freshwater resources to survive. The outdoor recreation industry, much of which is water-related in our region, is a significant economic resource that would be harmed by increasing frequency and severity of droughts. Health impacts from flooding include increased prevalence of mold and indoor air quality problems, asthma and respiratory diseases, and waterborne diseases²¹. Additionally, flooding can injure or even kill and can also cause displacement, which disproportionately impacts vulnerable populations and places their access to economic opportunity in jeopardy.

²⁰ Melillo, et al.

²¹ Luber, p. 225.

Ecosystem services

Tennessee is host to an incredible amount of aquatic diversity, but the 320 fish species, 77 crayfish species, 129 freshwater mussels species present in the state, and many habitats that host these species, especially cold headwaters and springs, are at risk from the warming climate, pollution, and development²². Wetlands provide flood control, water purification, natural habitats, and recreation areas throughout the state, and even a 20 percent loss of wetland acres would cost Tennessee between \$55 million - \$4 billion²³. Polluted water not only increases treatment costs, but can also cause health disruptions, productivity losses, economic losses to commercial fisheries, and decreased commercial navigation²⁴. Our communities benefit from healthy aquatic systems in many ways: they are a source of drinking water, supply water to businesses and power plants, provide local climate regulation, and are also sources of entertainment and recreation.

Built environment

The built environment is vulnerable to changes in water quantity - flooding stresses sewer and stormwater infrastructure, damages property, disrupts transportation infrastructure, and can damage pumping and water treatment stations, which could lead to drinking water shortages. In downtown Nashville, where there is a combined sewer and stormwater system, flooding can cause this to overflow, sending untreated waste directly into the Cumberland River, creating water quality issues. Flooding can also damage buildings and infrastructure and costs to recover can run into the billions, as did the May 2010 flood.



Figure 21: Great Blue Heron
Photo by Danna Haile

²² TN SWAP 2015, p. 237.

²³ TN SWAP 2015, p. 239.

²⁴ University of Maryland, Center for Integrative Environmental Research, *Economic Impacts of Climate Change on Tennessee*, 2008, p. 14.

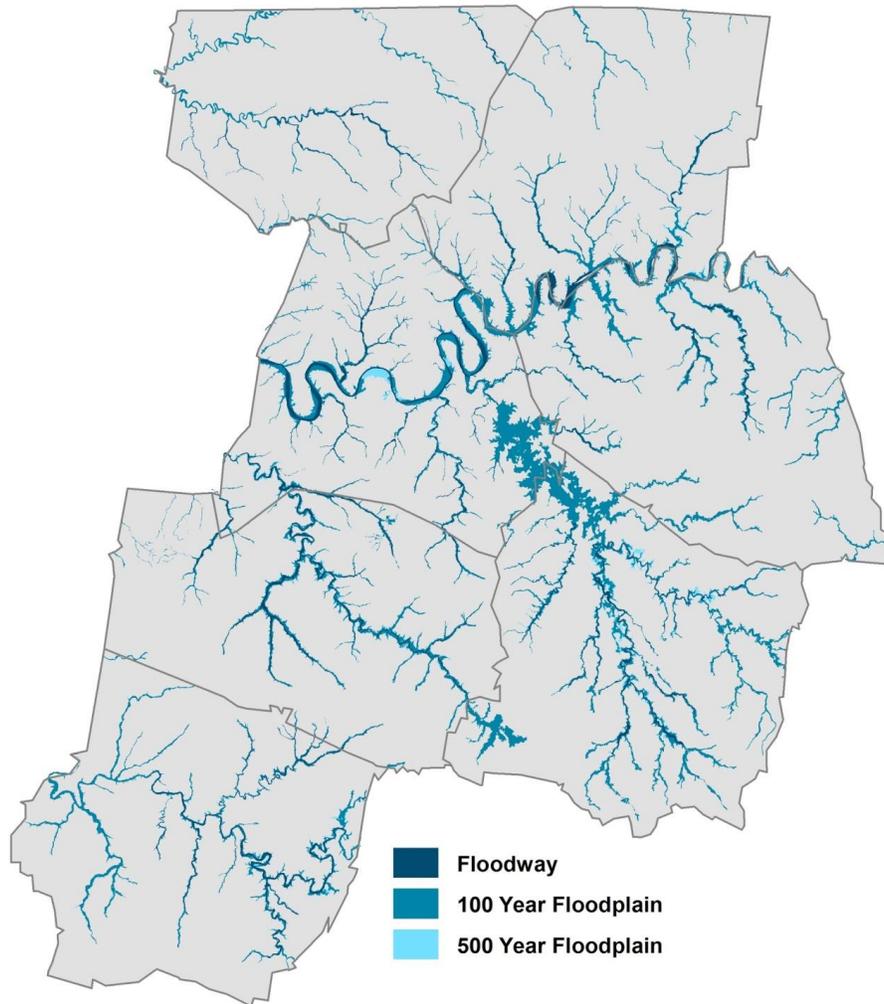


Figure 22: Floodways, 100 year and 500 year floodplains
Data Source: FEMA, 2008

4.3 Growth and Development

Current landscape - ecoregions, land use and land cover conditions

Our region of Middle Tennessee is composed of Davidson, Maury, Rutherford, Robertson, Sumner, Williamson, and Wilson Counties. This seven-county area is located within the Western Highland Rim, the Outer Nashville Basin, and the Inner Nashville Basin of the larger Interior Basin of the Southeastern United States. These three ecoregions are characterized by rolling, heavily forested topography covered by deciduous forest interspersed with pasture and cropland. The Inner Nashville Basin has the lowest

elevation of the three ecoregions and is the most highly developed. The area's natural vegetation is oak-hickory forest, bluestem prairie, and cedar glades²⁵.

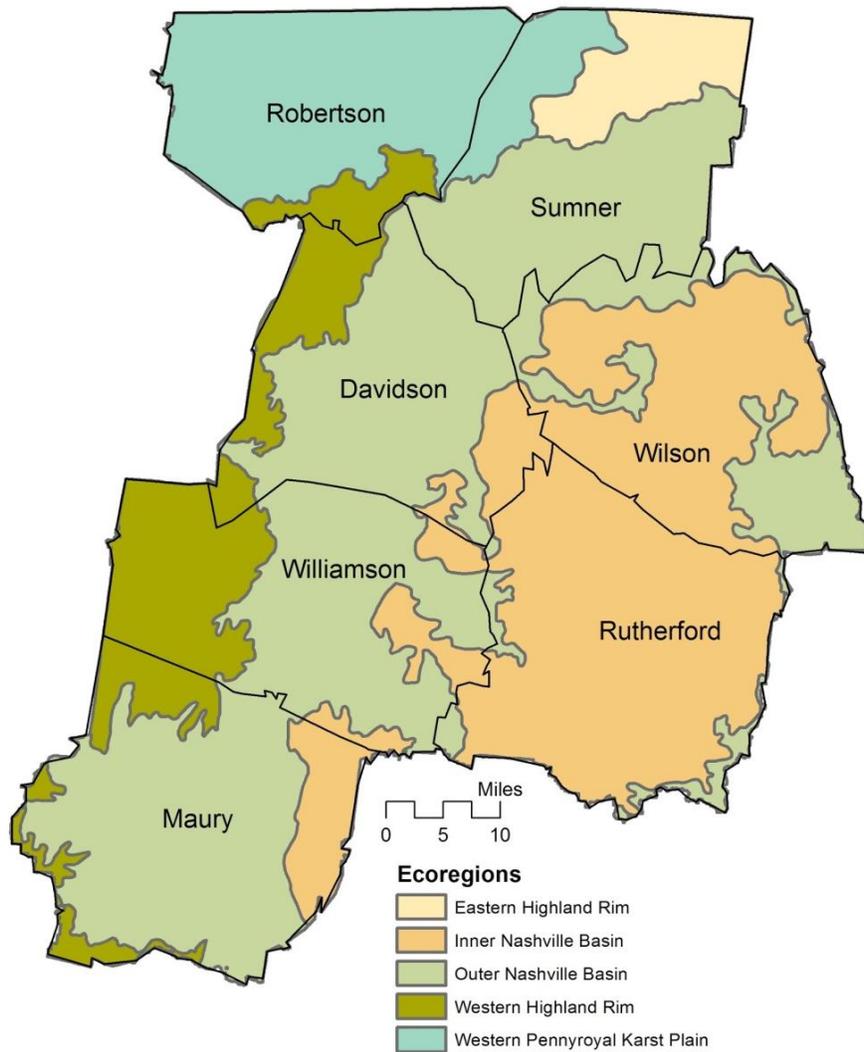


Figure 23: The region's five ecoregions
Data Source: US EPA Level IV Ecoregions

²⁵ Bailey, R.G., Avers, P.E., King, T., and McNab, W.H., eds., 1994, Ecoregions and subregions of the United States (map) (supplementary table of map unit descriptions compiled and edited by McNab, W.H. and Bailey, R.G.): Washington, D.C., U.S. Department of Agriculture - Forest Service, scale 1:7,500,000. http://www.epa.gov/wed/pages/ecoregions/tn_eco.htm#Principal

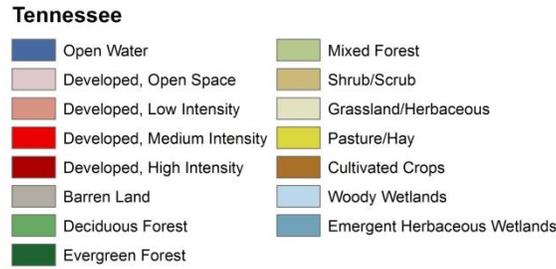
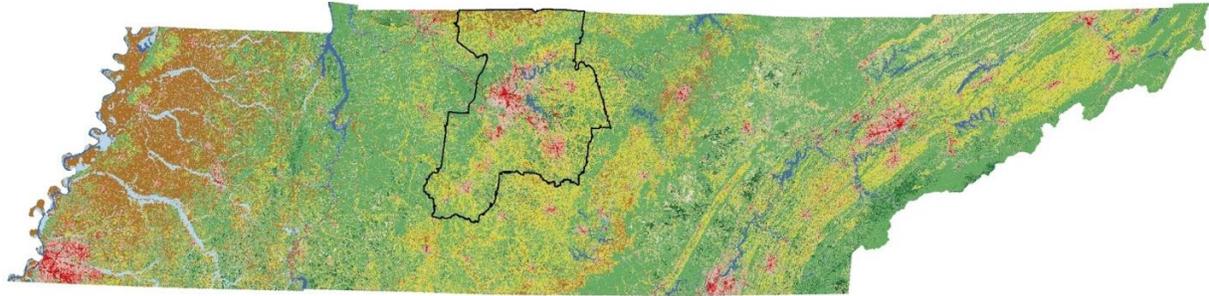


Figure 24: Land cover, Tennessee with Nashville Area MPO boundary
 Data Source: National Land Cover Database, 2011

All of the forested areas of Tennessee have been influenced by human activities, including logging, agriculture, mining, pollution, and development. Invasive species and introduced exotic plants have also competed with native species to change the composition of forest vegetation. This region is classified as the Mesophytic Forest, which is composed of American beech, sugar maple, yellow-poplar, white oak, white ash, northern red oak, black oak, Shumard oak, blackgum, pignut hickory, and other oaks and hickories²⁶.

Statewide land use and resulting land cover trends reflect an overall increase in developed land. Between 1982 and 2007, there has been an 85% increase in developed acres, accompanied by a decrease in cropland. The small decrease in forest lands during this time may indicate that most of the development has occurred in land that was previously agricultural not forested. During this same period, 25% of existing cropland was converted to other uses²⁷. The percent and rate of development varies greatly from county to county. According to the Local Planning Office of the Tennessee Department of Economic and Community Development, development was high in the 1990s, during which high growth counties developed 2-4% of total county acres, while low growth, rural counties developed 1-2% of total county acres²⁸.

²⁶ TWRA Wildlife Technical Report 09-09, pp. 17-18.

²⁷ Thurman, p. 15.

²⁸ Ibid., p. 17.

Table 3. Percent of Land by Category, Tennessee (Non-Federal Land)

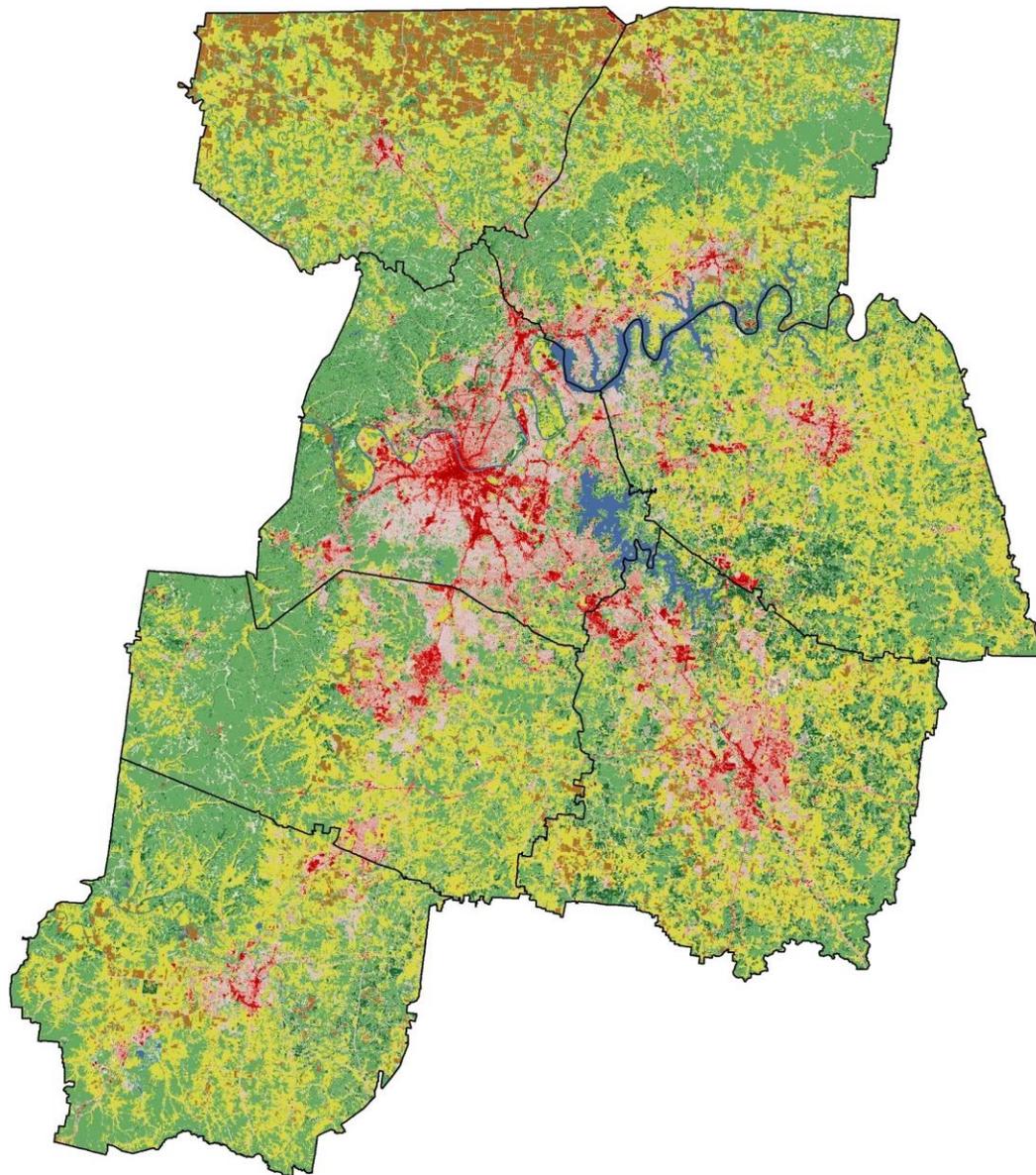
Land Use	1982		1987		1992	
	Acres (in thous.)	Percent of Land	Acres (in thous.)	Percent of Land	Acres (in thous.)	Percent of Land
Cropland	5,525	22.1%	5,297	21.2%	4,766	19.1%
Conservation Reserve Program Land	n/a	n/a	174	0.7%	441	1.8%
Pastureland	5,290	21.2%	5,077	20.3%	5,100	20.4%
Rangeland	0	0.0%	0	0.0%	0	0.0%
Forestland	12,061	48.2%	12,093	48.4%	12,062	48.3%
Other Rural Land	487	1.9%	464	1.9%	446	1.8%
Developed Land	1,640	6.6%	1,875	7.5%	2,158	8.6%
Total	25,002	100%	24,979	100%	24,972	100%
Land Use	1997		2002		2007	
	Acres (in thous.)	Percent of Land	Acres (in thous.)	Percent of Land	Acres (in thous.)	Percent of Land
Cropland	4,574	18.3%	4,505	18.1%	4,142	16.6%
Conservation Reserve Program Land	374	1.5%	241	1.0%	255	1.0%
Pastureland	4,912	19.7%	4,837	19.4%	4,978	20.0%
Rangeland	0	0.0%	0	0.0%	0	0.0%
Forestland	11,978	48.0%	11,939	48.0%	11,835	47.6%
Other Rural Land	523	2.1%	553	2.2%	632	2.5%
Developed Land	2,606	10.4%	2,812	11.3%	3,083	12.4%
Total	24,968	100%	24,887	100%	24,925	100%

Source: Natural Resource Conservation Service (NRCS), National Resource Inventory. Percentages calculated by TACR.

NOTE: NRCS presents margins of error for all estimates. For more information please see http://www.nrcs.usda.gov/technical/NRI/2007/2007_NRI_Summary.pdf

Figure 25: Changes in land use, 1982 - 2007

Source: Thurman, p. 15



Nashville Area MPO Region

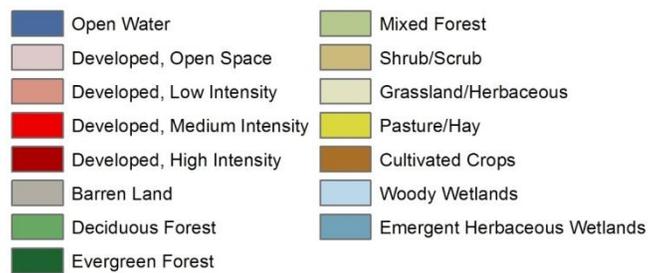


Figure 26: Land cover and county boundaries, Nashville Area MPO, 2011

Source: National Land Cover Database, 2011

More than 1.6 million people reside within this 2800 square mile area, and over the past decade, the region has experienced sprawling development that threatens the rural countryside and strains the area's infrastructure and community services²⁹. Current land use is mixed throughout the region, with pasture/hay, deciduous forest, developed land, cultivated crops, and open water making up the majority of land cover. The majority of land in Robertson, Sumner, and Wilson Counties is rural and or agricultural. Current development in these three counties is dispersed, low density, and auto-oriented³⁰. Davidson County is the most highly developed of the region. Population forecasts for the region estimate an additional one million more people to reside in this area by 2040, which equates to an increase of over 75%.

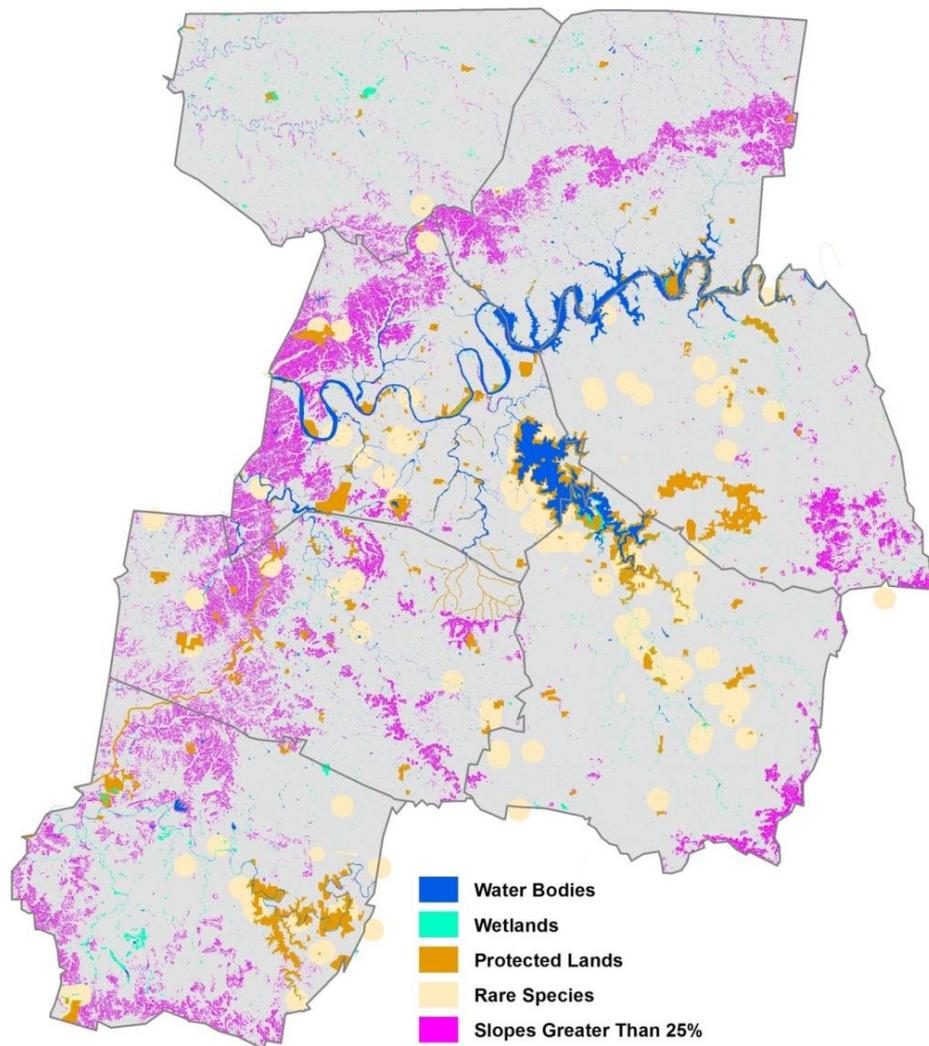


Figure 27: Key environmental features
Data Source: DFIRM, DTM, NWI, TDEC/TWRA files

²⁹ MPO, Tri-County Transportation and Land Use Study, 2012, p. 2-1.

³⁰ MPO, Tri-County Transportation and Land Use Study, 2012, p. 2-7.

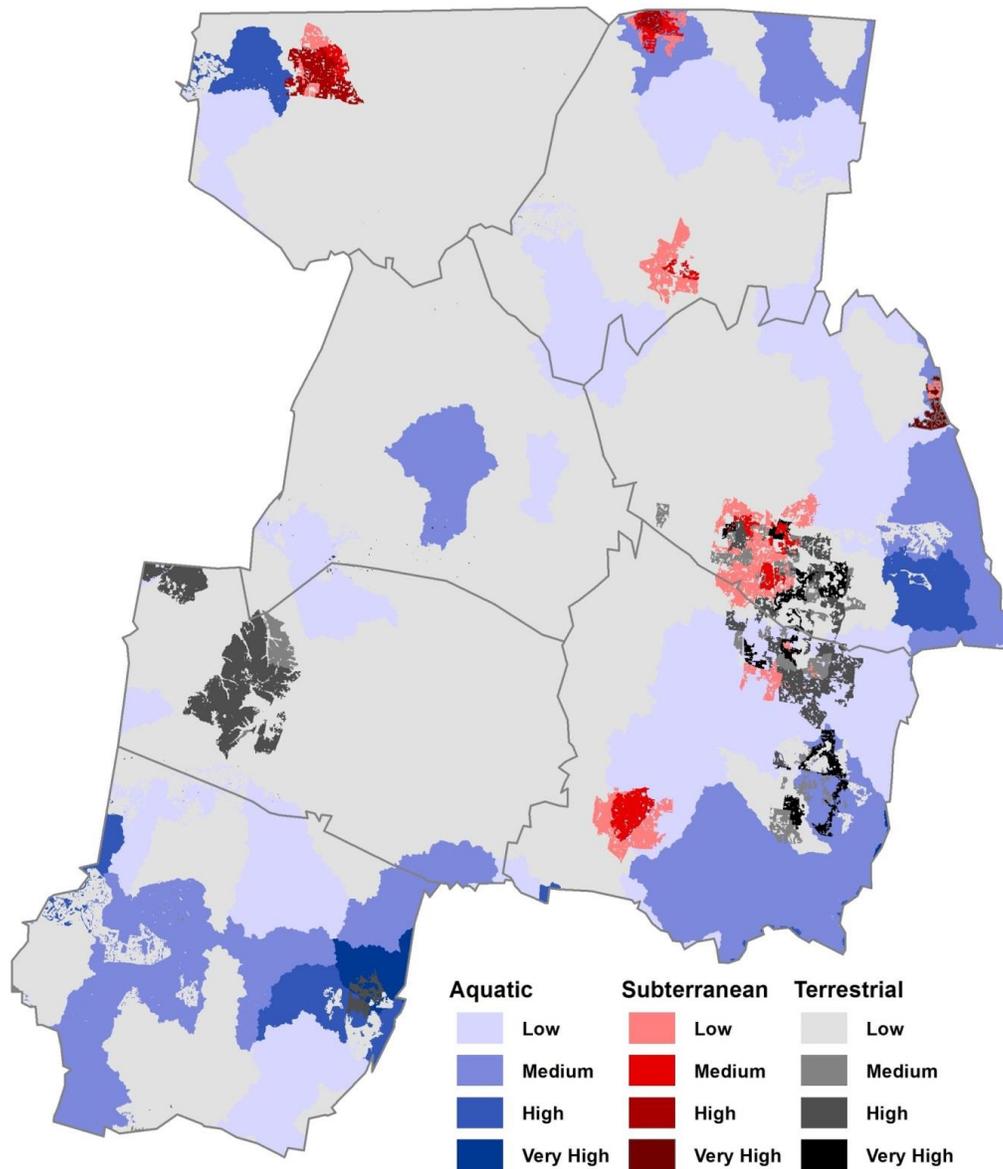


Figure 28: Priority aquatic, subterranean, and terrestrial habitats

Data Source: TN SWAP, 2005

As seen in Figure 27, a large area of forested ridge with steep slopes runs through the region with prominence in Williamson, Davidson, and Sumner counties. Additionally, rare and endemic species are found throughout the area. Figure 28 shows the aquatic, subterranean, and terrestrial priority habitat areas throughout the region. Priority habitat areas were sourced from the Tennessee State Wildlife Action Plan, which defined these areas as locations where species of “Greatest Conservation Need (GCN)” were highly concentrated. This type of mapping effort will allow conservation partners, developers, and land use planners to collaborate and protect imperiled species from extinction. The areas of GCN are taken into account when the MPO analyzes proposed transportation projects for funding. Additionally, where the GCN areas overlap with projected growth and development further

studies should be done to ensure the region grows in a manner which is sustainable for these high priority habitats, thereby protecting these valuable resources for present and future generations.

Projected conditions:

The intensity of regional development is expected to increase in the future. These conditions are predicted using the Nashville Area MPO's Land Use Allocation Model (LUAM) which allocates household population and employment to the MPOs planning horizon years (2020, 2030, and 2040) based on various growth scenarios. The model was prepared using data provided by county planning departments, representatives from public service agencies, and the MPO staff.

The trend scenario depicted in the following map represents the development of the region if it continues to follow presently adopted plans, programs and policies. The trend reflects projected demand for population, employment, goods and services in this timeframe and existing characteristics of the region. Under this business as usual scenario, open space is significantly depleted, and large portions of Williamson, Rutherford, Wilson, and Sumner Counties are converted to single-family residential uses, while Maury and Robertson Counties are predominantly residential agricultural land use.

The trend scenario land use would dramatically increase the amount of developed land in the region, resulting in loss of green space, increased impervious surface area, and sprawling development patterns.

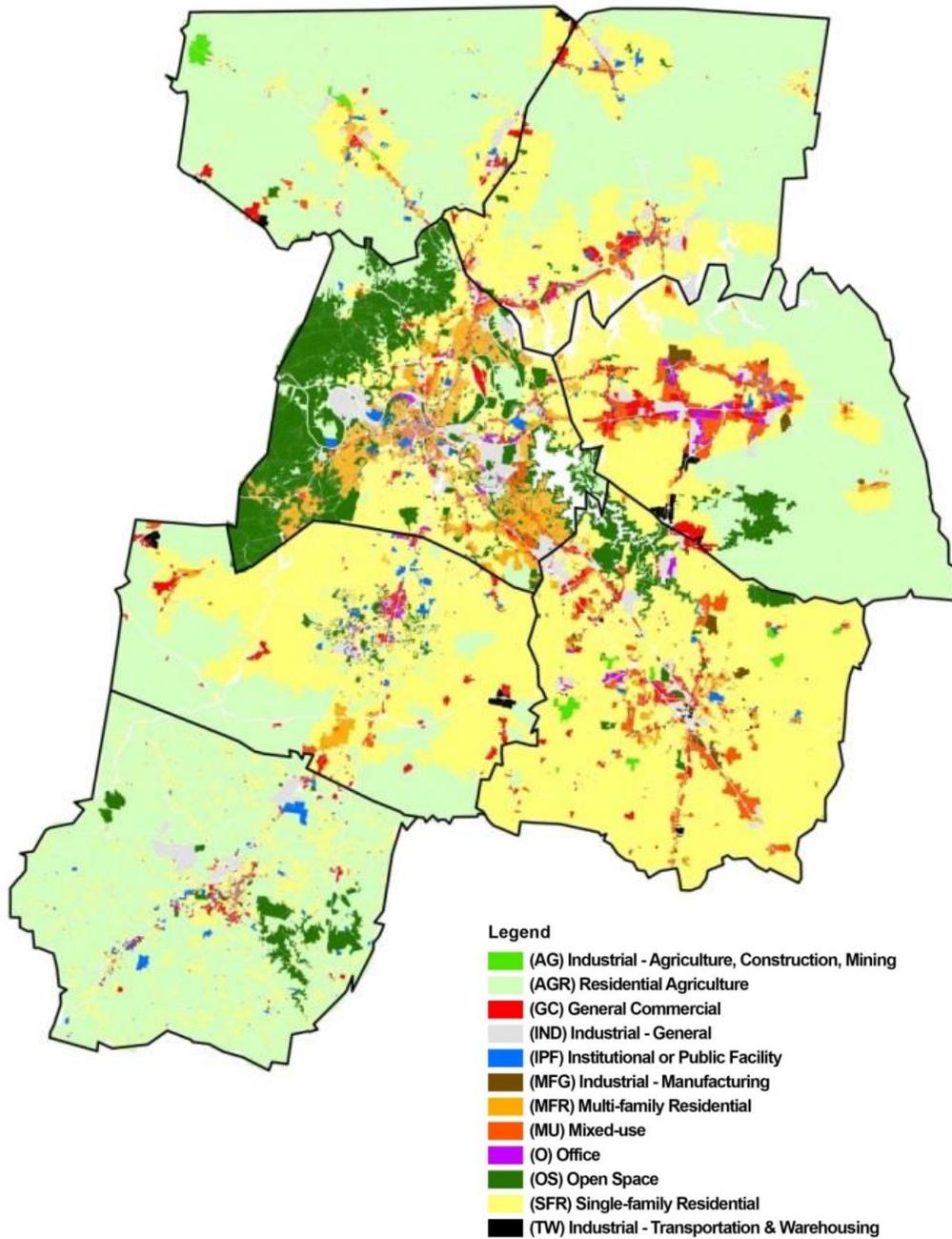


Figure 29: Projected future land use (FLU) for the MPO region, 2040
 Source: Local Government Planning, Zoning, and Tax Data

Figure 30 shows the relative intensity and density of land development trends from 1970 to 2010 and projections to 2040. We can see significant increases in land use intensity throughout the region. Of particular interest is the extreme rate of growth and development in Williamson and Rutherford counties leading to widespread sprawl throughout the two counties.

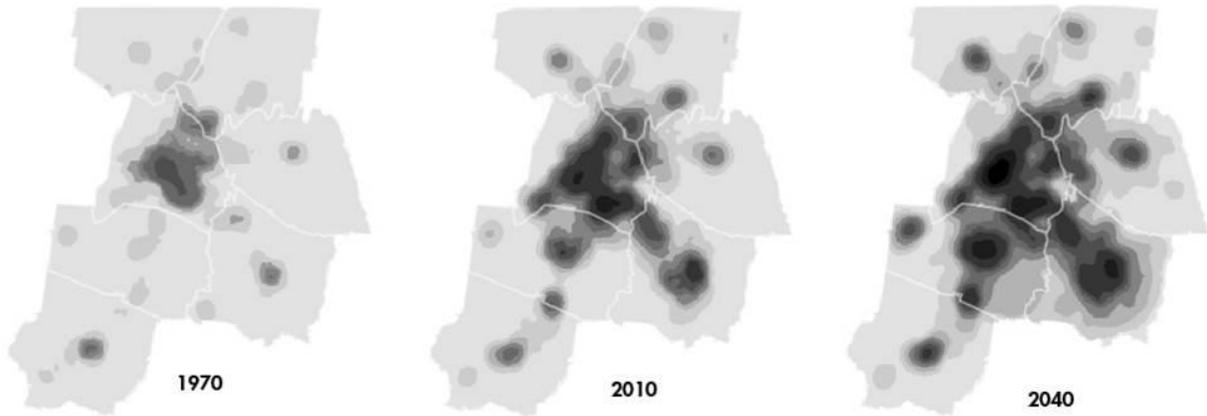


Figure 30: Land use development trends from 1970 to 2010 and forecasts to 2040

Source: Woods and Poole Population Forecasts and Nashville Area MPO Land Use Allocation Model

Demographic, Social, and Economic Trends

Growth and development has dramatically affected our regional economy, demographics, and social stressors. Our planning region encompasses a wide variety of population densities, economic activities, and land uses. Nashville Davidson County has the largest population and economic activity of the study area and is a vital business, transportation, and tourism center for this region. The Nashville Area MPO's economy is diverse and includes the insurance, healthcare, higher education, entertainment, tourism, publishing, and finance sectors. In every county, the management and professional industries employ the largest percentage of workers. While the region is rich in agricultural land and heritage, the farming, fishing, and forestry industries do not employ a large number of workers. Currently the region employs about 21% of its residents in the industrial sector, 18% retail, and 61% office. By the year 2040 office jobs are projected to increase to about 68% while industrial falls to 14% and retail will hold steady at 18%.

Year	MPO	Davidson	Maury	Robertson	Rutherford	Sumner	Williamson	Wilson	TN	MPO/TN
1990	640,605	417,239	32,943	16,299	63,121	42,000	41,284	27,719	2,777,447	23%
2000	887,397	532,062	44,456	25,011	104,707	57,610	81,092	42,459	3,471,226	26%
2010	971,904	542,778	39,998	28,066	133,805	55,355	120,263	51,639	3,581,414	27%
2015	1,067,548	585,974	43,100	30,806	150,853	60,662	138,235	57,918	3,846,687	28%
2020	1,180,595	635,738	47,043	33,591	170,093	66,686	162,311	65,133	4,155,814	28%
2030	1,442,259	745,177	55,746	39,857	215,490	80,227	223,802	81,960	4,848,844	30%
2040	1,759,652	869,137	65,609	47,190	271,416	95,976	307,887	102,437	5,655,937	31%
2010-2040	81%	60%	64%	68%	103%	73%	156%	98%	58%	

Figure 31: Employment trends by county, 1990-2040

Source: U.S. Department of Labor, Woods and Poole Economics, Inc.

Category	Detailed Category	2010		2040		Change
		Jobs	% of Jobs	Jobs	% of Jobs	2010-2040
Industrial	Farm & Agricultural Services	10,914	1.1%	13,501	0.8%	23.7%
	Mining	1,704	0.2%	1,320	0.1%	-22.5%
	Construction Employment	51,638	5.3%	73,975	4.2%	43.3%
	Manufacturing Employment	59,708	6.1%	55,628	3.2%	-6.8%
	Trans, Comm & Public Utilities	36,204	3.7%	49,056	2.8%	35.5%
	Wholesale Trade	40,600	4.2%	55,742	3.2%	37.3%
Retail	Retail Trade	177,684	18.3%	315,023	17.9%	77.3%
Office	Finance, Insurance & Real Estate	98,550	10.1%	191,446	10.9%	94.3%
	Services	390,503	40.2%	857,336	48.7%	119.5%
	Government	104,399	10.7%	146,625	8.3%	40.4%

Figure 32: Regional employment by industry/sector, 2010-2040

Source: U.S. Department of Labor, Woods and Poole Economics, Inc.

Year	Category	MPO	Davidson	Maury	Robertson	Rutherford	Sumner	Williamson	Wilson	TN
2010	Industrial	21%	18%	26%	37%	29%	28%	13%	29%	25%
	Retail	18%	18%	18%	17%	18%	19%	20%	22%	11%
	Office	61%	65%	56%	46%	53%	54%	67%	50%	64%
2040	Industrial	14%	13%	18%	25%	19%	19%	8%	20%	19%
	Retail	18%	15%	21%	16%	23%	21%	17%	26%	11%
	Office	68%	72%	61%	59%	58%	60%	75%	54%	71%

Figure 33: Percentage of jobs by sector and county

Source: U.S. Department of Labor, Woods and Poole Economics, Inc.

By the year 2040, more than 2.6 million people are expected to reside within the Nashville Area MPO. This growth is expected to be concentrated within three of the MPO counties. Davidson (2nd most populous in the state, at 813,000 in 2040) will see a population increase of about 29% from 2010 to 2040, Rutherford (4th, 593,000 in 2040) will increase 125%, and Williamson (5th, 536,000 in 2040) will see an increase in population of over 190%.

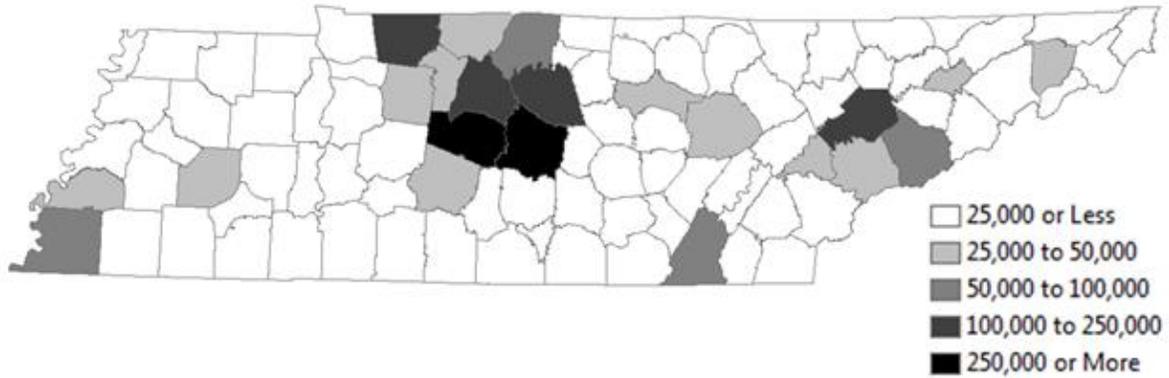


Figure 34: Projected statewide net population change by county, 2010 to 2040
 Source: MPO RTP 2040, 3-3

All counties in the region have experienced significant population growth since 1990. Rutherford and Williamson counties have seen the most dramatic increases - their populations have almost doubled, and this trend is expected to continue through 2040. Davidson County is expected to remain the center of the region’s economic activity and continue to have the largest population within the MPO region.

Year	MPO	Davidson	Maury	Robertson	Rutherford	Sumner	Williamson	Wilson	TN	MPO/TN
1990	977,637	510,784	54,812	41,494	118,570	103,281	81,021	67,675	4,894,492	20%
2000	1,221,741	569,891	69,498	54,433	182,023	130,449	126,638	88,809	5,703,719	21%
2010	1,499,305	628,133	81,141	66,469	263,740	161,250	184,035	114,537	6,356,897	24%
2015	1,686,745	657,627	86,860	74,140	318,027	173,851	242,386	133,854	6,767,159	25%
2020	1,877,601	688,587	92,767	81,962	372,900	186,825	301,132	153,428	7,192,931	26%
2030	2,261,551	751,314	104,690	97,705	483,096	212,993	418,992	192,761	8,054,712	28%
2040	2,643,254	813,297	116,509	113,350	592,812	238,950	536,434	231,902	8,910,265	30%
2010-2040	76%	29%	44%	71%	125%	48%	191%	102%	40%	

Figure 35: Population trends by county, 1990-2040

Source: U.S. Census Bureau, Woods & Poole Economics, Inc. (MPO RTP 2040, 3-4)

Based on current trends, by 2040 Middle Tennessee’s population will be larger than present day Denver and approach the size of the Seattle-Puget Sound Metropolitan area.

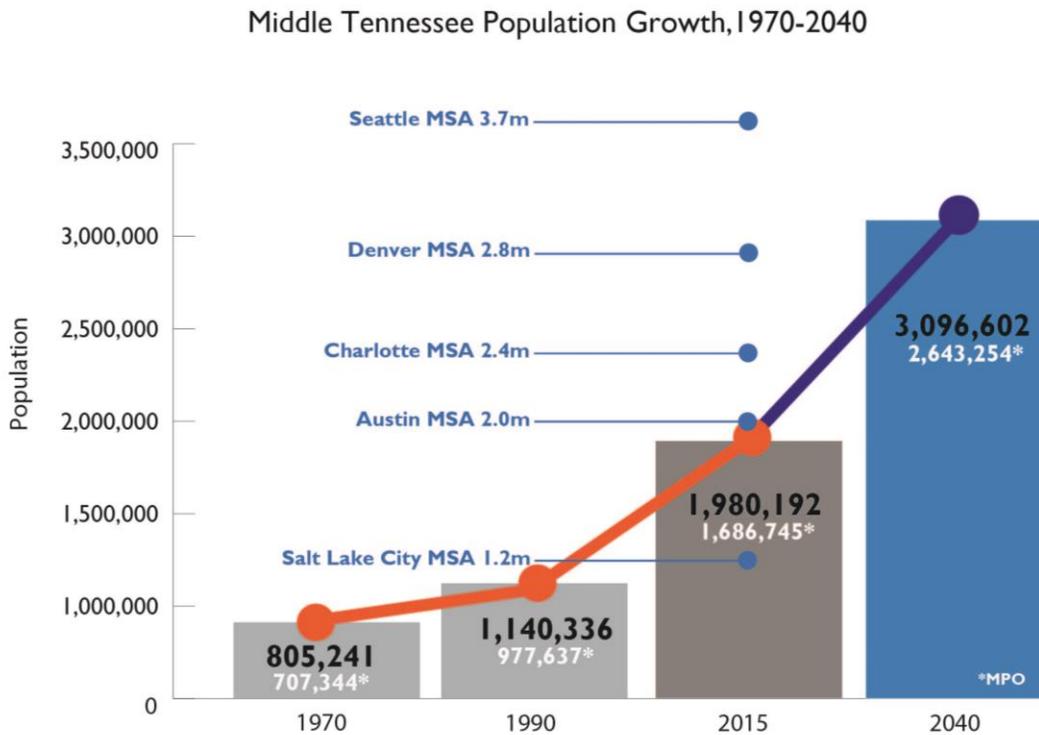


Figure 36: Middle Tennessee population growth compared to peer cities
 Source: U.S. Census Bureau, Woods & Poole Economics, Inc. (MPO, RTP 2040, 3-3)

The demographic diversity of the region is also rapidly increasing. Median age for the region is currently between 34 and 39 years of age, and projections show the fastest growing age groups in the region are aging boomers and millennials, bringing both an infusion of elderly and youth to the region. Both of these demographic groups show a preference for urban walkable neighborhoods and increasingly depend upon and demand high quality public transit. This trend is helpful if the region wishes to grow and develop in a manner less consistent with sprawl. Additionally, demographic information shows an increasing population of Hispanic individuals, which is projected to increase from 9 percent to 20 percent by 2040.

County	Hispanic Ethnicity		Non-Hispanic, Non-White		Total Ethnic and Racial Minority	
	2015	2040	2015	2040	2015	2040
Davidson	13%	34%	33%	34%	46%	68%
Maury	6%	19%	13%	12%	19%	31%
Robertson	7%	16%	8%	8%	15%	24%
Rutherford	8%	14%	17%	22%	25%	37%
Sumner	5%	13%	8%	9%	13%	22%
Williamson	5%	12%	8%	8%	13%	21%
Wilson	4%	12%	8%	9%	12%	21%
MPO Area	9%	20%	19%	20%	28%	40%

Figure 37: Ethnic and racial diversity by county, 2015 to 2040

Source: Woods & Poole Economics, Inc. (MPO, RTP 2040, 3-4)

Inter-county commuting patterns reflect economic dependencies throughout the region. The majority of workers in Robertson, Sumner, and Wilson counties travel outside of their county of residence for work. Most commuters rely heavily on personal automobiles, and nearly 8 out of 10 commuters drive alone to and from work (RTP 2015, 5-6). This contributes to greenhouse gas and other pollutant emissions in the region. It also strains our transportation infrastructure and leads to increasing traffic congestion which costs the region money in time lost and wasted fuel consumption.

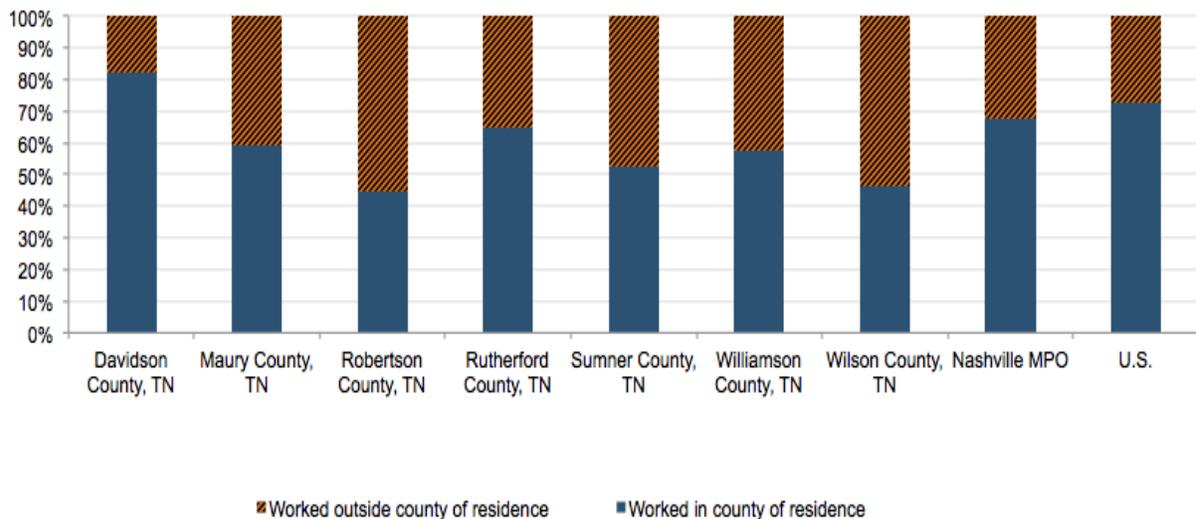


Figure 38: Place of work, 2013

Source: Headwaters Economics Economic Profile System report; Data source: U.S. Department of Commerce, 2013. Census Bureau, American Community Survey Office, Washington, D.C.

Poverty levels are significant throughout the region, and nearly a quarter of individuals are below the poverty level in Davidson County. Poverty levels are lowest in Williamson County, at 5.7% of individuals. Median household income is lowest in Maury County, at \$45,336, and highest in Williamson County, at \$89,779. For the entire MPO region, the majority of households earn between \$50,000 and \$74,999 annually.

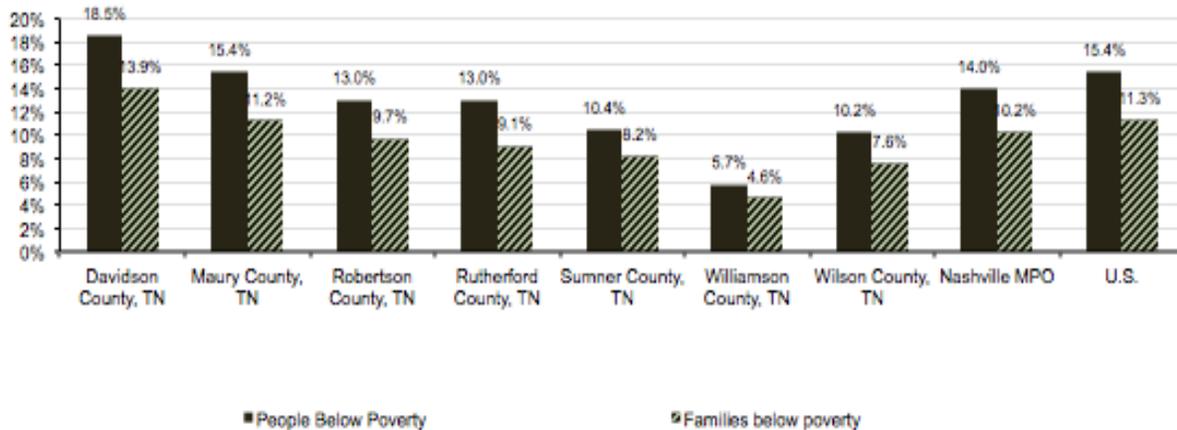


Figure 39: Individuals and families below poverty, 2013

Source: *Headwaters Economics Economic Profile System report*; Data source: U.S. Department of Commerce, 2013. Census Bureau, American Community Survey Office, Washington, D.C.

Impacts:

People

Our region’s growth and development directly affects the current and projected demographic, economic, and socio-economic realities of our communities. The existing disparities and inequalities that affect our communities will be exacerbated by the impacts of climate change, so to understand and respond to these impacts, the Nashville Area MPO has sought to identify environmental justice issues and vulnerable populations throughout the region. Furthermore, as a federal agency, the MPO is required to identify and minimize the negative health or environmental impacts of its programs that affect minority and low-income populations, and evaluate its programs for environmental justice (EJ) sensitivity. The MPO currently conducts EJ analysis on the impacts of funding and access to services for the following vulnerable demographic groups: non-Hispanic minorities, carless households, households in poverty, persons with physical disabilities, female head of household with child, the elderly, Hispanic persons, and persons with limited English proficiency. Each of these groups are identified using U.S. Census data from the American Community Survey 2009-2013 five year estimates gathered at the block group level. The Nashville Area MPO has modeled its EJ analysis technique from a methodology originally developed by the Delaware Valley Regional Planning Commission.

The MPO maps the locations of these vulnerable groups throughout the region to identify areas in which to expand outreach efforts to low-income, minority, and other vulnerable populations.

Environmental Justice Area

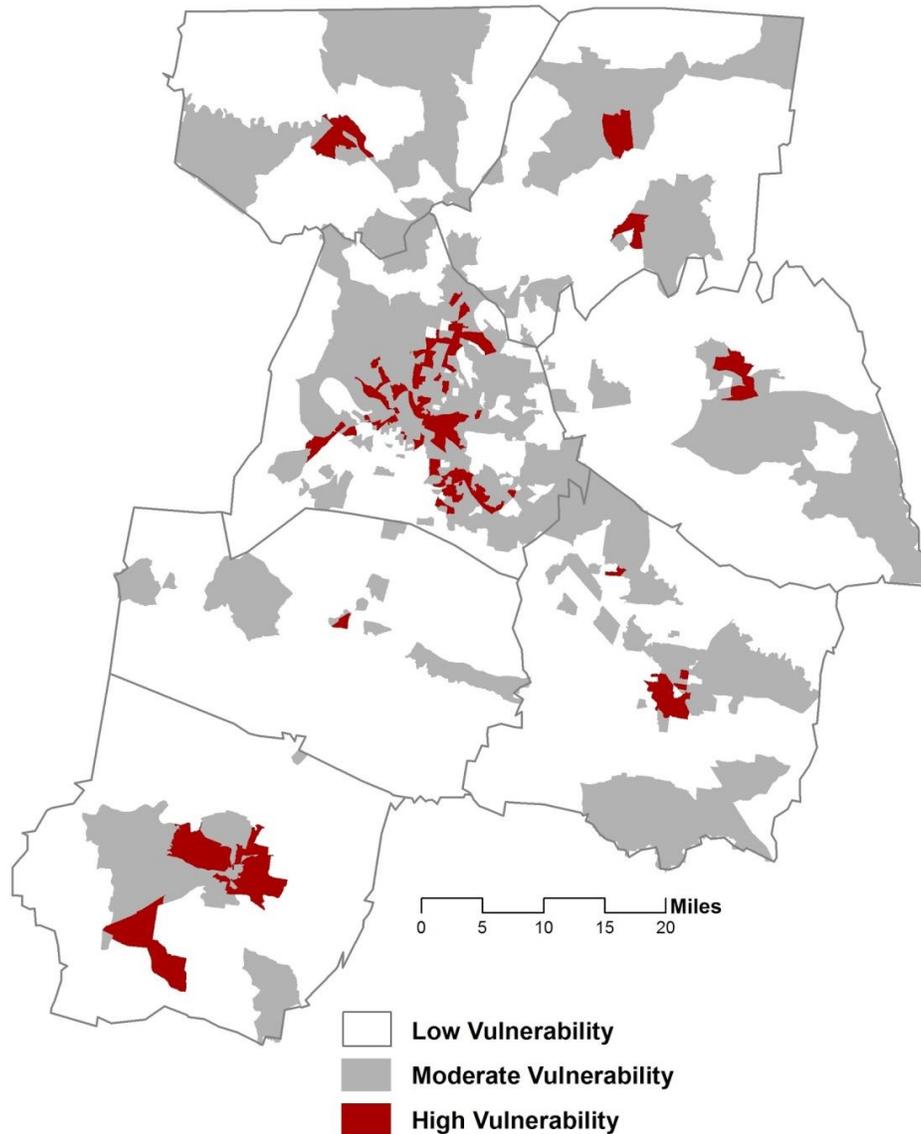


Figure 40: Overall degree of vulnerability (low, moderate, high)

Data Source: ACS 5-Year Estimates, 2009-2013

Degree of Vulnerability: A block group that contains a segment of the population considered vulnerable at a rate equal to or higher than the regional average is considered an EJ-sensitive tract. The number of vulnerable populations present in a block group at a higher than average rate is the Degree of Vulnerability (DOV). In this way each block group receives a Degree of Vulnerability score on a scale of 0-8, where each demographic group above the regional average increases a block groups DOV score by 1. The block groups are then categorized into low, moderate, or high vulnerability depending upon the DOV score. A block group with a DOV score of 0-2 is said to have low vulnerability. A score of 3-5 is

moderate vulnerability and a score of 6-8 is high vulnerability³¹. For example if a block group contained populations of elderly, carless households, and Hispanic minorities at a rate equal to or higher than the regional average, the DOV score for that block group would be 3 and the category it would be placed in would be “moderate vulnerability”.

While the MPO is utilizing just eight demographic groups for its vulnerability analysis it is important to note that a wide range of characteristics outside of this analysis may contribute to vulnerability. In fact, many different methodologies for calculating social vulnerability exist. Determining the best social vulnerability index to predict vulnerability to climate change is an emerging field and the MPO will continue to research and investigate methodologies to determine vulnerability throughout the region to a variety of stressors. Additionally, the MPO is in the development phase of an equity atlas project to further engage organizations that serve vulnerable populations and to refine our techniques for vulnerability mapping. Only through direct engagement with communities can you uncover the many unique assets that are vital to a community, but may not show up on traditional maps or through census demographic analysis alone.

The following maps depict the locations of block groups with higher than average occurrence for each of the vulnerable EJ population groups used in the DOV analysis:

³¹ Nashville Area MPO, RTP 2040, pp. 9-4 - 9-9.

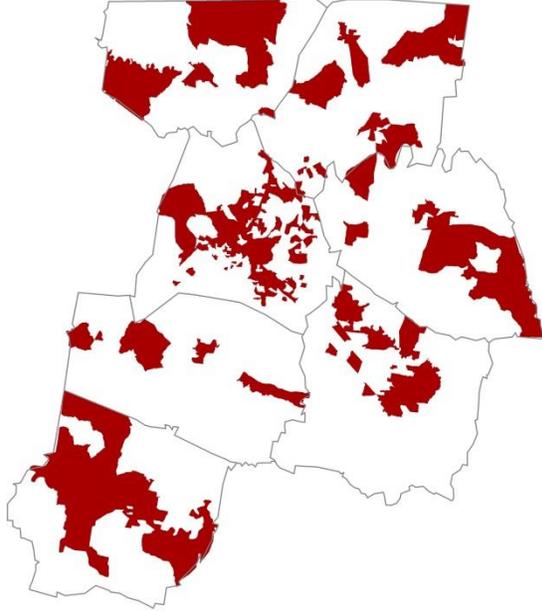


Figure 41: Households in Poverty
 Source: ACS 5-Year Estimates, 2009-2013

Households in Poverty

The poverty threshold is defined by the U.S. Department of Health and Human Services and describes the relationship between income and the family unit’s size. Impoverished families may be less able to afford adequate heating and cooling costs, healthful foods, and health care, and are therefore more vulnerable to extreme weather events and changes in food and energy prices that may strain their financial resources further. They may also have more hardships as a result of displacement from events such as flooding.

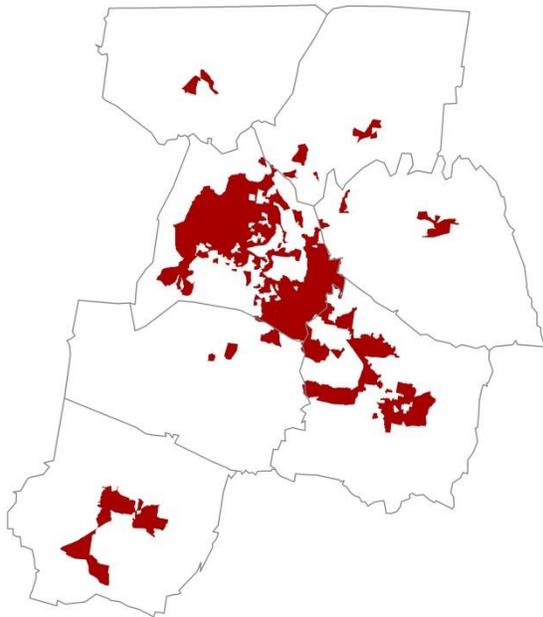


Figure 42: Non-Hispanic Minority Population
 Source: ACS 5-Year Estimates, 2009-2013

Non-Hispanic Minority Population

“Minority” is defined by the U.S. Department of Transportation as Black, Asian American, or American Indian and Alaskan Native. The Census also allows individuals to choose “Some other race alone”, or “Two or more races”. Race information is self-identified and self-reported.

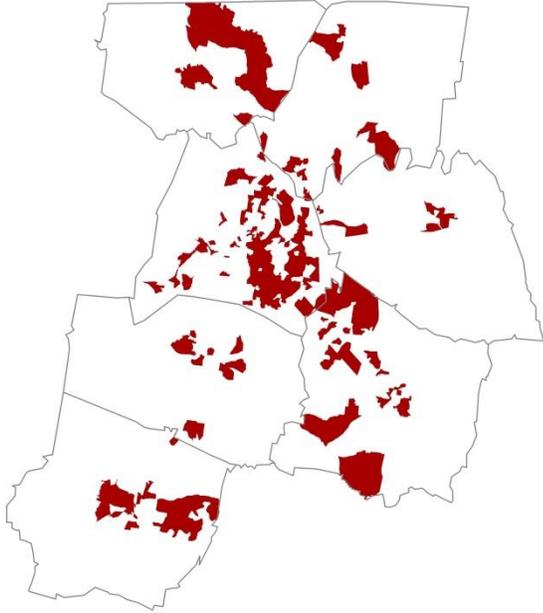


Figure 43: Hispanic Population
 Source: ACS 5-Year Estimates, 2009-2013

Hispanic Population

In the federal statistical system, one’s ethnic origin is considered to be separate from one’s race. Hispanic or Latino is therefore considered an ethnic category.

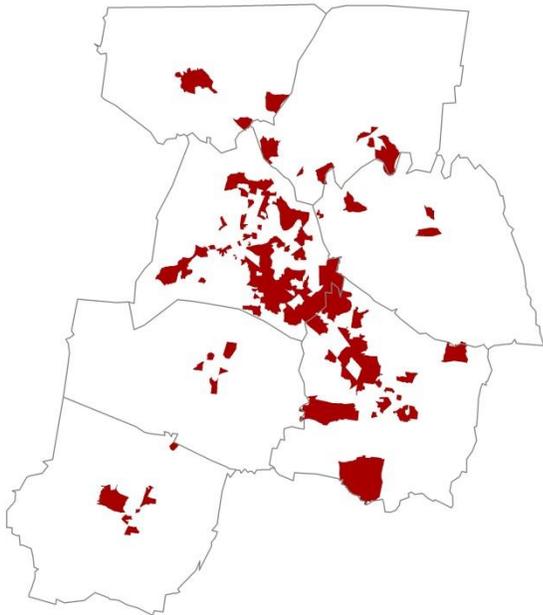


Figure 44: Limited English Proficiency Population
 Source: ACS 5-Year Estimates, 2009-2013

Limited English Proficiency Population

Inability to communicate in English may limit one’s ability to access necessary goods and services. This is particularly concerning during extreme weather events, as persons with limited English proficiency may not be able to understand early warning or shelter declarations if they are solely in English.

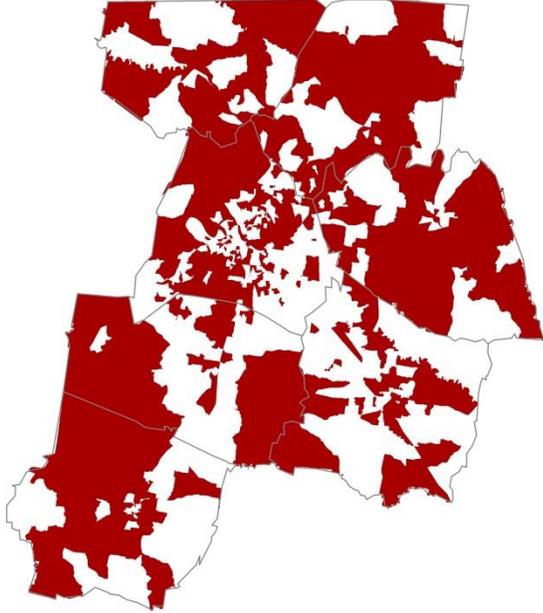


Figure 45: Elderly Population
 Source: ACS 5-Year Estimates, 2009-2013

Elderly Population

The likelihood of mobility issues increases with age. Elderly populations are more sensitive to temperature extremes and are more likely to suffer from heat stroke, hypothermia, and other illnesses.

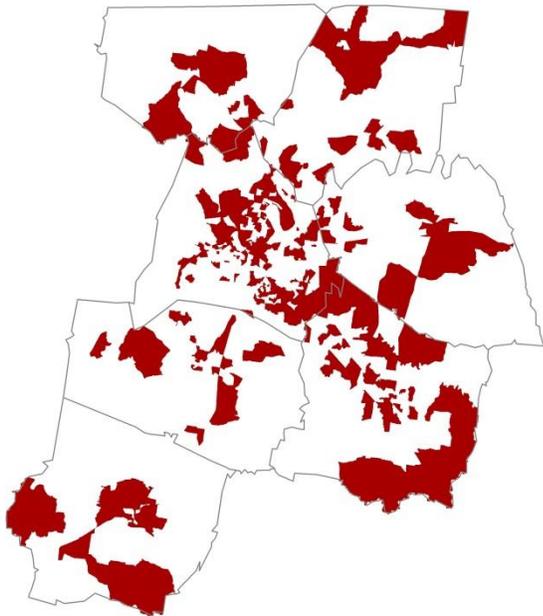


Figure 46: Single Mother Households
 Source: ACS 5-Year Estimates, 2009-2013

Single Mother Households

This factor allows women and children to be included in the DOV analysis. This population may require more support and services during extreme weather, especially if this status is combined with others.

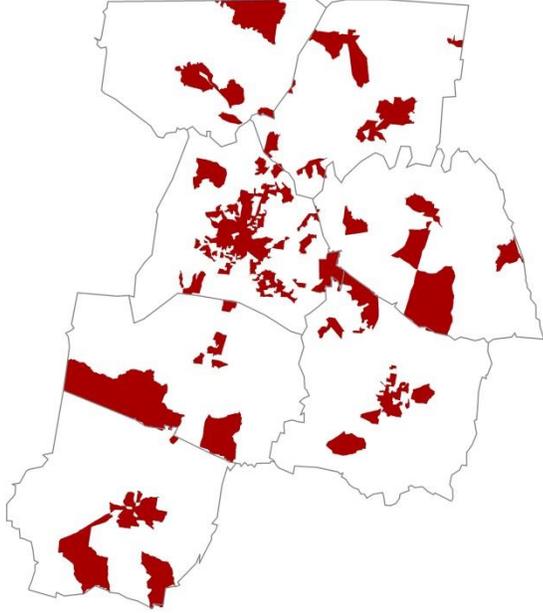


Figure 47: Carless Households
 Source: ACS 5-Year Estimates, 2009-2013

Carless Households

Carless households experience mobility issues, especially if they are not well served by transit options or if public transportation is not operating effectively. This group is more vulnerable to extreme weather, as they may not be able to seek proper shelter during evacuation events without a vehicle. They may also spend more time outside exposed to elements such as extreme heat.

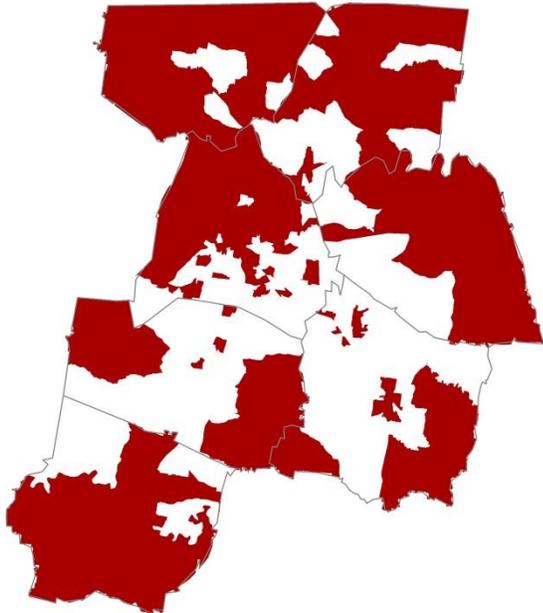


Figure 48: Physically Disabled Population
 Source: ACS 5-Year Estimates, 2009-2013

Physically Disabled Population

Each type of disability carries its own challenges, but in general, persons with a disability are not thoroughly considered during the development of emergency response plans. They may be less able to respond to calls for evacuation and to seek shelter, and may be more sensitive to temperature extremes. Many disabled populations have mobility challenges which may increase their exposure to elements such as extreme heat.

In addition to understanding where higher concentrations of vulnerable populations live in the region, these maps can be used to identify which of these areas might be at higher risk to climate-related stressors. For example, the following map shows the region’s vulnerable populations and their proximity to floodways, 100-year floodplains, and 500-year floodplains.

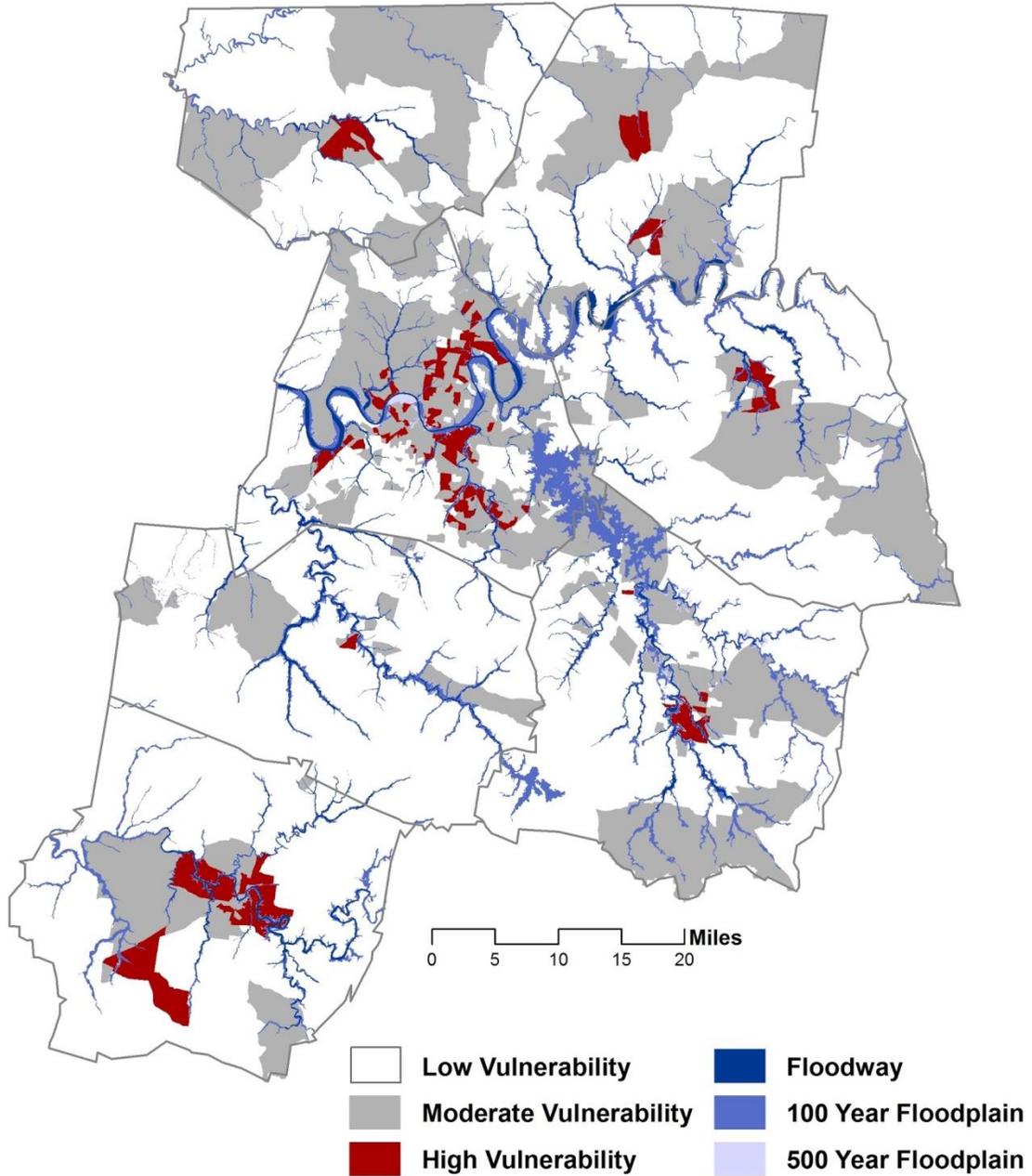


Figure 49: Flood zones relative to degree of vulnerability

Source: ACS 5-Year Estimates, 2009-2013, and FEMA Digital Flood Insurance Rate Maps

This spatial analysis will guide our outreach to specific communities and help determine the most effective focal areas for taking adaptation actions, such as in areas that are still recovering from the May 2010 flood.

For example, figure 50 below shows the overall degree of vulnerability of a section of Lower Mill Creek, in South Nashville, overlaid with the flood inundation boundary from the 2010 flood, aerial photography from the day after the flood, and Red Cross Emergency Shelter locations as they existed in 2011. Those communities in the highly vulnerable and flood-prone area of the top portion of the map are more than two miles away from the nearest shelter. Many of these individuals do not own a vehicle and accessing emergency shelters during flooding conditions may prove to be quite difficult for them. Fortunately, in part due to similar mapping conducted by Dr. David Padgett at TSU, the city of Nashville has worked diligently to significantly increase the emergency shelter locations throughout the city, with a specific emphasis on the areas of the city with the highest concentrations of vulnerability.

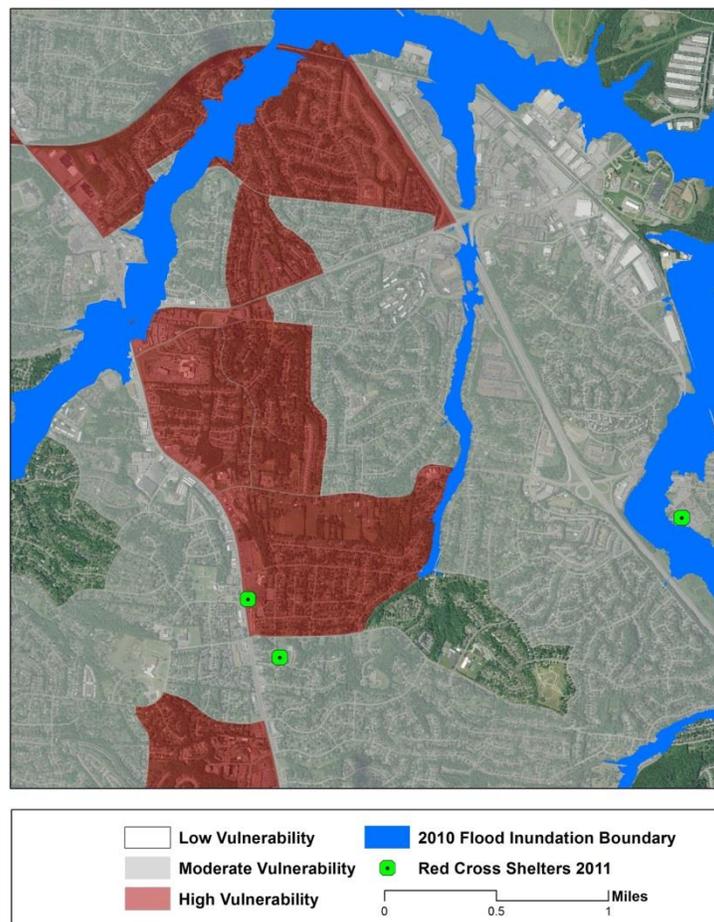


Figure 50: May 2010 flood inundation, vulnerability index, and shelter locations in the Lower Mill Creek
Source: ACS 5-year estimates 2009-2013, Red Cross Shelter Locations in 2011 from Tennessee State University, 2010 Flood Inundation Boundary from Davidson County GIS Department, Aerial photography from May 2010

This type of spatial analysis can be very useful to understand regional trends, growth patterns, and concentrations of vulnerability in the region. However, it is important to recognize that not every group may be represented by census data, and vulnerable populations that are more thinly spread throughout the region may not be visible in this large-scale analysis. Just because an area shows as “low vulnerability” does not mean it is absent of vulnerable populations. Additionally, further granularity of data should be sought to determine the specific locations within block groups that are most vulnerable. Collaboration with organizations and stakeholders that have a deeper understanding of their communities will allow for a higher degree of accuracy in mapping these vulnerable populations. This information can also be used to determine the best locations for educational workshops to relay information about emergency preparedness and climate risks to vulnerable populations. Additionally, these workshops could serve as opportunities to help vulnerable populations and emergency responders find ways to overcome the “digital divide” and make sure that information is being shared in a timely manner to those without internet and smartphones during emergencies.



Figure 51: Bountiful Blessings Farm
Photo by Danna Haile

Ecosystem services

Impacts from growth and development include increased loss of productive farmland and other vegetated areas that, when intact, can absorb CO₂ emissions and provide significant temperature regulation for our region. Growth and development also alters hydrologic cycles and aquatic habitats and can have negative impacts on fisheries and water body health. Development tends to fragment habitats with new construction and results in reductions in biodiversity in developing areas.

Furthermore, population growth comes with increased energy and water demand, which can strain natural resources and the existing infrastructure that delivers these services. The increased impervious surface area that is associated with development has dramatic implications for regional hydrology and pollution control. For example, flash flooding becomes far more likely when storm events can't be absorbed into the ground, heavy metals from road surfaces and parking lots more easily contaminate streams and other water bodies as runoff from rain events, and loss of vegetation increases the region's heat island effect.

Built environment

One consequence of this rapid regional development that is of particular environmental concern is the increased amount of impervious surfaces on the landscape. Figure 52 below shows maps of the region from 2001 and 2011 with impervious surfaces visible in gray. Figure 53 on the following page displays locations with increases in impervious surface area in orange.

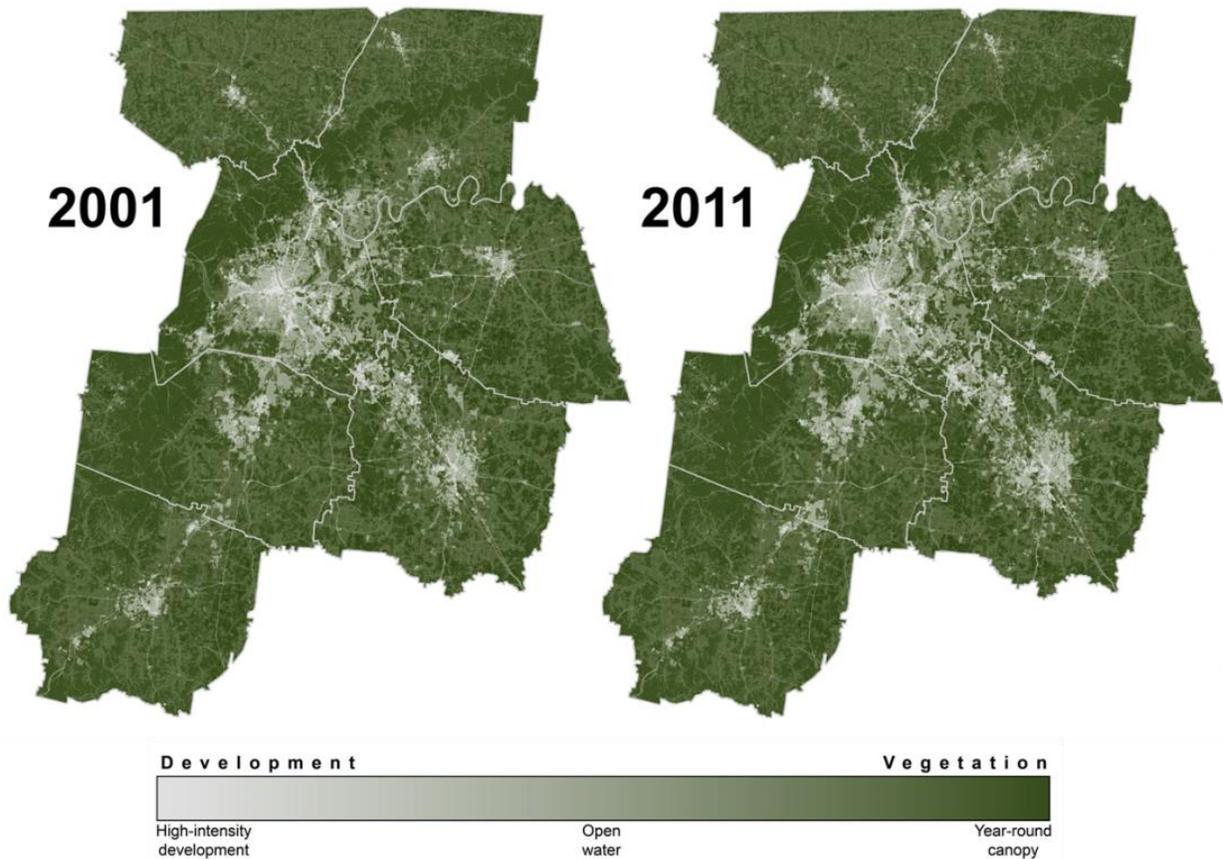


Figure 52: Increasing intensity of development, 2001 - 2011
Data Source: National Land Cover Database, 2001 and 2011

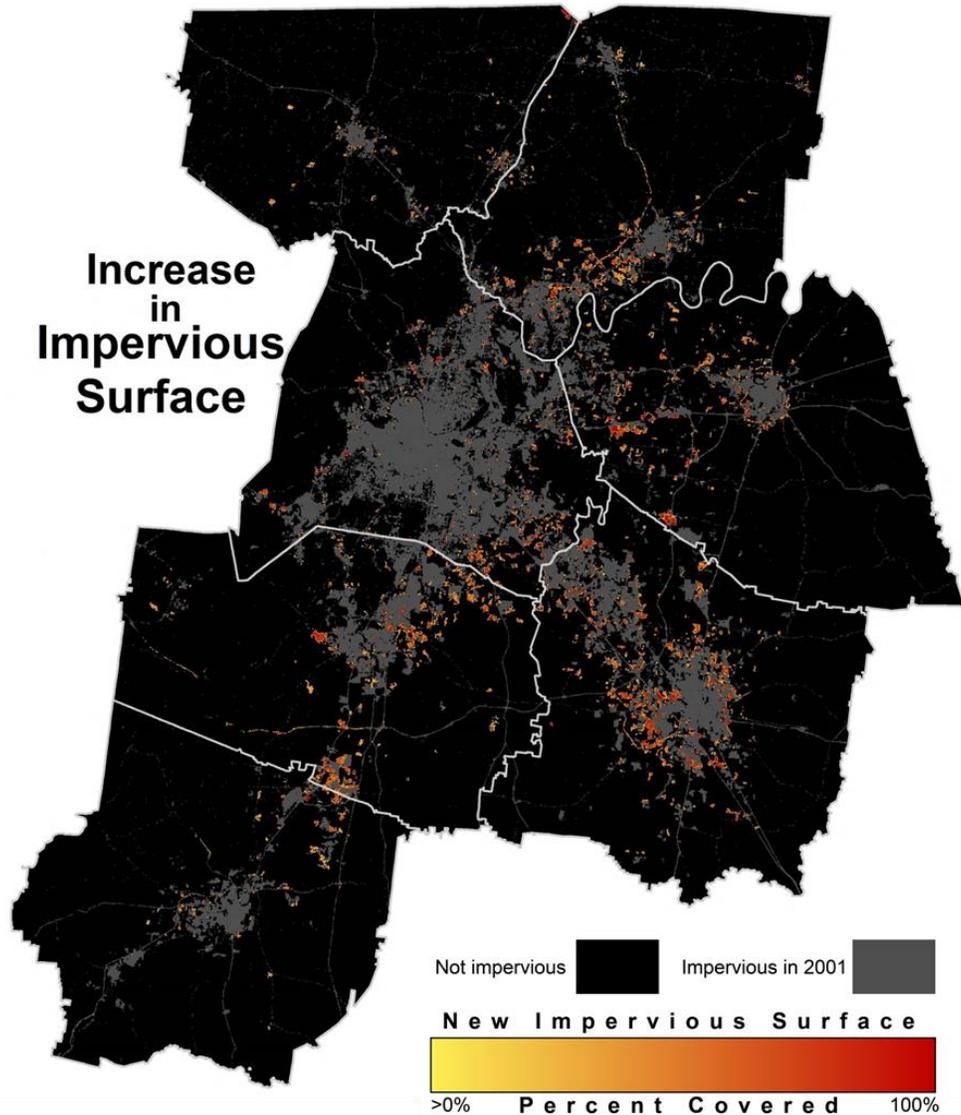


Figure 53: Increase in impervious surface area, 2001 to 2011, Nashville Area MPO

Data Source: National Land Cover Database, 2001 and 2011

Much of this increase in impervious surface area has occurred due to suburbanization and urban sprawl. This ring like effect of increased impervious surface on the edges of urbanized areas is sometimes called the “ring of fire.” The following series of figures show aerial photographs from the late 1990s and the same locations in 2011. The visible areas are where changes in land cover have occurred. The solid yellow blocks are areas where land cover remained constant. From these images it is easy to see the dramatic shift on the periphery of cities in the region from farmland to suburban-style residential subdivisions.

The predominant land cover was agricultural pastureland. The solid yellow blocks show areas where there has been no change in land cover.



Figure 54: Northeast Spring Hill, Williamson County, a community 30 miles south of Nashville, in 1999
Data Source: Google Earth 1999

There has been near total conversion to residential and commercial development.



Figure 55: Northeast Spring Hill in 2011
Data Source: Google Earth 2011

This development pattern accounts for the bulk of the increase in impervious surface in the region from 2001 to 2011. While growth can indicate economic and community vitality and an increasing housing stock can help maintain affordability, it is important to consider the impact of various development patterns on the region's people and environment.

For example, it is possible to address the needs of a growing population and help control dramatic increases in housing costs without widespread urban sprawl and the resulting increase in impervious surface. Tools such as urban infill, urban growth boundaries, density requirements for subdivisions, zoning to conserve agricultural and forest land, and encouraging a larger diversity and mixture of housing types such as cottage, row house, town house, condo, and apartments can alleviate some of the negative consequences of residential growth. Additionally, policies that encourage mixed use zoning where people can live, work, and play within a denser area tend to minimize sprawl and reduce the negative environmental impacts of development. In contrast, strict separations of zoning uses leave people isolated in residential communities that may be far from where they work and shop.



Figure 56: Farmland in West Murfreesboro, Rutherford County, in 1997
 Data Source: Google Earth 1999



Figure 57: The same West Murfreesboro view in 2011, now converted to residential developments
 Data Source: Google Earth 2011

Again, the predominant land cover has shifted over time from agricultural pastureland to suburban style residential subdivisions and roads. This trend toward suburban and exurban residential sprawl can be seen throughout the region.

While development has predominantly occurred on farmland, forest land cover has also been reduced. Furthermore, as the flatter agricultural lands become developed, development has begun to extend even more into the forested and steep ridged parts of the region. This is problematic for a variety of reasons. These areas, in many cases, serve as critical wildlife habitat. Development of steep slopes and forested areas decreases the overall tree canopy, which leads to higher temperatures, reduces the capture of air pollutants and carbon emissions, and alters hydrologic cycles by increasing the speed, temperature, and pollution of waters entering streams, which can lead to flooding and landslides.



Figure 58: Suburban sprawl
Photo source, MPO

If the region is to accommodate its projected growth in a sustainable and climate resilient manner, it is imperative to implement effective land use policies and growth management strategies that preserve the ecological health of our landscapes. In many cases, these solutions encourage the redevelopment of existing sites and increasing density to avoid sprawling into undeveloped land. These goals can be accomplished both by restricting development as well as by incentivizing developers to build in a more sustainable manner.

4.4 Assessment of Climate Relevant Land Use Policies, Practices, and Governance

There are many land use and comprehensive plans associated with our various municipality and county governments that aim to manage and prepare for future growth and resource allocation. These plans identify policies for schools, parks, water and sewer, transportation, and emergency procedures and are listed in the Appendix. Nearly every jurisdiction in the MPOs planning boundary has some type of comprehensive plan to address their needs into the future.

Most counties and municipalities do not incorporate climate change considerations into their plans for the future, but Davidson County is one of the leaders of this effort in the region. The City of Cookeville, which is outside of the MPO region, was the first to include climate provisions in their comprehensive plan. This resulted when it was the location of the Climate Solutions University southeast pilot community in 2008. This was followed by the completion of a full climate adaptation plan by the Sumner County Planning Department in 2010, during the first full year of the CSU program. However, Davidson County has been the most active in actually taking actions toward resilience, even without a formal climate plan in place. As of this publication Nashville has submitted an application to “100 Resilient Cities” to gain funding and support for a county-wide resilience plan. If awarded, the grant would provide funding to the city to hire a Chief Resilience Officer for a period of at least three years.

The following plans and legislation are a few examples of resiliency tools that could be implemented in all counties of our study region to improve our long-term regional, environmental, public, and economic health.

Metropolitan Nashville Water Services Long Term Control Plan

Metropolitan Nashville Water Services (MWS) Long Term Control Plan was established in 2009 as part of the Clean Water Nashville Overflow Abatement Program to bring MWS into compliance with state and federal water quality standards by reducing sewer system overflows and improving the water in the Cumberland and its tributaries. The Plan aims to reduce the number of combined sewer overflows (CSO), reduce the impact of CSOs on the Cumberland River, and invest in controls for the eight CSO locations that still exist. Control methods include removing a portion of stormwater flow from the system via conveyance systems or storage facilities to temporarily store excess flow³².

Overall, the plan aims to incorporate green infrastructure and low impact designs to reduce stormwater loading to the combined sewer system, eliminate two of the eight CSO sites, reduce discharge frequency and volume of the remaining sites, and improve the water quality levels of the Cumberland River to meet the community’s needs³³. Additionally, Nashville has been in a pilot phase of a new low impact design manual which would require new developments to absorb at least the first inch of rainwater

³² Metro Water Services, *Long Term Control Plan - Metro Nashville Combined Sewer Overflows*, 2011, p. 34.

³³ *Ibid*, p. 35.

onsite before any enters the storm sewer system. Thus far the program has been voluntary with the offer of incentives to developers who opt in. The plan is expected to shift to a mandatory program in 2016. This will be a significant move toward stormwater resilience for addressing the CSO issues, reducing the impacts of new development stormwater, and managing the anticipated shift to more intense rainfall events in future years. It may also serve as a model for surrounding counties as its use is proven to be practical and effective for Davidson County. Green Infrastructure Master Plan

The Metropolitan Government of Nashville and Davidson County's Green Infrastructure Master Plan was developed in 2009 to provide an analysis of potential green infrastructure developments and their impacts on the combined sewer system (CSS) area. The plan assessed the impacts of rainfall harvesting, green roofs, urban trees, and bioinfiltration areas, permeable surfaces, and tree planters for the CSS area. Capturing 80% of the 1.36 billion gallons of annual runoff from the 1,300 acres of rooftops in the CSS area would require 62.2 million gallons of additional storage. If all of the 708 buildings with flat roofs in the study area were converted with green roofs, 112 million gallons could be removed from the CSS system annually. There is the potential for 811 additional acres of urban trees to be established in the CSS area, which would remove an additional 660 million gallons from the CSS system annually. Finally, properly designed bioinfiltration systems, permeable pavement, and tree planters could remove better than 80% of parking lot runoff annually.

The plan also explored incentives and financing schemes for green infrastructure developments, including stormwater fee discounts, rebates and installation financing, development incentives, grants, and awards and recognition programs. The plan concluded that further development of a green infrastructure program in Nashville and the rest of the region is necessary.

Urban Tree Canopy Assessment

The Metropolitan Nashville and Davidson County Urban Tree Canopy (UTC) Assessment was conducted in 2010 for the Metro Tree Advisory Committee for the Metro Nashville area. The assessment reported that the county had an existing tree canopy that covered 47% of the study area, though this tree canopy coverage was not evenly distributed throughout the county. The report recommended that the metro government focus on preservation of the existing canopy and improve or enhance coverage in areas where it is low but gains are possible, prioritize public/private partnerships to promote tree planting, species selection, and strengthening of tree-related ordinances to increase the UTC, and conduct additional assessments to monitor progress and the effectiveness of incentives, codes, ordinances, and other tree-related programs. Ensuring coordination between the tree canopy initiative and the green infrastructure master plan would help strengthen both efforts.

Metropolitan Nashville-Davidson County Multi-Hazard Mitigation Plan

The federally mandated hazard mitigation plan identifies goals and measures of mitigation and risk reduction to respond to disasters and inform local policy decisions for future land use. The top five hazards identified for Davidson County are: flooding, winter storms, tornadoes, extreme temperatures, and thunderstorms. Mitigation goals include: reducing exposure to hazard related losses for existing and

future development, promoting awareness of hazards and vulnerability among citizens, business, industry, and government, and maximizing use of available funding for more effective mitigation activities. It is imperative that all hazard mitigation plans throughout the region plan not just for past events, but consider how climate change may impact events in the future. FEMA has asked that all hazard mitigation plans take climate change into consideration. These multi-hazard mitigation plans are crucial not just for emergency preparedness locally, but are a required prerequisite to qualify for federal disaster relief aid. The findings and recommendations from this adaptation plan can help inform how local hazard mitigation plans incorporate climate resilience, which is now required but guidance on how to do that is not always clear.

Nashville Open Space Plan

The Nashville Open Space plan was published in 2011 as a partnership between the Mayor’s Office of the Metropolitan Government of Nashville and Davidson County and the Land Trust for Tennessee. The report presented Nashville’s open space vision, which included four large anchor zones in each corner of the county connected by corridors along streams and greenways. The report also developed a number of goals to make Nashville the “greenest city in the Southeast”: increase the Metro park system by 30 percent in the next 10 years; protect 10,000 acres of floodplain and environmentally sensitive areas with low-impact design, land swaps, and regulation; establish an anchor park in Southeast Nashville; improve greenway linkages; double the downtown tree canopy in 10 years; transition 20 percent of impervious surfaces in downtown to pervious surfaces or natural plantings; and create large preserves in every bend of the Cumberland River in the next 10 years³⁴. Many of these recommendations were then folded into the city’s comprehensive plan adopted in 2015, following a three-year planning process called NashvilleNext. There is an opportunity to expand and coordinate the Nashville Open Space Plan with an upcoming Regional Open Space planning process being planned by Cumberland Region Tomorrow for the 10-county middle Tennessee region. These climate findings will be relevant to all open space planning and to the MPO’s transportation planning considerations.

NashvilleNext

The NashvilleNext plan was developed by the Metropolitan Nashville Planning Department and adopted by the Metro Planning Commission in 2015 to identify and prioritize Davidson County’s goals for the next 25 years. Major community outreach and input was integral to the plan’s development, and the community’s goals and vision for the city include: ensuring opportunity for all, expanding accessibility, creating economic prosperity, fostering strong neighborhoods, improving education, championing the environment, and preserving Nashville’s character. Some of the major priorities identified in the plan are: preserving neighborhood character while building housing close to transit and jobs, protecting rural character and natural resources, creating walkable centers with jobs, housing and services in suburban and urban areas, expanding walking, biking, and transit, and ensuring that the city is affordable for all Nashvillians.

³⁴ Nashville Open Space Plan, 2011.

Public Transit Master Plans

Nashville's Metropolitan Transit Authority (MTA) and the Regional Transit Authority (RTA) began a strategic planning process in mid-2015 to develop a 20-year comprehensive transit plan for the Nashville area. This process, called nMotion, should be concluded by Spring 2016 and will evaluate the current state of Davidson County's transit system, identify opportunities to improve the system, increase ridership and service, and meet the growing transit needs for the region. The MTA/RTA system currently offers 46 routes in Davidson County, nine regional bus routes, and the Music City Star regional rail, which services Davidson and Wilson counties. An opportunity exists to factor in this transit planning process increased consideration for hazard mitigation, infrastructure specifications that account for changing climate conditions, and ensuring access for the more vulnerable populations.

2040 Regional Transportation Plan

The Nashville Area MPO's 2040 Regional Transportation Plan (RTP) pulls from the counties' local comprehensive plans to unify the region's most important transportation priorities for federal funding. The MPO also engaged with the public and other stakeholders through studies that focused on improving the transportation system and the connections between land use, urban design, and economic development. These studies include: Regional Freight and Goods Movement Study, Regional Bicycle and Pedestrian Study, State Route 109 Access Management Study, Southeast Area Transportation and Land Use Study, and the Major Transit Study for the Northwest Corridor. This climate adaptation plan serves as a companion piece to the 2040 RTP and serves to highlight the MPOs region-wide efforts to address climate change and various environmental issues of concern for the region. Implementation of the regional transportation plan represents an opportunity to incorporate climate resilience into federal transportation funding decisions and coordinate with each of the plans and processes listed above both for Nashville area and the surrounding counties.

SAFE/NERVE

After the May 2010 flood, the Nashville Office of Emergency Management developed two web-based tools to gather real-time data about flood and emergency weather conditions that they could then communicate to the public. SAFE, the Situational Awareness for Flooding Events, is an internal mapping tool that provides real-time information about river height, weather prediction information, and soil saturation levels. This information can be used to estimate how high rivers are expected to rise and where waters will flow during flood events. NERVE, the Nashville Emergency Response Viewing Engine, is a mapping tool that provides information to the public during natural or man-made disasters, such as: road closures, shelter locations, school closings, locations of food and water distribution centers and Disaster Assistance Centers. These innovative tools have been used during disasters and extreme weather events to keep residents safe, but they require access to the internet or smartphones. Emergency responders throughout the region must remain mindful of populations without access to these tools and ensure that they are effectively communicating with all members of the community, especially those that are most vulnerable.

It is imperative that all documents and policies, including those listed above, explicitly include analysis and consideration of climate variability. Creating policies based solely on what has occurred in the past will not adequately prepare us for the changing conditions we expect in the future. Incorporating climate change considerations into all policies and documents would better protect our region, decision-makers, and citizens from preventable damages that result from climate change.

5.0. Strategic Adaptation Framework

5.1 Restatement of Stressors and Risks

As a result of our stakeholder engagement and planning process, we have developed a climate action plan which is designed to prioritize solutions to our top risks, which are:

- Extreme weather
 - Heat
 - Flood
 - Drought
 - Storms/Winds/Hail
- Water quality and quantity issues
- Growth and development - loss of habitat, agricultural land, and ecosystem services

All of these risks pose threats to human wellbeing, environmental health and economic integrity. Solutions are varied and could include prioritizing green infrastructure developments for urban and rural areas to improve air quality and decrease the effects of extreme heat, developing public transportation systems that support walking, biking, and mass transit to encourage active lifestyles and reduce emissions, and creating interconnected conservation areas that would support local ecosystem services, provide space for outdoor recreation, and yield mental health benefits.

5.2 Practical Vision of Transformation, Desired Future Condition

The Nashville Area MPO and its stakeholders have defined a practical vision for the future in which adaptation efforts have been successfully implemented. This is our desired future condition:

Middle Tennessee is resilient to the climate and non-climate stressors facing the region. Government, business, the natural and built environment, and people are minimally impacted by these risks, and the region supports livable, prosperous, sustainable, and diverse communities.

In order to achieve our desired future condition, there is a fundamental transformation that must occur in the region. Success would mean that ***regional and community leaders across all sectors and jurisdictions prioritize and sustain collaborative action for climate resilience.***

The following goals are the broad responses that are necessary to address our primary risks, achieve transformational change, and create our desired future condition. All goals prioritize the region's most vulnerable communities and citizens. As a result, vulnerable communities are more resilient because the region recognizes the existence of these groups, sees them as integral members of the community, and considers them in all policies, plans, and solutions for climate resilience.

Goal 1: The region implements preemptive adaptation measures and responses to extreme weather events that are planned, coordinated, and timely.

Goal 2: The leaders and residents of the region value and protect water resources and prioritize improved water quality and conservation for the benefit of human and natural systems.

Goal 3: The region's growth and development promotes equitable prosperity and is sustainable for people and natural resources.

Goal 4: The region's leaders and organizations work collaboratively and effectively in all resilience actions.

Through concerted, unified effort, Middle Tennessee can become resilient to the climate and non-climate stressors facing the region. Through collaborative partnerships, people, government, business, organizations, and the natural and built environment will be minimally impacted by these risks, and the region will support livable, prosperous, sustainable, and diverse communities.

By identifying common risks and mutual self-interests, public agencies and nonprofits can collaborate with private landowners and business interests to create solutions together that can't be done alone. For example, city governments at risk of flooding and water pollution from poorly managed upstream land uses can create a system of funding for upstream rural counties to better manage their private land use, development, and farming practices so the whole region reaps the co-benefits. Additional benefits of collaborative action are: cities serve the safety and health of their people, business utilizes wise risk management, and farmers conserve their critical soil and water resources. When all levels of a community can come together around a clear, mutually beneficial common goal, there is no limit to what can be accomplished.

5.3 Adaptation Strategies and Actions

The region must move from a culture of independent activity by multiple agencies, governments and private entities, to a culture of collaborative action by all. For that to happen, government and private sectors must choose to recognize the value of becoming partners in sustainability and environmental stewardship. When leaders and citizens understand the risks and impacts associated with climate change on the natural and built environment, the economy, and other people, the benefits of proactive resilience strategies will motivate them to collaborate and take action. Policies will be changed to address the greatest risks of climate change. Progress will be defined, measured, and reported, and funding sources will be identified. Accordingly, we propose to institute five strategies to achieve the above goals and catalyze collaborative action for climate resilience:

1. Collaborate - Partner across sectors and jurisdictions and engage diverse stakeholders to identify and pursue common goals.
2. Educate - Educate government/businesses/organizations/citizens about co-benefits and methods of collaboration for climate resilience.
3. Change Policy - Empower leaders to work cooperatively for resilience policies at local and regional scales.
4. Monitor – Establish, evaluate, and track progress on consensus priorities, goals, and actions.
5. Build Capacity - Ensure sustainable funding and personnel to pursue resilience actions (capacity, resources, funding).

6.0 Climate Adaptation Plan

The following actions are necessary to achieve the goals that will lead to climate resilience and our desired future condition. These actions will be monitored over time and updated as projects are completed and our understanding of the risks of climate change evolve and deepen. Each project will be given a time horizon of either short term (“S”, 6 to 12 months) or long term (“L”, up to 5 years).

Implementation of these actions will be managed by forming a Regional Resilience Working Group (RRWG) that will meet at regular intervals and serve to guide, coordinate and promote action steps taken by various agencies, organizations, and businesses in pursuit of regional resilience goals.

The MPO’s role will include the following:

1. Convene and facilitate the work of the regional resilience working group,
2. Work with local city and county governments for education and policy in support of resilience for federal funded transportation projects,
3. Contribute expertise and advice to educate stakeholder groups and support their actions in the region.

The fourth goal lists actions specific to the RRWG. These are activities to be initiated in the next 6-12 months and will be regularly revisited and updated as part of the work of the Regional Resilience Working Group.

The following is an acronym key for stakeholders listed in the action plan table:

CRC:	Cumberland River Compact
CRT:	Cumberland Region Tomorrow
EARS:	Emergency Awareness and Readiness Services for the Deaf and Hard of Hearing
FHWA:	Federal Highway Administration
HON:	Hands on Nashville
MPO:	Nashville Area Metropolitan Planning Organization
OEM:	Office of Emergency Management
RRWG:	Regional Resilience Working Group
SELC:	Southern Environmental Law Center
TDA:	Tennessee Department of Agriculture
TDEC:	Tennessee Department of Environment and Conservation
TDOT:	Tennessee Department of Transportation
TGA:	Lightning 100/ Team Green Adventures
TIRRC:	Tennessee Immigrant and Refugee Rights Coalition
TPL:	The Trust for Public Land
TSU:	Tennessee State University
TWRA:	Tennessee Wildlife Resources Agency
USDOT:	United States Department of Transportation
USGS:	United States Geologic Survey
UGL:	Urban Green Lab
VU:	Vanderbilt University

Goal 1: Adaptation and response to extreme weather events are planned, coordinated, timely, and enacted on a regional scale.

Action	Time Frame	Key Stakeholders
1.1 Conduct detailed transportation infrastructure vulnerability assessment to extreme weather within the MPO planning area.	S	MPO, TDOT, FHWA, VU
1.2 Map service gaps of storm shelters throughout the region.	S	MPO, OEMs, the Red Cross, TSU
1.3 Ensure that all emergency response and hazard mitigation plans consider the impacts of climate change to the region and are including this information in their plans.	L	MPO, OEMs
1.4 Participate in decision making process for flood wall for downtown Nashville.	L	TBD
1.5 Conduct heat mapping for urban areas.	S	MPO, TPL
1.6 Conduct workshops for vulnerable populations on emergency preparedness and access to services.	S	EARS, OEMs, TIRRC, the Red Cross
1.8 Develop climate metrics for MPO evaluation of proposed transportation projects.	S	MPO, TDOT, FHWA
1.9 Ensure adequate maintenance of existing transportation infrastructure.	L	TDOT, MPO

Goal 2: The region values and protects water resources and prioritizes improved water quality and conservation for the benefit of human and natural systems.

Action	Time Frame	Key Stakeholders
2.1 Establish enhanced protection of riparian buffer zones for impaired waterways.	L	TDA, CRC, Local Planning Departments
2.2 Restrict development on steep slopes.	L	MPO, SELC, Local Planning Departments
2.3 Restrict development in floodplains.	L	MPO, SELC, Local Planning Departments,

Goal 2: The region values and protects water resources and prioritizes improved water quality and conservation for the benefit of human and natural systems.

Action	Time Frame	Key Stakeholders
2.4 Invest in green infrastructure to reduce impermeability and Combined Sewer Overflows.	L	MPO, CRC, Local Public Works Departments
2.5 Prioritize complete streets and improvement of urban tree canopy to address flooding, heat, air quality.	L	MPO, TDOT, FHWA, SELC, CRC Local Public Works Departments
2.6 Establish public and private partnerships to address water quality issues.	L	Army Corps of Engineers, CRC, USGS, Local universities, Citizen groups, HON, MPO, Schneider Electric
2.7 Ensure adequate maintenance of existing stormwater infrastructure.	L	Local Public Works Departments
2.8 Ensure free flow of water through culverts and utilize box culverts where possible.	L	CRC, Army Corps of Engineers, TDOT, MPO
2.9 Reduce the number of variances approved to existing water quality ordinances.	S	Local governments and water utility providers, CRC
2.10 Protect remaining healthy waters, as well as sensitive ecosystems, and high value forests.	L	CRC, CRT, MPO, TWRA, TDEC, TDA
2.11 Improve recreational access to water resources where possible to inspire future clean water advocates.	S	CRC, other watershed groups, Local parks departments
2.12 Restore natural flow and decrease flooding and recreational risks by removing antiquated low-head dams.	L	CRC, Army Corps of Engineers
2.13 Collaborate to increase water efficiency and conservation practices to conserve both water and energy.	S	CRC, UGL, water utility providers

Goal 3: The region's growth and development promotes equitable prosperity and is sustainable for people and natural resources.

Action	Time Frame	Key Stakeholders
3.1 Continue to invest in the acquisition of lands dedicated to parks, greenways, and open space throughout the region.	L	SELC, Land Trust for TN, CRT, MPO
3.2 Create Regional Open Space Plan to determine where new conservation areas should be located in the future.	L	CRT, CRC, MPO
3.3 Identify and map environmentally sensitive areas in the region at high risk of being developed.	L	MPO, CRT, TWRA, TDEC, TDA
3.4 Conduct a Regional Tree Canopy Assessment that focuses on the tree coverage of urban areas within the region.	L	MPO, Local Public Works Departments
3.5 Encourage tree plantings, establish maintenance funds and tree ordinances.	S	MPO, CRC, HON, TGA, Local Public Works Departments
3.6 Establish a density requirement for new developments to reduce sprawl into forested areas.	L	MPO, Local Planning Departments
3.7 Encourage incentive mechanisms to reduce sprawl, protect carbon sinks, and improve resilience.	L	MPO, SELC, Local Planning Departments, CRC/TNC
3.8 Establish a percent impervious cap for new development.	L	MPO, Local Planning Departments, Local Water Departments
3.9 Prioritize the development of mass transit for the region, and continue to invest in sidewalks, greenways, and bike infrastructure to encourage active mobility. Improve connectivity issues, especially for vulnerable populations.	L	MPO, SELC, MTA, RTA, Chambers of Commerce, Local Planning Departments, Walk/Bike Nashville
3.10 Create equity atlas for the MPO region.	S	MPO, Organizations that represent vulnerable populations

Goal 3: The region's growth and development promotes equitable prosperity and is sustainable for people and natural resources.

Action	Time Frame	Key Stakeholders
3.11 Research the economic benefits of green infrastructure and jobs training for low income people.	S	Local Housing Authorities, TSU
3.12 Explore options for integrating renewable energy technologies, such as solar, to serve low income housing to decrease the burden of energy bills.	S	Local Housing Authorities
3.13 Establish more rigorous regulations for car and truck emissions to maintain air quality despite our growing population.	L	MPO, TDOT, USDOT
3.14 Educate and motivate to encourage energy and water conservation and home energy upgrades (rebates, etc.).	S	UGL, HON, CRC
3.15 Explore community composting models to determine efficacy and feasibility for our region.	S	Local Public Works Departments, Local Composting Companies

Goal 4: The region works collaboratively and effectively in all resilience actions.

Action	Time Frame	Key Stakeholders
4.1 Explore effective government/nonprofit partnerships to expand government's capacity to affect change.	S	RRWG, CRC
4.2 Create a Regional Resilience Working Group to meet regularly to monitor and evaluate resilience progress and increase partnerships between government, nonprofits, and business sectors.	S	MPO, CRC, CRT
4.3 Maximize the utilization of volunteers to perform direct action resilience efforts.	S	MPO, RRWG, HON, TGA, CRC

Goal 4: The region works collaboratively and effectively in all resilience actions.

Action	Time Frame	Key Stakeholders
4.4 Conduct outreach on the findings of this plan throughout the region to create engagement with and support for the action plan.	S	MPO, RRWG
4.5 Monitor and review progress and success and continuously reprioritize goals and actions to represent need, capacity, and opportunity.	S	MPO, RRWG

Appendix

A. References and Resources

305(b) Report: *The Status of Water Quality in Tennessee*, 2014.

https://www.tn.gov/assets/entities/environment/attachments/water-quality_2014-305b-final.pdf

Bailey, R.G., Avers, P.E., King, T., and McNab, W.H., eds., 1994, Ecoregions and subregions of the United States (map) (supplementary table of map unit descriptions compiled and edited by McNab, W.H. and Bailey, R.G.): Washington, D.C., U.S. Department of Agriculture - Forest Service, scale 1:7,500,000.

http://www.epa.gov/wed/pages/ecoregions/tn_eco.htm#Principal

Dabson, Brian. (2007). *Rural-Urban Interdependence: Why Metropolitan and Rural America Need Each Other*. Washington, DC: The Brookings Institution. http://www.rupri.org/Forms/Dabson_Brookings.pdf

Flanagan, Barry E.; Gregory, Edward W.; Hallisey, Elaine J.; Heitgerd, Janet L.; and Lewis, Brian (2011) "A Social Vulnerability Index for Disaster Management," *Journal of Homeland Security and Emergency Management*: Vol. 8: Iss. 1, Article 3.

<http://gis.cdc.gov/grasp/svi/A%20Social%20Vulnerability%20Index%20for%20Disaster%20Management.pdf>

Gundersen, C., A. Satoh, A. Dewey, M. Kato & E. Engelhard. *Map the Meal Gap 2015: Food Insecurity and Child Food Insecurity Estimates at the County Level*. Feeding America, 2015.

http://www.feedingamerica.org/hunger-in-america/our-research/map-the-meal-gap/2013/TN_AllCounties_CDs_MMG_2013.pdf

Headwaters Economics Economic Profile System report. U.S. Department of Commerce, 2013. Census Bureau, American Community Survey Office, Washington, D.C.

Melillo, Jerry M., Terese (T.C.) Richmond, and Gary W. Yohe, Eds., 2014: *Climate Change Impacts in the United States: The Third National Climate Assessment*. U.S. Global Change Research Program, 841 pp. doi:10.7930/J0Z31WJ2.

Metropolitan Government of Nashville and Davidson County, *Nashville Open Space Plan*, 2011.

<http://www.conservationfund.org/images/projects/files/Nashville-Naturally-Green-Infrastructure-Plan-The-Conservation-Fund-2011.pdf>

Metro Water Services, *Long Term Control Plan - Metro Nashville Combined Sewer Overflows*, 2011.

<http://www.cleanwaternashville.org/content/resources/pdfs/pdr/LongTermControlPlan.pdf>

Nashville Area Metropolitan Planning Organization: *Tri-County Transportation and Land Use Study*, 2012.

http://www.nashvillempo.org/docs/tricounty/TriCounty_FINAL_REPORT.pdf

Nashville Area Metropolitan Planning Organization: *Regional Transportation Plan 2040*, 2015.

NOAA, Service Assessment, Record Floods of Greater Nashville: Including Flooding in Middle Tennessee and Western Kentucky, May 1-4, 2010, p. xi.

http://www.nws.noaa.gov/os/assessments/pdfs/Tenn_Flooding.pdf

Phillips, Spencer. 2013. A user's guide to ecosystem services: moving from understanding to action. Charlottesville, Virginia: Key Log Economics. http://www.mfpp.org/wp-content/uploads/2013/11/UsersGuideToEcosystemServices_Ver1.0_20130711.pdf

Summary for Policymakers. In: *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* [Field, C.B., V.R. Barros, D.J. Dokken, K.J. Mach, M.D. Mastrandrea, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L. White (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, p. 6.

Tennessee Advisory Commission on Intergovernmental Relations, Thurman L., Terry B., Gibson, T., Green, H.. *Land Use and Planning in Tennessee - Part II: Land Use and Transportation Planning*, 2011. <https://www.tn.gov/assets/entities/tacir/attachments/LandUseAndPlanning.pdf>

Tennessee Department of Transportation, *Assessing the Vulnerability of Tennessee Transportation Assets to Extreme Weather*, Final Report, 2015.

Tennessee Permanent Stormwater Management and Design Guidance Manual, Chapter 2: *Why Green Infrastructure as a Stormwater Solution for Tennessee*. <http://tnpermanentstormwater.org/manual/04%20Chapter%20%20Why%20Runoff%20Reduction%20in%20Tennessee.pdf>

Tennessee Wildlife Resources Agency, *Climate Change and Potential Impacts to Wildlife in Tennessee - An Update to Tennessee's State Wildlife Action Plan*. Technical Report 09-09. <https://www.tn.gov/assets/entities/twra/attachments/tnclimatechange.pdf>

Tennessee Wildlife Resources Agency, *Tennessee State Wildlife Action Plan*, 2015. <http://www.tnswap.com/pdf/2015swap.pdf>

The Council on Environmental Quality, *Revised Draft Guidance on Consideration of Greenhouse Gas Emissions and Climate Change in NEPA Reviews*, 2014. https://www.whitehouse.gov/sites/default/files/docs/nepa_revised_draft_ghg_guidance_searchable.pdf

University of Maryland, Center for Integrative Environmental Research, *Economic Impacts of Climate Change on Tennessee*, 2008. <http://cier.umd.edu/climateadaptation/Tennessee%20Economic%20Impacts%20of%20Climate%20Change%20Full%20Report.pdf>

United States Department of Transportation, Climate Adaptation Plan: *Ensuring Transportation Infrastructure and System Resilience*, 2014.

<https://www.transportation.gov/sites/dot.gov/files/docs/2014-%20DOT-Climate-Adaptation-Plan.pdf>

U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, Communities Putting Prevention to Work: Nashville/Davidson County, Obesity Prevention.

http://www.cdc.gov/nccdphp/dch/programs/communitiesputtingpreventiontowork/communities/profiles/pdf/cppw_communityprofile_b1_nashville-davidsoncounty_tn_508.pdf

B. Full Stakeholder and Advisor List

Stakeholders:	Advisors:
Center for Independent Living of Middle TN	City of Mt. Juliet
Clean Air Partnership of Middle Tennessee	Metropolitan Nashville Airport Authority
Cumberland Region Tomorrow	Metro Nashville Mayor's Office - Office of New Americans
Cumberland River Compact	Metro Nashville Planning Department
Fifty Forward	The Nature Conservancy
Greater Nashville Regional Council (GNRC)	
Green Leaf Aquaponics	
Hands On Nashville	
LaVergne City Government	
League of Women Voters	
Lightning 100/ Team Green Adventures	
Lipscomb University Institute of Sustainability	
Metro Office of Emergency Management	
Metro Parks and Greenways	
Metro Public Health Department	
Metro Public Works/Horticulturalist	
Metro Water	
Nashville Mayor's Office	
Red Cross	
Rutherford County Government	
Schneider Electric	
Southern Environmental Law Center (SELC)	
Tennessee Department of Agriculture Division of Forestry	
Tennessee Department of Transportation	
Tennessee Department of Environment and Conservation (TDEC)	

Stakeholders:

Advisors:

Tennessee Disability Coalition

Tennessee Immigrant and Refugee Rights Coalition
(TIRRC)

Tennessee State University

Tennessee Wildlife Resource Agency (TWRA)

The Nature Conservancy

Urban Green Lab

US EPA

Vanderbilt Engineering Department

Vanderbilt Institute for Energy and the
Environment (VIEE)

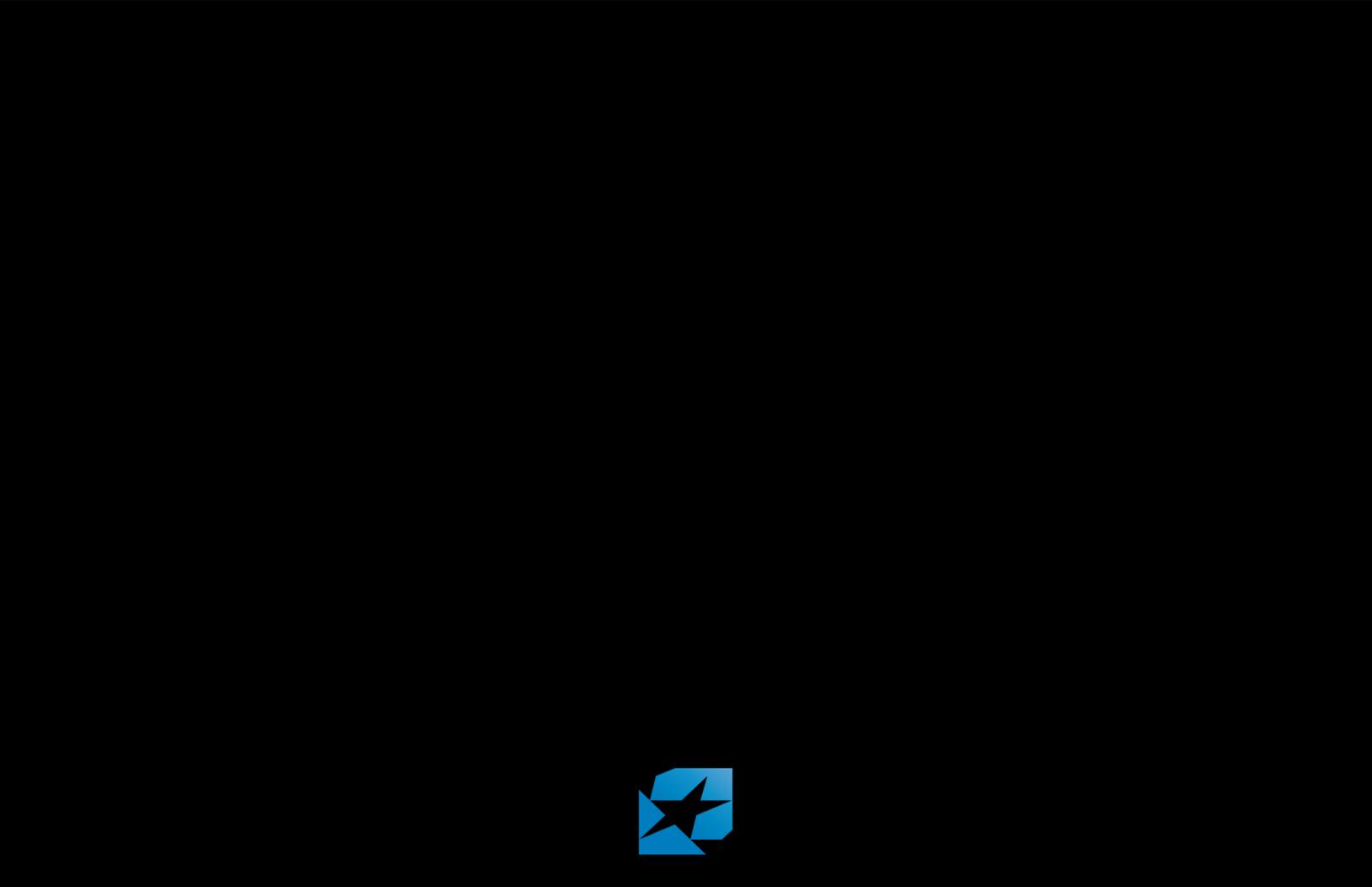
C. Relevant Planning Documents

County	Planning Document
Davidson	NashvilleNext, Belle Meade Zoning Code, Goodlettsville Land Use Plan, Ridgetop Future Land Use Plan
Maury	Maury County Comprehensive Plan
Robertson	Coopertown Land Use and Transportation Plan, Draft Robertson County Comprehensive Plan, Greenbrier Land Use Plan, Millersville Future Land Use Plan, Millersville Zoning Ordinance, Portland Future Land Use Plan, Ridgetop Future Land Use Plan, Robertson County Zoning Ordinance, White House Comprehensive Plan
Rutherford	Rutherford County Comprehensive Land Use Plan (2011), Murfreesboro Comprehensive Plan (2015), Town of Smyrna Comprehensive Plan (2007), City of LaVergne Zoning, Eagleville Zoning Ordinance
Sumner	2035 Comprehensive Plan: Sumner County’s Blueprint to the Future, Gallatin General Land Use Plan, Hendersonville Land Use and Transportation Plan, Long Hollow Pike-Station Camp Plan, Millersville Future Land Use Plan, Millersville Zoning Ordinance, Portland Future Land Use Plan, Westmoreland Future Land Use Plan, White House Comprehensive Plan
Williamson	Brentwood Zoning Ordinance, Comprehensive Plan for Thompson’s Station, Fairview Long-range Growth and Land Use Plan, Franklin Land Use Plan, Nolensville Land Use Plan, Spring Hill Future Land Use Plan, Springfield Future Land Use Plan, Williamson County Comprehensive Land Use Plan, Spring Hill Bicycle and Greenway Plan
Wilson	Lebanon Future Land Use Plan, Mt. Juliet Land Use and Transportation Plan, Wilson County Gateway Land Use Master Plan

D. Community Water Systems by County

County	Population Served	Community Water Systems
Davidson	566,533	Nashville, Cumberland river, Cumberland U.D., Madison Suburban, Harpeth Valley, West Wilson U.D., Old Hickory UD
Maury	78,420	Duck River, Columbia, Spring Hill, Springs
Robertson	37,553	Red River, Springfield, East Montgomery
Rutherford	182,455	Murfreesboro WD, Lavergne, Smyrna, East Fork Stones River, Percy Priest Lake, Nashville, Consolidated UD, Stones River
Sumner	159,496	Gallatin, Hartsville, Westmoreland, White House UD, Cumberland River, Old Hickory Lake, City Lake, Drakes Creek, Sportman Lake, Franklin KY, Hendersonville
Williamson	118,869	Mallory Valley, Nashville, Harpeth Valley, Franklin, Water Authority of Dickson Co, Milcrofton, Harpeth River, Spring Hill UD, Nolensville, H.B. & T.S. UD, Wells, Smyrna
Wilson	91,354	W. Wilson UD, Cumberland UD, Lebanon, Old Hickory Lake, Cumberland River, Wells, Gladeville, Unconsolidated UD

Source: Appendix A, http://www.tn.gov/environment/water/docs/water-supply/source_water_assessment_epa_report_aug_2003.pdf



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