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Tennessee State of the Environment Report

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Table of Contents

Introduction

This report analyzes the state of the environment in Tennessee and compares it to the Southeast (i.e., Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, South Carolina, and Tennessee) and the United States where possible. Focusing on critical aspects such as air and water quality, energy and climate, and land use and conservation, the report explores environmental trends locally, regionally, and nationally.

The report seeks to inform researchers, students, policymakers, stakeholders, and the public about the status of Tennessee's environment using publicly available data and supporting literature. The report begins with an evaluation of the status of land conservation, highlighting changes in land use patterns. The report then delves into climate and energy trends in Tennessee, examining the balance between affordability, reliability, and carbon reduction efforts. It also investigates the air and water quality in Tennessee, exploring factors such as pollution levels, sources of contamination, and the impacts on human health. When applicable, the report identifies connections to current public and private governance initiatives, identifying opportunities for improvement and potential policy interventions.

By presenting a comprehensive analysis of Tennessee’s environment, this report aims to foster a greater awareness and understanding of the challenges and opportunities facing the state and the Southeast. The goal of the report is to provide knowledge about the state of the environment that will enable researchers, students, policymakers, stakeholders, and the public to understand the steps necessary to protect the environment and manage the natural resources of Tennessee.

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Conservation

The U.S. Natural Resources Conservation Service considers conservation to be the "protection, preservation, management, or restoration of natural environments and the ecological communities that inhabit them."[1] Conservation is fundamental to ensure present actions do not exhaust Tennessee's natural resources for future generations. Understanding key metrics on the state of conservation in Tennessee is critical to encouraging rational environmental management.

Tennessee currently has 246,976 acres of land protected by conservation easements, of which 56.9% are held by nongovernmental organizations (NGOs), 41% are held by federal agencies, and the remaining 2.1% are held by local organizations and state government. The largest individual holder of conservation easements in the state is The Land Trust for Tennessee, an NGO with 103,070 acres (41.7% of total). In addition, 4,707 acres (1.9% of total protected lands) are protected through the Agricultural Conservation Easement Program, a federal program which assists working farms by limiting non-agricultural activity and protecting cropland, grassland, and wetland habitats.[2]

Tennessee is home to 104 endangered species, both florae and faunae.[3] The state has the most biodiverse freshwater fish population in the U.S.,[4] but its aquatic habitats contain the highest number of threatened species. Of the 83 endangered faunae, 77 live in aquatic, marsh, or wetland habitats, making wetlands conservation critical to species conservation in Tennessee. Up to 56% of wetlands in North America have been lost in the last three hundred years,[5] and wetlands now comprise 3.3% of Tennessee's land cover and 16.3% of the Southeast's land cover (Table 1).

Land conservation also plays an important role in climate change mitigation and adaptation. Tennessee and the entire Southeast perform well on the Environmental Protection Agency's (EPA) Land Use, Land Use Change, and Forestry (LULUCF) greenhouse gas emissions category. Nationally, LULUCF served as a net sink of 690.07 Million Metric Tons (MMT) of carbon dioxide (CO_2) equivalent in 2021, with Tennessee sequestering 31.91 MMT.[6] All Southeastern states

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[1] Natural Resources Conservation Service, "What Does Conservation Mean?," *United States Department of Agriculture* (September 2022), https://www.nrcs.usda.gov/sites/default/files/2022-09/English%20Whats%20CONSERVATION%20Mean_4.pdf.

[2] Natural Resources Conservation Service, "Agricultural Conservation Easement Program," *United States Department of Agriculture* (n.d.), https://www.nrcs.usda.gov/programs-initiatives/acep-agricultural-conservation-easement-program. U.S. Endowment for Forestry and Communities, "National Conservation Easement Database," (n.d.), https://www.conservationeasement.us/adv-search/.

[3] U.S. Fish and Wildlife Service, Listed species with spatial current range believed to or known to occur in Tennessee, Environmental Conservation Online System (January 21, 2024), https://ecos.fws.gov/ecp/report/species-listings-by-state?stateAbbrev=TN&stateName=Tennessee&statusCategory=Listed. The original list contains 131 entries, but there are 27 repetitions due to the way the data is labelled.

[4] Sally J. Petre et al., "2017 Region IV Warmwater Streams and Rivers Fisheries Report," *Tennessee Wildlife Resources Agency,* 2 (2017), https://www.tn.gov/content/dam/tn/twra/documents/region-iv-reports/Warmwater-Streams-Report-2017.pdf.

[5] Nick C. Davidson, How much wetland has the world lost? Long-term and recent trends in global wetland area, Marine and Freshwater Research (September 23, 2014), http://dx.doi.org/10.1071/MF14173.

[6] Environmental Protection Agency, Emissions by Inventory Sector, Greenhouse Gas Inventory Data Explorer (August 18, 2023), https://cfpub.epa.gov/ghgdata/inventoryexplorer/index.html#iallsectors/allsectors/allgas/inventsect/all.

were among the 15 largest net sinks in the United States, sequestering more than 18 MMT.[7] This status is primarily due to Southeastern forest land that is retained as forested land, which accounts for most net sequestration in Southeastern states. Despite having relatively little forest cover, the Southeast sequesters substantial amounts of carbon because its forests are relatively young.[8] Annual LULUCF emissions are not necessarily constitutive of the environmental quality of land use, however, because even though younger forests sequester more carbon each year, older forests sequester more overall.[9]

Between 2001 and 2021, the Southeast region and Tennessee maintained their share of forested area (-0.5% and -0.01%, respectively), whereas Davidson County lost 5.2% (Table 1). At all geographic levels, grassland, hay, and agriculture saw a significant decline, whereas developed land increased (Table 1).

Table 1. Change in land use percentage between 2001 and 2021 in Davidson County, Tennessee, and the Southeast region. "Other" includes shrub/scrub, lichens, and moss.

	Southeast			**Tennessee**			**Davidson County**		
	2001 % of total area	2021 % of total area	% Change	2001 % of total area	2021 % of total area	% Change	2001 % of total area	2021 % of total area	% Change
Forest	42.3%	42.1%	-0.5%	50.8%	50.8%	-0.01%	40.5%	38.4%	-5.2%
Grassland, Hay & Agriculture	26.1%	25.0%	-4.4%	32.8%	31.4%	-4.1%	13.7%	12.2%	-10.9%
Wetlands	16.3%	16.3%	0.2%	3.3%	3.3%	0.9%	0.3%	0.3%	12.2%
Developed land	9.5%	10.7%	11.6%	9.8%	10.8%	10.7%	40.8%	44.1%	8.3%
Other	2.9%	3.2%	8.4%	0.8%	1.1%	29.7%	0.1%	0.3%	162.0%
Open Water	2.6%	2.5%	-1.9%	2.2%	2.2%	-0.1%	4.5%	4.5%	-1.3%
Barren Land	0.2%	0.2%	7.2%	0.1%	0.2%	16.1%	0.2%	0.3%	53.8%

Data Source: National Land Cover Database

[7] *Ibid.*
[8] Simon Besnard et al., Mapping global forest age from forest inventories, biomass and climate data, Earth System Science Data (October 26, 2021), https://doi.org/10.5194/essd-13-4881-2021.
[9] National Council for Air and Stream Improvement, Forest Carbon from Young vs. Old Forests (January 2021), https://www.ncasi.org/wp-content/uploads/2021/01/NCASI22_Forest_Carbon_YoungVsOld_print.pdf.

Climate

Tennessee's climate is changing rapidly, and the *average* temperature has increased by roughly 0.5°F over the last century. The Tennessee average temperature increase, though, is roughly a third of the increase in average temperature across the U.S. as a whole.[10]

Between 1970 and 1996, there were 15 years in Nashville with at least one day where temperatures did not exceed freezing; since 1996, there have only been two such years (2022 and 2024).[11] Furthermore, since 2010, Tennessee has had an average of 3.39 severe storms each year compared to 0.61 in the preceding three decades.[12] Climate change is associated with increased intensity of wet weather events, and major weather events in the state have illustrated that fact. On August 21, 2021, 20.73 inches of rain fell in 24 hours in Humphrey County, which was not only the most rainfall in 24 hours in the state's history but also in the recorded history of any landlocked state.[13] Although Tennessee does not have a dedicated mesonet – a statewide network of meteorological tracking stations - many states have engaged government-university partnerships to implement mesonets, which help local officials prepare for and react to severe weather events more effectively.[14]

Efforts to mitigate climate change have been underway in the US and Tennessee for decades. Since their peak in 2007, US carbon emissions declined to their lowest levels since at least 1990 in 2020 and 2021 (Figure 1).[15] Tennessee emits slightly below the national average per capita – 13.30 MT compared to 14.79 MT, respectively – and performs well regarding current emissions levels relative to the rest of the Southeast, whose average emissions per capita are 19.60 MT.[16, 17]

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[10] Jennifer Runkle et al., Tennessee State Climate Summary 2022, NOAA National Centers for Environmental Information (2022), https://statesummaries.ncics.org/chapter/tn/. *See also* Tennessee Climate Office, "Monthly Reports," *Eastern Tennessee State University Department of Geosciences* (n.d.), https://www.etsu.edu/cas/geosciences/tn-climate/monthly-reports/.

[11] NOAA National Centers for Environmental Information, Tennessee Global Summary of the Year, National Centers for Environmental Information (January 1, 2024), https://www.ncdc.noaa.gov/cdo-web/datasets/GSOY/locations/FIPS:47/detail. In January 2024, an arctic blast hit the Southeast driving temperatures below freezing across the state. The NOAA data only covers through January 1, 2024, so this incident was not included there. *See* National Weather Service, "January 14-21, 2024 Snow & Arctic Cold," *National Oceanic and Atmospheric Administration* (January 21, 2024), https://www.weather.gov/ohx/20240114.

[12] NOAA National Centers for Environmental Information, Tennessee Billion-Dollar Weather and Climate Disasters, National Centers for Environmental Information (January 9, 2024), https://www.ncei.noaa.gov/access/billions/time-series/TN/cost.

[13] National Weather Service Tennessee; August 21, 2021 Flash Flooding; National Weather Service (March 8, 2022); https://storymaps.arcgis.com/stories/13b68e35b8fd48e0b0188f1645992b98.

[14] National Mesonet Program, A Model for Effective Public-Private Partnership, National Weather Service (n.d.), https://nationalmesonet.us/nmp-partners/.

[15] *Id* supra note 6.

[16] *Id* supra note 6.

[17] Population data from U.S. Census Bureau; Annual Estimates of the Resident Population for the United States, Regions, States, District of Columbia ad Puerto Rico: April 1, 2020 to July 1, 2023; U.S. Census Bureau (December 18, 2023), https://www.census.gov/data/tables/time-series/demo/popest/2020s-state-total.html.

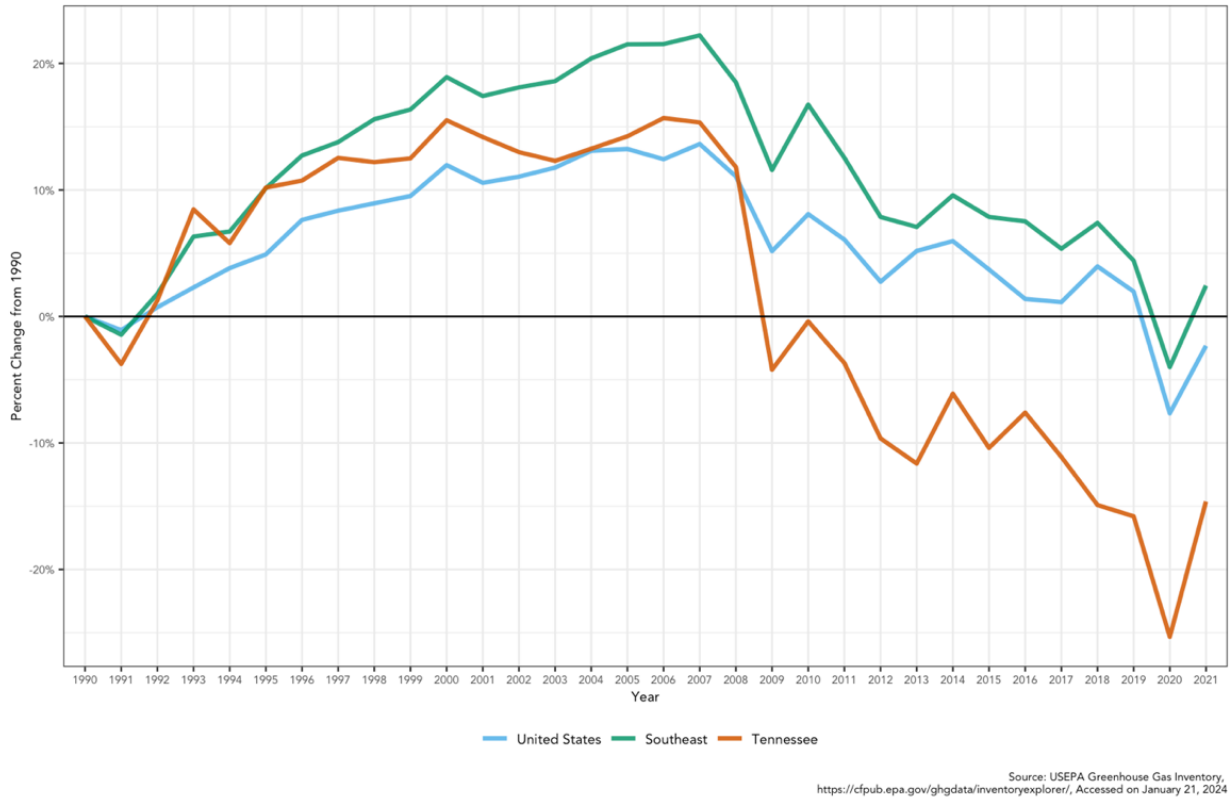


Figure 1. Percent change in gross emissions relative to 1990 levels, from 1991 to 2021 for the United States, the Southeast region, and Tennessee. In 2007, Tennessee made significant strides in reducing its emissions, which continue to decrease more rapidly, on average, than the US and the Southeast.[18]

In 2021, Tennessee's sectoral emissions varied from those of the US and Southeast. For example, Tennessee's transportation emissions were 43% greater than the national average (40.87% compared to 28.61% of total annual emissions) (Figure 2).[19] Tennessee's residential emissions were also 38.26% greater than the Southeast's in 2021 (5.24% compared to 3.79% of total annual emissions).[20] At the same time, Tennessee's emissions from its electric power industry (22%) were lower than those of the national and Southeast regions (25.11% and 32.33%, respectively).[21]

[18] Environmental Protection Agency, Emissions by Economic Sector, Greenhouse Gas Inventory Data Explorer (August 18, 2023), https://cfpub.epa.gov/ghgdata/inventoryexplorer/index.html#iallsectors/allsectors/allgas/inventsect/all.
[19] *Ibid.*
[20] *Ibid.*
[21] *Ibid.*

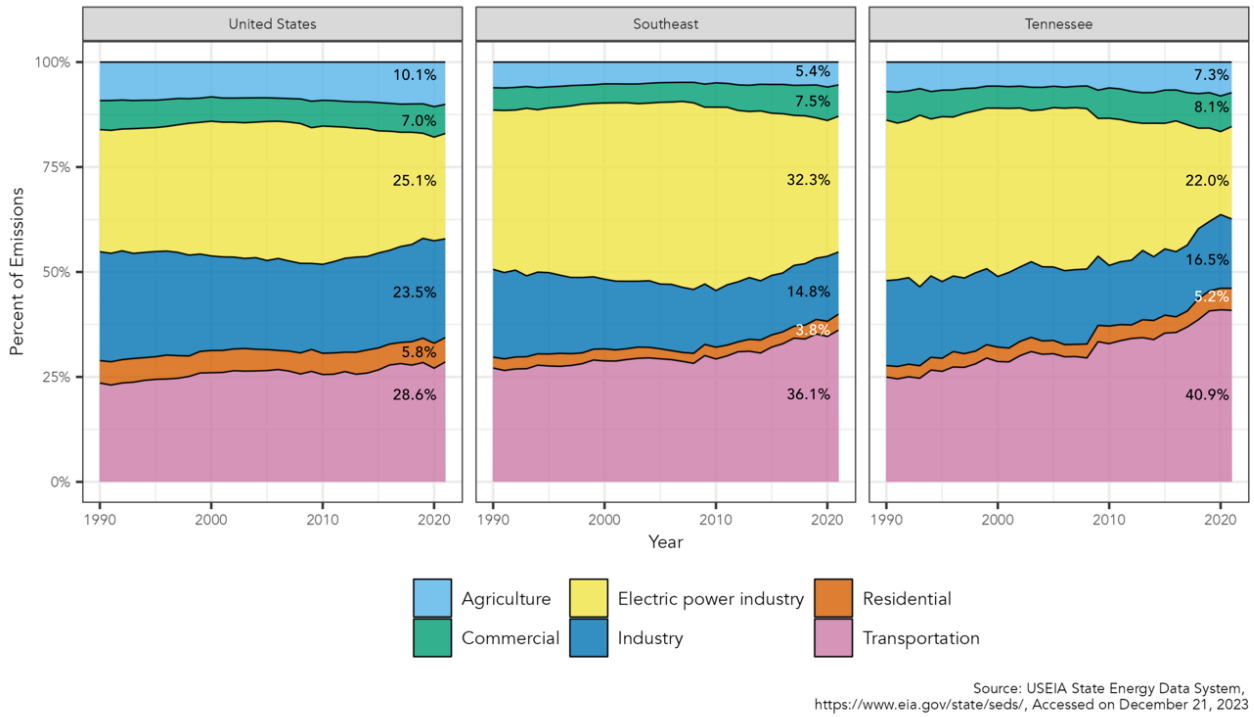


Figure 2. Emissions by sector from 1990 to 2021 for the United States, Southeast Region, and Tennessee. The Tennessee transportation sector proportionally emits more than the US and Southeast. While the Tennessee electric power industry was responsible for a significant share of sectoral emissions in the 1990s, it has lessened its proportional share over time to be less than its Southeast and US counterparts.

The state and its cities have taken steps to address sustainability. Tennessee adopted a Smart Growth Policy in 1998 to encourage sustainable development.[22] On a local level, all four of Tennessee's most populous counties have climate action plans with specific emissions and resilience targets. In 2023, Tennessee and its three largest cities received Climate Pollution Reduction Grant funding to develop the Volunteer Emission Reduction Strategy (TVERS).[23] The TVERS will publish its Priority Climate Action Plan to the EPA by March 2024, including high-priority measures to immediately reduce carbon emissions and analyze emissions reductions from a set of potential strategies. The challenge for Tennessee and much of the Southeast is that many state and national governments and private sector organizations have adopted climate policies and programs that will substantially reduce their emissions over the next two decades. These decarbonization initiatives increase the risk that Tennessee and the Southeast will fall behind as emissions reductions become necessary to comply with government and private sector requirements (Figure 4).

Despite these actions, Tennessee was still ranked among the "Most Vulnerable" and "Least Prepared" in the Trust for America's Health's most recent "Climate Change and Health"

[22] Tennessee Advisory Commission on Intergovernmental Relations, Growth Policy, Tennessee State Government (n.d.), https://www.tn.gov/tacir/growth-policy.html.
[23] Environmental Protection Agency, Planning Grant Award Status, Climate Pollution Reduction Grants: Planning Grants Program, 3 (January 19, 2024), https://www.epa.gov/system/files/documents/2023-10/cprg_planning_grant_award_status.pdf.

report.[24] Tennessee's primary human health risks from climate change arise from drought, severe storms, and the spread of vector-borne illnesses.[25] The Southeast is a vulnerable region for climate change, and even though Tennessee is ranked as high-risk relative to the nation, it is tied for the least vulnerable state in the Southeast.[26]

Energy

Tennessee's carbon emissions have decreased more quickly than most states, with each year since 2009 emitting less carbon than 1990 (Figure 1).[27] The relative greening of electricity production has catalyzed declines, and Tennessee has outpaced the nation in the shift toward non-carbon electricity production (Figure 3, 5).[28] This has occurred through the use of nuclear and hydroelectric resources, which comprised 97.3% of Tennessee's non-carbon electricity generation in 2023.[29] Wind and solar only entered the state in substantial quantities in 2002 and 2012, respectively, and still constitute a relatively small portion (i.e., less than 3%) of Tennessee's energy production, leaving ample potential for further green energy generation.[30]

Tennessee has consistently outproduced the rest of the Southeast and the nation in terms of non-carbon sources as a percentage of total electricity generation. Since 1990, Tennessee's non-carbon electricity generation has increased 85.09%, compared to 11.78% and 30.98% increases in the Southeast and US, respectively. The primary reason for this discrepancy was the beginning of commercial operation at the Watts Bar Nuclear Plants I and II in 1996 and 2016, which helped to increase Tennessee's nuclear generation from 24.88% to 45.67% of total electricity generation.[31] Watts Bar II is the U.S.'s newest nuclear powerplant.

[24] Matt McKillop et al., Climate Change and Health: Assessing State Preparedness, Trust for America's Health, 29 (December 2020), https://www.tfah.org/wp-content/uploads/2020/12/ClimateChange_HealthRpt_FINAL.pdf.
[25] *Id* supra note 24 at 37.
[26] *Id* supra note 24 at 29.
[27] *Id* supra note 6.
[28] U.S. Energy Information Administration, Net Generation by State by Type of Producer by Energy Source, Historical State Data (October 26, 2023), https://www.eia.gov/electricity/data/state/.
[29] *Ibid.*
[30] *Ibid.*
[31] Tennessee Valley Authority, Watts Bar Nuclear Plant, Tennessee Valley Authority (n.d.), https://www.tva.com/energy/our-power-system/nuclear/watts-bar-nuclear-plant.

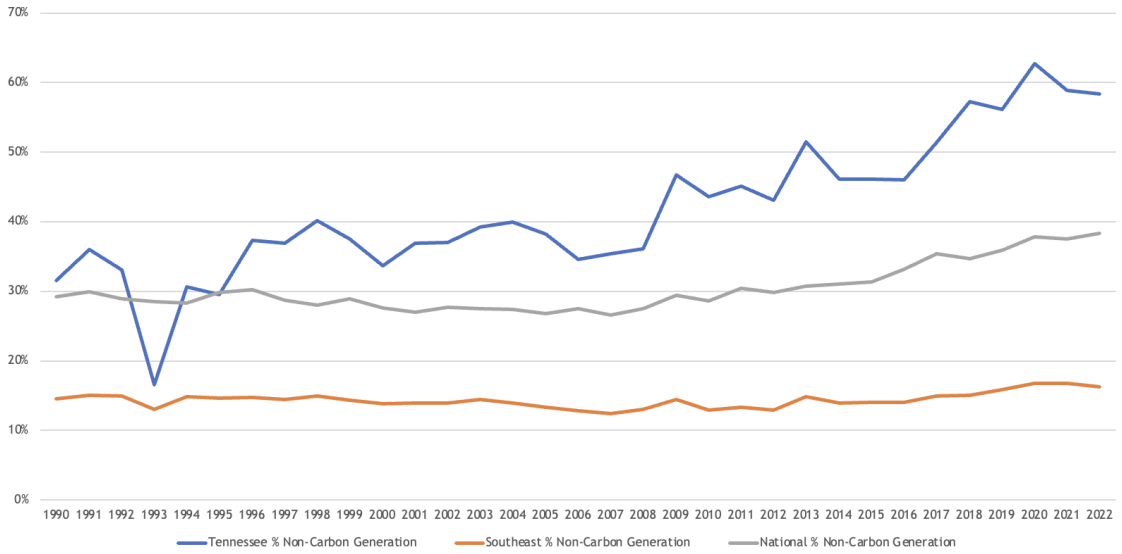


Figure 3. Percent of electricity production from non-carbon sources, from 1990 to 2022 for the United States, Southeast Region, and Tennessee. Tennessee has a greater share of non-carbon generation than its national and Southeastern counterparts.

The Tennessee Valley Authority (TVA) was established under federal law to provide electric power to the Tennessee Valley and TVA owns more than 90% of Tennessee's generation capacity.[32] Recently, the TVA began to shift away from coal-fired plants. However, TVA has often replaced retiring coal-fired plants with natural gas plants. Gas plants can operate for decades, and the construction of new gas plants represents a long-term shift in infrastructure and emissions that will likely extend well beyond the US goal of carbon-free electric generation by 2035.[33,34] Furthermore, Tennessee imports 28.8% of its electricity from sources that are not counted in TVA's own or generation metrics.[35] This opacity can make it difficult to account for sources and emissions for all of Tennessee's electricity.

TVA plans to supplement electric generation with small modular reactors over the next two decades, which reduce carbon emissions but also will require successful permitting, building, and connecting processes to move forward quickly and at a low-cost.[36] Given these current trends, projections by the Energy Information Administration anticipate that the East South Central Region (i.e., Kentucky, Tennessee, Mississippi, and Alabama) will have 28% greater carbon emissions per capita in 2050 than the national average (Figure 4). This emissions

[32] U.S. Energy Information Administration, Tennessee State Profile and Energy Estimates (September 21, 2023), https://www.eia.gov/state/analysis.php?sid=TN.
[33] Timothy J. Skone et al., Life Cycle Analysis of Natural Gas Extraction and Power Generation, U.S. Department of Energy National Energy Technology Laboratory (May 29, 2014), https://www.energy.gov/sites/prod/files/2019/09/f66/Life%20Cycle%20Analysis%20of%20Natural%20Gas%20Extraction%20and%20Power%20Generation%2005_29_14%20NETL.pdf.
[34] Paul Donohoo-Vallett et al., On the Path to 100% Clean Energy, U.S. Department of Energy (May 2023), https://www.energy.gov/sites/default/files/2023-05/DOE%20-%20100%25%20Clean%20Electricity%20-%20Final.pdf.
[35] "Tennessee Electricity Profile 2022: Supply and Disposition of Electricity," *U.S. Energy Information Agency* (November 2, 2023), Table 10, https://www.eia.gov/electricity/state/tennessee/.
[36] Antonio Vaya Soler et al., Small Modular Reactors Challenges and Opportunities, Organization of Economic Co-Operation and Development (2021), https://inis.iaea.org/collection/NCLCollectionStore/_Public/52/041/52041043.pdf.

trajectory suggests that key decisionmakers will need to think critically about present infrastructure to ensure that emissions levels do not fall behind regional and national levels.

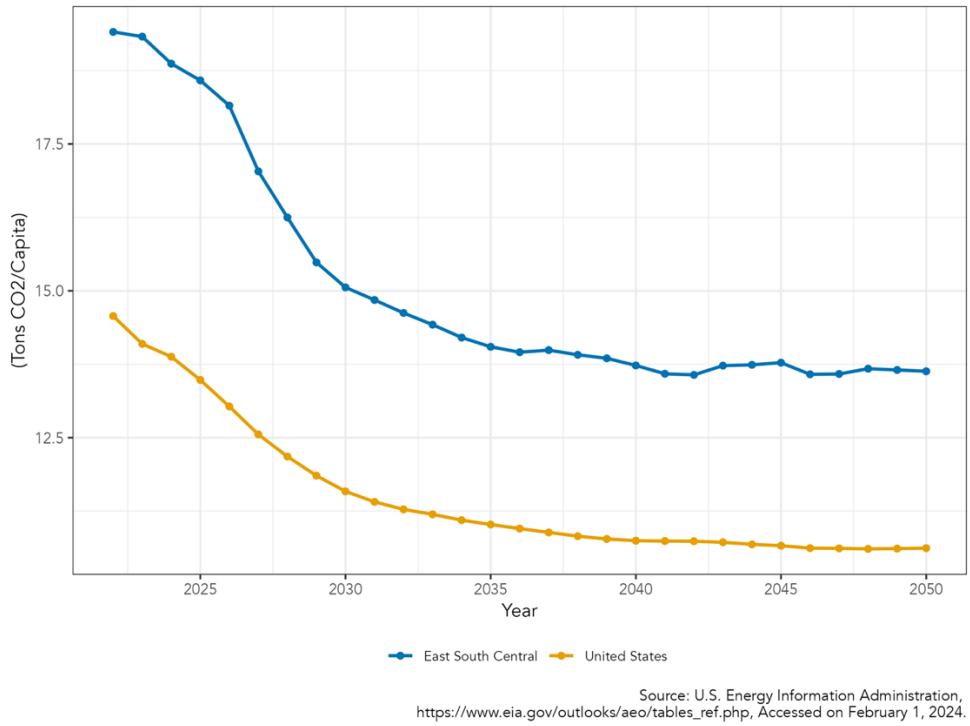
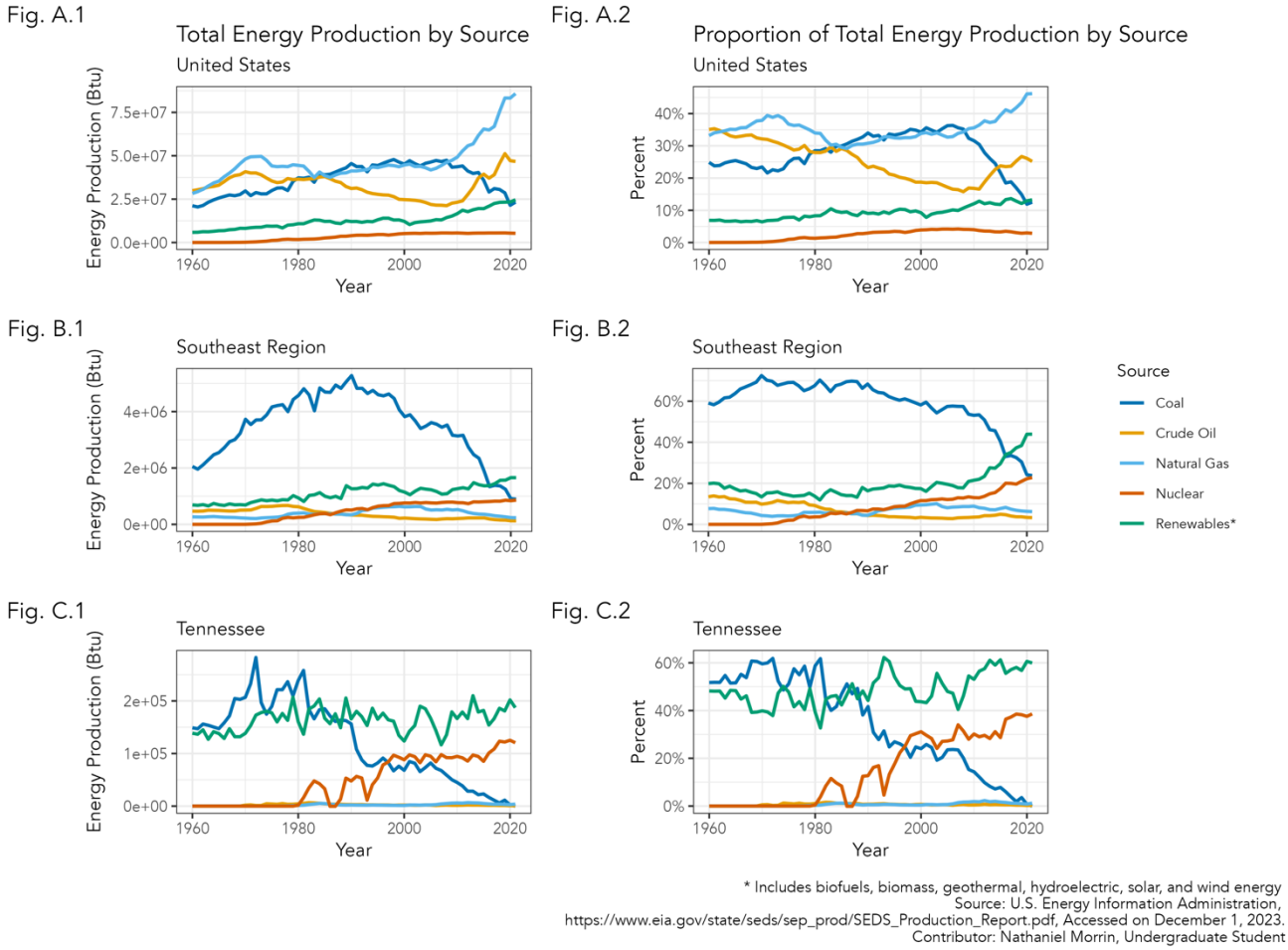


Figure 4. Projected per capita emissions (tons CO_2), from 2022 to 2050 in the East South Central region (i.e., Kentucky, Tennessee, Mississippi, and Alabama) and the United States for reference scenario. In 2050, It is expected that the East South Central Region will emit 28% more per capita than the national average, using a reference scenario that reflects current energy trends and existing laws and regulations.

Tennessee and the Southeast perform relatively worse on overall carbon efficiency of energy production and consumption. Tennessee ranks 23rd in the nation in energy consumption per capita,[37] but 25th in the nation (33.72 MT CO2e/billion Btu) in carbon efficiency of energy production and consumption.[38] Three Southeastern states (MS, KY, and FL) are among the ten least efficient in the nation.[39] Tennessee outpaced the Southeast and the nation in the reduction of carbon intensity of the energy supply used in state (1,000 Btu/Chained (2012) $ Real GDP), and since 2019, the state has dropped below the national mean (6,230 Btu/$ GDP in Tennessee in 2021, 6,430 Btu/$ GDP national average).[40] However, Tennessee ranks 20th in the United States on the carbon intensity of the energy supply used in the state. The

[37] U.S. Energy Information Administration, Total Energy Consumption per Capita by End-Use Sector, State Energy Data System 1960-2021 (June 23, 2023), https://www.eia.gov/state/seds/seds-data-complete.php#StatisticsIndicators.
[38] Energy consumption data from: U.S. Energy Information Administration, Total Energy Consumption by End-Use Sector, State Energy Data System 1960-2021 (June 23, 2023), https://www.eia.gov/state/seds/seds-data-complete.php#StatisticsIndicators. Emissions data from: Energy Production and Use, *Id* supra note 18.
[39] *Ibid.*
[40] Energy consumption data from: U.S. Energy Information Administration, Total Energy Consumption, Real GDP, and Energy Intensity, State Energy Data System 1960-2021 (June 23, 2023), https://www.eia.gov/state/seds/seds-data-complete.php#StatisticsIndicators.

Southeast consistently had higher average energy intensity than the national average between 1997-2021, although it has outpaced the nation in decreasing energy intensity as well (33.74% compared to 32.98%, respectively).



* Includes biofuels, biomass, geothermal, hydroelectric, solar, and wind energy
Source: U.S. Energy Information Administration, https://www.eia.gov/state/seds/sep_prod/SEDS_Production_Report.pdf, Accessed on December 1, 2023.
Contributor: Nathaniel Morrin, Undergraduate Student

Figure 5. Change in total energy production and energy production as a proportion of total energy production by source for (A) the United States, (B) the Southeast Region, and (C) Tennessee. While coal, oil, and natural gas make up the majority of energy production nationwide, the amount of energy produced by coal has decreased significantly since the early 2000s.

Despite relatively low energy rates (12.25 cents/kWh, ranked 13th), Tennessee families use far more energy and pay some of the highest electricity bills in the country. [41] In 2022, Tennessee had the highest average monthly residential electricity use in the nation (1,188 kWh/month) and ranked ninth in the nation for average monthly energy bills ($145.49/month).[42]

The term *energy burden* refers to the proportion of annual household income allocated to energy costs. In the US, the average energy burden is 3%. Low-income residents are

[41] U.S. Energy Information Administration, Average monthly bill (Annual data), Residential average monthly bill by Census Division, and State (October 25, 2023), https://www.eia.gov/electricity/data.php.
[42] *Ibid.*

disproportionately affected by high energy costs, as they spend more of their income on residential energy bills than wealthier households. For example, Davidson County has a low average energy burden (2%, average annual energy = $1725) because its average household income ($90,203) is relatively high (Figure 6). However, for a four-person family living under the federal poverty line (i.e., $30,000 annually), the energy burden is three times the average (6% of annual income).[43] This can be further complicated by the fact that some energy providers charge flat fees for usage (i.e. service charges) that impose regressive payments upon lower income users.

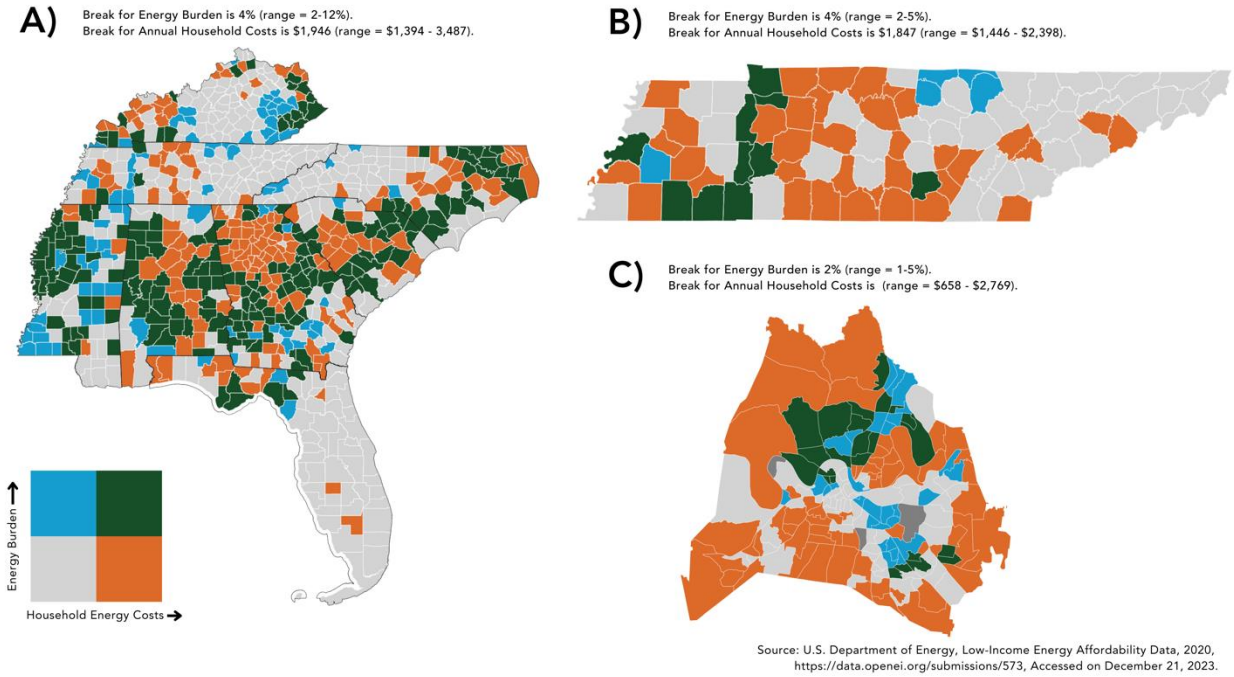


Figure 6. Average annual household energy costs and Energy Burden in the Southeast region (A), Tennessee (B), and Davidson County (C). Tennessee has the second lowest annual household energy costs in the southeast region, with a median annual household energy cost of $1,847 and a median energy burden of 4%. The median household energy cost in the Southeast region is $1,946, and the median energy burden is 4%. Davidson County has a low median energy burden (2%), although some communities may face disparate challenges in energy affordability related to their household income.

Air

For decades, Tennessee struggled with air quality, but in recent years air quality has improved substantially. Following an Environmental Protection Agency suit against the TVA in 1977,[44] the Authority agreed to put scrubbers on many of its coal-fired power plants; sulfur dioxide emissions from those plants have decreased 94% since 1977.[45] In addition, since 1995

[43] Office of State and Community Energy Programs, Low Income Energy Affordability Data Tool, U.S. Department of Energy (2020), https://www.energy.gov/scep/slsc/lead-tool.
[44] Robert F. Durant et al., *When Government Regulates Itself: The EPA/TVA Air Pollution Control Experience*, 43 Public Administration Review, 211 (1983), https://doi.org/10.2307/976329.
[45] Tennessee Valley Authority, Air Quality, Tennessee Valley Authority (n.d.), https://www.tva.com/environment/environmental-stewardship/air-quality.

TVA has installed Selective Catalytic Reduction systems on 21 coal-fired plants and every combined natural gas plant, which has helped to reduce NOx emissions from coal-fired power plants by 91%, and TVA has closed several of its coal-fired plants.[46] Along with the effects on electric generation of policy changes and litigation, Tennessee has experienced a trend away from heavily polluting industries. For instance, in 2011 coal represented more than 50% of Tennessee's electricity generation, and in 2022, its share in electricity generation declined to 20%.[47]

Between 1998 and 2000, all four of Tennessee's most populous counties experienced high ozone days with at least 15 times the frequency deemed acceptable according to American Lung Association reports; now, they are all below the passing mark of 3.2 weighted days per year.[48] Each of these counties has also reduced their particulate matter concentration to passing levels in the most recent American Lung Association State of the Air Report Card (Figure 7).[49]

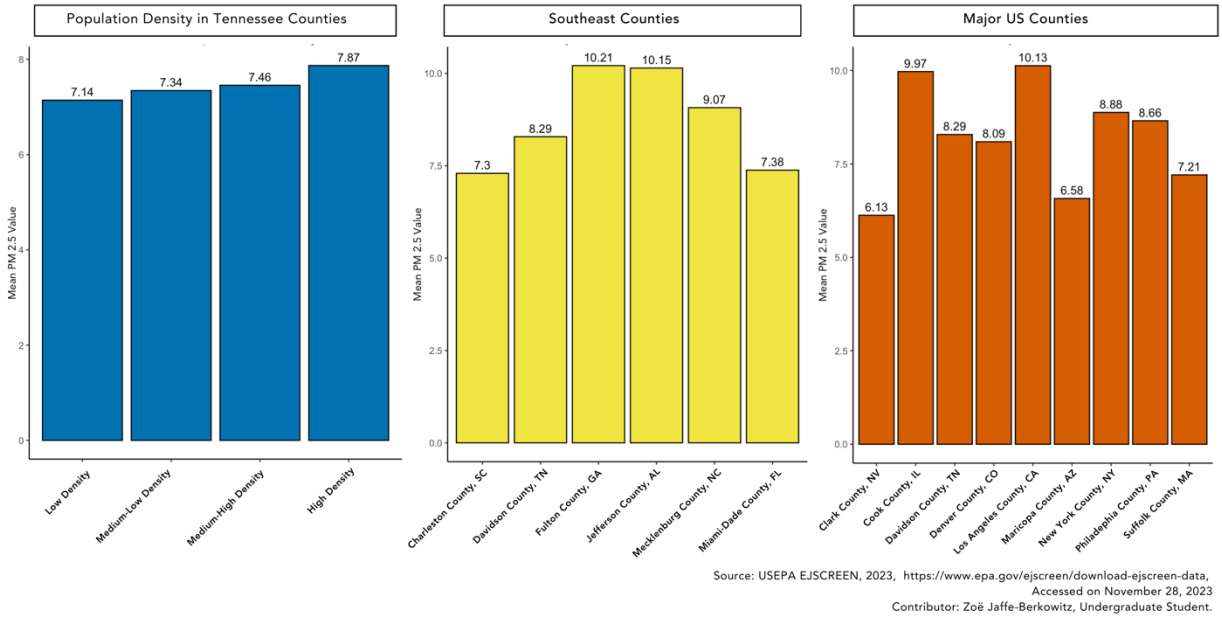


Figure 7. The graph on the left shows the difference in average PM 2.5 levels in Tennessee counties based on population density. The middle graph shows average PM 2.5 levels in large southeastern cities. The graph on the right shows the difference in average PM 2.5 levels in US counties where large cities are located.

Despite this improvement, the risks and adverse health outcomes associated with air pollution are not distributed equally in Tennessee, resulting in inequitable burdens borne by historically disadvantaged communities. Research suggests that communities of color are more likely to be exposed to PM2.5 than their white counterparts from anthropogenic sources spanning

[46] *Ibid.*
[47] *Id* supra note 28.
[48] American Lung Association, State Report Card: Tennessee, American Lung Association (2023), https://www.lung.org/research/sota/city-rankings/states/tennessee.
[49] *Ibid.*

industrial activity, transportation, and construction.[50] In 2023, Shelby County, TN, was rated the worst in the state (grade = D) by the American Lung Association, as compared to a B grade in Davidson County (percent white non-Hispanic individuals = 34.2%; as compared to 56.4% white non-Hispanic individuals in Davidson County).[51, 52]

The transition to electric vehicles, which do not have tailpipe emissions, may result in further air quality improvements, particularly in urban areas, but knowledge about electric vehicles is limited in Tennessee. A 2021 survey conducted by the Vanderbilt Poll revealed a significant knowledge gap among Tennesseans regarding the benefits of electric vehicle ownership, such as lower carbon emissions, personal and statewide economic advantages, and improved public health.[53] Electrifying the transportation sector may not only improve air quality and reduce carbon emissions, but also meet the criteria outlined in the federal Justice40 initiative, which aims to benefit disadvantaged communities by ensuring that 40% of all clean energy investments are committed to disadvantaged communities.[54, 55] The opportunity for EVs in Tennessee is substantial because in 2017 Tennessee transportation emitted 16% more carbon emissions per capita than the national average, and Davidson County emitted 63% more per capita (Table 2). Many of the states with the highest transportation air emissions are also those with the lowest EV uptake: states with at least 1% EV market share in 2019 (the top 26 states) emitted 35.52% less air pollution from transportation in 2020 (Table 3).[56, 57]

Table 2. Transportation emissions, measured as the tons of CO2 per resident emitted on-road in 2017, in the United States, the Southeast region, Tennessee, and Davidson County. Davidson county residents emit 62.82% more than the national average, whereas the state of TN and the SE region emit 16.17% and 7.43% more than the national average.

Geography	Total Emissions per year, tons	Average by area, tons/mi2/year	Average by population, tons/per/resident	% difference from national average
United States	1,747,657,704	460	5.38	--
Southeast Region	378,679,522	959	5.76	7.43%
Tennessee	41,989,164	996	6.25	16.17%
Davidson County	6,026,327	11,566	8.76	62.82%

[50] Christopher W. Tessum et al., PM2.5 polluters disproportionately and systemically affect people of color in the United States, 7 Sci. Adv., https://doi.org/10.1126/sciadv.abf4491.
[51] *Id* supra note 47.
[52] U.S. Census Bureau, Annual County Resident Population Estimates by Age, Sex, Race, and Hispanic Origin: Tennessee, U.S. Census Bureau (June 20, 2023), https://www.census.gov/data/tables/time-series/demo/popest/2020s-counties-detail.html.
[53] John G. Geer and Joshua D. Clinton, Fall 2021 – Vanderbilt University Poll, Vanderbilt University Center for the Study of Democratic Institutions (December 6, 2021), https://www.vanderbilt.edu/csdi/2021_Fall_slides_final.pdf.
[54] Ciaran L. Gallagher and Tracey Holloway, U.S. Decarbonization Impacts on Air Quality and Environmental Justice, 17 Env. Res. Letters (October 25, 2022), https://doi.org/10.1088/1748-9326/ac99ef.
[55] Justice40: A Whole-of-Government Initiative, The White House (n.d.), https://www.whitehouse.gov/environmentaljustice/justice40/.
[56] U.S. Department of Energy, Vehicle Registration Counts by State, Alternative Fuels Data Center (2021), https://afdc.energy.gov/vehicle-registration?year=2020.
[57] Environmental Protection Agency, 2020 National Emissions Inventory Data, Environmental Protection Agency (August 14, 2023), https://awsedap.epa.gov/public/single/?appid=20230c40-026d-494e-903f-3f112761a208&sheet=5d3fdda7-14bc-4284-a9bb-cfd856b9348d&opt=ctxmenu,currsel.

Data Sources: ORNL DARTEv2 (Database of Road Transportation Emissions), FHWA HPMS, American Census Bureau

Contributor: Junyi Ji, Ph.D. Student, Civil Engineering

Table 3. The table shows the average air pollution emissions from transportation in tons per capita by state stratified by state EV uptake. National average uptake was 0.410% and average emissions per capita were 0.067. Tennessee has EV uptake of 0.196% and per capita emissions of 0.076 tons.

EV Uptake (% of All Vehicles EV or PEV, 2020)	First Quartile (0.055%-0.155%)	Second Quartile (0.158%-0.272%)	Third Quartile (0.290%-0.520%)	Fourth Quartile (0.569%-2.012%)
States, in Order of Uptake	MS, ND, LA, WV, AR, WY, SD, AL, KY, OK, MT, SC	IA, NE, TN, IN, KS, ID, MO, WI, AK, OH, NM, MI	NC, TX, PA, MN, GA, RI, DE, NH, IL, ME, VA, FL, CT	NY, UT, NJ, MD, NV, AZ, MA, CO, VT, OR, WA, DC, HI, CA
Average Air Pollution from Transportation (2020, Tons/Capita)	0.092	0.076	0.056	0.045

Data Sources: US DOE, USEPA, US Census Bureau

Water

Drinking water quality in the United States varies by system size, technical and financial capacity, and source water type.[58] Between 2018 and 2022, The national average for Community Water Systems (CWS) (i.e., drinking water systems that serve the same population year-round) with one or more health-based violations was 15.5% (Figure 8). Tennessee had fewer CWS with health-based violations than the national average, with 12.4% of its systems reporting one or more health-based violations. System violations also tended to occur in medium and large CWS. Metro Nashville did not have any violations between 2018-2022.[59] It is estimated that Tennessee will need between $5-15 billion in water infrastructure improvements by 2040.[60] Importantly, roughly 95% of individuals living in rural communities source their drinking water from private wells and/or natural springs.[61] These rural areas in Eastern Tennessee are known to have limited access to public drinking water which contributes to Tennessee's high pervasiveness of drinking water unaffordability, a trend that is consistent throughout the Southeast region.[62]

[58] Maura Allaire et al., National Trends in Drinking Water Quality Violations, 115 Proc. of the Nat. Acad. of Sci. (February 12, 2018), https://doi.org/10.1073/pnas.1719805115.
[59] U.S. Environmental Protection Agency, SWDA Dataset, Enforcement and Compliance History Online (January 9, 2024), https://echo.epa.gov/tools/data-downloads
[60] Tennessee Association of Utility Districts, "Tennessee Infrastructure Scorecard," *Tennessee Department of Environment and Conservation* (November 30, 2021), 3, https://www.tn.gov/content/dam/tn/environment/water/srf/wr_srf_scorecord-instructions.pdf.
[61] Department of Health, Healthy Homes – Drinking Water, Tennessee Department of Environment and Conservation (n.d.), https://www.tn.gov/health/cedep/environmental/healthy-homes/hh/drinking-water.html.
[62] Laura A. Patterson, Sophia A. Bryson, and Martin W. Doyle, "Affordability of household water services across the United States," *PLOS Water* 2 (May 10, 2023), https://doi.org/10.1371/journal.pwat.0000123.

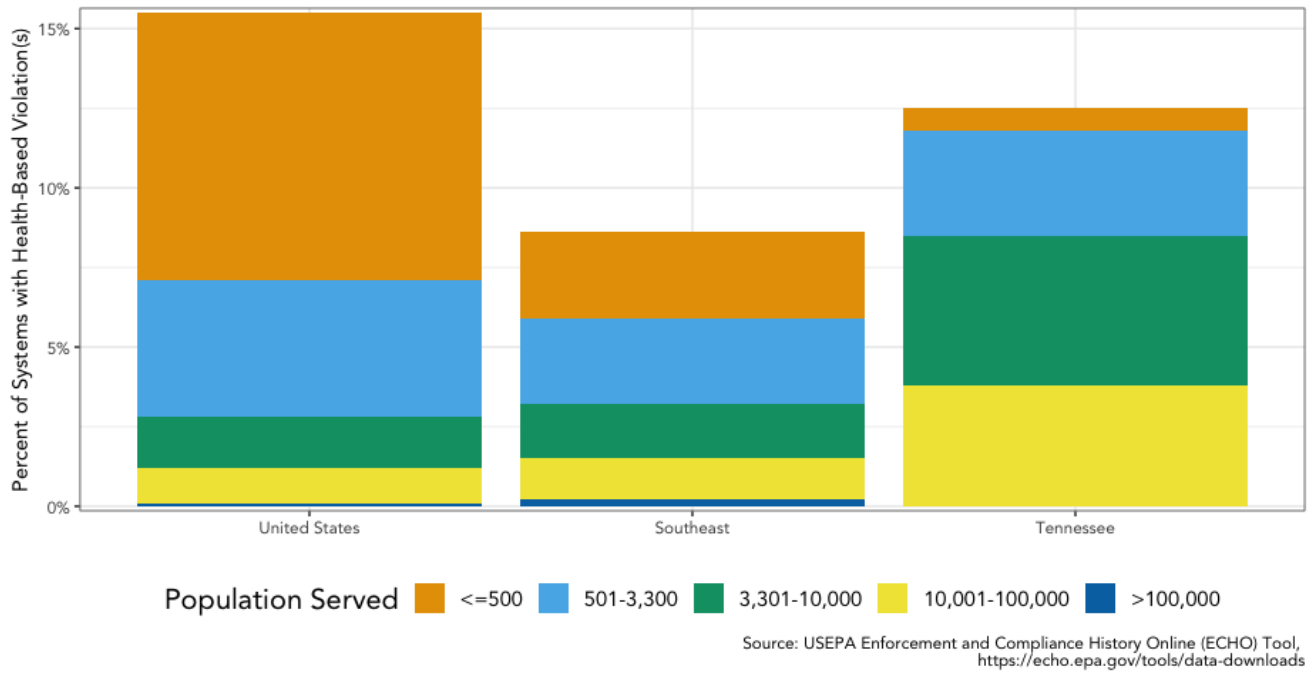


Figure 8. Percentage of Community Water Systems (CWS) with one or more health-based violations between 2018-2022 in the United States, Southeast, and Tennessee. The national average for CWS with one or more health-based violations was 15.5%, the majority of which occurred in CWS serving very small systems. CWS in the southeast region fare better than the US average, with 8.5% of systems with one or more health-based violation. Tennessee fares better than US, but worse than the SE region, with 12.4% of CWS with one or more health-based violation, mostly serving medium to large systems.

In Tennessee's most recent Water Quality Assessment, performed in 2022, 60.26% of the assessed length of rivers, and 41.98% of the assessed acreage of lakes and reservoirs were impaired.[63] Impaired waters are those that exceed water quality standards for at least one of their intended purposes (i.e. drinking, recreation, agriculture, wildlife, and industrial uses). Tennessee's river health performs worse than the national average (51% of mileage), but its lakes and reservoirs are relatively cleaner (national average 55%).[64]

[63] Brian Ham, Rivers and Streams (Water Quality Assessment), Tennessee Department of Environment and Conservation (August 10, 2022), https://tdec-division-of-water-tdec.hub.arcgis.com/datasets/90a4028db6054a0c9885d76a2628e127_6/explore.

[64] Keene Kelderman et al., The Clean Water Act at 50: Promises Half Kept at the Half-Century Mark, 4 (March 17, 2022), https://environmentalintegrity.org/wp-content/uploads/2022/03/CWA-report-3.23.22-FINAL.pdf. It is notable that 47 of the 69 assessed lakes and reservoirs were impaired, the figure for percentage by acreage is significantly influenced by the cleanliness of the Kentucky Reservoir, by far Tennessee's largest, without which the impaired acreage jumps to 50.73%. The Kentucky Reservoir is dammed far upstream, in Gilbertsville, KY, so the water cleanliness is reliant not just on Tennessee's effluent volume.

Table 4. Number of rivers, streams, and lakes that exceeded at least one benchmark for concentration of toxic materials or received at least one "Poor" grade.[65]

Region	Number of Impaired Waterways	Total Waterways	Percent Impaired
Tennessee	34	37	91.9%
Southeast	272	317	85.8%
U.S.	2,510	3,062	82%

Data Sources: National Aquatic Resources Survey

Since 2010, Tennessee's waterways have become substantially more impaired. The percent of rivers and streams that support all of their assessed functions decreased from 57.7% to 41%. Similar trends are visible within Tennessee's lakes and reservoirs, for which the area supporting all assessed functions has decreased from 67.9% to 58%.[66, 67] Water quality is negatively associated with treatment costs for municipalities and consumers, so present trends are likely to increase Tennessee's economic burden.[68, 69] Furthermore, less than half of the length of Tennessee's rivers and streams were assessed in 2022 which limits public information on water quality.

SB 1830, passed in 2016, prohibited post-construction stormwater management requirements exceeding the Federal Water Pollution Control Act, which limited local regulatory capacity.[70] Post-construction stormwater management is designed to address new developments that alter the composition and volume of chemical runoff in ways that "significantly affect receiving waterbodies."[71] As one of the fastest growing states, Tennessee continues to undergo substantial development, making post-construction stormwater management especially important in the state. Since 2010, Tennessee .[72]

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[65] U.S. Environmental Protection Agency, "National Rivers and Streams Assessment 2018-19," *National Aquatic Resource Surveys* (2023), https://www.epa.gov/national-aquatic-resource-surveys/data-national-aquatic-resource-surveys; U.S. Environmental Protection Agency, "National Lakes Assessment 2017," *National Aquatic Resource Surveys* (2022), https://www.epa.gov/national-aquatic-resource-surveys/data-national-aquatic-resource-surveys.
[66] Gregory M. Denton et al., "The Status of Water Quality in Tennessee," *Tennessee Department of Environment and Conservation* (November 2010), https://www.tn.gov/content/dam/tn/environment/water/documents/wr_wq_report-305b-2010.pdf.
[67] Division of Water Resources, "Water Quality Status: Tennessee's Clean Water Act Monitoring and Assessment Report," *Tennessee Department of Environment and Conservation* (May 2022), https://storymaps.arcgis.com/stories/5d4aa1dae4754b98a6cd9baf01d1477d.
[68] Office of Water, "A Compilation of Cost Data Associated with the Impacts and Control of Nutrient Pollution," *U.S. Environmental Protection Agency* (May 2015), https://www.epa.gov/sites/default/files/2015-04/documents/nutrient-economics-report-2015.pdf.
[69] James I. Price and Matthew T. Heberling, "The Effects of Source Water Quality on Drinking Water Treatment Costs: A Review and Synthesis of Empirical Literature," *Ecol. Econ.* 151 (September 3, 2018), https://doi.org/10.1016%2Fj.ecolecon.2018.04.014.
[70] Water Pollution, S.B. 1830 (2016), https://wapp.capitol.tn.gov/apps/BillInfo/Default.aspx?BillNumber=SB1830&GA=109.
[71] Office of Water, Post-Construction Runoff Control Minimum Control Measure, Environmental Protection Agency, 1 (December 2005), https://www3.epa.gov/npdes/pubs/fact2-7.pdf.
[72] Planning and Standards Unit, Year 2016 303(d) List, Tennessee Department of Environment and Conservation (May 2017) https://www.nrc.gov/docs/ML1802/ML18023A295.pdf.

The Supreme Court's May 2023 decision in *Sackett v. EPA* removed federal Clean Water Act protections from roughly half of the wetlands in the United States.[73] Given that wetlands comprise 16.3% of land cover in the Southeast (Table 1), this decision could have important effects on wetlands and water quality in the Southeastern US.

Tennessee's water also interacts with development activities through effects on flood risk. Over the next several decades, Tennessee is expected to experience a general increase in precipitation and severe storms.[74] Urbanization across the state will also limit groundwater infiltration which could make flooding both more frequent and more severe (Figure 9).[75]

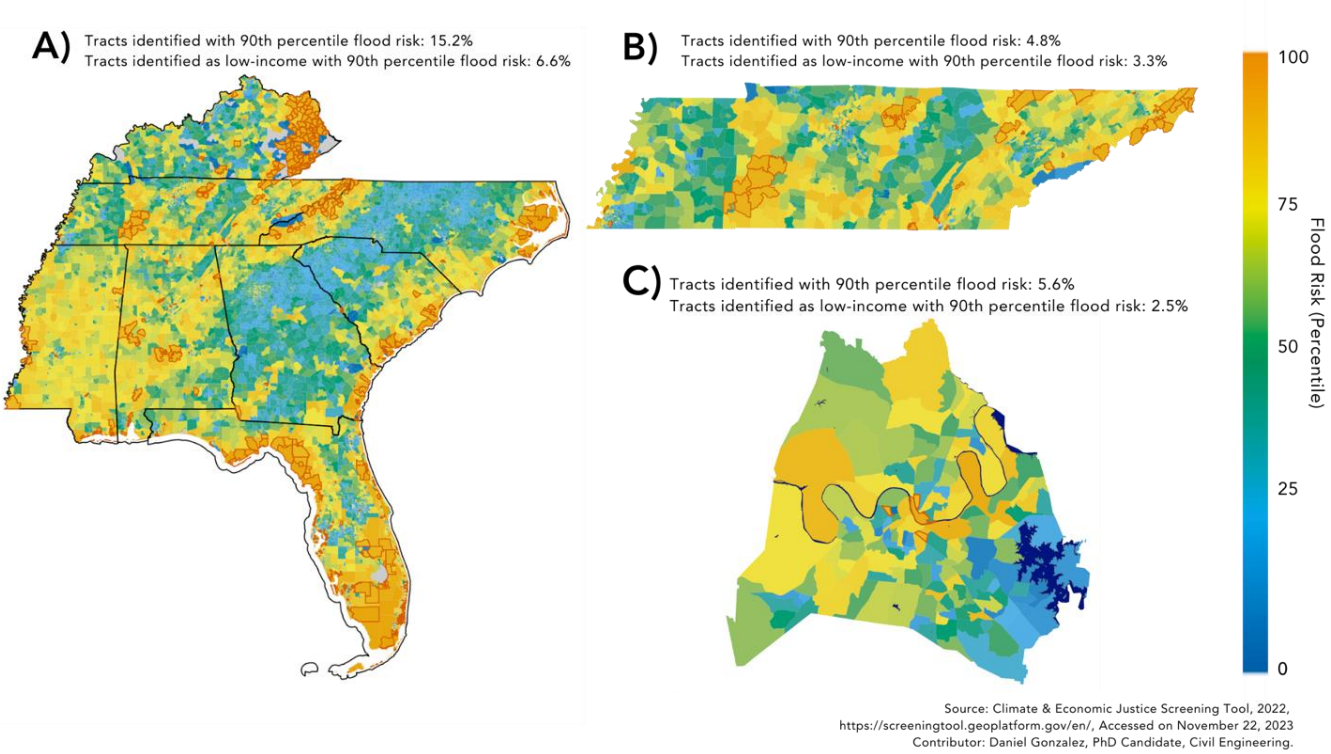

Figure 9. Percentile-ranked share of properties at risk of flood in 30 years for A) The Southeast, B) Tennessee, and C) Davidson County. The red contours delineate low-income census tracts (i.e., 65% or more of the tract with household income at or below 200% of the federal poverty line) with flood risk greater than 90%. Tennessee has a relatively low flood risk compared to the Southeast. In Davidson County, four tracts are considered low-income with 90th percentile flood risk, half of which are undergoing redevelopment as part of the "Imagine East Bank vision plan."

[73] Sackett v. EPA, 598 U.S. ___ (2023). An EPA official told the Washington Post that the Sackett decision could remove Clean Water Act protection from up to 63% of America's wetlands. Allyson Chiu; Biden Rule, Heeding Supreme Court, Could Strip Over Half of U.S. Wetlands' Protections; Washington Post (August 29, 2023), https://www.washingtonpost.com/climate-environment/2023/08/29/epa-new-wetland-rule/.

[74] NOAA Climate Program Office, Davidson County, U.S. Climate Resilience Toolkit Climate Explorer (n.d.), https://crt-climate-explorer.nemac.org/climate_maps/?city=Davidson%2BCounty%2C+TN&county=Davidson%2BCounty&area-id=47037&fips=47037&zoom=7&lat=36.1765901&lon=-86.7818523&id=days_pcpn_gt_1in.

[75] Building a Local Program to Improve the Quality of Permanent Stormwater Discharges, Tennessee Permanent Stormwater Management and Design Guidance Manual, 11 (2016), https://www.tn.gov/content/dam/tn/environment/water/water-based-systems-unit/wr_wq_stormwater-tn-perm-sw-mgmt-design-guide-manual-ch2-2016rev.pdf.

Currently, only 0.87% of Tennessee households are enrolled in FEMA's National Flood Insurance Program (NFIP), which could increase the financial strain of floods on Tennessee households.[76] Six of the ten states with the highest NFIP enrollment are in the Southeast, including by far the two highest, Louisiana and Florida (24.94% and 18.99%, respectively).[77] Although Tennessee has relatively low flood risk (Figure 9), other states in the Southeast are at especially high risk for flooding in the future because ocean levels in the region are rising at more than twice the global average rate.[78] This is further complicated by the fact that the Southeast has 84.5% of the US's total land and 74.1% of the population at or below 1M above sea level.[79]

[76] National Flood Insurance Program, Flood Insurance Data and Analytics, Federal Emergency Management Agency (October 2021), https://nfipservices.floodsmart.gov/reports-flood-insurance-data.
[77] *Ibid.*
[78] Sönke Dangendorf et al., Acceleration of U.S. Southeast and Gulf coast sea-level rise amplified by internal climate variability, 14 Nat. Comm. (2023), https://www.nature.com/articles/s41467-023-37649-9.
[79] Benjamin H. Strauss et al., Tidally adjusted estimates of topographic vulnerability to sea level rise and flooding for the contiguous United States, 7 Env. Res. Letters (March 14, 2012), https://iopscience.iop.org/article/10.1088/1748-9326/7/1/014033/meta.

Waste

Between 1995-2021, Tennessee increased its waste generation[80] by 116.7% (6,921,007 and 14,999,872 tons, respectively), but given the concurrent population increase, per capita waste generation declined 17%.[81] This fell short of the 1991 Solid Waste Management Act's goal to reduce Class I waste by 25% per capita. This has carbon emissions implications as organic waste disposed of in landfills can generate methane, a potent greenhouse gas. Currently, waste accounts for 14% of total methane generation in the U.S.[82] In 2021, Tennessee emitted 3.6 MMT CO_2e from waste (4.5% of total emissions), a 39% reduction since its peak in 1991.[83] One way states have attempted to mitigate waste emissions is through Landfill Gas (LFG) Energy Projects that harness natural methane emissions into useable fuel.[84] Tennessee has had slow uptake of these projects with only 23 operational LFG Energy systems in place on the 129 total landfills in the state (7.8% of total).[85] Meanwhile, across the nation, 20.2% of landfills have LFG Energy systems in place.

Tennessee reported the ninth most toxic releases in the nation (37,828 tons) in 2022, accounting for 2.29% of the total.[86] All eight southeastern states were in the top half in the nation, and in sum accounted for 14.19% of total toxic releases (234,876 tons).[87]

Some chemicals that have not yet been listed in the Safe Drinking Water Act, but for which there is evidence of potential toxicity, are measured by the EPA's Unregulated Contaminant Monitoring Rule.[88] Among these are "forever chemicals" like per- and polyfluoroalkyl substances (PFAS) that are associated with many health effects including increases in cholesterol, some forms of cancer, and poor maternal and child health outcomes.[89] Despite growing evidence, it is very difficult to regulate classes of chemicals like PFAS because they

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[80] Measured as tons disposed of in Class I landfills. Class I landfills "[take] non-hazardous municipal solid wastes such as household wastes, approved special wastes, and commercial wastes." Tennessee Department of Environment and Conservation, "Landfill Permit," *Tennessee Department of Environment and Conservation* (n.d.), https://www.tn.gov/environment/permit-permits/waste-permits1/landfill-permit.html.

[81] Division of Solid Waste Management, "Annual Report to the Governor and General Assembly On the Solid Waste Management Act of 1991: Fiscal Year 2020-2021," *Tennessee Department of Environment and Conservation* (April 6, 2022), 23, https://www.tn.gov/content/dam/tn/environment/solid-waste/documents/materials-management/mm-annual-report-governor-general-assembly/sw_mm_annual-report-dswm.pdf.

[82] Landfill Methane Outreach Program, "Basic Information About Landfill Gas," *U.S. Environmental Protection Agency* (n.d.), https://www.epa.gov/lmop/basic-information-about-landfill-gas.

[83] *Id* supra note 6.

[84] For more information on the process, see *Id* supra note 79.

[85] Landfill Methane Outreach Program, "State-Level Project and Landfill Totals from the LMOP Database," *U.S. Environmental Protection Agency* (August 3, 2023), https://www.epa.gov/lmop/project-and-landfill-data-state.

[86] "TRI Basic Data Files: U.S. 2022," *U.S. Environmental Protection Agency* (October 15, 2023), https://www.epa.gov/toxics-release-inventory-tri-program/tri-basic-data-files-calendar-years-1987-present.

[87] *Ibid.*

[88] "Monitoring Unregulated Drinking Water Contaminants," *U.S. Environmental Protection Agency* (n.d.), https://www.epa.gov/dwucmr.

[89] Agency for Toxic Substances and Disease Registry, "What are the Health Effects of PFAS?," *Centers for Disease Control* (January 18, 2024), https://www.atsdr.cdc.gov/pfas/health-effects/index.html.

have cumulative rather than acute effects which can limit scientific surety.[90] Nonetheless, it is important to keep track of these chemicals to inform future policy. Thus far in the Fifth Unregulated Contaminant Monitoring Rule testing (2023-2025), 497,340 tests have been done at 3,804 drinking water plants across the country measuring 29 types of PFAS and lithium concentrations.[91] Of those, 14,829 (2.98%) have found levels exceeding the Minimum Reporting Level (MRL).[92] In Tennessee, 106 unique drinking water facilities have been tested, 27 of which exceeded the MRL for at least one chemical. In total, 174 of the 10,269 (1.69%) tests performed in Tennessee exceeded the MRL which is lower than the national average.

[90] *See* Michael P. Vandenbergh, Sarah E. Light, and James Salzman, ed., *Private Environmental Governance* (2024).
[91] "Fifth Unregulated Contaminant Monitoring Rule Data Finder," *U.S. Environmental Protection Agency* (January 11, 2024), https://www.epa.gov/dwucmr/fifth-unregulated-contaminant-monitoring-rule-data-finder.
[92] *Ibid.*